Bookshelf: Calculate with Confidence

by Unknown Author

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cover - Section 1 (Page 1)

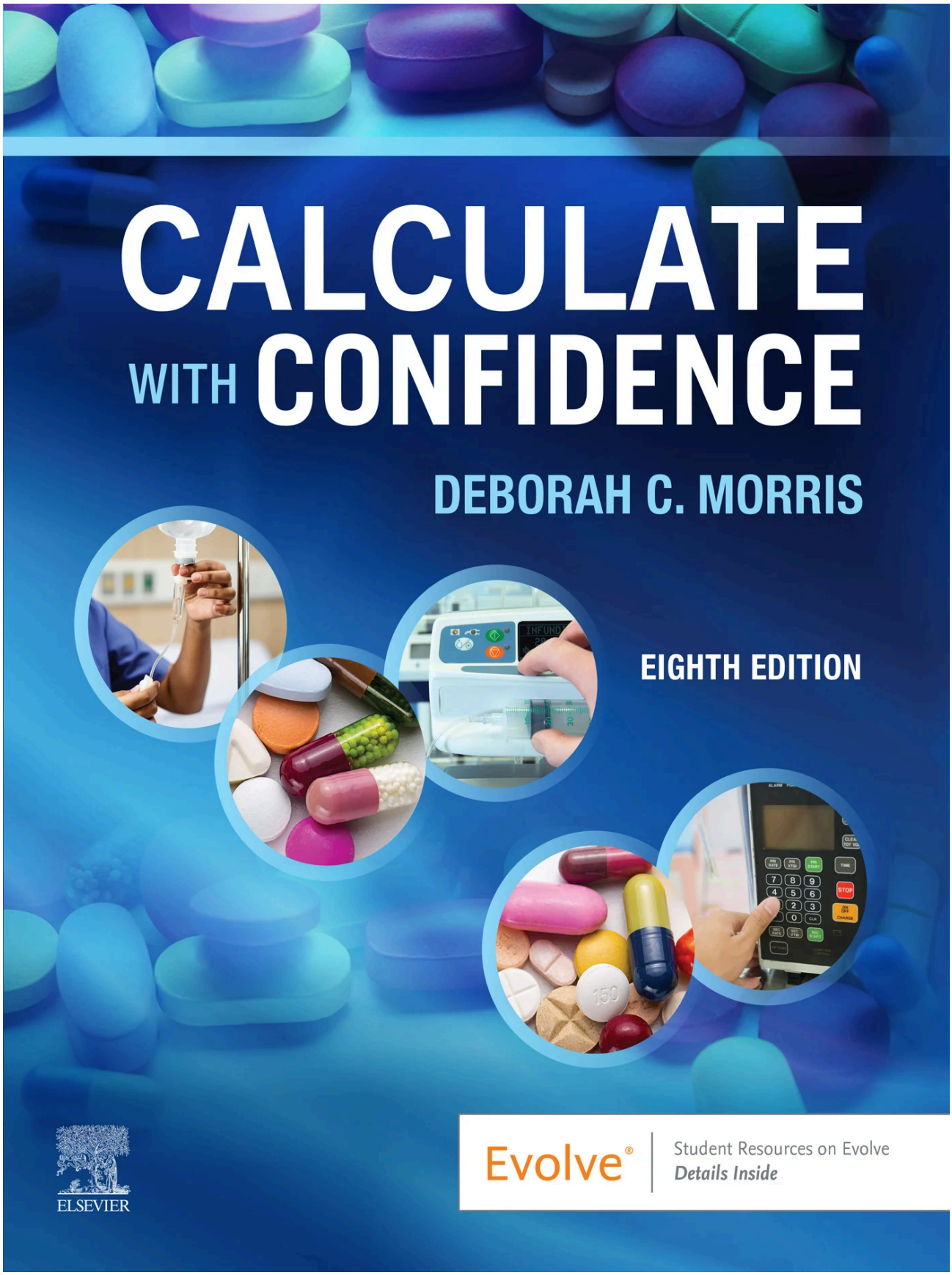


Table of Contents

Cover image

- Title page
- Evolve Student Resources
- Copyright
- Dedication
- Reviewers
- Preface to the Instructor
- Acknowledgments
- List of Illustrations
- List of Tables

Unit One: Math Review

- Pre-Test 2
- Introduction to Math Review
- Chapter 1: Fractions
- Types of Fractions
- Converting Fractions
- Comparing Fractions
- PRACTICE PROBLEMS
- PRACTICE PROBLEMS
- PRACTICE PROBLEMS
- CHAPTER REVIEW
- ANSWERS
- Chapter 2: Decimals
- Reading and Writing Decimals
- PRACTICE PROBLEMS
- PRACTICE PROBLEMS
- PRACTICE PROBLEMS
- PRACTICE PROBLEMS
- PRACTICE PROBLEMS
- PRACTICE PROBLEMS
- CHAPTER REVIEW
- ANSWERS
- Chapter 3: Ratio and Proportion
- Ratios

Proportions

Solving for x in Ratio and Proportion

Applying Ratio and Proportion to Dosage Calculation

PRACTICE PROBLEMS

CHAPTER REVIEW

ANSWERS

Chapter 4: Percentages

Converting Percentages to Fractions, Decimals, and Ratios

PRACTICE PROBLEMS

Percentage Measures

PRACTICE PROBLEMS

Comparing Percents and Ratios

PRACTICE PROBLEMS

Determining the Percent of a Quantity

Determining What Percent One Number Is of Another

PRACTICE PROBLEMS

Calculating the Percent of Change

PRACTICE PROBLEMS

CHAPTER REVIEW

ANSWERS

POST-TEST

ANSWERS

Unit Two: Systems of Measurement

Post-Test 65

Introduction to Systems of Measurement

Chapter 5: Metric System

Particulars of the Metric System

Rules of the Metric System

Units of Measure

Conversions Between Metric Units

Chapter 6: Apothecary and Household Systems and Additional Measures Used in Medication Administration

Apothecary System

Household System

Other Medication Measurements Used in Dosage Calculation

Chapter 7: Converting Within and Between Systems

Equivalents Among Metric and Household Systems

Converting

Methods of Converting

Converting Within the Same System

Converting Between Systems

Calculating Intake and Output

Chapter 8: Additional Conversions Useful in the Health Care Setting

Converting Between Celsius and Fahrenheit

Formulas for Converting Between Fahrenheit and Celsius Scales

Metric Measures Relating to Length

Conversions Relating to Weight

Military Time

Calculating Completion Times

Unit Three: Methods of Administration and Calculation

Introduction to Methods of Administration and Calculation

Chapter 9: Medication Administration

Medication Errors

Overview of Medication Errors

Preventing Medication Errors

Critical Thinking and Medication Administration

Factors That Influence Medication Dosages and Action

Special Considerations for the Elderly

The Rights of Medication Administration

Medication Reconciliation

Client Education

Home Care Considerations

The Nurse's Role in Medication Error Prevention

Routes of Medication Administration

Equipment Used for Medication Administration

Equipment for Administering Oral Medications to a Child

Chapter 10: Understanding and Interpreting Medication Orders

Verbal Orders

Transcription of Medication Orders

Writing a Medication Order

Components of a Medication Order

Interpreting a Medication Order

Chapter 11: Medication Administration Records and Drug Distribution Systems

Medication Orders

Medication Administration Record

Essential Components on a Medication Administration Record

Documentation of Medications

Use of Technology in Medication Administration

Medication Distribution Systems

Role of the Nurse When Using Technology

Scheduling Medication Times

Military Time

NGN Case Study

Chapter 12: Reading Medication Labels

Reading Medication Labels

The Medication Name and Tall Man Lettering

Chapter 13: Dosage Calculation Using the Ratio and Proportion Method

Use of Ratio and Proportion in Dosage Calculation

Chapter 14: Dosage Calculation Using the Formula Method

Formula for Calculating Dosages

Using the Formula Method

PRACTICE PROBLEMS

CHAPTER REVIEW

ANSWERS

Chapter 15: Dosage Calculation Using the Dimensional Analysis Method

Understanding the Basics of Dimensional Analysis

PRACTICE PROBLEMS

Dosage Calculation Using Dimensional Analysis

PRACTICE PROBLEMS

CHAPTER REVIEW

Unit Four: Oral and Parenteral Dosage Forms and Insulin

Introduction to Oral and Parenteral Dosage Forms and Insulin

Chapter 16: Oral Medications

Forms of Solid Oral Medications

Calculating Oral Liquids

Measuring Oral Liquids

Chapter 17: Parenteral Medications

Parenteral Medication Packaging

Reading Parenteral Labels

Medications Labeled in Percentage Strengths

Solutions Expressed in Ratio Strength

Medications Measured in Units

Medications in Milliequivalents

Guidelines for Calculating and Rounding Parenteral Medications

Calculating Injectable Medications

Calculating Dosages for Medications in Units

Mixing Medications in the Same Syringe

Chapter 18: Reconstitution of Solutions

Basic Principles for Reconstitution

Reconstituting Medications With More Than One Direction for Mixing (Multiple Strength Reconstitution)

Reconstitution From Package Insert Directions and Medications With Different Reconstitution Directions Depending on Route of Administration

Medications With Instructions to “See Accompanying Literature” (Package Insert) for Reconstitution and Administration

Calculation of Dosages

Reconstitution of Noninjectable Solutions

Chapter 19: Insulin

Introduction

Types of Insulin

Labels

Insulin Action Times

Appearance of Insulin

Insulin Administration

Insulin Orders

Current Recommendations Regarding Use of the Sliding Scale

Preparing a Single Dosage of Insulin in an Insulin Syringe

Measuring Two Types of Insulin in the Same Syringe

Unit Five: Intravenous, Heparin, and Critical Care Calculations and Pediatric and Adult Calculations Based on Weight

Introduction to Intravenous, Heparin, and Critical Care Calculations and Pediatric and Adult Calculations Based on Weight

Chapter 20: Intravenous Solutions and Equipment

IV Delivery Methods

IV Solutions

Administration of IV Fluids

Chapter 21: Intravenous Calculations

IV Flow Rate Calculation

Manually Regulated IVs

Calculating Flow Rates in Drops Per Minute Using a Formula and Dimensional Analysis

Dimensional Analysis

Calculation of IV Flow Rates Using a Shortcut Method

Calculating IV Flow Rates Using a Dial-Flow Controller

Calculating Intermittent IV Infusions Piggyback

Determining the Amount of Medication in a Specific Amount of Solution

Determining the Unknown for Time and Volume

Calculating a Problem with an Unknown Using the Formula Method and Dimensional Analysis

Recalculating an IV Flow Rate

Calculating Infusion and Completion Time

Calculating Infusion Time When Rate in mL/hr Is Not Indicated for Large Volumes of Fluid

Calculating Infusion Time for Small Volumes of Fluid

Monitoring the Infusion of IV Solutions

Charting IV Therapy

IV Push Medications

Administration of Medications by IV Push

Chapter 22: Heparin Calculations

Heparin Errors

Heparin Administration

Heparin Dosage Strengths

Other Anticoagulant Medications

Reading Heparin Labels

Calculation of Subcutaneous Dosages

Calculation of IV Heparin Solutions

Calculating Heparin Dosages Based on Weight

NGN Case Study

Chapter 23: Critical Care Calculations

Calculating Rate in mL/hr

Calculating Critical Care Dosages per Hour or per Minute

Medications Ordered in Milligrams per Minute

Calculating Dosages Based on mcg/kg/min

IV Flow Rates for Titrated Medications

Developing a Titration Table

PRACTICE PROBLEMS

CLINICAL REASONING

NGN Case Study

CHAPTER REVIEW

ANSWERS

Chapter 24: Pediatric and Adult Dosage Calculations Based on Weight

Older Adults (Geriatrics)

Pediatric Medication Dosages

Principles Relating to Basic Calculations

Calculation of Dosages Based on Body Weight

Converting Pounds to Kilograms

Converting Kilograms to Pounds

Converting Grams to Kilograms

Single-Dose Medications

Single-Dose Range Medications

Calculating Daily Doses

Adult Dosages Based on Body Weight

Calculating Dosages Using Body Surface Area

Use of a Nomogram to Determine BSA

Calculating BSA Using a Formula

Dosage Calculation Based on BSA

IV Therapy and Children

Calculating IV Medications Using a Volume Control Set

Calculation of Daily Fluid Maintenance

Pediatric Oral and Parenteral Medications

NGN Case Study

Comprehensive Post-Test

ANSWERS

References

Apothecary System

FDA and ISMP Lists of Look-Alike Drug Names With Recommended Tall Man Letters

TJC “Do Not Use” List of Abbreviations

ISMP List of Error-Prone Abbreviations, Symbols, and Dose Designations

ISMP List of High-Alert Medications in Acute Care Settings

ISMP List of High-Alert Medications in Community/Ambulatory Health Care

Index

Drug Label Index

Commonly Used Medication Abbreviations

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Dedication

To my children, Cameron, Kimberly, Kanin, and Cory, thanks for your love and support. You light up my life.

To my mother, your love, support, guidance, and nurturing helped me to become the person I am today.

To my husband, Reggie, thank you for all the hard work you did in helping me with the current and previous editions of this text. Your support and encouragement kept me on track and focused.

To the two special additions and loves of my life, my two grandsons, Ryan and Eison, you touch my life more than you know.

Thank you to friends, nursing colleagues, and students past and present. To future and current practitioners of nursing, I hope this book will be valuable in teaching the principles of dosage calculation and reinforcing the importance of safety in administration of medications to all clients regardless of the setting.

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unknown - Section 7 (Page 17)

Preface to the Instructor

Safety is a priority in the delivery of health care. To advance client safety and its importance in health care delivery worldwide, several organizations are involved in reinforcing the promotion of client safety in health care, which includes emphasis on improving safety in medication administration. These organizations include the Institute of Medicine (IOM), the Institute for Safe Medication Practices (ISMP), and The Joint Commission (TJC).

The Quality and Safety Education for Nurses (QSEN) looks at six competencies, two of which are relevant to medication administration: safety and informatics. *Safety* refers to reducing the risk of harm to clients, and *informatics* refers to technology used to mitigate errors. Safety and informatics will be referred to in this text where applicable. The text uses the term *client* to denote one who is the recipient of health care and can also be referred to as *patient, resident,* and *health care consumer*.

The eighth edition of ***Calculate with Confidence*** not only teaches the aspects of dosage calculation, it also emphasizes the importance of safety in medication administration. ***Calculate with Confidence*** is written to meet the needs of nursing students as well as nurses returning to the workforce after being away from the clinical setting. It is also suitable for courses within nursing curricula whose content reflects the calculation of dosages and solutions. The text can generally be used as a reference by any health care professional whose responsibilities include safe administration of medications and solutions to clients in diverse clinical settings.

Calculate with Confidence, eighth edition, has incorporated feedback from users of previous editions, including students, instructors, and reviewers. This edition has maintained a style similar to previous editions. The text presents three methods of dosage calculation—dimensional analysis, formula method, and ratio and proportion. Each method is illustrated, empowering students to choose the method that suits their learning style and works for them. It also enables the instructor to teach a preferred method or multiple methods to students.

The new edition responds to changes in the health care field and includes the introduction of new medications, discussion of new methods for medication administration, and an emphasis on clinical reasoning in prevention of medication errors. Principles of QSEN have been incorporated where applicable. An ample number of practice problems that include the shading of syringes where indicated continues to be featured to allow for visualization of dosages, reinforcement of clinical thinking skills, and prevention of medication errors. Safety alerts are also incorporated throughout the chapters to further reinforce the importance of error prevention in medication administration. Despite technological advances in equipment, health care professionals must continue to use clinical reasoning skills and have a consistent focus on safety to minimize the risk of harm to clients. Answers to practice problems include rationales to enhance understanding of principles and answers related to dosages. Answers have been placed at the end of chapters to allow for immediate feedback.

In response to the increased need for competency in basic math as an essential prerequisite for dosage calculation, practice problems in the basic math section are provided to allow the student to identify his or her strengths and weaknesses in basic math areas that provide the foundation for math skills applied in dosage calculation.

The once controversial use of calculators is now a more accepted practice, and they are used on many nursing examinations, including the NCLEX; however, their use is individualized. Many health care agencies have policies that require the use of calculators to verify calculations (e.g., critical care calculations) to avoid medication errors. A basic handheld calculator that has functions of addition, subtraction, multiplication, division, and a square root key is usually sufficient for medical dosage calculation, and students should know how to use such a calculator.

ORGANIZATION OF CONTENT

The eighth edition continues to be organized in a progression from simple topics to more complex ones, making content relevant to the needs of the student and using realistic practice problems to enhance learning and make material clinically applicable.

The 24 chapters are arranged into 5 units.

Unit One includes Chapters 1 through 4. This unit provides a review of basic arithmetic skills, including fractions, decimals, ratio and proportion, and percentages. A Pre-Test and Post-Test are included. This unit allows the student to determine his or her weaknesses and strengths in arithmetic and provides a review of basic math, which includes fractions, decimals, percents, and ratio and proportion. Ample practice problems as well as word problems are included in the basic math sections.

Unit Two includes Chapters 5 through 8. Chapters 5 through 7 introduce the student to the three systems of measurement: metric, household, and apothecary. The metric system is emphasized, and some aspects of household measures are discussed because of their implications for care at home. The apothecary system is discussed in terms of its non-use, and the error-prone abbreviations from this system to avoid in this system have been placed in Appendix A. Chapter 8 provides conversions relating to temperature, length, weight, and military time. Calculation of intake and output (I&O) is included (both basic and complex). A brief discussion of completion times for IV therapy is also presented.

Unit Three includes Chapters 9 through 15. This unit provides essential information that is needed as a foundation for dosage calculation and safe medication administration. Chapter 9 includes an expanded discussion of medication errors; routes of medication administration; equipment used in medication administration; the six basic rights of medication administration, as well as additional rights to be considered when administering medications; and the nursing role in preventing medication errors. Chapter 10 presents the abbreviations used in medication administration and interpretation of medication orders. Chapter 11 introduces students to medication administration records and has been updated to include the various medication distribution systems. Chapter 12 provides the student with the skills necessary to read medication labels to calculate dosages. Medication labels include medications in current use as well as some of the newer medication labels on the market. The important skill of reading labels is developed by providing practice with identification of information on labels. Resources that include TJC's official "Do Not Use" list and ISMP's list of Error-Prone Abbreviations, Symbols, and Dose Designations are emphasized and have been included in the appendices, along with other resources. Emphasis is placed on the nurse's responsibility to stay abreast of standards regarding medication orders to ensure client safety and prevent errors in medication administration. Chapters 13 through 15 introduce the various methods used for dosage calculation (ratio and proportion, formula method, and dimensional analysis). Practice problems are provided for each method, giving the student the opportunity to practice the various methods and choose the one preferred.

Unit Four includes Chapters 16 through 19. In Chapter 16, the student learns the principles and calculations related to oral medications (solid and liquids). In Chapter 17, the student learns about the various types of syringes and the skills needed for calculating injectable medications. Chapter 18 introduces concepts of solutions. Calculations associated with reconstituted solutions for injectable and oral medications are discussed. Calculations associated with preparation of noninjectable solutions, including nutritional feedings, determining the strength of solutions, and calculation of solutions, are also included. Chapter 19 introduces the student to insulin types, including U-500 insulin and the U-500 insulin syringe. The chapter has been expanded to include discussion of insulin pens, the use of the sliding scale, and glucose monitoring systems. The methods of dosage calculation are illustrated in the chapters (ratio and proportion, formula method, and dimensional analysis), and practice problems are provided in each chapter.

Unit Five includes Chapters 20 through 24. Chapters 20 and 21 provide a discussion of equipment used in the administration of intravenous (IV) fluids and IV solutions, as well as associated calculations related to IV therapy. Content includes a focus on safety with IV administration, recalculating IV flow rate with an alternative method of determining the percentage of variation, and determining infusion and completion time for IV therapy. IV labels have been added throughout the chapter, with a discussion of additives to IV solutions. Chapter 22 presents a discussion of heparin and new heparin labels. Heparin weight-based protocol has been expanded to include adjusting IV heparin based on activated partial thromboplastin time (aPTT). Chapter 23 provides the student with the skills necessary to calculate critical care IV medications. Titration of IV flow rates for titrated medications is explained, as well as how to develop a titration table. Additional practice problems have also been added to the chapter. Chapter 24 provides the student with the skills and principles for calculation of pediatric and adult dosages and verification of safe dosages based on weight. Determining the body surface area (BSA) using a nomogram and formula is discussed, and calculation and verification of safe dosages based on BSA is also included. Calculation of daily fluid maintenance, also referred to as daily fluid requirement (DFR), for children has also been included, as have practice problems.

Safety Alerts, Tips for Clinical Practice, Practice Problems, Clinical Reasoning scenarios, and Points to Remember are included throughout the text. A Comprehensive Post-Test is included at the end of the text and includes practice problems covering content from all 24 chapters. A Drug Label Index is also included.

NEW FEATURES TO THE EIGHTH EDITION

- • A change in format in some chapters for ease of reading.
- • Updates in the chapter on Medication Administration that include the "culture of safety" and the Risk Evaluation and Mitigation Strategy (REMS).
- • Discussion of Clinical Decision-Making Support Systems (CDSS) and Computerized Provider Order Entry (CPOE).
- • Updated labels that include current medications on the market are provided throughout the text, along with discussion of the Black Box Warning.
- • An update of the Insulin chapter with current insulin labels provided by Eli Lilly and Company and an updated discussion of insulin syringes, which includes the U-500 insulin syringe.
- • Current heparin labels in the Heparin Calculations chapter and throughout the text.
- • Labels presented in easily readable format.
- • Addition of case studies in select chapters to help prepare students for the Next-Generation NCLEX (NGN).
- • Updates to Medication Distribution Systems.
- • Calculation and verification of safe dosages using BSA.
- • Updates in the chapters on IV therapy that include calculations and equipment used to administer IV fluids.

ANCILLARIES

Evolve Resources for ***Calculate with Confidence*****,** eighth edition, are available to enhance student instruction. These online resources can be found at http://evolve.elsevier.com/GrayMorris/.

These resources correspond with the chapters of the main book and includes the following:

- • Updated Student Review Questions and Test Bank Questions to coincide with the chapters, as well as sample NCLEX Review Questions.
- • Elsevier's Interactive Drug Calculation Application, version 1: This interactive drug calculation application provides hands-on, interactive practice for the user to master drug calculations. Users can select the mode (Study, Exam, or Comprehensive Exam) and then the category for study and exam modes. There are eight categories that cover the main drug calculation topics. Users are also able to select the number of problems they want to complete and their preferred drug calculation method. A calculator is available for easy access within any mode, and the application also provides history of the work done by the user. There are 750 practice problems in this application.

It is my hope that this book will be a valuable asset to current and future practitioners. May it help you calculate dosages accurately and with confidence, using calculation and critical thinking skills to ensure that medications are administered safely to all clients regardless of the setting. This is both a priority and a primary responsibility of the nurse.

Deborah C. Morris

Acknowledgments

I would like to extend sincere gratitude and appreciation to those individuals from both the past and present who have inspired and encouraged me throughout the writing of the editions of this text. Who knew that this text would now be in its eighth edition? First and foremost, thank you to my family for all of your support during the writing of every edition. A special thanks to my daughter-in-law, who we call Marcy (Marcella Willis-Gray, MD), for taking the time out of your busy schedule to answer questions relating to medication orders and guiding me to the source to obtain an electronic medication administration record (eMAR) for use in this edition.

I am particularly thankful for the encouragement and support of present and former colleagues at Bronx Community College of the City University of New York (CUNY). Thanks to Professor Lois Augustus, former chairperson of the Department of Nursing and Allied Health Sciences, for your friendship and encouragement. Thank you to Mr. Clarence Hodge (Lecturer) who currently teaches Pharmacology Computations; your feedback has been invaluable. Thank you to Professor Helen Papas-Kavalis, a friend and colleague, for sharing your pediatric expertise when needed. A special note of thanks and sincere appreciation to Professor Ellen Hoist, a colleague and a friend, who provided me with support, mentoring, and encouragement from the beginning with the first edition of this text, when I expressed doubt of editions beyond the first. You could see the potential even when I expressed doubt.

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Thanks to past and present students at Bronx Community College in the Department of Nursing and Allied Health Sciences who provided the inspiration for me to write this text. You helped me to have an appreciation for the problems students encounter with basic math and the calculation of medication dosages.

I am especially grateful to the staff at Elsevier for their support and help in planning, writing, and producing the eighth edition of this text. A special thanks to Danielle M. Frazier and Yvonne Alexopoulos; thank you for your patience and understanding during a difficult time when I needed it most while doing the revisions. Thanks also to Tracey Schriefer and Clay S. Broeker for their work in producing the text.

To all of my friends, and especially to Anna Nunnally, my friend who always says I am her sis, thanks for your encouragement and admiration and for always saying “you can do it.” To my friend the late Frank A. Rucker, your encouragement, inspiring words, and admiration for me as an author will always remain with me.

I wish to acknowledge and thank Eli Lilly and Company for providing current images of medication labels for reproduction in this text. I also want to thank the companies that provided images of medication equipment and documents for use in this edition. Thanks to Omnicell for the image of their Automated Dispensing Cabinet (ADC) and Becton Dickinson and Company (BD) for the image of the Flow Controller. Thank you to Epic for providing the image of an eMAR and to ISMP and TJC for granting permission for documents used in the text.

Thank you all!

Deborah C. Morris

List of Illustrations

Figure 1.1 Coumadin 2.5 mg (expressed as 2½ mg).

Figure 1.2 Coumadin 7.5 mg (expressed as 7½ mg).

Figure 1.3 The shaded part of the circle, which is 5 parts, reflects the numerator, and the total number of parts (6) is the denominator. Therefore

$$\frac{5}{6}$$

means 5 of 6 equal parts.

Figure 2.1 Flomax, each capsule is 0.4 mg.

Figure 2.2 Coreg, each tablet is 3.125 mg.

Figure 5.1 Medicine cup showing volume measure in milliliters (mL).

Figure 6.1 Medicine cup showing metric/household measurements.

Figure 6.2 Medication labels showing milliequivalents and units.

Figure 7.1 Sample I&O flow sheet.

Figure 7.2 Charting IV fluids on an I&O flow sheet. *IVPB,* Intravenous piggyback; *LIB,* left in bag.

Figure 7.3 I&O flow sheet (completed 24 hours). *IVPB,* Intravenous piggyback; *LIB,* left in bag.

Figure 8.1 Celsius and Fahrenheit temperature scales.

Figure 8.2 Traditional 12-hour clock.

Figure 8.3 24-hour clock.

Figure 9.1 Sample of Speak Up poster.

Figure 9.2 (A) Container that holds a week's medications. (B) The Pill Timer beeps, flashes, and automatically resets every time it is closed.

Figure 9.3 Medicine cup.

Figure 9.4 (A) Plastic medicine cup. (B) Soufflé cup.

Figure 9.5 Medicine droppers.

Figure 9.6 Nipple.

Figure 9.7 A, Oral syringes. B, Calibrated spoon.

Figure 9.8 Parts of a syringe.

Figure 9.9 Types of syringes. (A) 3-mL syringe marked in 0.1 (tenths). (B) Tuberculin syringe marked in 0.01 (hundredths) and 0.1 (tenths) of a mL. (C) Insulin syringe marked in units (100). (D) Lo-Dose Insulin syringe marked in units (50).

Figure 9.10 (A) Acceptable devices for measuring and administering oral medication to children *(clockwise)*: measuring spoon, plastic syringes, calibrated nipple, plastic medicine cup, calibrated dropper, hollow-handled medicine spoon. (B) Medibottle used to deliver oral medication via a syringe.

Figure 10.1 Rubraca label. Notice the two names. The first, *Rubraca*, is the trade name, identified by the registration symbol®. The name in smaller and different print is *rucaparib*, the generic or official name.

Figure 10.2 Metformin hydrochloride is the generic name on the label. Notice the abbreviation USP that appears after the generic name on the label.

Figure 11.1 Handwritten medication administration record (MAR). Note: This MAR is intended to show the basic information that would be included on an MAR.

Figure 11.2 Electronic medication administration record (eMAR). (Used with permission of Epic Systems Corporation.)

Figure 11.3 Unit-dose cabinet.

Figure 11.4 Pyxis Med Station.

Figure 11.5 Omnicell XT Automated Dispensing Cabinet. (Used with permission of Omnicell, Inc.)

Figure 11.6 Barcode for unit drug dose.

Figure 11.7 Barcode reader.

Figure 12.1 (A) Atropine label (injectable solution). Dosage strength 0.5 mg per 5 mL or 0.1 mg per mL. (B) Morphine sulfate label. Extended-release capsules. The dosage strength is 20 mg per extended-release capsule.

Figure 12.2 Furosemide label. The dosage strength is 20 mg per 2 mL or 10 mg per mL.

Figure 12.3 Xarelto label.

Figure 12.4 Verzenio label.

Figure 12.5 (A) Medication label for DOPamine (injectable solution) with Tall Man lettering. The dosage strength is 200 mg per 5 mL or 40 mg per mL. (B) Medication label for DOBUTamine (injectable solution) label with Tall Man lettering. The dosage strength is 250 mg per 20 mL or 12.5 mg per mL.

Figure 12.6 Namenda label (oral solution). The dosage strength of this oral solution is 2 mg per mL.

Figure 12.7 Penicillin V Potassium label (oral solution). The dosage strength of this oral solution is 250 mg (per 5 mL) or 400,000 units (per 5 mL).

Figure 12.8 Lanoxin label. The label indicates 125 mcg (0.125 mg), which means 125 mcg is equivalent to 0.125 mg. The dosage strength is 125 mcg per tablet or 0.125 mg per tablet.

Figure 12.9 Adrenalin label (injectable solution). Adrenalin contains 1 g of medication per 1,000 mL solution (1 : 1,000) and 1 mg per mL.

Figure 12.10 Lidocaine label (injectable solution). Lidocaine 1% contains 1 g of medication per 100 mL of solution and 500 mg per 50 mL or 10 mg per mL.

Figure 12.11 (A) Ery Tab Delayed Release Tablet and Enteric Coated. (B) Rabeprazole Sodium Delayed Release Sprinkle Capsules. (C) Xeljanz XR Extended Release Tablets.

Figure 12.12 (A) Nitrostat label (sublingual). (B) Suboxone (sublingual film).

Figure 12.13 Ondansetron label (IV and IM).

Figure 12.14 Dilantin-125 label (oral suspension).

Figure 12.15 Trelegy Ellipta label (oral inhalation).

Figure 12.16 Clindamycin Injectable label.

Figure 12.17 Ondansetron Injectable label.

Figure 12.18 Namenda Oral Solution label.

Figure 12.19 Levothyroxine Sodium label (see directions for reconstituting).

Figure 12.20 Famotidine label. (Shake well before using. Not for Injection. Keep container tightly closed.) Discard unused suspension after 30 days.

Figure 12.21 Norvir label. (Store at room temperature, take Norvir with meals, find out about medicines that should not be taken with Norvir.)

Figure 12.22 Sinemet 25 mg/100 mg label. The dosage strength of carbidopa is 25 mg, and levodopa is 100 mg.

Figure 12.23 Percocet 2.5 mg/325 mg label. The label indicates the dosage strength of oxycodone hydrochloride as 2.5 mg and acetaminophen (Tylenol) is 325 mg.

Figure 12.24 Bactrim DS 800 mg/160 mg label. The label indicates the dosage strength of sulfamethoxazole as 800 mg and trimethoprim is 160 mg.

Figure 12.25 Biktarvy 50 mg/200 mg/25 mg label. The dosage strength of bictegravir is 50 mg, 200 mg is the dosage strength of emtricitabine, and 25 mg is the dosage strength of tenofovir alafenamide.

Figure 12.26 IV label for Sulfamethoxazole and Trimethoprim. Notice the dosage strength is stated for both medications per total volume of the vial, and directly next to it is the dosage strength for each medication per mL. (Calculation of ordered dosages is based on the Trimethoprim).

Figure 12.27 Black box warning for Vraylar.

Figure 12.28 Latuda label.

Figure 12.30 Prescribing information for Zyprexa, including a black box warning.

Figure 12.29 Unit-dose packages.

Figure 12.31 OTC label for Aleve.

Figure 16.1 Clonazepam tablet scored.

Figure 16.2 Pill/tablet cutter.

Figure 16.3 Sublingual (A) and buccal (B) tablets.

Figure 16.4 Layered tablet.

Figure 16.5 Forms of oral medications. (A) Scored tablet. (B) Chewable tablet. (C) Sublingual. (D) Timed-release tablet. (E) Capsule. (F) Timed-release capsule. (G) Gelatin capsule.

Figure 16.6 (A) CellCept oral suspension 200 mg per mL. (B) Valproic acid oral solution 250 mg per 5 mL.

Figure 16.7 Medicine cup.

Figure 16.8 Reading meniscus. The meniscus is caused by the surface tension of the solution against the walls of the container. The surface tension causes the formation of a concave or hollowed curvature on the surface of the solution. Read the level at the lowest point of the concave.

Figure 16.9 Medicine droppers.

Figure 16.10 Oral syringes.

Figure 16.11 Calibrated spoons.

Figure 17.1 Medication in ampules.

Figure 17.2 Medication in vials.

Figure 17.3 Medication in powder form.

Figure 17.4 Mix-o-vial.

Figure 17.5 (A) Carpuject syringe holder and needleless, prefilled sterile cartridge. (B) EpiPen 2-Pak.

Figure 17.6 Parts of a syringe.

Figure 17.7 (A) Luer-Lok. (B) Slip tip (non–Luer-Lok).

Figure 17.8 3-mL syringe.

Figure 17.9 Reading measured amount of a medication in a syringe.

Figure 17.10 Large hypodermics. (A) 5-mL syringe filled with 0.8 mL. (B) 10-mL syringe filled with 7.8 mL.

Figure 17.11 Tuberculin syringe.

Figure 17.12 Tuberculin syringe. The 0.4 mL calibration *(orange line)* is one of 0.1-increments; the 0.25 mL calibration *(green line)* is one of the 0.01-mL increments on the tuberculin syringe.

Figure 17.13 Insulin syringes. (A) 1-mL size (100 units). (B) Lo-Dose (50 units). (C) Lo-Dose (30 units). (D) U-500. (From Macklin D, Chernecky L, Infortuna H: *Math for clinical practice*, ed 2, St Louis, 2010, Mosby.)

Figure 17.14 1-mL capacity insulin syringe (100 units) with the dual-scale odd and even calibrations.

Figure 17.15 BD Safety Glide needle.

Figure 17.16 Tigan label.

Figure 17.17 Depo-Provera label.

Figure 18.1 Ceftriaxone 1-g vial reconstitution.

Figure 18.2 Directions for mixing Cefaclor Oral Suspension 125 mg per 5 mL. Notice the **directions for mixing** indicate to add 106 mL of water in two portions to the dry mixture and shake well after each addition. **The reconstituted solution** will provide a dosage strength of 125 mg per 5 mL. **The total volume** when mixed is 150 mL. **Storage directions:** Store in refrigerator. **Expiration:** Discard unused portion after 14 days.

Figure 18.3 Acyclovir 500 mg per vial. Notice there is no dosage strength stated with the reconstitution information. The dosage strength is 500 mg per 10 mL. This was determined by using the total amount of medication in the vial (500 mg) and the amount of diluent added (10 mL).

Figure 18.4 Pfizerpen (penicillin G potassium).

Figure 18.5 (A) Tazicef 1 gram. (B) Portion of Tazicef package insert.

Figure 18.6 (A) Olanzapine 10-mg label. (B) Olanzapine package insert.

Figure 18.7 The ADD-Vantage drug delivery system.

Figure 18.8 Kangaroo pump.

Figure 19.1 Label for U-100 insulin. (NPH)

Figure 19.2 Label for U-500 insulin.

Figure 19.3 (A) Rapid-acting (fast-acting). (B) Short-acting. (C) Intermediate-acting. (D) Long-acting.

Figure 19.4 Fixed-combination insulins.

Figure 19-5 (A) Paradigm® 515 insulin pump and Paradigm Link™ blood glucose monitor. (B) Prefilled Kwik Pens, Humulin N and Humulin 70/30.

Figure 19.6 Types of insulin syringes. (A) Single-scale (100 units). (B) Lo-Dose insulin syringe (50 units). (C) Lo-Dose insulin syringe (30 units). (D) Double-scale syringe (100 units). (E) U-500 insulin syringe (250 units).

Figure 19.7 Mixing insulins. Order: Humulin N 30 units subcut, Humulin R, 12 units subcut. Step 1, Inject 30 units of air into Humulin N first; do not allow needle to touch insulin. Step 2, Inject 12 units of air into Humulin R. Step 3, Withdraw 12 units; withdraw needle. Step 4, Insert needle into vial of Humulin N and withdraw 30 units. Total 30 units Humulin N (NPH) + 12 units Humulin R (Regular) = 42 units.

Figure 19.8 Total of two insulins combined. Total = 42 units (30 units Humulin N + 12 units Humulin R).

Figure 19.9 Farxiga 5-mg tablets.

Figure 19.10 Trulicity single-dose pen, 1.5 mg per 0.5 mL.

Figure 20.1 5% Dextrose (D_5W).

Figure 20.2 Lacated Ringer's and 5% dextrose (D_5LR).

Figure 20.3 5% Dextrose in 0.9% sodium chloride (D_5NS).

Figure 20.4 5% Dextrose in 0.45% sodium chloride (D_5 1/2 NS).

Figure 20.5 0.9% Sodium chloride.

Figure 20.6 20 mEq Potassium chloride in 5% dextrose and 0.45% sodium chloride.

Figure 20.7 25,000 units of Heparin in 250 mL of 5% Dextrose.

Figure 20.8 Sample IV orders.

Figure 20.9 Sample of charting IV fluids on an I&O record.

Figure 20.10 Intermittent lock covered with a rubber diaphragm.

Figure 20.11 (A) D_5W IV solution. (B) IV tubing.

Figure 20.12 (A) Piggyback. (B) Tandem.

Figure 20.13 Setup for blood administration.

Figure 20.14 The ADD-Vantage drug delivery system.

Figure 20.15 Mini-Bag Plus.

Figure 20.16 (A) Volume-controlled device. (B) Parts of a volume-control set.

Figure 20.17 Smart pump.

Figure 20.18 Infusion pump.

Figure 20.19 Syringe pump.

Figure 20.20 CADD Solis PCA Ambulatory Infusion Pump

Figure 21.1 Comparison of (A) macrodrops and (B) microdrops.

Figure 21.2 IV administration sets (package). **(A)** Set with drop factor of 10 (10 gtt =1 mL). **(B)** Set with drop factor of 60 (60 gtt = 1 mL).

Figure 21.3 Flow controller. (Courtesy and © Becton, Dickinson and Company, Franklin Lakes, NJ.)

Figure 22.1 (A) Lovenox label, 40 mg per 0.4 mL. (B) Fragmin label, 7,500 lU per 0.3 mL.

Figure 22.2 (A) 10,000 units per 10 mL (1,000 units per mL). (B) 50,000 units per 10 mL (5,000 units per mL). (C) 1-mL vial, 1,000 units per mL.

Figure 22.3 Heparin Lock Flush Solution, 100 units per 10 mL (10 units per mL).

Figure 22.4 Tuberculin syringe illustrating 0.75 mL drawn up.

Figure 22.5 Sample heparin weight-based protocol. *Note:* This protocol is for calculation purposes only.

Figure 24.1 West nomogram for estimation of body surface area. The surface area is indicated where a straight line that connects the height and weight levels intersects the surface area column or, if the patient is roughly of average size, from the weight alone *(enclosed area)*.

Figure 24.2 Volume-controlled device (buretrol).

unknown - Section 10 (Page 34)

List of Tables

TABLE 5.1 Basic Units of Metric Measurement

TABLE 5.2 Common Prefixes Used in Health Care

TABLE 7.1 Approximate Equivalents to Remember

TABLE 10.1 Symbols and Abbreviations for Units of Measure Used in Medication Administration

TABLE 10.2 Commonly Used Medication Abbreviations

TABLE 11.1 Commonly Used Abbreviations for Scheduling Medications

TABLE 17.1 Sample Dosage Strengths

TABLE 17.2 Maximum Volume for Sites/Routes

TABLE 24.1 Daily Fluid Maintenance Formula

Table 1 FDA-Approved List of Generic Drug Names with Tall Man Letters

Table 2 ISMP List of Additional Drug Names with Tall Man Letters***

Table Error-Prone Abbreviations, Symbols, and Dose Designations

unknown - Section 11 (Page 37)

UNIT ONE

Introduction to Math Review

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Although calculators are accessible for basic math operations, the nurse needs to be able to perform the processes involved in basic math. Even when a calculator is used, checking the accuracy of an answer oft en requires nurses to employ the skill of estimating an answer quickly in their heads. Calculators may indeed be recommended for complex calculations to ensure accuracy and save time; the types of calculations requiring their use are presented later in this text. However, because the basic math required for less complex calculations is oft en simple and can be done without the use of a calculator, it is a realistic expectation that each practitioner should be competent in the performance of basic math operations without its use. Performing basic math operations enables the nurse to think logically and critically about the dosage ordered and the dosage calculated.

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Identify the fraction(s) equal to 1.

- 1. 2625,34,88

$$\frac{26}{25}, \frac{3}{4}, \frac{8}{8}$$

_____

- Identify the fraction as a proper fraction, an improper fraction, or a mixed number.
- 2. 137

$$\frac{13}{7}$$

_____

- 3. 712

$$\frac{7}{12}$$

_____

- 4. 827

$$8\frac{2}{7}$$

_____

- 5. 358

$$3\frac{5}{8}$$

_____

- 6. 1414

$$\frac{14}{14}$$

_____

- 7. 521

$$\frac{5}{21}$$

_____

- Change the following fractions to whole or mixed numbers and reduce if necessary.
- 8. 2814

$$\frac{28}{14}$$

_____

- 9. 208

$$\frac{20}{8}$$

_____

- 10. 4810

$$\frac{48}{10}$$

_____

- Reduce the following fractions to lowest terms.
- 11. 1421

$$\frac{14}{21}$$

_____

- 12. 25100

$$\frac{25}{100}$$

_____

- 13. 2150

$$\frac{2}{150}$$

_____

- 14. 2430

$$\frac{24}{30}$$

_____

- 15. 2436

$$\frac{24}{36}$$

_____

- Perform the indicated operations; reduce to lowest terms where necessary.

- 16. 23÷39=

$$\frac{2}{3} \div \frac{3}{9} =$$

_____

- 17. 4÷39=

$$4 \div \frac{3}{9} =$$

_____

- 18. 25+19=

$$\frac{2}{5} + \frac{1}{9} =$$

_____

- 19. 717−256=

$$7\frac{1}{7} - 2\frac{5}{6} =$$

_____

- 20. 423×4=

$$4\frac{2}{3} \times 4 =$$

_____

- 21. 356+523=

$$3\frac{5}{6} + 5\frac{2}{3} =$$

_____

- 22. 567+357=

$$5\frac{6}{7} + 3\frac{5}{7} =$$

_____

- 23. 216−114=

$$2\frac{1}{6} - 1\frac{1}{4} =$$

_____

- 24. 9−35=

$$9 - \frac{3}{5} =$$

_____

- 25. 414−134=

$$4\frac{1}{4} - 1\frac{3}{4} =$$

_____

- 26. 715−134=

$$7\frac{1}{5} - 1\frac{3}{4} =$$

_____

- 27. $7-916=$

$$7-\frac{9}{16}=$$

_____

- 28. $3310-1710=$

$$3\frac{3}{10}-1\frac{7}{10}=$$

_____

- Change the following fractions to decimals; express your answer to the nearest tenth.
- 29. 67

$$\frac{6}{7}$$

_____

- 30. 620

$$\frac{6}{20}$$

_____

- 31. 23

$$\frac{2}{3}$$

_____

- 32. 78

$$\frac{7}{8}$$

_____

- Indicate the largest fraction in each group.
- 33. $34,45,78$

$$\frac{3}{4},\frac{4}{5},\frac{7}{8}$$

_____

- 34. $712,1112,412$

$$\frac{7}{12},\frac{11}{12},\frac{4}{12}$$

_____

- Perform the indicated operations with decimals. Provide the exact answer; do not round off.
- 35. 20.1 + 67.35 = _____
- 36. 0.008 + 5 = _____
- 37. 4.6 × 8.72 = _____
- 38. 56.47 - 8.7 = _____
- Divide the following decimals; express your answer to the nearest tenth.
- 39. 7.5 ÷ 0.004 = _____
- 40. 45 ÷ 1.9 = _____
- 41. 84.7 ÷ 2.3 = _____
- Indicate the largest decimal in each group.
- 42. 0.674, 0.659 _____
- 43. 0.375, 0.37, 0.38 _____
- 44. 0.25, 0.6, 0.175 _____

- Solve for *x*, the unknown value.
- 45. 8 : 2 = 48 : *x* _____
- 46. *x* : 300 = 1 : 150 _____
- 47. 110:x=12:15

$$\frac{1}{10} : x = \frac{1}{2} : 15$$

_____

- 48. 0.1 : 1 = 0.2 : *x* _____
- Round off to the nearest tenth.
- 49. 0.43 _____
- 50. 0.66 _____
- 51. 1.47 _____
- Round off to the nearest hundredth.
- 52. 0.735 _____
- 53. 0.834 _____
- 54. 1.227 _____
- Complete the table below, expressing the measures in their equivalents where indicated. Reduce to lowest terms where necessary.

	Percent	Decimal	Ratio	Fraction
55.	6%	_____	_____	_____
56.	_____	_____	7 : 20	_____
57.	_____	_____	_____	$5\frac{1}{4}$
58.	_____	0.015	_____	_____

	Percent	Decimal	Ratio	Fraction
55.	6%	_____	_____	_____
56.	_____	_____	7 : 20	_____
57.	_____	_____	_____	$5\frac{1}{4}$
58.	_____	0.015	_____	_____

- Find the following percentages. Express your answer to the hundredths place as indicated.
- 59. 5% of 95 _____
- 60. 14%

$$\frac{1}{4}\%$$

of 2,000 _____

- 61. 2 is what % of 600 _____
- 62. 20 is what % of 100 _____
- 63. 30 is what % of 164 _____
- 64. A client is instructed to take 112

$$1\frac{1}{2}$$

teaspoons of a cough syrup three (3) times a day.

- How many teaspoons of cough syrup will the client take each day?
- _____
- 65. A tablet contains 0.75 milligrams (mg) of a medication. A client receives three (3) tablets a day for five (5) days. How many mg of the medication will the client receive in five (5) days? _____
- 66. A client took 0.44 micrograms (mcg) of a medication every morning and 1.4 mcg each evening for five (5) days. What is the total amount of medication taken?
- _____

- 67. Write a ratio that represents that every tablet in a bottle contains 0.5 milligrams (mg) of a medication. _____
- 68. Write a ratio that represents 60 milligrams (mg) of a medication in 1 milliliter (mL) of a liquid. _____
- 69. A client takes 10 milliliters (mL) of a medication three (3) times a day. How long will 120 mL of medication last? _____
- 70. A client weighed 275 pounds (lb) before dieting. After dieting, the client weighed 250 lb. What is the percentage of change in the client's weight? _____
- 71. A client was prescribed 10 milligrams (mg) of a medication for a week. After a week, the health care provider reduced the medication to seven (7) mg. What was the percentage of decrease in medication? _____
- 72. A client received 22.5 milligrams (mg) of a medication in tablet form. Each tablet contained 4.5 mg of medication. How many tablets were given to the client? _____

Answers on 5



ANSWERS

- 1. 8/8
- 2. improper fraction
- 3. proper fraction
- 4. mixed number
- 5. mixed number
- 6. improper fraction
- 7. proper fraction
- 8. 2
- 9. 208=248=212

$$\frac{20}{8} = 2\frac{4}{8} = 2\frac{1}{2}$$

- 10. 4810=2810=445

$$\frac{48}{10} = 2\frac{8}{10} = 4\frac{4}{5}$$

- 11. 23

$$\frac{2}{3}$$

- 12. 14

$$\frac{1}{4}$$

- 13. 175

$$\frac{1}{75}$$

- 14. 45

$$\frac{4}{5}$$

- 15. 23

$$\frac{2}{3}$$

- 16. 2

- 17. 513

$$5\frac{1}{3}$$

- 18. 2345

$$\frac{23}{45}$$

- 19. 41342

$$4\frac{13}{42}$$

- 20. 1823

$$18\frac{2}{3}$$

- 21. 936=912

$$9\frac{3}{6} = 9\frac{1}{2}$$

- 22. 8117=947

$$8\frac{11}{7} = 9\frac{4}{7}$$

- 23. 1112

$$\frac{11}{12}$$

- 24. 825

$$8\frac{2}{5}$$

- 25. 224=212

$$2\frac{2}{4} = 2\frac{1}{2}$$

- 26. 5920

$$5\frac{9}{20}$$

- 27. 6716

$$6\frac{7}{16}$$

- 28. 1610=135

$$1\frac{6}{10} = 1\frac{3}{5}$$

- 29. 0.9
- 30. 0.3
- 31. 0.7
- 32. 0.9

- 33. 78

$$\frac{7}{8}$$

- 34. 1112

$$\frac{11}{12}$$

- 35. 87.45
- 36. 5.008
- 37. 40.112
- 38. 47.77
- 39. 1,875
- 40. 23.7
- 41. 36.8
- 42. 0.674
- 43. 0.38
- 44. 0.6
- 45. $x = 12$
- 46. $x = 2$
- 47. $x = 3$
- 48. $x = 2$
- 49. 0.4
- 50. 0.7
- 51. 1.5
- 52. 0.74
- 53. 0.83
- 54. 1.23

	Percent	Decimal	Ratio	Fraction
55.	6%	0.06	3 : 50	$\frac{3}{50}$
56.	35%	0.35	7 : 20	$\frac{7}{20}$
57.	525%	5.25	21 : 4	$5\frac{1}{4}$
58.	1.5%	0.015	3 : 200	$\frac{3}{200}$

- 59. 4.75

- 60. 5
- 61. 0.33%
- 62. 20%
- 63. 18.29%
- 64. 412

$$4\frac{1}{2}$$

teaspoons

- 65. 11.25 milligrams (mg)
- 66. 9.2 micrograms (mcg)
- 67. 0.5 mg : 1 tablet *or* 0.5 mg/1 tablet
- 68. 60 mg : 1 mL *or* 60 mg/1 mL
- 69. 4 days
- 70. 9%
- 71. 30%
- 72. 5 tablets

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Identify the fraction(s) equal to 1.

- 1.

$$\frac{26}{25}, \frac{3}{4}, \frac{8}{8}$$

_____

- Identify the fraction as a proper fraction, an improper fraction, or a mixed number.
- 2.

$$\frac{13}{7}$$

_____

- 3.

$$\frac{7}{12}$$

_____

- 4.

$$8\frac{2}{7}$$

_____

- 5.

$$3\frac{5}{8}$$

_____

- 6.

$$\frac{14}{14}$$

_____

- 7.

$$\frac{5}{21}$$

_____

- Change the following fractions to whole or mixed numbers and reduce if necessary.
- 8.

$$\frac{28}{14}$$

_____

- 9.

$$\frac{20}{8}$$

_____

- 10.

$$\frac{48}{10}$$

_____

- Reduce the following fractions to lowest terms.
- 11.

$$\frac{14}{21}$$

_____

- 12.

$$\frac{25}{100}$$

_____

- 13.

$$\frac{2}{150}$$

_____

- 14.

$$\frac{24}{30}$$

_____

- 15.

$$\frac{24}{36}$$

_____

- Perform the indicated operations; reduce to lowest terms where necessary.

- 16.

$$\frac{2}{3} \div \frac{3}{9} =$$

_____

- 17.

$$4 \div \frac{3}{9} =$$

_____

- 18.

$$\frac{2}{5} + \frac{1}{9} =$$

_____

- 19.

$$7\frac{1}{7} - 2\frac{5}{6} =$$

_____

- 20.

$$4\frac{2}{3} \times 4 =$$

_____

- 21.

$$3\frac{5}{6} + 5\frac{2}{3} =$$

_____

- 22.

$$5\frac{6}{7} + 3\frac{5}{7} =$$

_____

- 23.

$$2\frac{1}{6} - 1\frac{1}{4} =$$

_____

- 24.

$$9 - \frac{3}{5} =$$

_____

- 25.

$$4\frac{1}{4} - 1\frac{3}{4} =$$

_____

- 26.

$$7\frac{1}{5} - 1\frac{3}{4} =$$

_____

- 27.

$$7 - \frac{9}{16} =$$

_____

- 28.

$$3\frac{3}{10} - 1\frac{7}{10} =$$

_____

- Change the following fractions to decimals; express your answer to the nearest tenth.
- 29.

$$\frac{6}{7}$$

_____

- 30.

$$\frac{6}{20}$$

_____

- 31.

$$\frac{2}{3}$$

_____

- 32.

$$\frac{7}{8}$$

_____

- Indicate the largest fraction in each group.
- 33.

$$\frac{3}{4}, \frac{4}{5}, \frac{7}{8}$$

_____

- 34.

$$\frac{7}{12}, \frac{11}{12}, \frac{4}{12}$$

_____

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$$\frac{1}{10} : x = \frac{1}{2} : 15$$

_____

- 48. 0.1 : 1 = 0.2 : *x* _____
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58.	_____	0.015	_____	_____

- Find the following percentages. Express your answer to the hundredths place as indicated.
- 59. 5% of 95 _____
- 60.

$$\frac{1}{4}\%$$

of 2,000 _____

- 61. 2 is what % of 600 _____
- 62. 20 is what % of 100 _____
- 63. 30 is what % of 164 _____
- 64. A client is instructed to take

$$1\frac{1}{2}$$

teaspoons of a cough syrup three (3) times a day.

- How many teaspoons of cough syrup will the client take each day?
- _____
- 65. A tablet contains 0.75 milligrams (mg) of a medication. A client receives three (3) tablets a day for five (5) days. How many mg of the medication will the client receive in five (5) days? _____
- 66. A client took 0.44 micrograms (mcg) of a medication every morning and 1.4 mcg each evening for five (5) days. What is the total amount of medication taken?
- _____
- 67. Write a ratio that represents that every tablet in a bottle contains 0.5 milligrams (mg) of a medication. _____

- 68. Write a ratio that represents 60 milligrams (mg) of a medication in 1 milliliter (mL) of a liquid. _____
- 69. A client takes 10 milliliters (mL) of a medication three (3) times a day. How long will 120 mL of medication last? _____
- 70. A client weighed 275 pounds (lb) before dieting. After dieting, the client weighed 250 lb. What is the percentage of change in the client's weight? _____
- 71. A client was prescribed 10 milligrams (mg) of a medication for a week. After a week, the health care provider reduced the medication to seven (7) mg. What was the percentage of decrease in medication? _____
- 72. A client received 22.5 milligrams (mg) of a medication in tablet form. Each tablet contained 4.5 mg of medication. How many tablets were given to the client? _____

Answers on 5

ANSWERS

- 1. 8/8
- 2. improper fraction
- 3. proper fraction
- 4. mixed number
- 5. mixed number
- 6. improper fraction
- 7. proper fraction
- 8. 2
- 9.

$$\frac{20}{8} = 2\frac{4}{8} = 2\frac{1}{2}$$

- 10.

$$\frac{48}{10} = 2\frac{8}{10} = 4\frac{4}{5}$$

- 11.

$$\frac{2}{3}$$

- 12.

$$\frac{1}{4}$$

- 13.

$$\frac{1}{75}$$

- 14.

$$\frac{4}{5}$$

- 15.

$$\frac{2}{3}$$

- 16. 2
- 17.

$$5\frac{1}{3}$$

- 18.

$$\frac{23}{45}$$

- 19.

$$4\frac{13}{42}$$

- 20.

$$18\frac{2}{3}$$

- 21.

$$9\frac{3}{6} = 9\frac{1}{2}$$

- 22.

$$8\frac{11}{7} = 9\frac{4}{7}$$

- 23.

$$\frac{11}{12}$$

- 24.

$$8\frac{2}{5}$$

- 25.

$$2\frac{2}{4} = 2\frac{1}{2}$$

- 26.

$$5\frac{9}{20}$$

- 27.

$$6\frac{7}{16}$$

- 28.

$$1\frac{6}{10} = 1\frac{3}{5}$$

- 29. 0.9
- 30. 0.3
- 31. 0.7
- 32. 0.9
- 33.

$$\frac{7}{8}$$

- 34.

$$\frac{11}{12}$$

- 35. 87.45
- 36. 5.008
- 37. 40.112
- 38. 47.77
- 39. 1,875
- 40. 23.7
- 41. 36.8
- 42. 0.674
- 43. 0.38
- 44. 0.6
- 45. $x = 12$
- 46. $x = 2$
- 47. $x = 3$
- 48. $x = 2$
- 49. 0.4
- 50. 0.7
- 51. 1.5
- 52. 0.74
- 53. 0.83
- 54. 1.23

	Percent	Decimal	Ratio	Fraction
55.	6%	0.06	3 : 50	$\frac{3}{50}$
56.	35%	0.35	7 : 20	$\frac{7}{20}$
57.	525%	5.25	21 : 4	$5\frac{1}{4}$
58.	1.5%	0.015	3 : 200	$\frac{3}{200}$

	Percent	Decimal	Ratio	Fraction
55.	6%	0.06	3 : 50	$\frac{3}{50}$
56.	35%	0.35	7 : 20	$\frac{7}{20}$
57.	525%	5.25	21 : 4	$5\frac{1}{4}$
58.	1.5%	0.015	3 : 200	$\frac{3}{200}$

- 59. 4.75
- 60. 5
- 61. 0.33%
- 62. 20%
- 63. 18.29%
- 64.

$$4\frac{1}{2}$$

teaspoons

- 65. 11.25 milligrams (mg)
- 66. 9.2 micrograms (mcg)
- 67. 0.5 mg : 1 tablet *or* 0.5 mg/1 tablet
- 68. 60 mg : 1 mL *or* 60 mg/1 mL
- 69. 4 days
- 70. 9%
- 71. 30%
- 72. 5 tablets

unknown - Section 12 (Page 43)

Health care professionals need to have an understanding of fractions. Fractions may be seen in medical orders, client records, prescriptions, documentation relating to care given to clients, and literature related to health care. Nurses oft en encounter fractions when converting metric to household measures in dosage calculation.

Fractions may be used occasionally in the writing of a medication order or used by the pharmaceutical manufacturer on a medication label (which usually includes the metric equivalent). In 2010 the Institute for Safe Medication Practices (ISMP) president Michael R. Cohen edited the abridged edition of the book *Medication Errors,* which contained this statement: "Occasionally using fractions instead of metric designation could help prevent errors." In 2020, 10 years later, this statement still is very true. For example, the dosage embossed on 2.5-mg Coumadin tablets is "2½ mg" and on 7.5 mg is "7½ mg" (see Figures 1.1 and 1.2). The use of "2½ mg" and "7½ mg" prevents confusion with "25" mg and "75" mg, respectively, eliminating the possibility of a patient receiving a massive overdose of this anticoagulation medication.



Figure 1.1 Coumadin 2.5 mg (expressed as 2½ mg).



Figure 1.2 Coumadin 7.5 mg (expressed as 7½ mg).

As you will see later in the text, some methods of solving dosage calculations rely on expressing relationships in a fraction format. Therefore proficiency with fractions can be beneficial in a variety of situations.

A fraction represents a part of a whole (Figure 1.3). It is written as two quantities: an upper number referred, to as the **numerator** (parts of the whole), and a **denominator,** the bottom part of the fraction that represents the whole. The numerator and denominator are separated by a horizontal line. The horizontal line above the denominator is a division sign; therefore a fraction may also be read as the numerator divided by the denominator.

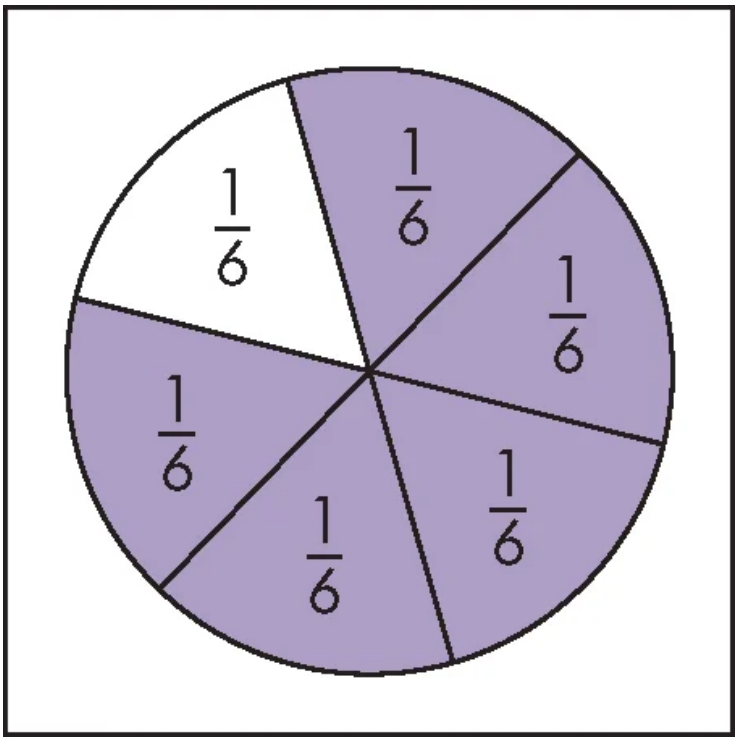


Figure 1.3 The shaded part of the circle, which is 5 parts, reflects the numerator, and the total number of parts (6) is the denominator. Therefore

$$\frac{5}{6}$$

means 5 of 6 equal parts.

$$\frac{\text{Numerator}}{\text{Denominator}} \leftarrow \text{horizontalIIbarII(divisionIIsign)}$$

Examples: Suppose you have to administer a medication that is scored (marked) for division into four parts to a client, and you must administer one part of the tablet. The denominator represents the whole tablet, and the numerator represents the amount you administer. The fraction, or part, of the tablet you administer is written as:

$$\frac{\text{Numerator}}{\text{Denominator}} = \frac{1\text{IIpart}}{4\text{IIparts}} = \frac{1}{4}$$

This number is read as one-fourth. The denominator is 4 because 4 parts make up the whole. If you administer one part, you administer

$$\frac{1}{4}$$

of the tablet.

Occasionally fractions may be used to show the relationship between part of a group and the whole group. For example, you are working on a surgical unit, and in a group of 18 clients who had surgery, 7 developed infections. The number of clients in the full group, 18, is the whole, or the denominator. You write the fraction of clients who developed infections as:

$$\frac{\text{Part (numerator)}}{\text{Whole (denominator)}} = \frac{\text{Clients who developed infections}}{\text{Whole group}} = \frac{7}{18}$$

Types of Fractions

There are various types of fractions:

Proper Fraction: Numerator is less than the denominator, and the fraction has a value of less than 1.

Examples:

$$\frac{1}{8}$$

,

$$\frac{5}{6}$$

,

$$\frac{7}{8}$$

,

$$\frac{1}{150}$$

Improper Fraction: Numerator is larger than, or equal to, the denominator, and the fraction has a value of 1 or greater than 1.

Examples:

$$\frac{3}{2}$$

,

$$\frac{7}{5}$$

,

$$\frac{300}{150}$$

,

$$\frac{4}{4}$$

Mixed Number: Whole number and a proper fraction in which the total value of the mixed number is greater than 1.

Examples:

$$3\frac{1}{3}$$

,

$$5\frac{1}{8}$$

,

$$9\frac{1}{6}$$

,

$$25\frac{7}{8}$$

Complex Fraction: Numerator, denominator, or both are fractions. The value may be less than, greater than, or equal to 1.

Examples:

$$\frac{3\frac{1}{2}}{2}$$

,

$$\frac{\frac{1}{3}}{\frac{1}{2}}$$

,

$$\frac{2}{1\frac{1}{4}}$$

,

$$\frac{2}{\frac{1}{150}}$$

Whole Numbers: Have an unexpressed denominator of one (1).

Examples:

$$1 = \frac{1}{1}$$

,

$$3 = \frac{3}{1}$$

,

$$6 = \frac{6}{1}$$

,

$$100 = \frac{100}{1}$$

Converting Fractions

An improper fraction can be changed to a mixed number or whole number by dividing the numerator by the denominator. If there is a remainder, that number is placed over the denominator, and the answer is reduced to lowest terms.

Examples:

$$\frac{6}{5} = 6 \div 5 = 1\frac{1}{5}$$

,

$$\frac{100}{25} = 100 \div 25 = 4$$

,

$$\frac{10}{8} = 10 \div 8 = 1\frac{2}{8} = 1\frac{1}{4}$$

A mixed number can be changed to an improper fraction by multiplying the whole number by the denominator, adding it to the numerator, and placing the sum over the denominator.

Examples:

$$5\frac{1}{8} = \frac{(5 \times 8) + 1}{8} = \frac{41}{8}$$

Comparing Fractions

Comparing the size of fractions is important in the administration of medications. It helps the new practitioner learn the value of medication dosages early on. Fractions can be compared if the numerators are the same by comparing the denominators or if the denominators are the same by comparing the numerators. These rules are presented in Box 1.1.

BOX 1-1 Rules for Comparing Size of Fractions

Here are some basic rules to keep in mind when comparing fractions.

- 1. If the numerators are the same, the fraction with the smaller denominator has the greater value.
- **Example 1:**

  $\frac{1}{2}$

  is larger than

  $\frac{1}{3}$

- **Example 2:**

  $\frac{1}{150}$

  is larger than

  $\frac{1}{300}$

- 2. If the denominators are the same, the fraction with the larger numerator has the greater value.
- **Example 1:**

  $\frac{3}{4}$

  is larger than

  $\frac{1}{4}$

- **Example 2:**

  $\frac{3}{100}$

  is larger than

  $\frac{1}{100}$

Two or more fractions with different denominators can be compared by changing both fractions to fractions with the same denominator (see Box 1.1). This is done by finding the lowest common denominator (LCD), or the lowest number evenly divisible by the denominators of the fractions being compared.

Example: Which is larger,

$$\frac{3}{4}$$

or

$$\frac{4}{5}$$

?

Solution: The lowest common denominator is 20, because it is the smallest number that can be divided by both denominators evenly. Change each fraction to the same terms by dividing the lowest common denominator by the denominator and multiplying that answer by the numerator. The answer obtained from this is the new numerator. The numerators are then placed over the lowest common denominator.

For the fraction

$$\frac{3}{4}$$

: 20 ÷ 4 = 5; 5 × 3 = 15; therefore

$$\frac{3}{4}$$

becomes

$$\frac{15}{20}$$

.

For the fraction

$$\frac{4}{5}$$

: 20 ÷ 5 = 4; 4 × 4 = 16; therefore

$$\frac{4}{5}$$

becomes

$$\frac{16}{20}$$

.

Therefore

$$\frac{4}{5}\left(\frac{16}{20}\right)$$

is larger than

$$\frac{3}{4}\left(\frac{15}{20}\right)$$

Box 1.2 presents fundamental rules of fractions.

BOX 1-2 Fundamental Rules of Fractions

In working with fractions, there are some fundamental rules that we need to remember.

- 1. When the numerator and denominator of a fraction are both multiplied or divided by the same number, the value of the fraction remains unchanged.
- **Examples:**

$$\frac{1}{2} = \frac{1 \times (2)}{2 \times (2)} = \frac{2}{4} = \frac{2 \times (25)}{4 \times (25)} = \frac{50}{100}$$

, etc.

- $$\frac{50}{100} = \frac{50 \div (10)}{100 \div (10)} = \frac{5}{10} = \frac{5 \div (5)}{10 \div (5)} = \frac{1}{2}$$

, etc.

- As shown in the examples, common fractions can be written in various forms, provided that the numerator, divided by the denominator, always yields the same number (quotient). The particular form of a fraction that has the smallest possible whole number for its numerator and denominator is called the *fraction in its lowest terms.* In the example, therefore 50/100, 5/10, or 2/4 is 1/2 in its lowest terms.
- 2. To change a fraction to its lowest terms, divide its numerator and its denominator by the largest whole number that will divide both evenly.
- **Example:** Reduce

$$\frac{128}{288}$$

to lowest terms.

- $$\frac{128}{288} = \frac{128 \div 32}{288 \div 32} = \frac{4}{9}$$

- *Note:* When you do not see the largest number that can be divided evenly at once, the fraction may have to be reduced by using repeated steps.
- **Example:**

$$\frac{128}{288} = \frac{128 \div 4}{288 \div 4} = \frac{32}{72} = \frac{32 \div 8}{72 \div 8} = \frac{4}{9}$$

- *Note:* If both the numerator and denominator cannot be divided evenly by a whole number, the fraction is already in lowest terms. Fractions should always be expressed in their lowest terms.
- 3. LCD (lowest common denominator) is the smallest whole number that can be divided evenly by all of the denominators within the problem.
- **Examples:**

$$\frac{1}{3}$$

and

$$\frac{5}{12}$$

: 12 is evenly divisible by 3; therefore 12 is the LCD.

- $$\frac{3}{7}$$

,

$$\frac{2}{14}$$

, and

$$\frac{2}{28}$$

: 28 is evenly divisible by 7 and 14; therefore 28 is the LCD.

PRACTICE PROBLEMS

Circle the fraction with the least value in each of the following sets.

- 1.

$$\frac{6}{30} \quad \frac{4}{5}$$

- 2.

$$\frac{5}{4} \quad \frac{6}{8}$$

- 3.

$$\frac{1}{75} \quad \frac{1}{100} \quad \frac{1}{150}$$

- 4.

$$\frac{6}{18} \quad \frac{7}{18} \quad \frac{8}{18}$$

- 5.

$$\frac{4}{5} \quad \frac{17}{85} \quad \frac{3}{5}$$

- 6.

$$\frac{4}{8} \quad \frac{1}{8} \quad \frac{3}{8}$$

- 7.

$$\frac{1}{40} \quad \frac{1}{10} \quad \frac{1}{5}$$

- 8.

$$\frac{1}{300} \quad \frac{1}{200} \quad \frac{1}{175}$$

- 9.

$$\frac{4}{24} \quad \frac{5}{25} \quad \frac{10}{24}$$

- 10.

$$\frac{4}{3} \quad \frac{1}{2} \quad \frac{1}{6}$$

Circle the fraction with the greater value in each of the following sets.

- 11.

$$\frac{6}{8} \quad \frac{5}{9}$$

- 12.

$$\frac{7}{6} \quad \frac{2}{3}$$

- 13.

$$\frac{1}{72} \quad \frac{6}{12} \quad \frac{1}{24}$$

- 14.

$$\frac{1}{10} \quad \frac{1}{6} \quad \frac{1}{8}$$

- 15.

$$\frac{1}{75} \quad \frac{1}{125} \quad \frac{1}{225}$$

- 16.

$$\frac{2}{5} \quad \frac{6}{5} \quad \frac{3}{5}$$

- 17.

$$\frac{1}{8} \quad \frac{4}{6} \quad \frac{1}{4}$$

- 18.

$$\frac{7}{9} \quad \frac{5}{9} \quad \frac{8}{9}$$

- 19.

$$\frac{1}{10} \quad \frac{1}{50} \quad \frac{1}{150}$$

- 20.

$$\frac{2}{15} \quad \frac{1}{15} \quad \frac{6}{15}$$

Answers on 21

Reducing Fractions

Fractions should always be reduced to their lowest terms.



RULE

To reduce a fraction to its lowest terms, the numerator and denominator are each divided by the largest number by which they are both evenly divisible.

Example 1: Reduce the fraction

$$\frac{6}{20}$$

.

Solution: Both numerator and denominator are evenly divisible by 2.

$$\frac{6}{20} \div \frac{2}{2} = \frac{3}{10}$$

$$\frac{6}{20} = \frac{3}{10}$$

Example 2: Reduce the fraction

$$\frac{75}{100}$$

.

Solution: Both numerator and denominator are evenly divisible by 25.

$$\frac{75}{100} \div \frac{25}{25} = \frac{3}{4}$$

$$\frac{75}{100} = \frac{3}{4}$$



PRACTICE PROBLEMS

Reduce the following fractions to their lowest terms.

- 21.

$$\frac{10}{15} =$$

_____

- 22.

$$\frac{7}{49} =$$

_____

- 23.

$$\frac{64}{128} =$$

_____

- 24.

$$\frac{100}{150} =$$

_____

- 25.

$$\frac{20}{28} =$$

_____

- 26.

$$\frac{14}{98} =$$

_____

- 27.

$$\frac{10}{18} =$$

_____

- 28.

$$\frac{24}{36} =$$

_____

- 29.

$$\frac{10}{50} =$$

_____

- 30.

$$\frac{9}{27} =$$

_____

- 31.

$$\frac{9}{9} =$$

_____

- 32.

$$\frac{15}{45} =$$

_____

- 33.

$$\frac{124}{155}$$

_____

- 34.

$$\frac{12}{18} =$$

_____

- 35.

$$\frac{36}{64} =$$

_____

Answers on 21

Adding Fractions



RULE

To add fractions with the same denominator, add the numerators, place the sum over the denominator, and reduce to lowest terms.

Example 1:

$$\frac{1}{6}+\frac{4}{6}=\frac{5}{6}$$

Example 2:

$$\frac{1}{6}+\frac{3}{6}+\frac{4}{6}=\frac{8}{6}$$

$$\frac{8}{6}+\frac{4}{3}=1\frac{1}{3}$$



RULE

To add fractions with different denominators, change fractions to their equivalent fraction with the lowest common denominator, add the numerators, write the sum over the common denominator, and reduce if necessary.



NOTE

In addition to reducing to lowest terms in Example 2, the improper fraction was changed to a mixed number.

Example 1:

$$\frac{1}{4}+\frac{1}{3}$$

Solution: The lowest common denominator is 12. Change to equivalent fractions.

$$\begin{array}{r} \frac{1}{4}=\frac{3}{12} \\ +\frac{1}{3}=\frac{4}{12} \\ \hline \frac{7}{12} \end{array}$$

Example 2:

$$\frac{1}{2}+1\frac{1}{3}+\frac{2}{4}$$

Solution: Change the mixed number

$$1\frac{1}{3}$$

to

$$\frac{4}{3}$$

. Find the lowest common denominator, change fractions to equivalent fractions, add, and reduce if necessary. The lowest common denominator is 12.

$$\begin{array}{l}\frac{1}{2}=\frac{6}{12}\\ \frac{4}{3}=\frac{16}{12}\\ \underline{+\frac{2}{4}=\frac{6}{12}}\\ \frac{28}{12}=2\frac{4}{12}=2\frac{1}{3}\end{array}$$

Subtracting Fractions



RULE

To subtract fractions with the same denominator, subtract the numerators, and place this amount over the denominator. Reduce to lowest terms if necessary.

Example 1:

$$\frac{5}{4}-\frac{3}{4}=\frac{2}{4}=\frac{1}{2}$$

Example 2:

$$2\frac{1}{6}-\frac{5}{6}$$

Solution: Change the mixed number

$$2\frac{1}{6}$$

to

$$\frac{13}{6}$$

$$\frac{13}{6}-\frac{5}{6}=\frac{8}{6}=\frac{4}{3}=1\frac{1}{3}$$



RULE

To subtract fractions with different denominators, find the lowest common denominator, change to equivalent fractions, subtract the numerators, and place the sum over the common denominator. Reduce to lowest terms if necessary.

Example 3:

$$\frac{15}{6} - \frac{3}{5}$$

Solution: The lowest common denominator is 30. Change to equivalent fractions, and subtract.

$$\begin{aligned} \frac{15}{6} &= \frac{75}{30} \\ -\frac{3}{5} &= \frac{18}{30} \\ \hline \frac{57}{30} &= 1\frac{27}{30} = 1\frac{9}{10} \end{aligned}$$

Example 4:

$$2\frac{1}{5} - \frac{4}{3}$$

Solution: Change the mixed number

$$2\frac{1}{5}$$

to

$$\frac{11}{5}$$

. Find the lowest common denominator, change to equivalent fractions, subtract, and reduce if necessary. The lowest common denominator is 15.

$$\begin{aligned} \frac{11}{5} &= \frac{33}{15} \\ -\frac{4}{3} &= \frac{20}{15} \\ \hline \frac{13}{15} \end{aligned}$$

Subtracting a Fraction From a Whole Number



RULE

To subtract a fraction from a whole number, follow these steps:

- 1. Borrow 1 from the whole number and change it to a fraction, creating a mixed number.
- 2. Change the fraction so that it has the same denominator as the fraction to be subtracted.
- 3. Subtract the fraction from the mixed number.
- 4. Reduce if necessary.

Example 1: Subtract

$$\frac{7}{12}$$

from 6.

$$6 = 5 + \frac{1}{1} = 5\frac{12}{12}$$
$$-\frac{7}{12} = \frac{7}{12}$$
$$5\frac{5}{12}$$

Subtracting Fractions Using Borrowing



RULE

To subtract fractions using borrowing, use the following steps:

- 1. Change both fractions to the same denominator if necessary.
- 2. Borrow 1 from the whole number and change it to the same denominator as the fraction in the mixed number. Add the two fractions together.
- 3. Subtract the fractions and the whole numbers.
- 4. Reduce if necessary.

Example 2:

$$5\frac{1}{4} - 3\frac{3}{4}$$

In the above example, because

$$\frac{3}{4}$$

is larger than

$$\frac{1}{4}$$

subtraction of the fractions is not possible. Both fractions have the same denominator; no changes need to be made. Therefore borrow 1 from the whole number part (5), and add the 1 to the fractional part

$$\left(\frac{1}{4}\right)$$

.

This results in

$$5\frac{1}{4} = 4 + \frac{1}{1} + \frac{1}{4} = 4 + \frac{4}{4} + \frac{1}{4} = 4\frac{5}{4}$$

$$5\frac{1}{4} = 4\frac{5}{4}$$
$$-3\frac{3}{4} = 3\frac{3}{4}$$
$$1\frac{5-3}{4} = 1\frac{2}{4} = 1\frac{1}{2}$$

Example 3: Subtract

$$4\frac{3}{4}$$

from

$$9\frac{2}{3}$$

.

Both fractions need to be changed to the same denominator of 12:

$$9\frac{2}{3} = 9\frac{8}{12}$$

and

$$4\frac{3}{4} = 4\frac{9}{12}$$

Subtraction of the fractions is not possible because

$$\frac{9}{12}$$

is larger than

$$\frac{8}{12}$$

.

Therefore borrow 1 from 9.

$$9\frac{8}{12} = 8 + \frac{1}{1} + \frac{8}{12} = 8 + \frac{12}{12} + \frac{8}{12} = 8\frac{20}{12}$$

Now subtract:

$$\begin{array}{r} 9\frac{2}{3} = 9\frac{8}{12} = 8\frac{20}{12} \\ -4\frac{3}{4} = 4\frac{9}{12} = 4\frac{9}{12} \\ \hline 4\frac{11}{12} \end{array}$$

Multiplying Fractions



RULE

- 1. Cancel terms if possible.
- 2. Multiply the numerators, multiply the denominators.
- 3. Reduce the result (product) to the lowest terms, if necessary.

Notice in this example that the numerator and denominator of any of the fractions involved in multiplication may be cancelled when they can be divided by the same number (cross-cancellation).

Example 1:

$$\frac{3}{\cancel{4}_{2}} \times \frac{\cancel{2}^{1}}{5} = \frac{3}{10}$$

Example 2:

$$\frac{2}{4} \times \frac{3}{4}$$

Solution: Reduce

$$\frac{2}{4}$$

to

$$\frac{1}{2}$$

and then multiply.

$$\frac{1}{2} \times \frac{3}{4} = \frac{3}{8}$$

Example 3:

$$6 \times \frac{5}{6}$$

$$\frac{\cancel{6}^{1}}{1} \times \frac{5}{\cancel{6}_{1}} = 5$$

or

$$\frac{6 \times 5}{6} = \frac{30}{6} = 5$$

Example 4:

$$3\frac{1}{3} \times 2\frac{1}{2}$$

Solution: Change mixed numbers to improper fractions. Proceed with multiplication.

$$3\frac{1}{3} = \frac{10}{3}; 2\frac{1}{2} = \frac{5}{2}$$

$$\frac{10}{3} \times \frac{5}{2} = \frac{50}{6} = 8\frac{2}{6} = 8\frac{1}{3}$$

or

$$\frac{\overset{5}{\cancel{10}}}{3} \times \frac{5}{\underset{1}{\cancel{2}}} = \frac{25}{3} = 8\frac{1}{3}$$

Dividing Fractions



RULE

- 1. To divide fractions, invert (turn upside down) the second fraction (divisor); change ÷ to ×.
- 2. Cancel terms, if possible.
- 3. Multiply fractions.
- 4. Reduce where necessary.

Example 1:

$$\frac{3}{4} \div \frac{2}{3}$$

Solution:

$$\frac{3}{4} \times \frac{3}{2} = \frac{9}{8} = 1\frac{1}{8}$$

Example 2:

$$1\frac{3}{5} \div 2\frac{1}{10}$$

Solution: Change mixed numbers to improper fractions. Proceed with steps of division.

$$1\frac{3}{5} = \frac{8}{5}; 2\frac{1}{10} = \frac{21}{10}$$

$$\frac{\cancel{8}^{1}}{\cancel{5}_{1}} \times \frac{\cancel{10}^{2}}{21} = \frac{16}{21}$$

Example 3:

$$5 \div \frac{1}{2}$$

Solution:

$$5 \times \frac{2}{1} = \frac{10}{1} = 10$$

or

$$\frac{5}{1} \times \frac{2}{1} = \frac{10}{1} = 10$$

With dosage calculations that involve division, the fractions may be written as follows:

$$\frac{1/4}{1/2}$$

. In this case,

$$\frac{1}{4}$$

is the numerator and

$$\frac{1}{2}$$

is the denominator. Therefore the problem is set up as:

$$\frac{1}{4} \div \frac{1}{2}$$

, which becomes

$$\frac{1}{\cancel{4}_{2}} \times \frac{\cancel{2}^{1}}{1} = \frac{1}{2}$$

.

PRACTICE PROBLEMS

Change the following improper fractions to mixed numbers, and reduce to lowest terms.

- 36.

$$\frac{18}{5} =$$

_____

- 37.

$$\frac{60}{14} =$$

_____

- 38.

$$\frac{13}{8} =$$

_____

- 39.

$$\frac{35}{12} =$$

_____

- 40.

$$\frac{112}{100} =$$

_____

Change the following mixed numbers to improper fractions.

- 41.

$$1\frac{4}{25} =$$

_____

- 42.

$$4\frac{2}{8} =$$

_____

- 43.

$$4\frac{1}{2} =$$

_____

- 44.

$$3\frac{3}{8} =$$

_____

- 45.

$$15\frac{4}{5} =$$

_____

Add the following fractions and mixed numbers, and reduce fractions to lowest terms.

- 46.

$$\frac{2}{3} + \frac{5}{6} =$$

_____

- 47.

$$2\frac{1}{8} + \frac{2}{3} =$$

_____

- 48.

$$2\frac{3}{10} + 4\frac{1}{5} + \frac{2}{3} =$$

_____

- 49.

$$7\frac{2}{5} + \frac{2}{3} =$$

_____

- 50.

$$12\frac{1}{2} + 10\frac{1}{3} =$$

_____

Subtract and reduce fractions to lowest terms.

- 51.

$$\frac{4}{3} - \frac{3}{7} =$$

_____

- 52.

$$3\frac{3}{8} - 1\frac{3}{5} =$$

_____

- 53.

$$\frac{15}{16} - \frac{1}{4} =$$

_____

- 54.

$$2\frac{5}{6} - 2\frac{3}{4} =$$

_____

- 55.

$$\frac{1}{8} - \frac{1}{12} =$$

_____

- 56.

$$14 - \frac{5}{9} =$$

_____

- 57.

$$3\frac{3}{10} - 1\frac{7}{10} =$$

_____

Multiply the following fractions and mixed numbers, and reduce to lowest terms.

- 58.

$$\frac{2}{3} \times \frac{4}{5} =$$

_____

- 59.

$$\frac{6}{25} \times \frac{3}{5} =$$

_____

- 60.

$$\frac{1}{50} \times 3 =$$

_____

- 61.

$$2\frac{5}{8} \times 2\frac{3}{4} =$$

_____

- 62.

$$\frac{5}{12} \times \frac{4}{9} =$$

_____

Divide the following fractions and mixed numbers, and reduce to lowest terms.

- 63.

$$2\frac{6}{7} \div 1\frac{2}{3} =$$

_____

- 64.

$$\frac{1}{60} \div \frac{1}{2} =$$

$$\frac{1}{60} \div \frac{1}{2} =$$

_____

- 65.

$$6 \div \frac{2}{5} =$$

_____

- 66.

$$\frac{7}{8} \div \frac{7}{8} =$$

_____

- 67.

$$3\frac{1}{3} \div 1\frac{7}{12} =$$

_____

Answers on 21

CHAPTER REVIEW

Change the following improper fractions to mixed numbers, and reduce to lowest terms.

- 1.

$$\frac{10}{8} =$$

_____

- 2.

$$\frac{30}{4} =$$

_____

- 3.

$$\frac{67}{10} =$$

_____

- 4.

$$\frac{11}{4} =$$

_____

- 5.

$$\frac{64}{15} =$$

_____

- 6.

$$\frac{100}{13} =$$

_____

Change the following mixed numbers to improper fractions.

- 7.

$$7\frac{3}{8} =$$

_____

- 8.

_____

- 9.

$$3\frac{1}{5} =$$

_____

- 10.

$$12\frac{3}{4} =$$

_____

- 11.

$$6\frac{5}{7} =$$

_____

Add the following fractions and mixed numbers. Reduce to lowest terms.

- 12.

_____

- 13.

$$\frac{1}{4} + \frac{1}{6} + \frac{1}{8} =$$

_____

- 14.

$$6\frac{1}{4}+\frac{2}{9}+\frac{1}{36}=$$

_____

- 15.

$$10\frac{1}{6}+12\frac{4}{6}=$$

_____

- 16.

$$1\frac{4}{5}+7\frac{9}{10}+3\frac{1}{2}=$$

_____

Subtract the following fractions and mixed numbers. Reduce to lowest terms.

- 17.

$$2\frac{1}{4}-1\frac{1}{2}=$$

_____

- 18.

_____

- 19.

$$\frac{4}{5}-\frac{1}{4}=$$

_____

- 20.

$$4\frac{1}{6}-1\frac{1}{3}=$$

_____

- 21.

$$\frac{8}{5}-\frac{1}{3}=$$

_____

- 22.

$$\frac{5}{6}-\frac{7}{12}=$$

_____

- 23.

_____

- 24.

_____

Multiply the following fractions and mixed numbers. Reduce to lowest terms.

- 25.

$$\frac{1}{3} \times \frac{4}{12} =$$

_____

- 26.

$$2\frac{7}{8} \times 3\frac{1}{4} =$$

_____

- 27.

$$36 \times \frac{3}{4} =$$

_____

- 28.

_____

- 29.

$$\frac{10}{25} \times \frac{5}{3} =$$

_____

- 30.

_____

- 31.

$$\frac{3}{5} \times 3\frac{1}{8} =$$

_____

- 32.

$$2\frac{2}{5} \times 4\frac{1}{6} =$$

_____

- 33.

$$2 \times 4\frac{3}{8} =$$

_____

- 34.

_____

Divide the following fractions and mixed numbers. Reduce to lowest terms.

- 35.

_____

- 36.

$$25 \div 12\frac{1}{2} =$$

_____

- 37.

_____

- 38.

$$\frac{4}{6} \div \frac{1}{2} =$$

_____

- 39.

_____

- 40.

_____

Arrange the following fractions in order from largest to the smallest.

- 41.

$$\frac{15}{30} \div 10 =$$

_____

- 42.

_____

- 43.

$$12 \div \frac{2}{3} =$$

_____

- 44.

_____

- 45.

_____

Arrange the following fractions in order from largest to the smallest.

- 46.

$\frac{3}{16}$

,

$\frac{1}{16}$

,

$\frac{5}{16}$

,

$\frac{14}{16}$

,

$\frac{7}{16}$

- 47.

$\frac{5}{12}$

,

,

,

$\frac{5}{6}$

,

Apply the principles of borrowing, and subtract the following:

- 48.

_____

- 49.

_____

- 50.

_____

- 51. A client is instructed to drink 20 ounces of water within 1 hour. The client has only been able to drink 12 ounces. What portion of the water remains? (Express your answer as a fraction reduced to lowest terms.) _____
- 52. A child's oral Motrin Suspension contains 100 milligrams per teaspoonful. 20 milligrams represents what part of a dosage? _____
- 53. A client is receiving 240 milliliters of Ensure by mouth as a supplement. The client consumes 200 milliliters. What portion of the Ensure remains? (Express your answer as a fraction reduced to lowest terms.) _____
- 54. A client takes 1½ tablets of medication four times per day for 4 days. How many tablets will the client have taken at the end of the 4 days? _____
- 55. A juice glass holds 120 milliliters. If a client drinks 2⅓ glasses, how many milliliters did the client consume? _____
- 56. On admission a client weighed 150¾ lb. On discharge the client weighed 148½ lb. How much weight did the client lose? _____
- 57. How many hours are there in 3½ days? _____
- 58. A client consumed the following: 2¼ ounces of tea, ⅓ ounce of juice, 1½ ounces of Jell-O. What is the total number of ounces consumed by the client? _____
- 59. One tablet contains 200 milligrams of pain medication.
- How many milligrams are in 3½ tablets? _____
- 60. A bottle of medicine contains 30 doses. How many doses are in 2½ bottles? _____
- 61. The nurse gave a client ¾ tablespoons (tbs) of medication with breakfast, ½ tbs at lunch, ½ tbs at dinner, and 1¼ tbs at bedtime. How much medication did the nurse administer? _____
- 62. A client weighed 160½ pounds (lb) at the previous visit to the doctor. At this visit, the client weighs 2¾ lb more. How many lb does the client weigh? _____
- 63. At the beginning of a shift there are 5¼ bottles of hand sanitizer available. At the end of the shift, 3½ bottles are left. How much was used? _____
- 64. A client was given a 16-ounce container of water to drink throughout the day. If the client drank ⅞ of the container, how many ounces did the client drink? _____
- 65. How many 1½-ounce doses of medication are there in a 24-ounce bottle? _____
- 66. A bottle contains 36 tablets. If a client took ⅓ of the tablets, how many tablets are left? _____
- 67. A client drank 4¾ ounces of juice, 5½ ounces of coffee, and 4¼ ounces of water. How much fluid did the client drink? _____
- 68. One tablet contains 400 milligrams of medication. A client was given 1½ tablets for 5 days. How many milligrams of medication did the client receive in 5 days? _____
- 69. An order is written for a client to receive 1½ ounces of a powdered medication dissolved in water. The client drank ¾ ounces of the medication. How much more medication must be given to the client? _____
- 70. An infant grew ¾ inch in the first month, ½ inch in the second month, ⅞ inch in the third month, and 1⅛ inches in the fourth month. How many inches has the infant grown? _____
- 71. For 4 days a client received 2½ ounces of medication 4 times per day. How many ounces did the client receive over 4 days? _____
- 72. A bottle contains 24 ounces of a liquid pain medication. If a typical dose is ¾ ounce, how many doses are there in the bottle? _____
- 73. A nurse worked 9¾ hours on Monday, 11½ hours on Tuesday, and 10¾ hours on Wednesday. How many hours did she work for the 3 days? _____
- 74. A nurse needs ½ hour to complete an intake interview form on each new client. How many intake interview forms can the nurse complete in 2½ hours?
- _____
- 75. A client drinks ¾ of a glass of juice that contains 180 milliliters. How many milliliters of juice did the client drink? _____
- 76. A client is instructed to drink the equivalent of 8 glasses of water daily. How many times will the client need to drink ½ glass of water? _____

- 77. One tablet contains 150 milligrams of medication. How many milligrams are in 3½ tablets? _____
- 78. A client at home was instructed to take ¾ ounce of medication with meals. The nurse learns that the client took ⅔ ounce. Did the client take too little, too much, or just the right amount? _____
- 79. A client has taken ¾ of a bottle of tablets that contained 100 tablets. How many tablets has the client taken? _____
- 80. A client drank 3½ cups of water from a cup that held 210 milliliters. How many milliliters did the client drink? _____

Answers on 22

ANSWERS

Chapter 1

Answers to Practice Problems

- 1. LCD = 30; therefore

$$\frac{6}{30}$$

has the lesser value.

- 2. LCD = 8; therefore

$$\frac{6}{8}$$

has the lesser value.

- 3.

$$\frac{1}{150}$$

has the lesser value; the denominator (150) is larger.

- 4.

has the lesser value; the numerator (6) is smaller.

- 5.

has the lesser value; reduced to

the numerator (1) is smaller.

- 6.

$$\frac{1}{8}$$

has the lesser value; the numerator (1) is smaller.

- 7.

has the lesser value; the denominator (40) is larger.

- 8.

$$\frac{1}{300}$$

has the lesser value; the denominator (300) is larger.

- 9.

has the lesser value; the numerator (4) is smaller.

- 10. LCD = 6; therefore

has the lesser value.

- 11. LCD = 72; therefore

$$\frac{6}{8}$$

has the higher value.

- 12. LCD = 6; therefore

has the higher value.

- 13. LCD = 72; therefore

has the higher value.

- 14.

has the higher value; the denominator (6) is smaller.

- 15.

has the higher value; the denominator (75) is smaller.

- 16.

$$\frac{6}{5}$$

has the higher value; the numerator (6) is larger.

- 17. LCD = 24; therefore

  has the higher value.
- 18.

  has the higher value; the numerator (8) is larger.
- 19.

  has the higher value; the denominator (10) is smaller.
- 20.

  has the higher value; the numerator (6) is larger.
- 21.

- 22.
- 23.
- 24.
- 25.
- 26.

- 27.
- 28.
- 29.
- 30.
- 31.

- 32.
- 33.
- 34.
- 35.
- 36.

- 37.
- 38.
- 39.
- 40.
- 41.

- 42.
- 43.
- 44.
- 45.
- 46.

- 47.
- 48.
- 49.
- 50.
- 51.

- 52.
- 53.
- 54.
- 55.
- 56.

- 57.
- 58.
- 59.
- 60.
- 61.

- 62.
- 63.
- 64.
- 65. 15
- 66. 1
- 67.

Answers to Chapter Review

- 1.

- 2.
- 3.
- 4.
- 5.
- 6.

- 7.
- 8.
- 9.
- 10.
- 11.

- 12. LCD = 30;
- 13. LCD = 24;
- 14. LCD = 36;
- 15.
- 16. LCD = 10;
- 17. LCD = 4;

$$\frac{3}{4}$$

- 18. LCD = 30;
- 19. LCD = 20;
- 20. LCD = 6;
- 21. LCD = 15;
- 22. LCD = 12;

- 23.

- 24. LCD = 18;

- 25.

- 26.

- 27. 27
- 28.

- 29.
- 30.
- 31.
- 32. 10
- 33.
- 34. $\frac{1}{2}$
- 35.
- 36. 2

- 37.

- 38.

$$1\frac{1}{3}$$

- 39.

- 40.

- 41.

- 42. 2
- 43. 18
- 44.

$$\frac{1}{16}$$

- 45.

- 46.

$\frac{14}{16}$

,

$\frac{7}{16}$

,

$\frac{5}{16}$

,

$\frac{3}{16}$

,

$\frac{1}{16}$

- 47.

$\frac{5}{6}$

,

,

$\frac{5}{12}$

,

,

- 48.
- 49.
- 50.

- 51.

of water remains

- 52.

the dosage

- 53.

of Ensure remains

- 54. 24 tablets
- 55. 280 milliliters
- 56. 2¼ lb
- 57. 84 hours
- 58.

ounces

- 59. 700 milligrams
- 60. 75 doses
- 61. 3 tbs
- 62. 163¼ lb
- 63. 1¾ bottles
- 64. 14 ounces
- 65. 16 (1½ ounce doses in the bottle)
- 66. 24 tablets
- 67. 14½ ounces
- 68. 3,000 milligrams

- 69. ¾ ounce
- 70. 3¼ inches
- 71. 40 ounces
- 72. 32 (¾ ounce doses in the bottle)
- 73. 32 hours
- 74. 5 interview forms
- 75. 135 milliliters
- 76. 16 times
- 77. 525 milligrams
- 78. Too little
- 79. 75 tablets
- 80. 735 milliliters

unknown - Section 12 (Page 48)

Health care professionals need to have an understanding of fractions. Fractions may be seen in medical orders, client records, prescriptions, documentation relating to care given to clients, and literature related to health care. Nurses oft en encounter fractions when converting metric to household measures in dosage calculation.

Fractions may be used occasionally in the writing of a medication order or used by the pharmaceutical manufacturer on a medication label (which usually includes the metric equivalent). In 2010 the Institute for Safe Medication Practices (ISMP) president Michael R. Cohen edited the abridged edition of the book *Medication Errors,* which contained this statement: "Occasionally using fractions instead of metric designation could help prevent errors." In 2020, 10 years later, this statement still is very true. For example, the dosage embossed on 2.5-mg Coumadin tablets is "2½ mg" and on 7.5 mg is "7½ mg" (see Figures 1.1 and 1.2). The use of "2½ mg" and "7½ mg" prevents confusion with "25" mg and "75" mg, respectively, eliminating the possibility of a patient receiving a massive overdose of this anticoagulation medication.



Figure 1.1 Coumadin 2.5 mg (expressed as 2½ mg).



Figure 1.2 Coumadin 7.5 mg (expressed as 7½ mg).

As you will see later in the text, some methods of solving dosage calculations rely on expressing relationships in a fraction format. Therefore proficiency with fractions can be beneficial in a variety of situations.

A fraction represents a part of a whole (Figure 1.3). It is written as two quantities: an upper number referred, to as the **numerator** (parts of the whole), and a **denominator,** the bottom part of the fraction that represents the whole. The numerator and denominator are separated by a horizontal line. The horizontal line above the denominator is a division sign; therefore a fraction may also be read as the numerator divided by the denominator.

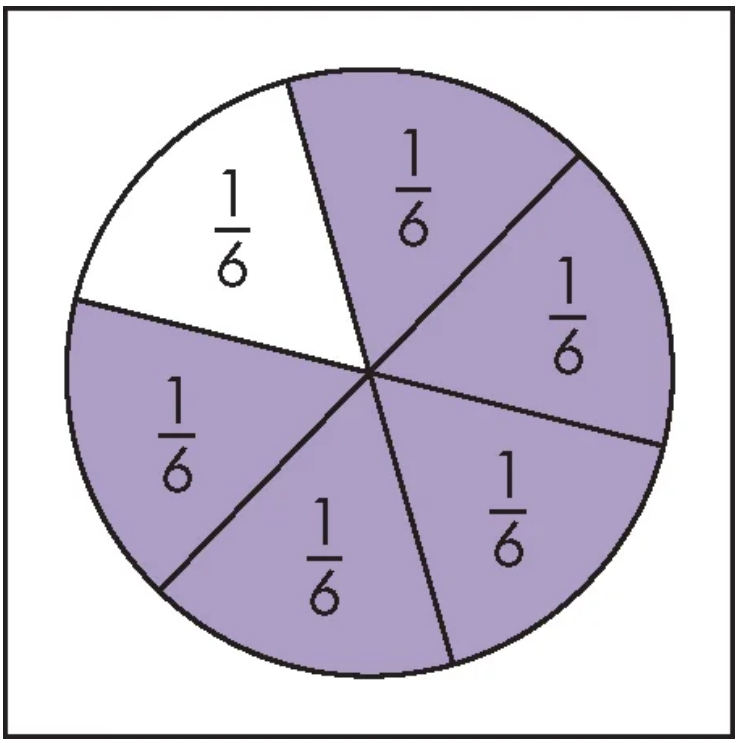


Figure 1.3 The shaded part of the circle, which is 5 parts, reflects the numerator, and the total number of parts (6) is the denominator. Therefore

$$\frac{5}{6}$$

means 5 of 6 equal parts.

$$\frac{\text{Numerator}}{\text{Denominator}} \leftarrow \text{horizontalIIbarII(divisionIIsign)}$$

Examples: Suppose you have to administer a medication that is scored (marked) for division into four parts to a client, and you must administer one part of the tablet. The denominator represents the whole tablet, and the numerator represents the amount you administer. The fraction, or part, of the tablet you administer is written as:

$$\frac{\text{Numerator}}{\text{Denominator}} = \frac{1\text{IIpart}}{4\text{IIparts}} = \frac{1}{4}$$

This number is read as one-fourth. The denominator is 4 because 4 parts make up the whole. If you administer one part, you administer

$$\frac{1}{4}$$

of the tablet.

Occasionally fractions may be used to show the relationship between part of a group and the whole group. For example, you are working on a surgical unit, and in a group of 18 clients who had surgery, 7 developed infections. The number of clients in the full group, 18, is the whole, or the denominator. You write the fraction of clients who developed infections as:

$$\frac{\text{Part (numerator)}}{\text{Whole (denominator)}} = \frac{\text{Clients who developed infections}}{\text{Whole group}} = \frac{7}{18}$$

Types of Fractions

There are various types of fractions:

Proper Fraction: Numerator is less than the denominator, and the fraction has a value of less than 1.

Examples:

$$\frac{1}{8}$$

,

$$\frac{5}{6}$$

,

$$\frac{7}{8}$$

,

$$\frac{1}{150}$$

Improper Fraction: Numerator is larger than, or equal to, the denominator, and the fraction has a value of 1 or greater than 1.

Examples:

$$\frac{3}{2}$$

,

$$\frac{7}{5}$$

,

$$\frac{300}{150}$$

,

$$\frac{4}{4}$$

Mixed Number: Whole number and a proper fraction in which the total value of the mixed number is greater than 1.

Examples:

$$3\frac{1}{3}$$

,

$$5\frac{1}{8}$$

,

$$9\frac{1}{6}$$

,

$$25\frac{7}{8}$$

Complex Fraction: Numerator, denominator, or both are fractions. The value may be less than, greater than, or equal to 1.

Examples:

$$\frac{3\frac{1}{2}}{2}$$

,

$$\frac{\frac{1}{3}}{\frac{1}{2}}$$

,

$$\frac{2}{1\frac{1}{4}}$$

,

$$\frac{2}{\frac{1}{150}}$$

Whole Numbers: Have an unexpressed denominator of one (1).

Examples:

$$1 = \frac{1}{1}$$

,

$$3 = \frac{3}{1}$$

,

$$6 = \frac{6}{1}$$

,

$$100 = \frac{100}{1}$$

Converting Fractions

An improper fraction can be changed to a mixed number or whole number by dividing the numerator by the denominator. If there is a remainder, that number is placed over the denominator, and the answer is reduced to lowest terms.

Examples:

$$\frac{6}{5} = 6 \div 5 = 1\frac{1}{5}$$

,

$$\frac{100}{25} = 100 \div 25 = 4$$

,

$$\frac{10}{8} = 10 \div 8 = 1\frac{2}{8} = 1\frac{1}{4}$$

A mixed number can be changed to an improper fraction by multiplying the whole number by the denominator, adding it to the numerator, and placing the sum over the denominator.

Examples:

$$5\frac{1}{8} = \frac{(5 \times 8) + 1}{8} = \frac{41}{8}$$

Comparing Fractions

Comparing the size of fractions is important in the administration of medications. It helps the new practitioner learn the value of medication dosages early on. Fractions can be compared if the numerators are the same by comparing the denominators or if the denominators are the same by comparing the numerators. These rules are presented in Box 1.1.

BOX 1-1 Rules for Comparing Size of Fractions

Here are some basic rules to keep in mind when comparing fractions.

- 1. If the numerators are the same, the fraction with the smaller denominator has the greater value.
- **Example 1:**

  $\frac{1}{2}$

  is larger than

  $\frac{1}{3}$

- **Example 2:**

  $\frac{1}{150}$

  is larger than

  $\frac{1}{300}$

- 2. If the denominators are the same, the fraction with the larger numerator has the greater value.
- **Example 1:**

  $\frac{3}{4}$

  is larger than

  $\frac{1}{4}$

- **Example 2:**

  $\frac{3}{100}$

  is larger than

  $\frac{1}{100}$

Two or more fractions with different denominators can be compared by changing both fractions to fractions with the same denominator (see Box 1.1). This is done by finding the lowest common denominator (LCD), or the lowest number evenly divisible by the denominators of the fractions being compared.

Example: Which is larger,

$$\frac{3}{4}$$

or

$$\frac{4}{5}$$

?

Solution: The lowest common denominator is 20, because it is the smallest number that can be divided by both denominators evenly. Change each fraction to the same terms by dividing the lowest common denominator by the denominator and multiplying that answer by the numerator. The answer obtained from this is the new numerator. The numerators are then placed over the lowest common denominator.

For the fraction

$$\frac{3}{4}$$

: 20 ÷ 4 = 5; 5 × 3 = 15; therefore

$$\frac{3}{4}$$

becomes

$$\frac{15}{20}$$

.

For the fraction

$$\frac{4}{5}$$

: 20 ÷ 5 = 4; 4 × 4 = 16; therefore

$$\frac{4}{5}$$

becomes

$$\frac{16}{20}$$

.

Therefore

$$\frac{4}{5}\left(\frac{16}{20}\right)$$

is larger than

$$\frac{3}{4}\left(\frac{15}{20}\right)$$

Box 1.2 presents fundamental rules of fractions.

BOX 1-2 Fundamental Rules of Fractions

In working with fractions, there are some fundamental rules that we need to remember.

- 1. When the numerator and denominator of a fraction are both multiplied or divided by the same number, the value of the fraction remains unchanged.
- **Examples:**

$$\frac{1}{2} = \frac{1 \times (2)}{2 \times (2)} = \frac{2}{4} = \frac{2 \times (25)}{4 \times (25)} = \frac{50}{100}$$

, etc.

- $$\frac{50}{100} = \frac{50 \div (10)}{100 \div (10)} = \frac{5}{10} = \frac{5 \div (5)}{10 \div (5)} = \frac{1}{2}$$

, etc.

- As shown in the examples, common fractions can be written in various forms, provided that the numerator, divided by the denominator, always yields the same number (quotient). The particular form of a fraction that has the smallest possible whole number for its numerator and denominator is called the *fraction in its lowest terms.* In the example, therefore 50/100, 5/10, or 2/4 is 1/2 in its lowest terms.
- 2. To change a fraction to its lowest terms, divide its numerator and its denominator by the largest whole number that will divide both evenly.
- **Example:** Reduce

$$\frac{128}{288}$$

to lowest terms.

- $$\frac{128}{288} = \frac{128 \div 32}{288 \div 32} = \frac{4}{9}$$

- *Note:* When you do not see the largest number that can be divided evenly at once, the fraction may have to be reduced by using repeated steps.
- **Example:**

$$\frac{128}{288} = \frac{128 \div 4}{288 \div 4} = \frac{32}{72} = \frac{32 \div 8}{72 \div 8} = \frac{4}{9}$$

- *Note:* If both the numerator and denominator cannot be divided evenly by a whole number, the fraction is already in lowest terms. Fractions should always be expressed in their lowest terms.
- 3. LCD (lowest common denominator) is the smallest whole number that can be divided evenly by all of the denominators within the problem.
- **Examples:**

$$\frac{1}{3}$$

and

$$\frac{5}{12}$$

: 12 is evenly divisible by 3; therefore 12 is the LCD.

- $$\frac{3}{7}$$

,

$$\frac{2}{14}$$

, and

$$\frac{2}{28}$$

: 28 is evenly divisible by 7 and 14; therefore 28 is the LCD.

PRACTICE PROBLEMS

Circle the fraction with the least value in each of the following sets.

- 1.

$$\frac{6}{30} \quad \frac{4}{5}$$

- 2.

$$\frac{5}{4} \quad \frac{6}{8}$$

- 3.

$$\frac{1}{75} \quad \frac{1}{100} \quad \frac{1}{150}$$

- 4.

$$\frac{6}{18} \quad \frac{7}{18} \quad \frac{8}{18}$$

- 5.

$$\frac{4}{5} \quad \frac{17}{85} \quad \frac{3}{5}$$

- 6.

$$\frac{4}{8} \quad \frac{1}{8} \quad \frac{3}{8}$$

- 7.

$$\frac{1}{40} \quad \frac{1}{10} \quad \frac{1}{5}$$

- 8.

$$\frac{1}{300} \quad \frac{1}{200} \quad \frac{1}{175}$$

- 9.

$$\frac{4}{24} \quad \frac{5}{25} \quad \frac{10}{24}$$

- 10.

$$\frac{4}{3} \quad \frac{1}{2} \quad \frac{1}{6}$$

Circle the fraction with the greater value in each of the following sets.

- 11.

$$\frac{6}{8} \quad \frac{5}{9}$$

- 12.

$$\frac{7}{6} \quad \frac{2}{3}$$

- 13.

$$\frac{1}{72} \quad \frac{6}{12} \quad \frac{1}{24}$$

- 14.

$$\frac{1}{10} \quad \frac{1}{6} \quad \frac{1}{8}$$

- 15.

$$\frac{1}{75} \quad \frac{1}{125} \quad \frac{1}{225}$$

- 16.

$$\frac{2}{5} \quad \frac{6}{5} \quad \frac{3}{5}$$

- 17.

$$\frac{1}{8} \quad \frac{4}{6} \quad \frac{1}{4}$$

- 18.

$$\frac{7}{9} \quad \frac{5}{9} \quad \frac{8}{9}$$

- 19.

$$\frac{1}{10} \quad \frac{1}{50} \quad \frac{1}{150}$$

- 20.

$$\frac{2}{15} \quad \frac{1}{15} \quad \frac{6}{15}$$

Answers on 21

Reducing Fractions

Fractions should always be reduced to their lowest terms.



RULE

To reduce a fraction to its lowest terms, the numerator and denominator are each divided by the largest number by which they are both evenly divisible.

Example 1: Reduce the fraction

$$\frac{6}{20}$$

.

Solution: Both numerator and denominator are evenly divisible by 2.

$$\frac{6}{20} \div \frac{2}{2} = \frac{3}{10}$$

$$\frac{6}{20} = \frac{3}{10}$$

Example 2: Reduce the fraction

$$\frac{75}{100}$$

.

Solution: Both numerator and denominator are evenly divisible by 25.

$$\frac{75}{100} \div \frac{25}{25} = \frac{3}{4}$$

$$\frac{75}{100} = \frac{3}{4}$$



PRACTICE PROBLEMS

Reduce the following fractions to their lowest terms.

- 21.

$$\frac{10}{15} =$$

_____

- 22.

$$\frac{7}{49} =$$

_____

- 23.

$$\frac{64}{128} =$$

_____

- 24.

$$\frac{100}{150} =$$

_____

- 25.

$$\frac{20}{28} =$$

_____

- 26.

$$\frac{14}{98} =$$

_____

- 27.

$$\frac{10}{18} =$$

_____

- 28.

$$\frac{24}{36} =$$

_____

- 29.

$$\frac{10}{50} =$$

_____

- 30.

$$\frac{9}{27} =$$

_____

- 31.

$$\frac{9}{9} =$$

_____

- 32.

$$\frac{15}{45} =$$

_____

- 33.

$$\frac{124}{155}$$

_____

- 34.

$$\frac{12}{18} =$$

_____

- 35.

$$\frac{36}{64} =$$

_____

Answers on 21

Adding Fractions



RULE

To add fractions with the same denominator, add the numerators, place the sum over the denominator, and reduce to lowest terms.

Example 1:

$$\frac{1}{6}+\frac{4}{6}=\frac{5}{6}$$

Example 2:

$$\frac{1}{6}+\frac{3}{6}+\frac{4}{6}=\frac{8}{6}$$

$$\frac{8}{6}+\frac{4}{3}=1\frac{1}{3}$$



RULE

To add fractions with different denominators, change fractions to their equivalent fraction with the lowest common denominator, add the numerators, write the sum over the common denominator, and reduce if necessary.



NOTE

In addition to reducing to lowest terms in Example 2, the improper fraction was changed to a mixed number.

Example 1:

$$\frac{1}{4}+\frac{1}{3}$$

Solution: The lowest common denominator is 12. Change to equivalent fractions.

$$\begin{array}{r} \frac{1}{4}=\frac{3}{12} \\ +\frac{1}{3}=\frac{4}{12} \\ \hline \frac{7}{12} \end{array}$$

Example 2:

$$\frac{1}{2}+1\frac{1}{3}+\frac{2}{4}$$

Solution: Change the mixed number

$$1\frac{1}{3}$$

to

$$\frac{4}{3}$$

. Find the lowest common denominator, change fractions to equivalent fractions, add, and reduce if necessary. The lowest common denominator is 12.

$$\begin{array}{l}\frac{1}{2}=\frac{6}{12}\\ \frac{4}{3}=\frac{16}{12}\\ \underline{+\frac{2}{4}=\frac{6}{12}}\\ \frac{28}{12}=2\frac{4}{12}=2\frac{1}{3}\end{array}$$

Subtracting Fractions



RULE

To subtract fractions with the same denominator, subtract the numerators, and place this amount over the denominator. Reduce to lowest terms if necessary.

Example 1:

$$\frac{5}{4}-\frac{3}{4}=\frac{2}{4}=\frac{1}{2}$$

Example 2:

$$2\frac{1}{6}-\frac{5}{6}$$

Solution: Change the mixed number

$$2\frac{1}{6}$$

to

$$\frac{13}{6}$$

$$\frac{13}{6}-\frac{5}{6}=\frac{8}{6}=\frac{4}{3}=1\frac{1}{3}$$



RULE

To subtract fractions with different denominators, find the lowest common denominator, change to equivalent fractions, subtract the numerators, and place the sum over the common denominator. Reduce to lowest terms if necessary.

Example 3:

$$\frac{15}{6} - \frac{3}{5}$$

Solution: The lowest common denominator is 30. Change to equivalent fractions, and subtract.

$$\begin{aligned} \frac{15}{6} &= \frac{75}{30} \\ -\frac{3}{5} &= \frac{18}{30} \\ \hline \frac{57}{30} &= 1\frac{27}{30} = 1\frac{9}{10} \end{aligned}$$

Example 4:

$$2\frac{1}{5} - \frac{4}{3}$$

Solution: Change the mixed number

$$2\frac{1}{5}$$

to

$$\frac{11}{5}$$

. Find the lowest common denominator, change to equivalent fractions, subtract, and reduce if necessary. The lowest common denominator is 15.

$$\begin{aligned} \frac{11}{5} &= \frac{33}{15} \\ -\frac{4}{3} &= \frac{20}{15} \\ \hline \frac{13}{15} \end{aligned}$$

Subtracting a Fraction From a Whole Number



RULE

To subtract a fraction from a whole number, follow these steps:

- 1. Borrow 1 from the whole number and change it to a fraction, creating a mixed number.
- 2. Change the fraction so that it has the same denominator as the fraction to be subtracted.
- 3. Subtract the fraction from the mixed number.
- 4. Reduce if necessary.

Example 1: Subtract

$$\frac{7}{12}$$

from 6.

$$6 = 5 + \frac{1}{1} = 5\frac{12}{12}$$
$$-\frac{7}{12} = \frac{7}{12}$$
$$5\frac{5}{12}$$

Subtracting Fractions Using Borrowing



RULE

To subtract fractions using borrowing, use the following steps:

- 1. Change both fractions to the same denominator if necessary.
- 2. Borrow 1 from the whole number and change it to the same denominator as the fraction in the mixed number. Add the two fractions together.
- 3. Subtract the fractions and the whole numbers.
- 4. Reduce if necessary.

Example 2:

$$5\frac{1}{4} - 3\frac{3}{4}$$

In the above example, because

$$\frac{3}{4}$$

is larger than

$$\frac{1}{4}$$

subtraction of the fractions is not possible. Both fractions have the same denominator; no changes need to be made. Therefore borrow 1 from the whole number part (5), and add the 1 to the fractional part

$$\left(\frac{1}{4}\right)$$

.

This results in

$$5\frac{1}{4} = 4 + \frac{1}{1} + \frac{1}{4} = 4 + \frac{4}{4} + \frac{1}{4} = 4\frac{5}{4}$$

$$5\frac{1}{4} = 4\frac{5}{4}$$
$$-3\frac{3}{4} = 3\frac{3}{4}$$
$$1\frac{5-3}{4} = 1\frac{2}{4} = 1\frac{1}{2}$$

Example 3: Subtract

$$4\frac{3}{4}$$

from

$$9\frac{2}{3}$$

.

Both fractions need to be changed to the same denominator of 12:

$$9\frac{2}{3} = 9\frac{8}{12}$$

and

$$4\frac{3}{4} = 4\frac{9}{12}$$

Subtraction of the fractions is not possible because

$$\frac{9}{12}$$

is larger than

$$\frac{8}{12}$$

.

Therefore borrow 1 from 9.

$$9\frac{8}{12} = 8 + \frac{1}{1} + \frac{8}{12} = 8 + \frac{12}{12} + \frac{8}{12} = 8\frac{20}{12}$$

Now subtract:

$$\begin{array}{r} 9\frac{2}{3} = 9\frac{8}{12} = 8\frac{20}{12} \\ -4\frac{3}{4} = 4\frac{9}{12} = 4\frac{9}{12} \\ \hline 4\frac{11}{12} \end{array}$$

Multiplying Fractions



RULE

- 1. Cancel terms if possible.
- 2. Multiply the numerators, multiply the denominators.
- 3. Reduce the result (product) to the lowest terms, if necessary.

Notice in this example that the numerator and denominator of any of the fractions involved in multiplication may be cancelled when they can be divided by the same number (cross-cancellation).

Example 1:

$$\frac{3}{\cancel{4}_{2}} \times \frac{\cancel{2}^{1}}{5} = \frac{3}{10}$$

Example 2:

$$\frac{2}{4} \times \frac{3}{4}$$

Solution: Reduce

$$\frac{2}{4}$$

to

$$\frac{1}{2}$$

and then multiply.

$$\frac{1}{2} \times \frac{3}{4} = \frac{3}{8}$$

Example 3:

$$6 \times \frac{5}{6}$$

$$\frac{\cancel{6}^{1}}{1} \times \frac{5}{\cancel{6}_{1}} = 5$$

or

$$\frac{6 \times 5}{6} = \frac{30}{6} = 5$$

Example 4:

$$3\frac{1}{3} \times 2\frac{1}{2}$$

Solution: Change mixed numbers to improper fractions. Proceed with multiplication.

$$3\frac{1}{3} = \frac{10}{3}; 2\frac{1}{2} = \frac{5}{2}$$

$$\frac{10}{3} \times \frac{5}{2} = \frac{50}{6} = 8\frac{2}{6} = 8\frac{1}{3}$$

or

$$\frac{\overset{5}{\cancel{10}}}{3} \times \frac{5}{\underset{1}{\cancel{2}}} = \frac{25}{3} = 8\frac{1}{3}$$

Dividing Fractions



RULE

- 1. To divide fractions, invert (turn upside down) the second fraction (divisor); change ÷ to ×.
- 2. Cancel terms, if possible.
- 3. Multiply fractions.
- 4. Reduce where necessary.

Example 1:

$$\frac{3}{4} \div \frac{2}{3}$$

Solution:

$$\frac{3}{4} \times \frac{3}{2} = \frac{9}{8} = 1\frac{1}{8}$$

Example 2:

$$1\frac{3}{5} \div 2\frac{1}{10}$$

Solution: Change mixed numbers to improper fractions. Proceed with steps of division.

$$1\frac{3}{5} = \frac{8}{5}; 2\frac{1}{10} = \frac{21}{10}$$

$$\frac{8}{\cancel{5}_{1}} \times \frac{\cancel{10}^{2}}{21} = \frac{16}{21}$$

Example 3:

$$5 \div \frac{1}{2}$$

Solution:

$$5 \times \frac{2}{1} = \frac{10}{1} = 10$$

or

$$\frac{5}{1} \times \frac{2}{1} = \frac{10}{1} = 10$$

With dosage calculations that involve division, the fractions may be written as follows:

$$\frac{1/4}{1/2}$$

. In this case,

$$\frac{1}{4}$$

is the numerator and

$$\frac{1}{2}$$

is the denominator. Therefore the problem is set up as:

$$\frac{1}{4} \div \frac{1}{2}$$

, which becomes

$$\frac{1}{\cancel{4}_{2}} \times \frac{\cancel{2}^{1}}{1} = \frac{1}{2}$$

.

PRACTICE PROBLEMS

Change the following improper fractions to mixed numbers, and reduce to lowest terms.

- 36.

$$\frac{18}{5} =$$

_____

- 37.

$$\frac{60}{14} =$$

_____

- 38.

$$\frac{13}{8} =$$

_____

- 39.

$$\frac{35}{12} =$$

_____

- 40.

$$\frac{112}{100} =$$

_____

Change the following mixed numbers to improper fractions.

- 41.

$$1\frac{4}{25} =$$

_____

- 42.

$$4\frac{2}{8} =$$

_____

- 43.

$$4\frac{1}{2} =$$

_____

- 44.

$$3\frac{3}{8} =$$

_____

- 45.

$$15\frac{4}{5} =$$

_____

Add the following fractions and mixed numbers, and reduce fractions to lowest terms.

- 46.

$$\frac{2}{3} + \frac{5}{6} =$$

_____

- 47.

$$2\frac{1}{8} + \frac{2}{3} =$$

_____

- 48.

$$2\frac{3}{10} + 4\frac{1}{5} + \frac{2}{3} =$$

_____

- 49.

$$7\frac{2}{5} + \frac{2}{3} =$$

_____

- 50.

$$12\frac{1}{2} + 10\frac{1}{3} =$$

_____

Subtract and reduce fractions to lowest terms.

- 51.

$$\frac{4}{3} - \frac{3}{7} =$$

_____

- 52.

$$3\frac{3}{8} - 1\frac{3}{5} =$$

_____

- 53.

$$\frac{15}{16} - \frac{1}{4} =$$

_____

- 54.

$$2\frac{5}{6} - 2\frac{3}{4} =$$

_____

- 55.

$$\frac{1}{8} - \frac{1}{12} =$$

_____

- 56.

$$14 - \frac{5}{9} =$$

_____

- 57.

$$3\frac{3}{10} - 1\frac{7}{10} =$$

_____

Multiply the following fractions and mixed numbers, and reduce to lowest terms.

- 58.

$$\frac{2}{3} \times \frac{4}{5} =$$

_____

- 59.

$$\frac{6}{25} \times \frac{3}{5} =$$

_____

- 60.

$$\frac{1}{50} \times 3 =$$

_____

- 61.

$$2\frac{5}{8} \times 2\frac{3}{4} =$$

_____

- 62.

$$\frac{5}{12} \times \frac{4}{9} =$$

_____

Divide the following fractions and mixed numbers, and reduce to lowest terms.

- 63.

$$2\frac{6}{7} \div 1\frac{2}{3} =$$

_____

- 64.

$$\frac{1}{60} \div \frac{1}{2} =$$

$$\frac{1}{60} \div \frac{1}{2} =$$

_____

- 65.

$$6 \div \frac{2}{5} =$$

_____

- 66.

$$\frac{7}{8} \div \frac{7}{8} =$$

_____

- 67.

$$3\frac{1}{3} \div 1\frac{7}{12} =$$

_____

Answers on 21

CHAPTER REVIEW

Change the following improper fractions to mixed numbers, and reduce to lowest terms.

- 1.

$$\frac{10}{8} =$$

_____

- 2.

$$\frac{30}{4} =$$

_____

- 3.

$$\frac{67}{10} =$$

_____

- 4.

$$\frac{11}{4} =$$

_____

- 5.

$$\frac{64}{15} =$$

_____

- 6.

$$\frac{100}{13} =$$

_____

Change the following mixed numbers to improper fractions.

- 7.

$$7\frac{3}{8} =$$

_____

- 8.

_____

- 9.

$$3\frac{1}{5} =$$

_____

- 10.

$$12\frac{3}{4} =$$

_____

- 11.

$$6\frac{5}{7} =$$

_____

Add the following fractions and mixed numbers. Reduce to lowest terms.

- 12.

_____

- 13.

$$\frac{1}{4} + \frac{1}{6} + \frac{1}{8} =$$

_____

- 14.

$$6\frac{1}{4}+\frac{2}{9}+\frac{1}{36}=$$

_____

- 15.

$$10\frac{1}{6}+12\frac{4}{6}=$$

_____

- 16.

$$1\frac{4}{5}+7\frac{9}{10}+3\frac{1}{2}=$$

_____

Subtract the following fractions and mixed numbers. Reduce to lowest terms.

- 17.

$$2\frac{1}{4}-1\frac{1}{2}=$$

_____

- 18.

_____

- 19.

$$\frac{4}{5}-\frac{1}{4}=$$

_____

- 20.

$$4\frac{1}{6}-1\frac{1}{3}=$$

_____

- 21.

$$\frac{8}{5}-\frac{1}{3}=$$

_____

- 22.

$$\frac{5}{6}-\frac{7}{12}=$$

_____

- 23.

_____

- 24.

_____

Multiply the following fractions and mixed numbers. Reduce to lowest terms.

- 25.

$$\frac{1}{3} \times \frac{4}{12} =$$

_____

- 26.

$$2\frac{7}{8} \times 3\frac{1}{4} =$$

_____

- 27.

$$36 \times \frac{3}{4} =$$

_____

- 28.

_____

- 29.

$$\frac{10}{25} \times \frac{5}{3} =$$

_____

- 30.

_____

- 31.

$$\frac{3}{5} \times 3\frac{1}{8} =$$

_____

- 32.

$$2\frac{2}{5} \times 4\frac{1}{6} =$$

_____

- 33.

$$2 \times 4\frac{3}{8} =$$

_____

- 34.

_____

Divide the following fractions and mixed numbers. Reduce to lowest terms.

- 35.

_____

- 36.

$$25 \div 12\frac{1}{2} =$$

_____

- 37.

_____

- 38.

$$\frac{4}{6} \div \frac{1}{2} =$$

_____

- 39.

_____

- 40.

_____

Arrange the following fractions in order from largest to the smallest.

- 41.

$$\frac{15}{30} \div 10 =$$

_____

- 42.

_____

- 43.

$$12 \div \frac{2}{3} =$$

_____

- 44.

_____

- 45.

_____

Arrange the following fractions in order from largest to the smallest.

- 46.

$\frac{3}{16}$, $\frac{1}{16}$, $\frac{5}{16}$, $\frac{14}{16}$, $\frac{7}{16}$

- 47.

$\frac{5}{12}$

,

,

,

$\frac{5}{6}$

,

Apply the principles of borrowing, and subtract the following:

- 48.

_____

- 49.

_____

- 50.

_____

- 51. A client is instructed to drink 20 ounces of water within 1 hour. The client has only been able to drink 12 ounces. What portion of the water remains? (Express your answer as a fraction reduced to lowest terms.) _____
- 52. A child's oral Motrin Suspension contains 100 milligrams per teaspoonful. 20 milligrams represents what part of a dosage? _____
- 53. A client is receiving 240 milliliters of Ensure by mouth as a supplement. The client consumes 200 milliliters. What portion of the Ensure remains? (Express your answer as a fraction reduced to lowest terms.) _____
- 54. A client takes 1½ tablets of medication four times per day for 4 days. How many tablets will the client have taken at the end of the 4 days? _____
- 55. A juice glass holds 120 milliliters. If a client drinks 2⅓ glasses, how many milliliters did the client consume? _____
- 56. On admission a client weighed 150¾ lb. On discharge the client weighed 148½ lb. How much weight did the client lose? _____
- 57. How many hours are there in 3½ days? _____
- 58. A client consumed the following: 2¼ ounces of tea, ⅓ ounce of juice, 1½ ounces of Jell-O. What is the total number of ounces consumed by the client? _____
- 59. One tablet contains 200 milligrams of pain medication.
- How many milligrams are in 3½ tablets? _____
- 60. A bottle of medicine contains 30 doses. How many doses are in 2½ bottles? _____
- 61. The nurse gave a client ¾ tablespoons (tbs) of medication with breakfast, ½ tbs at lunch, ½ tbs at dinner, and 1¼ tbs at bedtime. How much medication did the nurse administer? _____
- 62. A client weighed 160½ pounds (lb) at the previous visit to the doctor. At this visit, the client weighs 2¾ lb more. How many lb does the client weigh? _____
- 63. At the beginning of a shift there are 5¼ bottles of hand sanitizer available. At the end of the shift, 3½ bottles are left. How much was used? _____
- 64. A client was given a 16-ounce container of water to drink throughout the day. If the client drank ⅞ of the container, how many ounces did the client drink? _____
- 65. How many 1½-ounce doses of medication are there in a 24-ounce bottle? _____
- 66. A bottle contains 36 tablets. If a client took ⅓ of the tablets, how many tablets are left? _____
- 67. A client drank 4¾ ounces of juice, 5½ ounces of coffee, and 4¼ ounces of water. How much fluid did the client drink? _____
- 68. One tablet contains 400 milligrams of medication. A client was given 1½ tablets for 5 days. How many milligrams of medication did the client receive in 5 days? _____
- 69. An order is written for a client to receive 1½ ounces of a powdered medication dissolved in water. The client drank ¾ ounces of the medication. How much more medication must be given to the client? _____
- 70. An infant grew ¾ inch in the first month, ½ inch in the second month, ⅞ inch in the third month, and 1⅛ inches in the fourth month. How many inches has the infant grown? _____
- 71. For 4 days a client received 2½ ounces of medication 4 times per day. How many ounces did the client receive over 4 days? _____
- 72. A bottle contains 24 ounces of a liquid pain medication. If a typical dose is ¾ ounce, how many doses are there in the bottle? _____
- 73. A nurse worked 9¾ hours on Monday, 11½ hours on Tuesday, and 10¾ hours on Wednesday. How many hours did she work for the 3 days? _____
- 74. A nurse needs ½ hour to complete an intake interview form on each new client. How many intake interview forms can the nurse complete in 2½ hours?
- _____
- 75. A client drinks ¾ of a glass of juice that contains 180 milliliters. How many milliliters of juice did the client drink? _____
- 76. A client is instructed to drink the equivalent of 8 glasses of water daily. How many times will the client need to drink ½ glass of water? _____

- 77. One tablet contains 150 milligrams of medication. How many milligrams are in 3½ tablets? _____
- 78. A client at home was instructed to take ¾ ounce of medication with meals. The nurse learns that the client took ⅔ ounce. Did the client take too little, too much, or just the right amount? _____
- 79. A client has taken ¾ of a bottle of tablets that contained 100 tablets. How many tablets has the client taken? _____
- 80. A client drank 3½ cups of water from a cup that held 210 milliliters. How many milliliters did the client drink? _____

Answers on 22

ANSWERS

Chapter 1

Answers to Practice Problems

- 1. LCD = 30; therefore

$$\frac{6}{30}$$

has the lesser value.

- 2. LCD = 8; therefore

$$\frac{6}{8}$$

has the lesser value.

- 3.

$$\frac{1}{150}$$

has the lesser value; the denominator (150) is larger.

- 4.

has the lesser value; the numerator (6) is smaller.

- 5.

has the lesser value; reduced to

the numerator (1) is smaller.

- 6.

$$\frac{1}{8}$$

has the lesser value; the numerator (1) is smaller.

- 7.

has the lesser value; the denominator (40) is larger.

- 8.

$$\frac{1}{300}$$

has the lesser value; the denominator (300) is larger.

- 9.

has the lesser value; the numerator (4) is smaller.

- 10. LCD = 6; therefore

has the lesser value.

- 11. LCD = 72; therefore

$$\frac{6}{8}$$

has the higher value.

- 12. LCD = 6; therefore

has the higher value.

- 13. LCD = 72; therefore

has the higher value.

- 14.

has the higher value; the denominator (6) is smaller.

- 15.

has the higher value; the denominator (75) is smaller.

- 16.

$$\frac{6}{5}$$

has the higher value; the numerator (6) is larger.

- 17. LCD = 24; therefore

  has the higher value.
- 18.

  has the higher value; the numerator (8) is larger.
- 19.

  has the higher value; the denominator (10) is smaller.
- 20.

  has the higher value; the numerator (6) is larger.
- 21.

- 22.
- 23.
- 24.
- 25.
- 26.

- 27.
- 28.
- 29.
- 30.
- 31.

- 32.
- 33.
- 34.
- 35.
- 36.

- 37.
- 38.
- 39.
- 40.
- 41.

- 42.
- 43.
- 44.
- 45.
- 46.

- 47.
- 48.
- 49.
- 50.
- 51.

- 52.
- 53.
- 54.
- 55.
- 56.

- 57.
- 58.
- 59.
- 60.
- 61.

- 62.
- 63.
- 64.
- 65. 15
- 66. 1
- 67.

Answers to Chapter Review

- 1.

- 2.
- 3.
- 4.
- 5.
- 6.

- 7.
- 8.
- 9.
- 10.
- 11.

- 12. LCD = 30;
- 13. LCD = 24;
- 14. LCD = 36;
- 15.
- 16. LCD = 10;
- 17. LCD = 4;

$$\frac{3}{4}$$

- 18. LCD = 30;

- 19. LCD = 20;

- 20. LCD = 6;

- 21. LCD = 15;

- 22. LCD = 12;

- 23.

- 24. LCD = 18;

- 25.

- 26.

- 27. 27
- 28.

- 29.
- 30.
- 31.
- 32. 10
- 33.
- 34. $\frac{1}{2}$
- 35.
- 36. 2

- 37.
- 38.

$$1\frac{1}{3}$$

- 39.
- 40.
- 41.
- 42. 2
- 43. 18
- 44.

$$\frac{1}{16}$$

- 45.

- 46.

$\frac{14}{16}$

,

$\frac{7}{16}$

,

$\frac{5}{16}$

,

$\frac{3}{16}$

,

$\frac{1}{16}$

- 47.

$\frac{5}{6}$

,

,

$\frac{5}{12}$

,

,

- 48.
- 49.
- 50.

- 51.

of water remains

- 52.

the dosage

- 53.

of Ensure remains

- 54. 24 tablets
- 55. 280 milliliters
- 56. 2¼ lb
- 57. 84 hours
- 58.

ounces

- 59. 700 milligrams
- 60. 75 doses
- 61. 3 tbs
- 62. 163¼ lb
- 63. 1¾ bottles
- 64. 14 ounces
- 65. 16 (1½ ounce doses in the bottle)
- 66. 24 tablets
- 67. 14½ ounces
- 68. 3,000 milligrams

- 69. ¾ ounce
- 70. 3¼ inches
- 71. 40 ounces
- 72. 32 (¾ ounce doses in the bottle)
- 73. 32 hours
- 74. 5 interview forms
- 75. 135 milliliters
- 76. 16 times
- 77. 525 milligrams
- 78. Too little
- 79. 75 tablets
- 80. 735 milliliters

unknown - Section 13 (Page 57)

Medication dosages and other measurements in the health care system use metric measures, which are based on the decimal system. An understanding of decimals is crucial to the calculation of dosages. In the administration of medications, nurses calculate dosages that contain decimals in addition to encountering labels that may have dosage strengths expressed as decimals. Some examples include Coreg, terbutaline, Flomax, and clonidine. See example labels in Figures 2.1 and 2.2 with dosage strengths expressed in decimal format.

Figure 2.1 Flomax, each capsule is 0.4 mg.

Figure 2.2 Coreg, each tablet is 3.125 mg.

Decimal points in dosages have been cited as a major source of medication errors. A misunderstanding of the value of a dosage expressed as a decimal or the omission of a decimal point can result in a serious medication error. Decimals should be written with great care to prevent misinterpretation of a value. A clear understanding of the importance of decimal points and their value will assist the nurse in the prevention of medication errors. A decimal is a fraction that has a denominator that is a multiple of 10. A decimal fraction is written as a decimal by the use of a decimal point (.). The decimal point is used to indicate place value. Some examples are as follows:

Fraction	Decimal Number
	0.3
	0.18

Fraction	Decimal Number
	0.175

The decimal point represents the center that separates whole and fractional amounts. The position of the numbers in relation to the decimal point indicates the place of value of numbers.

- • The whole number is placed to the **left** of the decimal point. These numbers have a value of one (1) or greater.
- • Decimal fractions are written to the **right** of the decimal point and represent a value that is less than one (1) or part of one. The words for all decimal fractions end in *-th(s)*.

The easiest way to understand decimals is to memorize the place values (Box 2.1).

BOX 2-1 Decimal Place Values

The decimal value is determined by its position to the right of the decimal point.

Example 1: 0.3 = three tenths

Example 2: 0.03 = three hundredths

Example 3: 0.003 = three thousandths

SAFETY ALERT!

When there is no whole number before a decimal point, place a zero (0) to the left of the decimal point to emphasize that the number is a decimal fraction and has a value less than 1. This will emphasize its value and prevent errors in interpretation and avoid errors in dosage calculation. This zero does not change the value of the number. This has been emphasized by the Institute for Safe Medication Practices (ISMP) and is a requirement of the accrediting body for health care organizations, The Joint Commission (TJC), when writing decimal fractions in medical notation and is part of TJC's official "Do Not Use" list.

The source of many medication errors is misplacement of a decimal point or incorrect interpretation of a decimal value.

Reading and Writing Decimals

RULE

To read the decimal numbers, read:

- 1. The whole number
- 2. The decimal point as “and”
- 3. The decimal fraction by naming the value of the last decimal place

Notice that the words for all decimal fractions end in *-th(s)*.

Example 1: The decimal number 1.125 is read as “one and one hundred twenty-five thousandths.”

Example 2: The number 12.5 is read as “twelve and five tenths.”

Example 3: The number 10.03 is read as “ten and three hundredths.”

RULE

When reading decimal numbers in which a zero is placed before the decimal, such as in a decimal fraction (whose value is less than 1), read the number alone, without stating the zero.

Example 1: The number 0.4 is read as “four tenths.”

Example 2: The number 0.175 is read as “one hundred seventy-five thousandths.”

TIPS FOR CLINICAL PRACTICE

An exception to this is in an emergency situation when a nurse must take a verbal order over the phone from a prescriber. When repeating back an order for a medication involving a decimal, the zero should be read aloud to prevent a medication error.

Example: “Zero point 4” would be the verbal interpretation of Example 1 and “zero point 175” of Example 2. In addition to repeating the order back, the receiver of the order should write down the complete order or enter it into a computer, then read it back, and receive confirmation of the order from the individual giving the order.

RULE

To write a decimal number, write the following:

- 1. The whole number (If there is no whole number, write zero [0] to the left of the decimal.)
- 2. The decimal point to indicate the place value of the rightmost number
- 3. The decimal portion of the number to the right of the decimal

Example 1: Written, seven and five tenths = 7.5

Example 2: Written, one hundred twenty-five thousandths = 0.125

Example 3: Written, five tenths = 0.5

RULE

When writing decimals, placing a zero after the last digit of a decimal fraction does not change its value and is not necessary.

Example: 0.37 = 0.370

SAFETY ALERT!

When writing decimals, trailing zeros should not be placed at the end of the number to avoid misinterpretation of a value. This is also a recommendation of the Institute for Safe Medication Practices (ISMP) and is a part of The Joint Commission's (TJC) official "Do Not Use" List. TJC forbids the use of trailing zeros for medication orders or other medication-related documentation. Omitting trailing zeros decreases the potential for giving a client 10 times the ordered dose or more. Exception: A trailing zero may be used only when required to demonstrate the level of precision of the value being reported, such as for laboratory results, imaging studies that report the size of lesions, or catheter/tube sizes.

Because the last zero does not change the value of the decimal, it is not necessary. For example, the required notation is 0.37, not 0.370, and 30, not 30.0, which could be interpreted as 370 and 300, respectively, if the decimal point is not clear or is missed.

RULE

Zeros added before or after the decimal point of a decimal number may change its value.

Example 1: 0.375 ≠ (is not equal to) 0.0375

Example 2: 2.025 ≠ 20.025

However, .7 = 0.7 and 15 = 15.0, but you should write 0.7 (with a leading zero) and 15 (without a trailing zero).

PRACTICE PROBLEMS

Write each of the following numbers in word form.

- 1. 8.35 _____
- 2. 11.001 _____
- 3. 4.57 _____
- 4. 5.0007 _____
- 5. 10.5 _____
- 6. 0.163 _____

Write each of the following in decimal form.

- 7. four tenths _____
- 8. eighty-four and seven hundredths _____
- 9. seven hundredths _____
- 10. two and twenty-three hundredths _____
- 11. five hundredths _____
- 12. nine thousandths _____

Answers on 39

Comparing the Value of Decimals

It is essential to be able to compare decimal amounts and know which has the greater or lesser value in the calculation of dosages. This helps prevent errors in dosage and gives the nurse an understanding of the size of a dosage (i.e., 0.5 mg, 0.05 mg).

SAFETY ALERT!

Understanding the value of decimals helps ensure accuracy and prevents misinterpretation of values. There is an appreciable difference between 0.5 milligram (mg) and 0.05 milligram. In fact, 0.5 mg is 10 times larger than 0.05 mg. In dosage calculations, a misinterpretation of the value of decimals can result in serious consequences.

RULE

When decimal numbers contain whole numbers, the whole numbers are compared to determine which is greater.

Example 1: 4.8 is greater than 2.9

Example 2: 11.5 is greater than 7.5

Example 3: 7.37 is greater than 6.94

RULE

If the whole numbers being compared are the **same** (e.g., 5.6 and 5.2) or if there is **no whole number** (e.g., 0.45 and 0.37), then the number in the **tenths** place determines which decimal is greater.

Example 1: 0.45 is greater than 0.37

Example 2: 1.75 is greater than 1.25

RULE

If the whole numbers are the same or zero and the numbers in the tenths place are the same, then the decimal with the higher number in the hundredths place has the greater value, and so forth.

Example 1: 0.67 is greater than 0.66

Example 2: 0.17 is greater than 0.14

PRACTICE PROBLEMS

Circle the decimal with the largest value in the following: _____

- 13. 0.5 0.15 0.05
- 14. 2.66 2.36 2.87
- 15. 0.125 0.375 0.25
- 16. 0.175 0.1 0.05
- 17. 7.02 7.15 7.35
- 18. 0.067 0.087 0.077

Answers on 39

Adding and Subtracting Decimals

RULE

To add or subtract decimals, place the numbers in columns so that the decimal points are lined up directly under one another and add or subtract from right to left. Zeros may be added at the end of the decimal fraction, making all decimals of equal length, but unnecessary zeros should be eliminated in the final answer.

SAFETY ALERT!

Eliminate unnecessary zeros in the final answer to avoid confusion and prevent errors in misinterpretation of values.

Example 1: Add 16.4 + 21.8 + 13.2

Example 2: Add 2.25 + 1.75

Example 3: Subtract 2.6 from 18.6

Example 4: Add 11.2 + 16

Example 5: Subtract 3.78 from 12.84

Example 6: Subtract 0.007 from 0.05

Example 7: Add 6.54 + 2.26

Example 8: Add 0.7 + 0.75 + 0.23 + 2.324

Example 9: Subtract 0.2 from 0.375

PRACTICE PROBLEMS

Add the following decimals.

- 19. 4.7 + 5.3 + 8.4 = _____
- 20. 38.52 + 0.029 + 1.9 = _____
- 21. 0.7 + 3.25 = _____
- 22. 2.2 + 1.67 = _____

Subtract the following decimals.

- 23. 3.67 – 0.75 = _____
- 24. 64.3 – 21.2 = _____
- 25. 0.08 – 0.045 = _____
- 26. 6.75 – 0.87 = _____

Answers on 39

Multiplying Decimals

RULE

To multiply decimals, multiply as with whole numbers. In the answer (product), count off from right to left as many decimal places as there are in the numbers being multiplied. Zeros may also be added to the left if necessary.

Answer: 3.84

In Example 1, 1.2 has one number after the decimal, and 3.2 also has one. Therefore you will need to place the decimal point two places to the left in the answer (product).

RULE

When there are insufficient numbers in the answer for correct placement of the decimal point, add as many zeros as needed to the left of the answer.

Answer: 0.8775

In Example 2, 1.35 has two numbers after the decimal, and 0.65 also has two. Therefore you will need to place the decimal point four places to the left in the answer (product), and add a zero in front of the decimal point.

Answer: 0.0363

In Example 3, four decimal places are needed (two numbers after each decimal in 0.11 and 0.33), but there are only three numbers in the product. A zero must be placed to the left of these numbers for correct placement of the decimal point. Place a zero before the decimal point.

Answer: 0.080 = 0.08

In Example 4, three decimal places are needed (1.6 has one number after the decimal and 0.05 has two), so a zero has to be placed between the decimal point and 8 to allow for enough places. The unnecessary zero is eliminated in the final answer, and a zero is placed before the decimal point.

Multiplication by Decimal Movement

RULE

This method may be preferred when doing metric conversions because it is based on the decimal system. Multiplying by 10, 100, 1,000, and so forth can be done by moving the decimal point to the right the same number of places as there are zeros in the number by which you are multiplying.

When multiplying by 10, move the decimal one place to the right; by 100, two places to the right; by 1,000, three places to the right; and so forth.

Example 1: 1.6 × 10 = 16 (The multiplier 10 has 1 zero; decimal point moved 1 place to the right.)

Example 2: 5.2 × 100 = 520 (The multiplier 100 has 2 zeros; decimal point moved 2 places to the right.)

Example 3: 0.463 × 1,000 = 463 (The multiplier 1,000 has 3 zeros; decimal point moved 3 places to the right.)

Example 4: 6.64 × 10 = 66.4 (The multiplier 10 has 1 zero; decimal point moved one place to the right.)

SAFETY ALERT!

When multiplying decimals, be sure the decimal is placed in the correct position in the answer (product). Misplacement of decimal points can lead to a critical medication error.

PRACTICE PROBLEMS

Multiply the following decimals.

- 27. 3.15 × 0.015 = _____
- 28. 3.65 × 0.25 = _____
- 29. 9.65 × 1,000 = _____
- 30. 8.9 × 0.2 = _____
- 31. 14.001 × 7.2 = _____

Answers on 39

Dividing Decimals

Division of decimals is done in the same manner as division of whole numbers except for placement of the decimal point. Incorrect placement of the decimal point changes the numerical value and can cause errors in calculation. Errors made in the division of decimals are commonly caused by improper placement of the decimal point, incorrect placement of numbers in the quotient (answer), and omission of necessary zeros in the quotient.

The parts of a division problem are as follows:

The number being divided is called the **dividend,** the number being divided into the dividend is the **divisor,** and the answer is the **quotient.**

Symbols used to indicate division are as follows:

- 1.

Example: Read as 27 divided by 9.

- 2. ÷

Example: 9 Read as 27 divided by 9.

- 3. The horizontal bar with the dividend on the top and the divisor on the bottom

Example: Read as 27 divided by 9.

- 4. The slanted bar with the dividend to the left and the divisor to the right

Example: Read as 27 divided by 9.

Dividing a Decimal by a Whole Number

RULE

To divide a decimal by a whole number, place the decimal point in the quotient directly above the decimal point in the dividend. Proceed to divide as with whole numbers.

Example: Divide 17.5 by 5

Answer: 3.5

Dividing a Decimal or a Whole Number by a Decimal

RULE

To divide by a decimal, the decimal point in the divisor is moved to the right until the number is a whole number. The decimal point in the dividend is moved the same number of places to the right, and zeros are added as necessary. Proceed to divide as with whole numbers.

Example: Divide 6.96 by 0.3

Answer: 23.2

Division by Decimal Movement

RULE

To divide a decimal by 10, 100, or 1,000, move the decimal point to the **left** the same number of places as there are zeros in the divisor.

Example 1: 0.46 ÷ 10 = 0.046 (The divisor 10 has 1 zero; the decimal point is moved 1 place to the left.)

Example 2: 0.07 ÷ 100 = 0.0007 (The divisor 100 has 2 zeros; the decimal point is moved 2 places to the left.)

Example 3: 0.75 ÷ 1,000 = 0.00075 (The divisor 1,000 has 3 zeros; the decimal point is moved 3 places to the left.)

Rounding Off Decimals

The determination of how many places to carry your division when calculating dosages is based on the equipment being used. Some syringes are marked in **tenths** and some in **hundredths.** As you become familiar with the equipment used in dosage calculation, you will learn how far to carry your division and when to round off. To ensure accuracy, most calculation problems require that you carry your division at least **two decimal places (hundredths place)** and **round off to the nearest tenth.**

RULE

To express an answer to the nearest tenth, carry the division to the hundredths place (two places after the decimal). If the number in the hundredths place **is 5 or greater**, add 1 to the tenths place. If the number **is less than 5**, drop the number to the right of the desired decimal place.

Example 1: Express 4.15 to the nearest tenth.

Answer: 4.2 (The number in the hundredths place is 5, so the number in the tenths place is **increased by one.** 4.1 becomes 4.2.)

Example 2: Express 1.24 to the nearest tenth.

Answer: 1.2 (The number in the hundredths place is less than 5, so the number in the **tenths place does not change.** The 4 is dropped.)

Example 3: Express 0.98 to the nearest tenth.

Answer: 1.0 = 1 (The number in the hundredths place is 8, so the number in the tenths place is **increased by one.** 0.9 becomes 1. The zero at the end of this decimal is dropped, because it is unnecessary and can cause potential confusion.)

RULE

To express an answer to the nearest hundredth, carry the division to the thousandths place (three places after the decimal). If the number in the thousandths place is **5 or greater**, add one to the hundredths place. If the number **is less than 5**, drop the number to the right of the desired decimal place.

Example 1: Express 0.176 to the nearest hundredth.

Answer: 0.18 (The number in the thousandths place is 6, so the number in the hundredths place is **increased by one.** 0.17 becomes 0.18.)

Example 2: Express 0.554 to the nearest hundredth.

Answer: 0.55 (The number in the thousandths place is less than 5, so the number in **the hundredths place does not change.**) The 4 is dropped.

Example 3: Express 0.40 to the nearest hundredth.

Answer: 0.4 (There is a 0 in the hundredths place. When this is rounded to the hundredths, the final zero should be dropped. It is not necessary to clarify the number and can cause potential confusion.)

NOTE

In some instances, such as critical care or pediatrics, it may be necessary to compute decimal calculations to thousandths (three decimal places) and round to hundredths (two decimal places). These areas may require this level of accuracy.

PRACTICE PROBLEMS

Divide the following decimals. Carry division to the hundredths place where necessary. Do not round off.

- 32. 2 ÷ 0.5 = _____
- 33. 1.4 ÷ 1.2 = _____
- 34. 63.8 ÷ 0.9 = _____
- 35. 39.6 ÷ 1.3 = _____
- 36. 1.9 ÷ 3.2 = _____

Express the following decimals to the nearest tenth.

- 37. 3.57 _____
- 38. 0.95 _____
- 39. 1.98 _____

Express the following decimals to the nearest hundredth.

- 40. 3.550 _____
- 41. 0.607 _____
- 42. 0.738 _____

Divide the following decimals.

- 43. 0.005 ÷ 10 = _____
- 44. 0.004 ÷ 100 = _____

Multiply the following decimals.

- 45. 58.4 × 10 = _____
- 46. 0.5 × 1,000 = _____

Answers on 39

Changing Fractions to Decimals

RULE

To change a fraction to a decimal, divide the numerator by the denominator and add zeros as needed. If the numerator doesn't divide evenly into the denominator, carry division three places.

Example 1:

Example 2:

Changing fractions to decimals can also be a method of comparing fraction size. The fractions being compared are changed to decimals, and the rules relating to comparing decimals are then applied. (See Comparing the Value of Decimals, p. 27.)

Example: Which fraction is larger,

or

?

Solution:

= 0.333 ... as a decimal

= 0.333 ... as a decimal

Answer:

is therefore the larger fraction.

Changing Decimals to Fractions

RULE

To convert a decimal to a fraction, write the decimal number as a whole number in the numerator of the fraction, and express the denominator of the fraction as a power of 10. Place the number 1 in the denominator of the fraction, and add as many zeros as there are places to the right of the decimal point. Reduce to lowest terms if necessary. (See Reading and Writing Decimals, p. 25.)

Example 1: 0.4 is read “four tenths” and written

, which =

when reduced.

Example 2: 0.65 is read “sixty-five hundredths” and written

which

when reduced.

Example 3: 0.007 is read “seven thousandths” and written

.

Notice that the number of places to the right of the decimal point is the same as the number of zeros in the denominator of the fraction.

PRACTICE PROBLEMS

Change the following fractions to decimals, and carry the division three places as indicated. Do not round off.

- 47.

_____

- 48.

_____

- 49.

_____

Change the following decimals to fractions, and reduce to lowest terms.

- 50. 0.75 _____
- 51. 0.0005 _____
- 52. 0.04 _____

Answers on 39

POINTS TO REMEMBER

- • Read decimals carefully.
- • When the decimal fraction is not preceded by a whole number (e.g., .12), always place a “0” to the left of the decimal (0.12) to avoid interpretation errors and to avoid overlooking the decimal point.
- • Never follow a whole number with a decimal point and zero. This could result in a medication error because of misinterpretation (e.g., 3, not 3.0).

- • Add zeros to the right as needed for making decimals of equal spacing for addition and subtraction. These zeros do not change the value. Eliminate unnecessary zeros at the end in the final answer.
- • Adding zeros at the end of a decimal (except when called for to create decimals of equal length for addition or subtraction) can result in error (e.g., 1.5, not 1.50).
- • Adding zeros after the decimal point can change the value (e.g., 1.5 is not equal to 1.05, nor is it the same number).
- • To convert a fraction to a decimal, divide the numerator by the denominator.
- • To convert a decimal to a fraction, write the decimal number as a whole number in the numerator and the denominator as a power of 10. Reduce to lowest terms (e.g.,

).
- • Double-check work to avoid errors.

CHAPTER REVIEW

Identify the decimal with the largest value in the following sets.

- 1. 0.4, 0.44, 0.444 _____
- 2. 0.8, 0.7, 0.12 _____
- 3. 1.32, 1.12, 1.5 _____
- 4. 0.1, 0.05, 0.2 _____
- 5. 0.725, 0.357, 0.125 _____

Arrange the following decimals from smallest to largest.

- 6. 0.5, 0.05, 0.005 _____
- 7. 0.123, 0.1023, 1.23 _____
- 8. 0.64, 4.6, 0.46 _____
- 9. 5.15, 5.05, 5.55 _____
- 10. 0.73, 0.307, 0.703 _____

Perform the indicated operations. Give exact answers.

- 11. 3.005 + 4.308 + 2.47 = _____
- 12. 20.3 + 8.57 + 0.03 = _____
- 13. 5.886 – 3.143 = _____
- 14. 8.17 – 3.05 = _____
- 15. 3.8 – 1.3 = _____

Solve the following. Carry division to the hundredths place where necessary.

- 16. 5.7 ÷ 0.9 = _____
- 17. 3.75 ÷ 2.5 = _____
- 18. 1.125 ÷ 0.75 = _____
- 19. 0.15 × 100 = _____
- 20. 15 × 2.08 = _____

- 21. 472.4 × 0.002 = _____

Express the following decimals to the nearest tenth.

- 22. 1.75 _____
- 23. 0.13 _____

Express the following decimals to the nearest hundredth.

- 24. 1.427 _____
- 25. 0.147 _____

Change the following fractions to decimals. Carry division three decimal places as necessary.

- 26.

  _____
- 27.

  _____
- 28.

  _____

Change the following decimals to fractions, and reduce to lowest terms.

- 29. 1.01 _____
- 30. 0.065 _____

Add the following decimals.

- 31. You are to give a client one tablet labeled 0.15 milligram (mg) and one labeled 0.025 mg. What is the total dosage of these two tablets? _____
- 32. If you administer two tablets labeled 0.04 milligram (mg), what total dosage will you administer? _____
- 33. You have two tablets, one labeled 0.025 milligram (mg) and the other 0.1 mg. What is the total dosage of these two tablets? _____
- 34. You have just administered 3 tablets with dose strength of 1.5 milligrams (mg) each. What was the total dosage? _____
- 35. If you administer two tablets labeled 0.6 milligram (mg), what total dosage will you administer? _____

Multiply the following numbers by moving the decimal.

- 36. 0.08 × 10 = _____
- 37. 0.002 × 100 = _____

Divide the following numbers, and round to the nearest hundredth.

- 38. 0.13 ÷ 0.25 = _____
- 39. 4 ÷ 4.1 = _____
- 40. 6.45 ÷ 10 = _____

Round the following decimals to the nearest thousandth.

- 41. 4.2475 _____
- 42. 0.5673 _____
- 43. 7.8393 _____
- 44. 2.3249 _____
- 45. A client's water intake is 1.05 liters (L), 0.65 L, 2.05 L, and 0.8 L. What is the total intake in liters? _____
- 46. A client's creatinine level on admission was 2.5 milligrams per deciliter (mg/dL). By discharge the creatinine level dropped 0.9 mg. What is the client's current creatinine level? _____
- 47. A baby weighed 4.85 kilograms (kg) at birth and now weighs 7.9 kg. How many kilograms did the baby gain? _____
- 48. A client received a series of injections of medication in milliliters (mL): 1.5 mL, 2.3 mL, and 2.1 mL. What was the total amount of medication (in mL) the client received? _____
- 49. A client's sodium intake at one meal was the following: 0.002 gram (g), 0.35 g. How many grams of sodium did the client consume? _____
- 50. True or False? 2.4 grams (g) = 2.04 g _____
- 51. 0.7 milligram (mg) of a medication has been ordered. The recommended maximum dosage of the medication is 0.35 mg, and the minimum recommended dosage is 0.175 mg. Is the dosage ordered within the allowable limits? _____
- 52. A client weighed 85.4 kilograms (kg) in January. In February, the client gained 1.8 kg. In March, the client gained 2.3 kg. How much did the client weigh at the end of March? _____
- 53. If a dosage of medication is 2.5 milliliters (mL), how much medication is needed for 25 dosages? _____
- 54. A client received 17.5 milligrams (mg) of a medication in tablet form. Each tablet contained 3.5 mg of medication. How many tablets were given to the client? _____
- 55. A client received a total of 4.5 grams (g) of a medication. If the client received the total over a 3-day period and was given 3 doses per day, what was the strength of each dose? _____
- 56. A client is brought to the emergency room with a body temperature of 95.3°F. If the normal body temperature is 98.6°F, how far below normal was the client's temperature? _____
- 57. A vial holds a total of 7.5 milliliters (mL) of medication. If two injections are withdrawn from the vial (1.6 mL and 0.8 mL), how much medication is left in the vial? _____
- 58. One dose of flu vaccine is 0.5 milliliter (mL). How much vaccine is needed to vaccinate 30 walk-ins at a clinic? _____
- 59. A client's hemoglobin was 13.8 grams (g) before surgery. During surgery, the hemoglobin dropped 4.5 g. What was the hemoglobin value after it dropped? _____
- 60. For a certain medication, the safe dosage should be greater than or equal to 0.7 gram (g) but less than or equal to 2 g. Which of the following dosages fall within the range? (More than one answer is correct.)
- 0.8 g, 0.25 g, 2.5 g, 1.25 g
- 61. In a 24-hour period, a premature infant drank 5.5 milliliters (mL), 15 mL, 5.25 mL, 15 mL, 6 mL, and 12.5 mL. How many mL did the infant drink in 24 hours? _____
- 62. A baby weighed 3.7 kilograms (kg) at birth. The baby now weighs 5.65 kg. How many kg did the baby gain? _____
- 63. A client receives a dosage of 5.5 milliliters (mL) of medication 4 times a day. How much medication would the client receive in 7 days? _____
- 64. A client received 17.5 milligrams (mg) of medication in tablet form. Each tablet contains 2.5 mg of medication. How many tablets were given to the client? _____
- 65. The doctor prescribed 1.5 tablets of a medication to be administered to a client 4 times a day for 7 days. How many tablets were prescribed? _____

Answers below

ANSWERS

Chapter 2

Answers to Practice Problems

- 1. eight and thirty-five hundredths
- 2. eleven and one thousandth
- 3. four and fifty-seven hundredths
- 4. five and seven ten thousandths
- 5. ten and five tenths
- 6. one hundred sixty-three thousandths
- 7. 0.4
- 8. 84.07
- 9. 0.07
- 10. 2.23
- 11. 0.05
- 12. 0.009
- 13. 0.5
- 14. 2.87
- 15. 0.375
- 16. 0.175
- 17. 7.35
- 18. 0.087
- 19. 18.4
- 20. 40.449
- 21. 3.95
- 22. 3.87
- 23. 2.92
- 24. 43.1
- 25. 0.035
- 26. 5.88
- 27. 0.04725
- 28. 0.9125
- 29. 9,650
- 30. 1.78
- 31. 100.8072
- 32. 4
- 33. 1.16
- 34. 70.88
- 35. 30.46
- 36. 0.59
- 37. 3.6
- 38. 1
- 39. 2
- 40. 3.55
- 41. 0.61
- 42. 0.74
- 43. 0.0005
- 44. 0.00004
- 45. 584
- 46. 500

- 47. 0.75
- 48. 0.555
- 49. 0.5
- 50.

- 51.

- 52.

- **Answers to Chapter Review**
- 1. 0.444
- 2. 0.8
- 3. 1.5
- 4. 0.2
- 5. 0.725
- 6. 0.005, 0.05, 0.5
- 7. 0.1023, 0.123, 1.23
- 8. 0.46, 0.64, 4.6
- 9. 5.05, 5.15, 5.55
- 10. 0.307, 0.703, 0.73
- 11. 9.783
- 12. 28.9
- 13. 2.743
- 14. 5.12
- 15. 2.5
- 16. 6.33
- 17. 1.5
- 18. 1.5
- 19. 15
- 20. 31.2
- 21. 0.94
- 22. 1.8
- 23. 0.1
- 24. 1.43

- 25. 0.15
- 26. 0.125
- 27. 0.06
- 28. 6.5
- 29.

- 30.

- 31. 0.175 mg
- 32. 0.08 mg
- 33. 0.125 mg
- 34. 4.5 mg
- 35. 1.2 mg
- 36. 0.8
- 37. 0.2
- 38. 0.52
- 39. 0.98
- 40. 0.65
- 41. 4.248
- 42. 0.567
- 43. 7.839
- 44. 2.325
- 45. 4.55 L
- 46. 1.6 mg/dL
- 47. 3.05 kg
- 48. 5.9 mL
- 49. 0.352 g
- 50. False
- 51. No, 0.7 mg is outside the allowable limits of the safe dosage range of 0.175 mg to 0.35 mg. It is twice the allowable maximum dosage.
- 52. 89.5 kg
- 53. 62.5 mL
- 54. 5 tablets
- 55. 0.5 g per dose
- 56. 3.3°F
- 57. 5.1 mL
- 58. 15 mL
- 59. 9.3 g
- 60. 0.8 g, 1.25 g
- 61. 59.25 mL
- 62. 1.95 kg
- 63. 154 mL
- 64. 7 tablets

- 65. 42 tablets

unknown - Section 14 (Page 68)

Ratio and proportion is one logical method for calculating medications. It can be used to calculate all types of medication problems. Nurses use ratios to calculate and to check medication dosages. Some medications express the strength of the solution by using a ratio. Example: An epinephrine label may state 1:1,000. Ratios are used in hospitals to determine the client-to-nurse ratio. Example: If there are 28 clients and 4 nurses on a unit, the ratio of clients to nurses is 28:4 or “28 to 4” or 7:1. As with fractions, ratios should be stated in lowest terms. Like a fraction, which indicates the division of two numbers, a ratio indicates the division of two quantities. The use of ratio and proportion is a logical approach to calculating medication dosages and other clinical calculations.

Ratios

A ratio is used to indicate a relationship between two numbers.

Linear Format

Numbers that are related can be written in a **linear format.** A ratio set up in a linear format uses a colon (:) to show the relationship between the two numbers. These numbers are separated by a colon (:).

Example: 3 : 4 The linear format is read as “three is to four.”

The colon indicates division; therefore a ratio is a fraction.

Fraction Format

A ratio can also be written in a **fraction format** to indicate a relationship between numbers. When writing a ratio in the fraction format, a line (-) is used to show the relationship between the numbers. The numbers or terms of the ratio are the numerator and the denominator.

RULE

The numerator is always the quantity written to the left of the colon (the first quantity), and the denominator is always to the right of the colon (second quantity). Like fractions, ratios should be stated in lowest terms.

Example 1: 3 : 4 (3 is the numerator, 4 is the denominator, and the ratio can be written in the fraction format as

). The fraction format is read as “three divided by four.”

Example 2: In a nursing class, if there are 25 male students and 75 female students, what is the ratio of male students to female students? 25 male students to 75 female students = 25 male students per 75 female students

. This is the same as a ratio of 25:75 or 1:3.

Ratio Measures in Solutions

Some medications express the strength of the solution by using a ratio. Ratio measures are commonly seen in solutions. Ratios represent parts of medication per parts of solution, for example, 1:10,000 (this means 1 part medication to 10,000 parts solution).

Example 1: A 1:5 solution contains 1 part medication in 5 parts solution.

Example 2: A solution that is 1 part medication in 2 parts solution would be written as 1:2.

Ratio strengths are always expressed in lowest terms.

TIPS FOR CLINICAL PRACTICE

The more solution a medication is dissolved in, the less potent the strength becomes. For example, a ratio strength of 1:1,000 (1 part medication to 1,000 parts solution) is more potent than a ratio strength of 1:10,000 (1 part medication to 10,000 parts solution). A misunderstanding of these numbers and what they represent can have serious consequences.

Proportions

A proportion is an equation of two ratios of equal value. The terms of the first ratio have a relationship to the terms of the second ratio. As shown with ratios, a proportion can be written in different formats (linear or fraction).

Example 1: 3 : 4 :: 6 : 8 (A double [:] colon is used to show the relationship between the two ratios and is read as “as.”) Read as “three is to four as six is to eight.”

Example 2: 3:4 = 6:8 (An equal [=] sign can be used in the place of a double colon.) Read as “three is to four equals six is to eight.”

Example 3:

(Written as a fraction, the equal [=] sign is used to show the relationship between the two ratios.) Read as “three-fourths equals six-eighths.”

When a proportion is written in linear format, it proves that the ratios are equal and that the proportion is true and can be done mathematically.

Example: 5:25 = 10:50

or

5:25::10:50

The terms in a linear proportion are called the *means* and *extremes*. Confusion of these terms can result in an incorrect answer. To avoid confusion of terms in proportions, remember **m** for the middle terms **(means)** and **e** for the end terms **(extremes)** of the proportion. Let's refer to our example to identify these terms.

The extremes are the outer or end numbers (previous example: 5, 50), and the means are the inner or middle numbers (previous example: 25, 10).

Example:

RULE

In a proportion, the product of the means (the two inner, or middle, numbers) equals the product of the extremes (the two outer, or end, numbers). To find the product of the means and extremes, you multiply.

In other words, the answers obtained when you multiply the means and extremes are equal.

NOTE

The product of the means, 250, equals the product of the extremes, 250, proving the ratios are equal and the proportion is true.

Example: 5:25 = 10:50

Because ratios are the same as fractions, the same proportion can be expressed as a fraction like this:

The fractions are equivalent, or equal.

The numerator of the first fraction and the denominator of the second fraction are the extremes. The denominator of the first fraction and the numerator of the second fraction are the means.

Example:

Cross-multiply to find the equal products of the means and extremes.

Solving for *x* in Ratio and Proportion

Because the product of the means always equals the product of the extremes, if three numbers of the two ratios are known, the fourth number can be found. The unknown quantity may be any of the four terms. In a proportion problem, the unknown quantity is represented by *x*. After multiplying the means and extremes, the unknown *x* is usually placed on the left side of the equation. Begin with the product containing the *x,* which will result in the *x* being isolated on the **left** and the answer on the **right.**

Example: 12:9 = 8:*x*

Steps:

12*x* = 72	1. Multiply the extremes and then the means. (This results in *x* being placed on the left side of the equation.)
	2. Divide both sides of the equation by the number preceding the *x*, in this instance 12, without changing the relationship. The number used for division should always be the number preceding the unknown (*x*), so that when this step is completed, the unknown (*x*) will stand alone on the left side of the equation.

$x=6$

Proof: Place the answer obtained for x in the equation, and multiply to be certain that the product of the means equals the product of the extremes.

Solving for x with a proportion in a fraction format can be done by cross-multiplication to determine the value of x.

Example:

Steps:

1. Cross-multiply to obtain the product of the means and extremes.

Divide both sides by the number preceding *x* (in this example, 4) to obtain the value for x.

Proof: Place the value obtained for *x* in the equation; the cross-products should be equal.

Solving for *x* in proportions that involve decimals in the equation can be done by the same process.

Example: 25:5 = 1.5:*x*

Steps:

$25x = 5$

1. Multiply the extremes and then the means. (The *x* will be placed on the left side of the equation.)

2. Divide both sides by the number preceding x (in this example, 25) to obtain the value for x.

Proof:

Solving for x in proportions that involve fractions in the equation can be done by the same process.

Example:

Steps:

1. Multiply the means and then the extremes. (The *x* will be placed on the left side of the equation.)

2. Divide *both* sides by the number preceding *x* (in this example, ⅕). Division of the two fractions becomes multiplication, and the second fraction is inverted. Multiply numerators and denominators.

3. Reduce the final fraction to solve for *x*.

Proof:

RULE

If the answer is expressed in fraction format for *x*, it must be reduced to **lowest terms**. Division should be carried **two decimal places** when an answer does not work out evenly and may have to be **rounded to the nearest tenth** to prove the answer correct.

Applying Ratio and Proportion to Dosage Calculation

Now that we have reviewed the basic definitions and concepts relating to ratio and proportion, let's look at how this might be applied in dosage calculation.

In dosage calculation, ratio and proportion may be used to represent **the weight of a medication that is in tablet or capsule form.**

Example 1:

This may also be expressed by stating the weight of the medication first:

This means that 1 tablet contains 0.125 mg or is equal to 0.125 mg of medication.

Example 2: If a capsule contains a dosage of 500 mg, this could be represented by a ratio as follows:

This may also be expressed stating the weight of the medication first:

Another use of ratio and proportion in dosage calculation is to express liquid medications used for oral administration and for injection. When stating a dosage of a liquid medication, a ratio expresses the **weight (strength) of a medication in a certain volume of solution.**

Example 1: A solution that contains 250 mg of medication in each **1 mL** could be written as:

1 mL contains 250 mg of medication.

Example 2: A solution that contains 80 mg of medication in each **2 mL** would be written as:

2 mL contains 80 mg of medication.

SAFETY ALERT!

When using ratio and proportion in dosage calculation, do not forget the units of measurement. Including units in the dosage strength will help you avoid some common errors. For example, if you have two solutions of a medication, one of the solutions contains 1 gram (g) of the medication in 25

milliliters (mL); the other contains 1 milligram (mg) of the medication in 25 milliliters (mL). Notice that although both of these solution strengths have a ratio of 1:25, they are obviously different from each other. To clearly distinguish between them and avoid error, the unit of measurement should be included. The first solution should be written as 1 g:25 mL. The second solution is written as 1 mg:25 mL.

Proving mathematically that ratios are equal and the proportion is true is important with medications. This can be illustrated by using the previous medication strength examples.

Example 1: 1 cap:500 mg = 2 cap:1,000 mg

If 1 cap contains 500 mg, 2 cap will contain 1,000 mg.

Example 2: 2 mL:80 mg = 1 mL:40 mg

Note: When ratio and proportion are used to calculate a medication dosage or to make a conversion of units, three of the four numbers will be known, and a proportion is set up to solve for the fourth number (the unknown). This will be demonstrated in later chapters on conversions and dosage calculations.

POINTS TO REMEMBER

- • Proportions represent two ratios that are equal and have a relationship to each other.
- • When three values are known, the fourth can be easily calculated.
- • When solving for the unknown (x), regardless of which term of the equation is the unknown, the unknown value (x) is usually placed on the left side. Begin with the product containing x, so x can be isolated on the left side and the answer on the right side.
- • Ratios and proportions can be stated in linear or fraction format.
- • Ratio can be used to state the amount of medication contained in a volume of solution, tablet, or capsule. When using ratio and proportion in dosage calculation, include the units of measurement in the dosage strength.
- • Proportions in linear format are solved by multiplying the means and extremes.
- • Ratios are always stated in their lowest terms.
- • Double-check work.

PRACTICE PROBLEMS

Express the following solution strengths as ratios.

- 1. 1 part medication to 100 parts solution _____
- 2. 1 part medication to 3 parts solution _____

Identify the strongest solution in each of the following:

- 3. 1:2, 1:20, 1:200 _____
- 4. 1:1,000, 1:5,000, 1:10,000 _____
- 5. Assume that the ratio of clients to nurses is 15 to 2. Express the ratio in fraction and linear format. _____

Express the following dosages as ratios in linear format. Include the unit of measurement and the numerical value.

- 6. An injectable liquid that contains 100 mg in each 0.5 mL _____
- 7. A tablet that contains 0.25 mg of medication _____
- 8. An oral liquid that contains 1 g in each 10 mL _____
- 9. A capsule that contains 500 mg of medication _____

Determine the value for x in the following problems. Express your answer to the nearest tenth as indicated.

- 10. 12.5: 5 = 24:x _____
- 11. 1.5:1 = 4.5:x _____
- 12. 750/3 = 600/x _____
- 13. 1/300:3 = 1/120:x _____
- 14. x:12 = 9:6 _____

Answers on 49

CHAPTER REVIEW

Express the following fractions as linear ratios. Reduce to lowest terms.

- 1.

- 2.
- 3.
- 4.
- 5.
- 6.

Express the following ratios as fractions. Reduce to lowest terms.

- 7. 3:7 _____
- 8. 4:6 _____
- 9. 1:7 _____
- 10. 8:6 _____
- 11. 3:4 _____

Solve for *x* in the following proportions. Carry division two decimal places as necessary.

- 12. 20:40 = *x*:10 _____
- 13.

_____

- 14. 0.12:0.8 = 0.6:*x* _____
- 15.

_____

- 16. *x*:9 = 5:10 _____
- 17.

_____

- 18.

_____

- 19. 125:0.4 = 50:*x* _____
- 20. *x*:1 = 0.5:5 _____
- 21.

_____

- 22. 0.5:0.15 = 0.3:*x* _____
- 23.

_____

- 24. 20:40 = *x*:15 _____
- 25.

_____

- 26. 12:1 = *x*:5.5 _____
- 27.

_____

Set up the following problems as a proportion and solve. Include labels in the setup and in the answer.

- 28. If 150 milligrams (mg) of medication are in 2 capsules (caps), how many mg of medication are in 10 caps? _____
- 29. If 60 milligrams (mg) of a medication are in 500 milliliters (mL), how many mL of solution contain 36 mg of medication? _____
- 30. If 1 kilogram (kg) equals 2.2 lb, how many kg are in 61.6 lb? _____
- 31. If one glass of milk contains 280 milligrams (mg) of calcium, how many mg of calcium are in 2½ glasses of milk? _____
- 32. The prescriber orders 0.25 milligram (mg) of a medication. The medication is available in 0.125-mg tablets. How many tablets will you give? _____

Express the following dosages as ratios. Be sure to include the units of measure and numerical value. Do not reduce the ratio.

- 33. A capsule that contains 250 mg of medication _____
- 34. An oral solution that contains 125 mg in each 5 mL _____
- 35. An injectable solution that contains 40 mg in each mL _____
- 36. An injectable solution that contains 1,000 mcg in each 2 mL _____
- 37. An injectable solution that contains 1 g in each 3.6 mL _____
- 38. A tablet that contains 0.4 mg of medication _____
- 39. A capsule that contains 1 g of medication _____
- 40. An oral liquid that contains 0.5 mg in each milliliter _____

Express the following strengths as ratios.

- 41. 1 part medication to 2,000 parts solution _____
- 42. 1 part medication to 400 parts solution _____
- 43. 1 part medication to 50 parts solution _____

Identify the weakest solution in each of the following:

- 44. 1:50, 1:500, 1:5,000 _____
- 45. 1:3, 1:6, 1:60 _____

Set up the following word problems as proportions and solve. Include labels in the setup and in the answer.

- 46. The prescriber orders 15 milligrams (mg) of a medication for every 10 lb of a client's weight. How many mg of medication will be given for a person who weighs 120 lb? _____
- 47. There are 40 milligrams (mg) of medication in every 5 milliliters (mL) of liquid. How much liquid is required to administer 120 mg of medication? _____
- 48. The ratio of male to female clients in a nursing facility is 3 to 5. If there are 40 women in the facility, how many men are there? _____
- 49. If 3 ounces (oz) of medicine must be mixed with 7 oz of water, how many ounces of water are needed for 12 oz of medicine? _____
- 50. A client's weight is reported as 65 kilograms (kg). How many pounds (lb) does the client weigh? (1 kg = 2.2 lb) _____
- 51. If 100 grams (g) of ice cream contain 20 g of fat, how many g of fat are in 275 g of ice cream? _____
- 52. A survey indicates that 8 out of 10 people suffer from colds each year. If there are 48,000 people in the area, how many people will suffer from colds? _____
- 53. A nurse counts a client's pulse at 19 beats in 15 seconds. If the nurse counts the client's pulse for 1 minute, how many beats would there be in 1 minute? (1 minute = 60 seconds) _____
- 54. If 30 milligrams (mg) of medication are in 2 tablets (tabs), how many mg of medication are in 10 tabs? _____
- 55. A client receives 275 milligrams (mg) of medication given evenly over 5½ hours. How many mg of the medication does the client receive per hour? _____
- 56. A client is receiving an intravenous medication at a rate of 6.25 milligrams (mg) per minute. After 50 minutes, how many mg of medications has the client received? _____
- 57. A label on a dinner roll wrapper reads, "2.5 grams (g) of fiber per ¾ ounce (oz) serving." If a client eats 1½ ounces of dinner rolls, how many g of fiber will the client consume? _____
- 58. If 100 milliliters (mL) of solution contain 20 milligrams (mg) of medication, how many mg of the medication will be in 650 mL of the solution? _____
- 59. The label on a bag of popcorn reads, "140 calories per serving; one serving is 4 cups." If you consume 1½ cups, how many calories did you consume? _____
- 60. If 40 vitamin tablets (tabs) contain 5,000 milligrams (mg), how many tabs are needed for a dosage of 375 mg? _____

Answers below and on 50

ANSWERS

Chapter 3

Answers to Practice Problems

- 1. 1:100
- 2. 1:3
- 3. 1:2
- 4. 1:1,000

- 5.

- 6. 100 mg:0.5 mL, 0.5 mL:100 mg
- 7. 0.25 mg:1 tab, 1 tab:0.25 mg
- 8. 1 g:10 mL, 10 mL:1 g
- 9. 500 mg:1 cap, 1 cap:500 mg
- 10. $x = 9.6$
- 11. $x = 3$
- 12. $x = 2.4$
- 13. $x = 7.5$
- 14. $x = 18$

Answers to Chapter Review

- 1. 2:3
- 2. 1:9
- 3. 3:4
- 4. 1:5
- 5. 1:2
- 6. 1:5
- 7.

- 8.

- 9.

- 10.

- 11.

- 12. $x = 5$
- 13. $x = 2$
- 14. $x = 4$
- 15. $x = 3.33$
- 16. $x = 4.5$
- 17. $x = 0.8$
- 18. $x = 1.33$ *or*

- 19. $x = 0.16$
- 20. $x = 0.1$
- 21. $x = 1.25$
- 22. $x = 0.09$
- 23. $x = 55$
- 24. $x = 7.5$
- 25. $x = 20.2$
- 26. $x = 66$
- 27. $x = 135$
- 28. 150 mg:2 caps = x mg:10 caps *or*

- $x = 750$ mg
- 29. 60 mg:500 mL = 36 mg:x mL *or*

- *x* = 300 mL
- 30. 1 kg:2.2 lb = *x* kg:61.6 lb *or*

- *x* = 28 kg
- 31. 1 glass:280 mg = 2½ glasses:*x* mg *or*

- *x* = 700 mg
- 32. 0.125 mg:1 tab = 0.25 mg:*x* tab *or*

- *x* = 2 tabs
- 33. 250 mg:1 cap *or* 1 cap:250 mg
- 34. 125 mg:5 mL *or* 5 mL:125 mg
- 35. 40 mg:1 mL *or* 1 mL:40 mg
- 36. 1,000 mcg:2 mL *or* 2 mL:1,000 mcg
- 37. 1 g:3.6 mL *or* 3.6 mL:1 g
- 38. 0.4 mg:1 tab *or* 1 tab:0.4 mg
- 39. 1 g:1 cap *or* 1 cap:1 g
- 40. 0.5 mg:1 mL *or* 1 mL:0.5 mg
- 41. 1:2,000
- 42. 1:400
- 43. 1:50
- 44. 1:5,000
- 45. 1:60
- 46. 15 mg:10 lb = *x* mg:120 lb *or*

- x = 180 mg
- 47. 40 mg : 5 mL = 120 mg : x mL *or*

- x = 15 mL
- 48. 3 males:5 females = x males:40 females *or*

- x = 24 males
- 49. 3 oz medicine:7 oz water = 12 oz medicine:x oz water *or*

- x = 28 oz
- 50. 1 kg : 2.2 lb = 65 kg : x lb
- *or*

- x = 143 lb
- 51. 100 g ice cream:20 g fat = 275 g ice cream:x g fat *or*

- x = 55 g
- 52. 8 cold sufferers:10 people = x cold sufferers:48,000 people *or*

- x = 38,400 people
- 53. 19 beats:15 seconds = x beats:60 seconds *or*

- x = 76 beats
- 54. 30 mg : 2 tabs = x mg : 10 tabs *or*

- x = 150 mg
- 55. 275 mg:5½ hours = x mg:1 hour *or*

- x = 50 mg
- 56. 6.25 mg:1 minute = x mg:50 minutes *or*

- x = 312.5 mg
- 57. 2.5 g:¾ oz = x g:1½ oz *or*

- x = 5 g
- 58. 20 mg:100 mL = x mg:650 mL *or*

- x = 130 mg
- 59. 140 calories:4 cups = x calories:1½ cups *or*

- x = 52.5 calories or 52½ calories
- 60. 5,000 mg:40 tabs = 375 mg:x tabs *or*

- x = 3 tabs

unknown - Section 15 (Page 77)

Percents, as decimals and fractions, are a way to express the relationship of parts to a whole. Percent (%) means parts per hundred. A percentage is the same as a fraction in which the denominator is 100, and the numerator indicates the part of 100 that is being considered.

The symbol used to indicate a percent (%) is placed after the number, as in 40%. The example 40% (40 percent) means 40 out of 100. Percents can be more than 100% (such as 200%) or less than 1% (0.1%). A percent may also contain a decimal (0.6%), a fraction (½%), or a mixed number (14½%).

Example: 4% = 4 percent =

(4 per 100) = 0.04

Health care professionals see percentages written with medications (e.g., magnesium sulfate 50%, lidocaine 2%). Solutions for the eye and topical (for external use) ointments, lotions, and creams use percentages to express dosage strength. For example, hydrocortisone cream is available in 1% and 2.5%. Timolol ophthalmic solutions are available in 0.25% and 0.5%.

In addition, nurses and other health professionals frequently administer solutions with the concentration expressed as a percent, such as intravenous (IV) solutions (e.g., 5% dextrose in water). IV means directly into a person's vein.

Percents may also be used by nurses when it is required to calculate percentages of partial quantities (e.g., to determine the percentage of a diet of fluids that a client consumed).

In current practice, percentage solutions are prepared by the pharmacy, and people can purchase solutions or components of the solutions over the counter. Some institutions require nurses to prepare solutions in house (in the hospital) as well as in home care for clients being cared for at home. Understanding percentages provides the foundation for preparing and calculating dosages for medications that are ordered in percentages.

Percentages are also used in the assessment of burns. The size of a burn (percentage of injured skin) is determined by using the rule of nines in an adult. The basis of the rule is that the body is divided into anatomical sections, each of which represents 9% or a multiple of 9% of the total body surface area (BSA). The total BSA is represented by 100%. Another method used is the age-specific burn diagram or chart. Burn size is expressed as a percentage of the total BSA. In children, age-related charts are used because their body proportions differ from those of an adult.

Let's get an understanding of the relationship of ratios, percents, fractions, and decimals by showing how to convert from one to another.

Converting Percentages to Fractions, Decimals, and Ratios

RULE

To convert a percent to a fraction:

- 1. Drop the percent sign.
- 2. Write the number as the numerator (top number in a fraction).
- 3. Write 100 as the denominator (bottom number in a fraction).
- 4. Reduce the fraction to lowest terms.

Example 1:

Example 2:

RULE

To convert a percent to a decimal:

- 1. Drop the percent sign.
- 2. Divide the number by 100; this is the same as moving the decimal point two places to the left (add zeros as needed).

Example 1:

Example 2:

Example 3:

(lowest terms). Divide the numerator of the fraction (3) by the denominator (4).

Example 3 is an alternative method. Drop the percent sign. Write the remaining number as the numerator. Write “100” as the denominator. Reduce the result to lowest terms. Divide the numerator by the denominator to obtain a decimal.

RULE

To convert a percent to a ratio:

- 1. Drop the percent sign.
- 2. Write the number as a fraction (place it in the numerator).
- 3. Write 100 as the denominator.
- 4. Reduce the fraction to lowest terms.
- 5. Place the numerator as the first term of the ratio and the denominator as the second term.
- 6. Separate the two terms with a colon (:).

Example 1:

Example 2:

RULE

To convert a fraction to a percent:

- 1. Multiply the fraction by 100.
- 2. Reduce if necessary.
- 3. Add the percent sign (%).

OR

- 1. Convert the fraction to a decimal.
- 2. Multiply decimal by 100, which is the same as moving the decimal point two places to the right.
- 3. Add the percent sign (%).

Example 1:

Example 2:

RULE

To convert a decimal to a percent:

- 1. Multiply the decimal number by 100, which is the same as moving the decimal point two places to the right. Add zeros if necessary.
- 2. Add the percent sign (%).

Example 1:

Example 2:

Another method that can be used to convert a decimal to a percent can be done as follows:

RULE

To convert a decimal to a percent:

- 1. Change the decimal to a fraction, then follow the steps to convert a fraction to a percent.
- 2. If the percent does not end as a whole number, express the percent with the remainder as a fraction, to the nearest whole percent, or to the nearest tenth of a percent.

Example:

RULE

To convert a ratio to a percent:

- 1. Convert the ratio to a fraction, and proceed with the steps for changing a fraction to a percent.

or

- 1. Convert the ratio to a fraction.
- 2. Convert the fraction to a decimal.
- 3. Convert the decimal to a percent.

Example:

PRACTICE PROBLEMS

Change the following percents to fractions, and reduce to lowest terms.

- 1. 1% _____
- 2. 2% _____
- 3. 50% _____
- 4. 150% _____
- 5. 3% _____

Change the following percents to decimals. Round to two decimal places, as indicated.

- 6. 10% _____
- 7. 35% _____
- 8. 50% _____
- 9. 14.2% _____

- 10.

Change each of the following percents to a ratio. Express in lowest terms.

- 11. 25% _____
- 12. 11% _____
- 13. 75% _____
- 14. 4.5% _____
- 15.

Change the following fractions to percents.

- 16.

- 17.

- 18.

- 19.

- 20.

Convert the following decimals to percents.

- 21. 1.32 _____
- 22. 0.02 _____
- 23. 0.8 _____
- 24. 2.3 _____
- 25. 0.013 _____

Change the following ratios to percents.

- 26. 1:25 _____
- 27. 3:4 _____
- 28. 1:10 _____
- 29. 1:100 _____
- 30. 1:2 _____

Answers on 64

Percentage Measures

As previously stated, **intravenous (IV) solutions are ordered in percentage strengths, and nurses need to be familiar with their meaning (e.g., 1,000 milliliters [mL] 5% dextrose in water). Percentage solution means the number of grams (g) of solute per 100 mL of diluent.**

Example 1: 1,000 mL IV of 5% dextrose and water contains 50 g (grams) of dextrose

Example 2: 250 mL IV of 10% dextrose contains 25 g (grams) of dextrose

PRACTICE PROBLEMS

Determine the number of grams of medication and dextrose as indicated in the following solutions.

- 31. How many grams of medication will 500 mL of a 10% solution contain? _____
- 32. How many grams of dextrose will 1,000 mL of a 10% solution contain? _____
- 33. How many grams of dextrose will 250 mL of a 5% solution contain? _____
- 34. How many grams of medication will 100 mL of a 50% solution contain? _____
- 35. How many grams of dextrose will 150 mL of a 5% solution contain? _____

Answers on 64

Comparing Percents and Ratios

Nurses as well as other health care professionals administer solutions that may be expressed as percents or ratios. Intravenous solutions come in varying percentages. Example: 0.45%, 5%. It is important to be clear on the numbers and quantities they represent. An IV solution that is 5% is more potent or concentrated than a 0.45% solution. Converting percentages and ratios to equivalent decimals can clarify values so that professionals can compare concentrations.

Like IV fluids, ointments, creams, and lotions can be available in different percentage strengths, and nurses need to be clear on the quantities they represent as well. A 0.025% ointment is more potent or concentrated than one that is 0.02%.

Example 1:

Example 2:

Compare solution concentrations expressed as a ratio, such as 1:1,000 and 1:10,000.

Example 1:

(1:1,000 is a stronger concentration than 1:10,000)

Example 2:

SAFETY ALERT!

The higher the percentage strength, the stronger the solution or ointment. A misunderstanding of these numbers (%) can have serious consequences.

Example: 10% IV solution is more potent than 5%. A solution of 5% is more potent than 0.9%. **Always check the percentage of IV solution prescribed.**

PRACTICE PROBLEMS

Identify the strongest solution, ointment, or cream in each of the following:

- 36. Ophthalmic solution 0.1%, 0.5%, 1% _____
- 37. Ointment 0.025%, 0.3%, 0.5% _____
- 38. Cream 0.02%, 0.025%, 0.25% _____
- 39. Solution 1:30, 1:300, 1:3 _____
- 40. Solution 0.33%, 0.9%, 0.45% _____

Answers on 64

Determining the Percent of a Quantity

Nurses may find it necessary to determine a given percentage or part of a quantity.

RULE

To determine a given percent of a number:

- 1. First convert the percent to a decimal or fraction.
- 2. Multiply the decimal or fraction by the number.

Example 1: A client reports drinking 25% of an 8-ounce cup of tea. Determine what amount 25% of 8 ounces is.

Solution: Change the percentage to a decimal:

Multiply the decimal by the number:

0.25 × 8 ounces = 2 ounces

Therefore 25% of 8 ounces = 2 ounces

The percent of a quantity may also be determined using a ratio and proportion written in linear or fraction format. For example, using the above problem:

25 : 100 = x : 8 *or*

Either one of these formats would net the same answer.

Example 2: 40% of 90

Solution:

Determining What Percent One Number Is of Another

RULE

To determine what percent one number is of another, it is necessary to make a fraction with the numbers.

- 1. The **denominator** (bottom number) of the fraction is the number following the word "of" in the problem.
- 2. The other number is the **numerator** (top number) of the fraction.
- 3. Convert the fraction to a decimal, and then convert to a percentage.

Example 1: 12 is what percentage of 60? *or* What percentage of 60 is 12?

Solution: Make a fraction using the two numbers:

Convert the fraction to a decimal:

Convert the decimal to a percentage:

Therefore 12 = 20% of 60 *or* 20% of 60 = 12

Example 2: 1.2 is what percentage of 4.8? *or* What percentage of 4.8 is 1.2?

Solution: Make a fraction using the two numbers:

Convert the fraction to a decimal:

Convert the decimal to a percentage:

Therefore 1.2 = 25% of 4.8 *or* 25% of 4.8 = 1.2

Example 3:

is what percentage of 8.5? *or* What percentage of 8.5 is

?

Solution: Make a fraction using the two numbers:

Convert the fraction to a decimal:

Convert the decimal to a percentage:

Therefore

of 8.5 *or* 41.2% of

PRACTICE PROBLEMS

- 41. A client drinks 30% of a bowl of broth that holds 200 milliliters (mL). How many mL did the client drink? _____
- 42. A client drinks 80% of a 5-ounce (oz) cup of ginger ale. How many oz did the client drink? _____

Perform the indicated operations. Round decimals to the hundredths place.

- 43. 60% of 30
- 44. 20% of 75
- 45. 2 is what percentage of 200?
- 46. 50 is what percentage of 500?
- 47. 40 is what percentage of 1,000?
- 48. 3% of 842
- 49. 0.7% of 60
- 50. 75% of 165
- 51. 25 is what percentage of 40?
- 52. 1.3 is what percentage of 5.2?
- 53.

of 68

- 54. What percentage of 8.4 is

? _____

Answers on 64

Calculating the Percent of Change

It may be useful to determine a percent of change (increase or decrease). For example, you might want to know if an increase or decrease in a client's weight is a significant increase or decrease.

RULE

To determine the percent of change:

- 1. Make a fraction of change =

- 2. Multiply the fraction by 100 to change the fraction to a percent OR change the fraction to a decimal and multiply decimal by 100, which is the same as moving the decimal point two places to the right.
- 3. Add the percent sign.

Example 1: A client's weight before surgery was 176 lb. Following 2 weeks of bed rest, the client's weight was 184.8 lb. What was the percent of increase in the client's weight?

Solution: The increase = 184.8 lb – 176 lb = 8.8 lb

Fraction of change

or

Change fraction to a decimal, multiply by 100.

Fraction of change

The percent of increase in the client's weight was 5%.

Example 2: A client was drinking 40 ounces of water per day, but this was reduced by 10 ounces per day. What is the percent of change?

Solution: The decrease = 40 ounces – 30 ounces = 10 ounces

Fraction of change

or

Change fraction to a decimal, multiply by 100.

Fraction of change

PRACTICE PROBLEMS

- 55. A client's weight before dieting was 300 lb. After one month of dieting, the client's weight was 240 lb. What was the percent of decrease in the client's weight? _____
- 56. A client was taking 400 milligrams (mg) of a pain medication. The doctor increased the dosage to 600 mg. What is the percent of increase in the dosage? _____

- 57. Physical therapy increases a client's pulse rate. The client's rate before the physical therapy was 60 beats per minute. At the completion of physical therapy, the rate is 75 beats per minute. What is the percent of increase in the pulse rate? _____
- 58. The number of nurses on the night shift has increased from 4 to 6. What is the percent of increase? _____
- 59. The population at a small assisted-living facility dropped from 150 to 135 residents. What was the percent of decrease in population? _____
- 60. In February, 2,500 cases of flu were reported. In June of the following year, 900 cases of flu were reported. What is the percent decrease in reported cases of flu? _____

Answers on 64

POINTS TO REMEMBER

- • Fractions, decimals, ratios, and percents are related equivalents.
- • Express ratios in lowest terms.
- • To convert a percent to a fraction, drop the % sign and place the remaining number as the numerator, write 100 as the denominator, and reduce the fraction to lowest terms.
- • To convert a percent to a decimal, drop the % sign and divide by 100.
- • To convert a percent to a ratio, first convert the percent to a fraction in lowest terms. Then, place the numerator as the first term of the ratio and the denominator as the second term. Separate the two terms with a colon (:).
- • To convert a fraction to a percent, multiply the fraction by 100, reduce if necessary, and add the % sign OR convert the fraction to a decimal, multiply the decimal by 100, and add the % sign.
- • To convert a decimal to a percent, multiply the decimal by 100 and add the % sign OR change the decimal to a fraction, then follow the steps to convert a fraction to a percent. If the percent does not terminate as a whole number, express the percent with the remainder as a fraction to the nearest whole percent, or to the nearest tenth of a percent.
- • To convert a ratio to a percent, convert the ratio to a fraction and proceed with the steps for changing a fraction to a percent OR convert the ratio to a fraction, convert the resulting fraction to a decimal and then to a percent.
- • Percentage solutions means the number of grams of solute per 100 milliliters of diluent.
- • The higher the percentage strength, the stronger the solution, ointment, or cream.
- • To determine the given percent or part of a quantity, convert the percent to a decimal or fraction. Multiply the decimal or fraction by the number. This can also be done using any of the formats for ratio and proportion.
- • To calculate the percent of change, make a fraction of the change

and multiply the fraction by 100 to change the fraction to a percent OR change the fraction to a decimal, multiply by 100, and add the % sign.

CHAPTER REVIEW

Complete the table below. Express each of the following measures in their equivalents where indicated. Reduce fractions and ratios to lowest terms; round decimals to hundreths.

	Percent	Ratio	Fraction	Decimal
1.	52%	_____	_____	_____
2.	71%	_____	_____	_____
3.	_____	_____		_____
4.	_____	1:50	_____	_____
5.	_____	_____	_____	0.06
6.	_____	_____		_____
7.	_____	_____		_____
8.	_____	7:1,000	_____	_____
9.	5%	_____	_____	_____
10.	2.5%	_____	_____	_____

Perform the indicated operations.

- 11. A client reports drinking 40% of a 12-ounce can of ginger ale. How many ounces did the client drink? _____
- 12. 40% of 140 _____
- 13. 100 is what percentage of 750? _____

- 14.

is what percentage of 60? _____

- 15. 15% of 250 _____
- 16. What percentage of 6.4 is 1.6? _____
- 17. Which of the following solutions is strongest: 0.0125%, 0.25%, 0.1%? _____

Change each of the following percentages to a ratio, and reduce to lowest terms.

- 18. 16% _____
- 19. 45% _____
- 20. A client is on a 1,000 milliliters (mL) fluid restriction per 24 hours. At breakfast and lunch, the client consumed 40% of the fluid allowance. How many mL did the client consume? _____
- 21. A client drank 75% of a 12-ounce can of ginger ale. How many ounces did the client drink? _____
- 22. A client consumes 55% of a bowl of chicken broth at lunch. The bowl holds 180 milliliters (mL). How many mL did the client consume? _____
- 23. In a class of 30 students, 6 students did not pass an exam. What percentage of the students did not pass the exam? _____
- 24. At the first prenatal visit, a client weighed 140 pounds. At the second visit, the client had a 5% weight increase. How many pounds did the client gain? _____
- 25. An infant consumed 55% of an 8-ounce bottle of formula. How many ounces of formula did the infant consume? _____
- 26. In a portion of turkey that is 100 grams (g), there are 23 g of protein and 4 g of fat.
- What percentage of the portion is protein? _____
- What percentage of the portion is fat? _____
- 27. A nursing review test has 130 questions, and you answer 120 correctly. What is your score, as a percentage? _____
- 28. A client's intake for the day was 2,000 calories, and 600 of the calories came from fat. What percentage of the client's intake came from fat? _____
- 29. A client began receiving 325 milligrams (mg) of a medication. The prescriber increased the dosage of medication by 10%. What will the new dosage be? _____ mg
- 30. The recommended daily allowance (RDA) of a vitamin is 14 milligrams (mg). If a multivitamin provides 55% of the RDA, how many mg of the vitamin would the client receive from the multivitamin? _____
- 31. A client's pulse rate decreases from 80 beats per minute to 72 beats per minute. What is the percent of decrease? _____
- 32. A client's medication is increased from 400 milligrams (mg) to 500 mg. What is the percent of increase in the dosage? _____
- 33. A client's weight increased from 120 lb to 132 lb. What was the percent of increase in body weight? _____
- 34. A client's intake decreased from 2,500 milliliters (mL) per day to 2,000 mL per day. What was the percent of decrease? _____
- 35. The number of capsules a client received each day has decreased from 3 capsules each day to 2 capsules per day. What is the percent of decrease? _____
- 36. If a client ate 400 calories at breakfast, what percentage of a 2,000-calorie diet was consumed? _____
- 37. A newborn weighed 3,751 grams (g) at birth and 3,352 g prior to discharge. What is the percentage of weight loss? _____
- 38. In August of one year, 15 cases of heat stroke were treated in the emergency room. In August of the next year, 12 cases of heat stroke were treated. What is the percent of decrease in cases of heat stroke? _____
- 39. A client is on a 2,000-calorie-per-day diet. If lunch accounts for 45% of a client's daily calories, how many calories can the client have for lunch? _____
- Convert the following percents to decimals.
- 40. 4.4% _____
- 41. 103% _____

Convert the following decimals to percents.

- 42. 0.32 _____
- 43. 0.06 _____

Identify the strongest in each of the following.

- 44. 1 : 10, 1 : 100, 1 : 200 _____
- 45. 1 : 25,

, 0.02% _____

Answers on 64

ANSWERS

Chapter 4

Answers to Practice Problems

- 1.

- 2.

- 3.
- 4.
- 5.
- 6. 0.1
- 7. 0.35
- 8. 0.5
- 9. 0.14
- 10. 0.0086
- 11. 1:4
- 12. 11:100
- 13. 3:4
- 14. 4.5:100
- 15. 0.4:100
- 16. 40%
- 17. 275%
- 18. 50%
- 19. 25%
- 20. 70%
- 21. 132%
- 22. 2%
- 23. 80%
- 24. 230%
- 25. 1.3%
- 26. 4%
- 27. 75%
- 28. 10%
- 29. 1%
- 30. 50%
- 31. 50 g
- 32. 100 g
- 33. 12.5 g

- 34. 50 g
- 35. 7.5 g
- 36. 1%
- 37. 0.5%
- 38. 0.25%
- 39. 1:3
- 40. 0.9%
- 41. 60 mL
- 42. 4 oz
- 43. 18
- 44. 15
- 45. 1%
- 46. 10%
- 47. 4%
- 48. 25.26
- 49. 0.42
- 50. 123.75
- 51. 62.5%
- 52. 25%
- 53. 0.17
- 54. 41.67%
- 55. 20%
- 56. 50%
- 57. 25%
- 58. 50%
- 59. 10%
- 60. 64%

Answers to Chapter Review

	Percent	Ratio	Fraction	Decimal
1.	52	13:25		0.52
2.	71%	71:100		0.71
3.	7%	7:100		0.07

	Percent	Ratio	Fraction	Decimal
4.	2%	1:50		0.02
5.	6%	3:50		0.06
6.	70%	7:10		0.7
7.	61%	61:100		0.61
8.	0.7%	7:1,000		0.007
9.	5%	1:20		0.05

	Percent	Ratio	Fraction	Decimal
10.	2.5%	1:40		0.03

- 11. 4.8 oz
- 12. 56
- 13. 13.3%
- 14. 0.83%
- 15. 37.5
- 16. 25%
- 17. 0.25%
- 18. 4 : 25
- 19. 9 : 20
- 20. 400 mL
- 21. 9 oz
- 22. 99 mL
- 23. 20%
- 24. 7 lb
- 25. 4.4 oz
- 26. 23% protein, 4% fat
- 27. 92.3%
- 28. 30%
- 29. 357.5 mg
- 30. 7.7 mg
- 31. 10%
- 32. 25%
- 33. 10%
- 34. 20%
- 35. 33.3% or

- 36. 20%
- 37. 10.6%
- 38. 20%
- 39. 900 calories
- 40. 0.044

- 41. 1.03
- 42. 32%
- 43. 6%
- 44. 1 : 10
- 45.

POST-TEST

After completing Unit One of this text, you should be able to complete this test. The test consists of a total of 75 questions. If you miss any questions in any section, review the chapter relating to that content.

- 1. There are 6 nurses and 48 clients at a nursing facility. What is the ratio of nurses to clients expressed as a fraction?
- 2. Write the following information as a proportion: 30 milligrams (mg) is to 1 dosage as 120 mg is to 4 dosages.
- 3. Identify the numerator and denominator in the following fraction:

- Numerator: _____
- Denominator: _____
- 4. A client drank 6 ounces (oz) of an 8-oz glass of juice. What percentage did the client drink?
- 5. 800 milligrams (mg) of a medication were prescribed for a client. A week later, the medication was reduced to 600 mg. What was the percent of decrease in the medication?
- 6. The tablets your client is to receive are labeled 0.1 milligram (mg), and you are to administer

tablets. What is the total dosage?

- 7. Convert the fraction

to a percent.

- 8. Convert the ratio 2 : 3 to a fraction and a percent. State the percent to the nearest whole percent. Fraction: _____ Percent: _____
- 9. A solution of 100 milliliters (mL) contains 10 grams (g) of dextrose. How many g of dextrose are in 1,000 mL of this solution?
- 10. A client drank

ounces (oz) of juice, and

oz of coffee for breakfast. How many oz did the client drink?

Reduce the following fractions to lowest terms.

- 11.
- 12.
- 13.

- 14.

- 15.

Perform the indicated operations with fractions; reduce to lowest terms where indicated.

- 16.

_____

- 17.

_____

- 18.

_____

- 19.

_____

- 20.

_____

- 21.

_____

- 22.

_____

- 23.

_____

- 24.

_____

- 25.

_____

Change the following fractions to decimals; express each answer to the nearest tenth.

- 26.

_____

- 27.

_____

- 28.

_____

- 29.

_____

Indicate the largest fraction in each group.

- 30.

_____

- 31.

_____

Perform the indicated operations with decimals. Provide exact answers.

- 32. 16.7 = 21 = _____
- 33. 0.007 = 17.4 = _____
- 34. 10.57 × 10 = _____
- 35. 36.8 – 3.86 = _____

Divide the following decimals; express each answer to the nearest tenth.

- 36. 67.8 ÷ 0.8 = _____
- 37. 9 ÷ 0.4 = _____
- 38. 5.01 ÷ 10 = _____

Indicate the largest decimal in each group.

- 39. 0.85, 0.085 _____
- 40. 3.002, 0.39, 0.399 _____
- 41. 0.478, 0.445, 0.493 _____

Solve for *x*, the unknown value.

- 42. 10 : 20 = *x* : 8 _____
- 43. 500 : *x* = 200 : 1 _____
- 44. 0.3 : *x* = 1.8 : 0.6 _____

- 45.

Round off to the nearest tenth.

- 46. 0.57 _____
- 47. 0.99 _____
- 48. 1.42 _____

Round off to the nearest hundredth.

- 49. 0.677 _____
- 50. 0.832 _____
- 51. 1.222 _____

Complete the table below. Express each of the measures in their equivalents where indicated. Reduce fractions and ratios to lowest terms; round decimals to hundredths.

Percent	Decimal	Ratio	Fraction
52. _____	_____	1:10	_____
53. 60%	_____	_____	_____
54.	_____	_____	_____
55. 25%	_____	_____	_____

Find the percentage.

- 56. 9% of 200 _____
- 57. 2.5% of 750 _____
- 58. 30 is what percent of 45? _____
- 59. 5 is what percent of 2,000? _____
- 60. 25 is what percent of 65? _____

Express the following solution strengths as ratios.

- 61. 1 part medication to 80 parts solution _____
- 62. 1 part medication to 300 parts solution _____
- 63. 1 part medication to 20 parts solution _____

Identify the strongest solution in each of the following:

- 64. 1:80, 1:800, 1:8,000 _____
- 65. 1:1,000, 1:2,000, 1:5,000 _____
- 66. A client who weighed 81.5 kilograms (kg) lost 3.75 kg. How much does the client weigh now? _____
- 67. A client's weight increased from 175 pounds (lb) to 210 lb. What was the percent of increase in the client's weight? _____
- 68. A client is receiving 0.6 milligram (mg) of a medication four (4) times a day. How many mg would the client receive after 2½ days? _____
- 69. If 6 oz of medication must be mixed with 15 oz of water, how many oz of water is needed for four (4) oz of medication? _____
- 70. A client is taking two (2) tablets twice a day for 14 days. The tablet contains 2.2 mg. How much medication did the client receive? _____
- 71. A client should have received 3.25 grams (g) of medication. In error the nurse administered 32.5 g. How much more medication did the client receive? _____
- 72. Write a ratio that represents 20 milligrams (mg) of a medication in 100 milliliters (mL) of liquid. _____
- 73. A client's weight decreased from 150 pounds (lb) to 132 lb. What is the percent of decrease in the client's weight? _____
- 74. A client receives a total of 13.5 milligrams (mg) from nine (9) tablets. What is the dosage strength of each tablet? _____
- 75. Write a ratio that represents every capsule in a bottle contains 0.75 milligram (mg). _____

Answers on 68

ANSWERS

- 1.
- 2.
-

- 3. 0.26, 1.2
- 4. 75%
- 5. 25%
- 6. 0.45 mg
- 7. 360%
- 8. Fraction:

  ; Percent: 67%
- 9. 100 g
- 10.
- 11.
- 12.
- 13.

- 14.
- 15.
- 16.
- 17.
- 18.

- 19.
- 20.
- 21.
- 22.
- 23.

- 24.

- 25.

- 26. 1.1
- 27. 0.1
- 28. 0.1
- 29. 0.9
- 30.

- 31.

- 32. 37.7
- 33. 17.407
- 34. 105.7
- 35. 32.94
- 36. 84.8
- 37. 22.5
- 38. 0.5
- 39. 0.85
- 40. 3.002
- 41. 0.493
- 42. $x = 4$

- 43.

- 44.

- 45. $x = 4$
- 46. 0.6
- 47. 1
- 48. 1.4
- 49. 0.68
- 50. 0.83
- 51. 1.22

	Percent	Decimal	Ratio	Fraction
52.	10%	0.1	1:10	
53.	60%	0.6	3:5	
54.		0.67	67:100	

	Percent	Decimal	Ratio	Fraction
55.	25%	0.25	1:4	

- 56. 18
- 57. 18.75
- 58. *or* 66.7% *or* 67%
- 59. 0.25%
- 60. 38.46% *or* 38.5% *or* 38%
- 61. 1:80
- 62. 1:300
- 63. 1:20
- 64. 1:80
- 65. 1:1,000
- 66. 77.75 kilograms (kg)
- 67. 20%
- 68. 6 milligrams (mg)
- 69. 10 oz
- 70. 123.2 milligrams (mg)
- 71. 29.25 grams (g)
- 72. 20 mg:100 mL *or* 1 mg:5 mL *or* 20 mg/100 mL; 1 mg/5 mL
- 73. 12%
- 74. 1.5 milligrams (mg)
- 75. 0.75 mg:1 capsule *or* 0.75 mg/1 capsule

unknown - Section 16 (Page 89)

UNIT TWO

Introduction to Systems of Measurement

For the nurse to be competent in the administration of medications, the nurse must be knowledgeable in the most frequently used and preferred measurement system to order, measure, and administer medications. The metric system is the preferred system of measurement used in health care. Because the metric system is the preferred system for health care, knowledge of the metric system is imperative. Let's begin with the discussion of the metric system.

- **Chapter 5 Metric System**
- **Chapter 6 Apothecary and Household Systems and Additional Measures Used in Medication Administration**
- **Chapter 7 Converting Within and Between Systems**
- **Chapter 8 Additional Conversions Useful in the Health Care Setting**

unknown - Section 17 (Page 90)

To administer medications safely to clients, it is important to have a thorough knowledge of the system of measurements used in medication administration. Understanding common equivalents and the systems of measurement used in medication administration will help in the prevention of **medication errors** related to incorrect dosages.

Historically, there were three different systems of measure used in medication administration: the apothecary, household, and metric systems. As stated, the metric system is the preferred system of measurement for medications and measurements used in the health care setting. For example, newborn weights are recorded in grams (g) and kilograms (kg); centimeters (cm) are used in obstetrics to express fundal height (upper portion of the uterus) and to measure incisions. As a nurse, more than 90% of the medication calculations you will encounter in the clinical setting will involve the metric system.

The metric system is an international decimal system of weights and measures that was introduced in France in the late seventeenth and eighteenth centuries. It is also referred to as the *International System of Units*. The International System of Units, universally abbreviated SI (from the French Le Systéme International d Unités), is the modern metric system of measurement. The abbreviations of this system of metric notations are the most widely accepted. The benefit of the metric system lies in its simplicity and accuracy because it is based on the decimal system. The nurse will find that medication calculation and administration skills involve familiarity and accuracy with the metric system to administer medications safely.

Prescribers should use the metric system for prescribing medications to prevent medication errors. The Joint Commission (TJC), U.S. Food and Drug Administration (FDA), and Institute for Safe Medication Practices (ISMP) concur that the metric system should be used to prevent medication errors. This includes writing prescriptions in the metric system, and all FDA-approved prescription medication labels provide metric dosage.

Particulars of the Metric System

- 1. The metric system is based on the decimal system, in which divisions and multiples of 10 are used. Therefore a lot of math can be done by decimal point movement.
- 2. Three basic units of measure are used in the metric system, as shown in Table 5.1.

TABLE 5.1

Basic Units of Metric Measurement

Table of Measure	Basic Unit	Abbreviation
Weight (solid)	**gram**	g
Volume (liquid)	**liter**	L
Length	**meter**	m

- Dosages are calculated by using metric measurements that relate to weight and volume. Meter (m), which is the base unit used for linear (length) measurement, is the least used measurement for dosage calculations but is important in the health care setting. Linear measurements are commonly used to measure the height of an individual, for serial abdominal girth (the circumference of the abdomen, usually measured at the umbilicus), the circumference of an infant's head, length of an amount of medicated ointment or paste, and for pressure ulcer measurements. These are examples of important measures that can be seen in the health care setting. Most length measurements seen in the health care setting are millimeters (mm) and centimeters (cm).
- 3. Common prefixes in this system denote the numerical value of the unit being discussed. Memorization of these prefixes is necessary for quick and accurate calculations. The prefixes in bold in Table 5.2 are the ones used most oft en in health care for dosage calculations. However, some of the prefixes may be used to express other values, such as laboratory values. *Kilo* is a common prefix used to identify a measure larger than the basic unit. The other common prefixes used in medication administration are smaller units: *centi, milli,* and *micro*.

TABLE 5.2

Common Prefixes Used in Health Care

Prefix	Numerical Value	Meaning
Kilo*	1,000	one thousand times
Hecto	100	one hundred times
Deka	10	ten times
Deci	0.1	one tenth
Centi*	0.01	one hundredth part of
Milli*	0.001	one thousandth part of
Micro*	0.000001	one millionth part of

*Prefixes used most often in medication administration.

- Let's look at the following example to see how the prefixes may be used.

Example: 67 milligrams

Prefix—*milli*—means measure in thousandths of a unit.

Gram is a unit of weight.

Therefore 67 milligrams = 67 thousandths of a gram.

- 4. Regardless of the size of the unit, the name of the basic unit is incorporated into the measure (see Table 5.1). This allows easy recognition of the unit of measure.

Example 1: milli**liter**—The word *liter* indicates you are measuring volume (*milli* indicates 1/1,000 of that volume).

Example 2: kilo**gram**—The word *gram* indicates you are measuring weight (*kilo* indicates 1,000 of that weight; 1 kilogram = 1,000 grams).

Example 3: kilo**liter**—The word *liter* indicates you are measuring volume (*kilo* indicates 1,000 of that volume; 1 kiloliter = 1,000 liters).

Example 4: deci**liter**—The word *liter* indicates that you are measuring volume (*deci* indicates 0.1 of that volume [liter], or 100 milliliters). "Female's normal hemoglobin is 12 to 16 g/dL," means there are 12 to 16 grams of hemoglobin contained in 100 milliliters of blood.

Example 5: cubic milli**meter** (mm^3)—cubic millimeter is a unit of volume of three-dimensional space (length × width × height). In a normal individual the white blood cell count ranges between 5,000 and 10,000 cells per cubic millimeter of blood. Therefore 1 mm^3 of blood contains between 5,000 and 10,000 white blood cells (5,000/mm^3 and 10,000/mm^3).

SAFETY ALERT!

Do not confuse units of measure in the metric system for weight, volume, and length that have similar names. Milligram is a unit of weight; milliliter is a unit of volume; and millimeter is a unit of length.

POINTS TO REMEMBER

It is important to memorize the prefixes and the amounts they represent. A mnemonic to help remember the important metric prefixes' order from largest measurement to smallest is: **K**itty **H**awk **D**oesn't **D**rink **C**anned **M**ilk **M**uch.

kilo, hecto, deka, deci, centi, milli, micro

- 5. The abbreviation for a unit of measure in the metric system is often the first letter of the word. Lowercase letters are used more often than capital letters.

Example 1: g = gram

Example 2: m = meter

The exception to this rule is liter, for which a capital letter is used.

Example 3: liter = L

- 6. When prefixes are used in combination with the basic unit, the first letter of the prefix and the first letter of the unit of measure are written together in lowercase letters.

Example 1: Milligram—abbreviated as *mg*. The *m* is taken from the prefix *milli* and the *g* from *gram,* the unit of weight.

Example 2: Microgram—abbreviated as **mcg.** Microgram is also abbreviated using the Greek symbol (µg). Use of this symbol for micrograms (µg) should not be used for communicating medical information, including medication orders. It can be misinterpreted as mg (milligrams), resulting in a thousandfold overdose.

SAFETY ALERT!

The abbreviation µg for microgram is listed on the Institute for Safe Medication Practice (ISMP) list of Error-Prone Abbreviations, Symbols, and Dose Designations (2015). Confusion of the symbol used for microgram with the abbreviation for milligram could cause a critical error in dosage calculation. These units differ from each other in value by 1,000.

Example 3: Milliliter—abbreviated as **mL.** Note that when *L (liter)* is used in combination with a prefix, it **remains capitalized.** Milliliter (mL) is a small volume, it is one-thousandth of a liter, and is commonly used in dosage calculation.

SAFETY ALERT!

You may see gram abbreviated as *Gm* or *gm*, liter as lowercase *l*, and milliliter as *ml*. These abbreviations are outdated and can lead to misinterpretation. Use only the standardized SI abbreviations. Use *g* for gram, *L* for liter, and *mL* for milliliter. Cubic centimeter, abbreviated *cc*, was used interchangeably for mL. Using *cc* for *mL* should not be done and has been misinterpreted for zeros (00) or units (U). In addition, cc is not a measure of volume; it is the amount of space occupied by a milliliter (mL). The use of the abbreviation *U* is prohibited and must be spelled out (unit). It has been mistaken for zero (0) and the number 4 (four). When in doubt about an abbreviation being used, never assume; ask the prescriber for clarification.

SAFETY ALERT!

It is critical to differentiate between the SI abbreviations for milligram (mg) and milliliter (mL). At a quick glance these abbreviations appear similar; however, confusing these two units can result in lethal consequences for a client.

Box 5.1 lists the common metric abbreviations.

BOX 5-1 Common Metric Abbreviations

- gram = g
- microgram = mcg

- milligram = mg
- kilogram = kg
- liter = L
- * deciliter = dL
- milliliter = mL

---

*Seen in the expression of laboratory values (e.g., hemoglobin, creatinine levels).

Rules of the Metric System

Certain rules specific to the metric system are important to remember (Box 5.2). **These rules are critical to the prevention of errors and ensure accurate interpretation of metric notations when used in medication orders. (Never assume.)** Ask for clarification if you are not sure of the abbreviation or notation to prevent an error.

BOX 5-2 Metric System Rules

- 1. Use Arabic numbers to express quantities in this system.
- **Example:** 1, 1,000, 0.5
- 2. Express parts of a unit or fractions of a unit as decimals.
- **Example:** 0.4 g, 0.5 L

- 3. Always write the quantity, whether in whole numbers or in decimals, before the abbreviation or symbol for a unit of measure.
- **Example:** 1,000 mg, 0.75 mL (not mg 1,000, mL 0.75)
- 4. Use a full space between the numeral and abbreviation.
- **Example:** 2 mL, 1 L (not 2mL, 1L)
- 5. Always place a leading zero to the left of the decimal point if there is no whole number. Eliminate trailing zeros to the right of the decimal point.
- **Example:** 0.4 mL, 2 mg (not .4 mL, 2.0 mg)
- 6. Do not use the abbreviation mg for microgram; it might be mistaken for mg. Remember mg is 1,000 times larger.
- 7. Do not use the abbreviation *cc* for mL. This abbreviation can be misinterpreted as zeros. mL is the acceptable unit for volume.
- **Example:** 2 mL (not 2 cc)
- 8. Avoid periods after the abbreviation for a unit of measure to avoid the possibility of it being misread for the number 1 in a poorly handwritten order.
- **Example:** mg (not mg.)
- 9. Place commas in values at 1,000 or above. ISMP recommends this to improve readability.
- **Example:** 100,000 units (not 100000 units)
- 10. Do not add “s” on a unit of measure to make it plural; this could lead to misinterpretation.
- **Example:** mg (not mgs)

SAFETY ALERT!

As part of the National Patient Safety Goals, TJC set up specific guidelines for the use of leading and trailing zeros. This is also a recommendation of ISMP. A zero should always be placed in front of the decimal when the quantity is less than a whole number **(leading zero)**. When the quantity

expressed is preceded by a whole number, zeros are not placed after the number **(trailing zeros)**. This rule is critical to preventing misinterpretation and medication errors. Always double-check the placement of decimals and zeros.

Example 1: .52 mL is written as 0.52 mL to **reinforce the decimal** and avoid being misread as 52 mL. Lack of a leading zero before the decimal point could result in the decimal point being missed and cause a critical error in dosage interpretation.

Example 2: 2.5 mL is written as 2.5 mL, not 2.50 mL. **Addition of unnecessary zeros can lead to errors in reading;** 2.50 mL may be misread as 250 mL instead of 2.5 mL. Unnecessary zeros can also result in the decimal point being missed and cause a critical error in dosage interpretation.

PRACTICE PROBLEMS

Applying the guidelines relating to the use of leading and trailing zeros, express the following values correctly.

- 1. .750 g _____
- 2. 1.70 mL _____
- 3. .68 L _____
- 4. 7.0 kg _____
- 5. .002 mg _____

Answers on 80

Units of Measure

Understanding common equivalents in the metric system can assist the nurse in preventing medication errors related to incorrect dosage.

Weight

The gram is the basic unit of weight. Medications may be ordered in grams or fractions of a gram, such as milligram or microgram.

- 1. The milligram is 1,000 times smaller than a gram:
-
- 2. The microgram is 1,000 times smaller than a milligram and 1 million times smaller than a gram. The word *micro* also means tiny or small. Micrograms are tiny parts of a gram (i.e., 1,000 mcg = 1 mg). A milligram is 1,000 times larger than a microgram. It takes 1 million mcg to make 1 g.
- 3. The kilogram is very large and is not used for measuring medications. A kilogram is 1,000 times larger than a gram (i.e., 1 kg = 1,000 g). This measure is often used to denote weights of clients, on which medication dosages are based. This is the only unit you will see used to identify a unit larger than the basic unit.

Volume

- 1. The **liter** is the basic unit.

- 2. The **milliliter** is 1,000 times smaller than a liter. It is abbreviated as *mL*.

- 3. As previously stated, **cubic centimeter** (cc) should not be used because of misinterpretation. The cubic centimeter is the amount of space that 1 mL of liquid occupies. Remember, mL is the correct term for volume. The use of cc for mL is currently prohibited by many health care organizations. TJC has also suggested that institutions prohibit the use of the abbreviation cc and add it to their "Do Not Use" List. ISMP also includes cc as an abbreviation that should not be used. Figure 5.1 shows metric measures that may be seen on a medication cup. ***Note:*** *mL* markings on the medicine cup indicate a capacity of 30 mL.

Figure 5.1 Medicine cup showing volume measure in milliliters (mL).

Although pint and quart are not metric measures, they have metric equivalents. For example, a quart is approximately the size of a liter: 1 quart ≈ 1,000 mL and 1 pint ≈ 500 mL. Although pint and quart are not measures used in medication administration, you may need them to calculate a solution, especially in home care. For pharmacological purposes, the equivalents stated for pint and quart are used.

Box 5.3 presents the metric units of measure used most often for dosage calculations and measurement of health status. This text will use the standardized abbreviations for metric units throughout.

BOX 5-3 Metric Equivalents to Memorize

Weight

1 kilogram (kg) = 1,000 grams (g)

1 gram (g) = 1,000 milligrams (mg)

1 milligram (mg) = 1,000 micrograms (mcg)

Volume

1 liter (L) = 1,000 milliliters (mL)

1 milliliter (mL) = 0.001 liter (L)

Length

1 meter (m) = 100 centimeters (cm) = 1,000 mm

1 millimeter (mm) = 0.001 meter (m) = 0.1 cm

Conversions Between Metric Units

Because the metric system is based on the decimal system, conversions between one metric system unit and another can be done by moving the decimal point. The number of places to move the decimal point depends on the equivalent. In the metric system the most common terms used are the kilogram, gram, milligram, microgram, liter, milliliter, and centimeter. To **convert** or make a **conversion** means to change from one unit to another. This converting can be simply changing a measure to its equivalent in the same system. Changing from grams to milligrams illustrates a metric measure changed to another metric measure. Each metric unit in common use for *medication administration* differs from the next by a factor of 1,000. Metric conversions can therefore be made by dividing or multiplying by **1,000.** A way to remember how far to move the decimal point is this: There are three (3) zeros in 1,000, and the decimal point is moved three places, the same as the number of zeros in the conversion (1,000). Knowledge of the size of a unit is important when converting by moving the decimal because this determines whether division or multiplication is necessary to make the conversion.

To make conversions within the metric system, remember the common conversion factors (1 kg = 1,000 g, 1 g = 1,000 mg, 1 mg = 1,000 mcg, and 1 L = 1,000 mL) and the following rules:

RULE

To convert a **smaller** unit of measure to a **larger** one, **divide** by moving the decimal point **three places to the left**.

Example 1: 100 mL = _____L (conversion factor: 1,000 mL = 1 L)
(smaller) (larger)

(Placing zero in front of the decimal is important.)

Example 2: 50 mg = _____g (conversion factor: 1,000 mg = 1 g)
(smaller) (larger)

(Placing zero in front of the decimal is important.)

RULE

To convert a larger unit of measure to a smaller one, multiply by moving the decimal three places to the right.

Example 1: 0.75 g = _____mg (conversion factor: 1 g = 1,000 mg)
(larger) (smaller)

Example 2: 0.04 kg = _____g (conversion factor: 1 kg = 1,000 g)
(larger) (smaller)

SAFETY ALERT!

When converting quantities within the metric system from one unit of measure to another, pay close attention to the decimal point. Moving the decimal point incorrectly (in the wrong direction) can result in a dangerous error.

PRACTICE PROBLEMS

Convert the following metric measures by moving the decimal.

- 6. 300 mg = _____ g
- 7. 6 mg = _____ mcg
- 8. 0.7 L = _____ mL
- 9. 180 mcg = _____ mg
- 10. 0.02 mg = _____ mcg
- 11. 4.5 L = _____ mL
- 12. 4.2 g = _____ mg
- 13. 0.9 g = _____ mg
- 14. 3,250 mL = _____ L
- 15. 42 g = _____ kg
- 16. 529 mg = _____ g
- 17. 645 mcg = _____ mg
- 18. 347 L = _____ mL
- 19. 238 g = _____ mcg
- 20. 3,500 mL = _____ L
- 21. 0.04 kg = _____ g
- 22. 658 kg = _____ g
- 23. 51 mL = _____ L
- 24. 1.6 mg = _____ mcg
- 25. 28 mL = _____ L

Answers on 80

POINTS TO REMEMBER

- • The liter and the gram are the basic units used for medication administration.
- • Conversion factors must be memorized to do conversions. The common conversion factors in the metric system are 1 kg = 1,000 g, 1 g = 1,000 mg, 1 mg = 1,000 mcg, and 1 L = 1,000 mL.
- • mL is the correct term to use in relation to volume, not cc:
- • Express answers using the following rules of the metric system:
  - 1. Fractional metric units are expressed as a decimal.
  - 2. Place a **leading zero** in front of the decimal point when the quantity is less than a whole number to prevent potential dosage error.
  - 3. Omit **trailing zeros** to avoid misreading of a value and potential error in dosage.
  - 4. The abbreviation for a measure is placed after the quantity.
  - 5. Place a full space between the numeral and abbreviation.
  - 6. Use standard SI abbreviations.
- • Converting common metric units used in medication administration from one unit of measure to another is done by multiplying or dividing by 1,000. The decimal point is moved the same number of zeros in the conversion (1,000), always 3 places.
- • Answers should be stated with the unit of measure as the label.
- • Place commas in amounts of 1,000 or above.
- • Never guess at the meaning of a metric notation; ask for clarification.

CHAPTER REVIEW

- 1. List the three units of measurement used in the metric system.
  - a. _____
  - b. _____
  - c. _____
- 2. Which is larger, kilogram or milligram? _____
- 3. 1 mL = _____ L
- 4. What units of measure are used in the metric system for:
  - a. liquid capacity? _____
  - b. weight? _____
- 5. 1,000 mg = _____ g
- 6. 1 L = _____ mL
- 7. 1,000 mcg = _____ mg
- 8. 1 kg = _____ g

Using the rules of the metric system, state the acceptable abbreviations for the following units of measure.

- 9. liter _____
- 10. microgram _____
- 11. milliliter _____
- 12. gram _____
- 13. kilogram _____

Provide the meaning for the following prefixes.

- 14. kilo _____
- 15. milli _____

Using abbreviations and the rules of the metric system, express the following quantities correctly.

- 16. Six tenths of a gram _____
- 17. Fifty kilograms _____
- 18. Four tenths of a milligram _____
- 19. Four hundredths of a liter _____
- 20. Four and two tenths micrograms _____
- 21. Five thousandths of a gram _____
- 22. Six hundredths of a gram _____
- 23. Two and six tenths milliliters _____
- 24. One hundred milliliters _____
- 25. Three hundredths of a milliliter _____

Convert the following metric measures by moving the decimal.

- 26. 950 mcg = _____ mg
- 27. 58.5 L = _____ mL
- 28. 130 mL = _____ L
- 29. 276 g = _____ mg
- 30. 550 mL = _____ L
- 31. 56.5 L = _____ mL
- 32. 205 g = _____ kg
- 33. 0.025 kg = _____ g
- 34. 0.056 L = _____ mL
- 35. 0.015 g = _____ mg
- 36. 250 mcg = _____ mg
- 37. 8 kg = _____ g
- 38. 2 kL = _____ L
- 39. 5 L = _____ mL
- 40. 0.75 L = _____ mL
- 41. 0.33 g = _____ mg
- 42. 750 mg = _____ g
- 43. 6.28 kg = _____ g
- 44. 36.5 mg = _____ g
- 45. 2.2 mg = _____ g
- 46. 400 g = _____ kg
- 47. 0.024 L = _____ mL
- 48. 100 mg = _____ g
- 49. 150 g = _____ mg
- 50. 85 mcg = _____ mg
- 51. 1.25 L = _____ mL
- 52. 0.05 mg = _____ mcg
- 53. 120 mg = _____ g
- 54. 475 mL = _____ L
- 55. 4.5 g = _____ mg
- 56. 8.6 mg = _____ mcg
- 57. 250,000 mcg = _____ mg
- 58. 40 mg = _____ g
- 59. 0.65 kg = _____ g
- 60. 37.5 mcg = _____ mg
- 61. 0.026 mg = _____ mcg
- 62. 36,000 mg = _____ g
- 63. 0.125 g = _____ mg
- 64. 5,524 g = _____ kg
- 65. 8,500 mcg = _____ mg

Which of the following is stated correctly using metric abbreviations and rules?

- 66. .5 g, 0.5 gm, .5 gm, 0.5 g _____

- 67. 4 KG, 4.0 Kg, Kg 04, 4 kg _____
- 68. 1500.0 mg, 1,500 MG, 1,500 mg, 1500 mg
- 69. 1.5 mm, 1.50 mm, 1½ mm, 1.5 Mm
- 70. cm 2, 2.0 cm, 2 cm, 0.2 cm
- 71. 80.0 mcg, 080 mcg, 80 mcg, mcg 80
- 72. mL .7, .7 mL, mL 0.7, 0.7 mL
- 73. Lasix 20.0 mg, Lasix 20 mg, Lasix 20 MG, Lasix mg 20 _____
- 74. Gentamicin 1½ mL, gentamicin 1.5 ml, gentamicin 1.5 mL, gentamicin 1½ ml _____
- 75. Ampicillin 500 mg, ampicillin 500.0 mg, ampicillin 500 MG, ampicillin mg 500 _____

Answers on 80

For additional practice problems, refer to the Conversions and Equivalents section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

ANSWERS

Chapter 5

Answers to Practice Problems

- 1. 0.75 g
- 2. 1.7 mL
- 3. 0.68 L
- 4. 7 kg
- 5. 0.002 mg
- 6. 0.3 g
- 7. 6,000 mcg
- 8. 700 mL
- 9. 0.18 mg
- 10. 20 mcg
- 11. 4,500 mL
- 12. 4,200 mg
- 13. 900 mg
- 14. 3.25 L
- 15. 0.042 kg
- 16. 0.529 g
- 17. 0.645 mg
- 18. 347,000 mL
- 19. 238,000,000 mcg
- 20. 3.5 L
- 21. 40 g
- 22. 658,000 g
- 23. 0.051 L

- 24. 1,600 mcg
- 25. 0.028 L

Answers to Chapter Review

- 1. gram (g), liter (L), meter (m)
- 2. kilogram (kg)
- 3. 0.001 L
- 4.
    - a. L (liter), mL (milliliter)
    - b. g (gram), mg (milligram), mcg (microgram), kg (kilogram)
- 5. 1 g
- 6. 1,000 mL
- 7. 1 mg
- 8. 1,000 g
- 9. L
- 10. mcg
- 11. mL
- 12. g
- 13. kg
- 14. one thousand times
- 15. the thousandth part of
- 16. 0.6 g
- 17. 50 kg
- 18. 0.4 mg
- 19. 0.04 L
- 20. 4.2 mcg
- 21. 0.005 g
- 22. 0.06 g
- 23. 2.6 mL
- 24. 100 mL
- 25. 0.03 mL
- 26. 0.95 mg
- 27. 58,500 mL
- 28. 0.13 L
- 29. 276,000 mg
- 30. 0.55 L
- 31. 56,500 mL
- 32. 0.205 kg
- 33. 25 g
- 34. 56 mL
- 35. 15 mg
- 36. 0.25 mg
- 37. 8,000 g
- 38. 2,000 L
- 39. 5,000 mL
- 40. 750 mL
- 41. 330 mg
- 42. 0.75 g
- 43. 6,280 g
- 44. 0.0365 g
- 45. 0.0022 g
- 46. 0.4 kg
- 47. 24 mL
- 48. 0.1 g
- 49. 150,000 mg
- 50. 0.085 mg
- 51. 1,250 mL
- 52. 50 mcg
- 53. 0.12 g

- 54. 0.475 L
- 55. 4,500 mg
- 56. 8,600 mcg
- 57. 250 mg
- 58. 0.04 g
- 59. 650 g
- 60. 0.0375 mg
- 61. 26 mcg
- 62. 36 g
- 63. 125 mg
- 64. 5.524 kg
- 65. 8.5 mg
- 66. 0.5 g
- 67. 4 kg
- 68. 1,500 mg
- 69. 1.5 mm
- 70. 2 cm
- 71. 80 mcg
- 72. 0.7 mL
- 73. Lasix 20 mg
- 74. Gentamicin 1.5 mL
- 75. Ampicillin 500 mg

unknown - Section 18 (Page 100)

Apothecary System

The apothecary system of measurement is an English system and considered to be one of the oldest systems of measure. It is also referred to as the *fractional system* because parts of units are expressed by using fractions, with the exception of the fraction one-half, which is expressed as *ss* or

. The unusual notations, which can be confusing, inclusion of fractions, Roman numerals, and medication errors resulting from its use have caused concern about the use of the apothecary system.

Although the metric system is the preferred system, you may still see remnants of the apothecary system on medication cups (dram). Ounce, which is apothecary, is still used today as part of the household system; however, the apothecary symbol for ounce (

) should not be used. Some medication labels may still include both apothecary and metric measures. However, many of the newer labels include metric measures only. Many of the newer syringes in use today no longer include a minim scale.

The Institute for Safe Medication Practices (ISMP) has recommended that all medications be prescribed and calculated with metric measures. The United States Pharmacopeia (USP) does not recognize the apothecary system as an official system for measurement of medication dosages. Because of the difficulty encountered with using the apothecary system, the medication errors resulting from its use, and the recommendations of TJC, ISMP, and the Food and Drug Administration (FDA or USFDA), the apothecary system measures and rules will not be focused on. The FDA is oft en referred to as the “consumer watchdog.” The FDA is responsible for protecting and promoting public health through regulation and supervision of products that include food and prescriptions and over-the-counter medications. See Appendix A for discussion of apothecary units, their metric equivalents, and the symbols and abbreviations in the apothecary system that have been identified as error prone and should not be used.

Household System

Household measures are used most often in the home care setting and less frequently in the clinical setting. The household system is derived from the apothecary system, the least accurate system of measure, and includes approximate equivalents. Conversions between household and metric are based on approximate equivalents, as can be seen with pints and quarts. For example, there are 32 ounces in a quart, which is generally accepted to be 1 liter (1,000 mL). The measures encountered most often include measures such as ounce, tablespoon, and teaspoon, which still appear on most medication cups. With medication errors being one of the most common causes of client harm, and reporting of errors caused by confusion between variable measuring systems, there has been a push by various national organizations to use metric measurements and eliminate these measures to reduce the possibility of errors. It is possible that these measures may be eliminated in the near future.

Dating back to 2009, the ISMP issued a call for practitioners to move to sole use of the metric system for measuring over-the-counter (OTC) and prescription oral doses. In 2011 the ISMP issued its “Statement on the Use of Metric Measurements to Prevent Errors with Oral Liquids.” This statement recommended the exclusive use of metric units when prescribing, dispensing, and administering medications, not teaspoon or non-metric measurements (ISMP, 2011). National Alert Network (NAN), which publishes alerts from the National Medication Errors Reporting Program, operated by ISMP, in “Move Toward Full Use of Metric Dosing: Eliminate Dosage Cups That Measure Liquids in Fluid Drams. Use Cups That Measure mL” (June 30, 2015), indicated the recommendation to prevent mix-ups between variable measurement systems. Multiple national organizations have called for the adoption of the metric system (milliliter) as the standard for prescribing and measuring doses of liquid medications. In addition to ISMP and FDA, these organizations include American Academy of Pediatrics (AAP), Centers for Disease Control and Prevention (CDC), and American Pharmacists Association (APhA).

Despite recommendations and some progress toward measuring and prescribing liquids in mL, in 2020 there are still dosing devices used that have household measures, and clients often use utensils in the home to take prescribed medications. Capacities of utensils such as a teaspoon, a tablespoon, and a cup vary from one house to another. When calculating doses or interpreting the health care provider's instructions for the client at home, the nurse must remember that household measures are used. Consequently, the nurse must be able to calculate equivalents for adaptation in the home, even though medication administration spoons, droppers, and medication measuring cups (Figure 6.1) are available.

Figure 6.1 Medicine cup showing metric/household measurements.

Particulars of the Household System

- 1. There are no standard rules for expressing household measures, which accounts for variations in their use.
- 2. Standard cookbook abbreviations are used in this system.
- 3. Arabic numbers and fractions are used to express quantities.
- 4. The smallest unit of measure in the household system is the drop (gtt).
- 5. The unit ounce used to measure liquid is sometimes referred to as fluid ounce.

See Box 6.1 for household measures and metric equivalents to memorize.

BOX 6-1 Household/Metric Equivalents

Unit	Abbreviation	Equivalent	Metric Equivalent
teaspoon	t (tsp)	----------	5 mL
tablespoon	T (tbs)	1 T = 3 t	15 mL
ounce (fluid)	oz	1 oz = 2 T	30 mL
cup (standard measuring)	C	1 cup = 8 oz	240 mL
pint	pt	1 pt = 2 cups (16 oz)	500 mL*
quart	qt	1 qt = 4 cups = 2 pt = 32 oz	1,000 mL*
pound (weight)	lb	1 lb = 16 oz	2.2 lb = 1 kg (1,000 g)

Note: The unit "ounce," which is used to measure liquid volume, is sometimes referred to as "fluid ounce."

*Approximate equivalent in the metric system.

SAFETY ALERT!

Although household utensils may be most familiar to clients, they may invite inaccuracies with medication dosages. Using ordinary household utensils may constitute a safety risk because ordinary household utensils do not come in standard sizes.

- • To ensure accurate dosages at home, utensils used should be marked or calibrated. Determine what kind of measuring devices the client is using at home and teach their proper use. Advise clients and their families to use the measuring device provided with the medication or purchase calibrated devices from the pharmacy as opposed to using their kitchen teaspoon, for example.
- • Review the household equivalents and abbreviations. Do not confuse the abbreviations for teaspoon (t) and tablespoon (T). 1 teaspoon = 5 mL, and 1 tablespoon = 15 mL; confusing the abbreviations and their equivalents could result in a threefold error.
- • Drops should never be used as a measure for medications, because the size of drops varies according to the diameter of the utensil and therefore can be inaccurate. When drops are ordered, the dropper often comes with the medication and should be used only for that medication.
- • Anything less than a teaspoon should be measured in a syringe-type device that has no needle, not in a measuring cup.

Other Medication Measurements Used in Dosage Calculation

Other measurements that may be used to indicate the strength or potency of certain medications include unit, international unit, milliunit, and milliequivalent (mEq). The quantity or amount is expressed using Arabic numbers, with the unit of measure following.

Units express the amount of medication present in 1 milliliter (mL) of solution and are specific to the medication for which they are used. Units measure a medication in terms of its action. Medications such as heparin, insulin, and penicillin are measured in the United States Pharmacopeia unit (USP unit). USP unit has been standardized between manufacturers and has been determined by the United States Pharmacopeia (USP). USP is a government agency that sets standards for medications.

International unit represents a unit of potency used to measure things such as vitamins and chemicals. These International units represent the amount of medication needed to produce a certain effect and are standardized by international agreement.

Milliunit is 1/1,000 of a unit. 1 unit is equal to 1,000 milliunits. Nurses may need to convert units to milliunits. For example, oxytocin (Pitocin) is available in units (10 USP units per 1 mL). Very small doses of oxytocin may be ordered in milliunits. When oxytocin is used to augment labor, the intravenous infusion rate can be 0.5 to 2 milliunits per minute (0.0005 = 0.002 USP units).

Milliequivalents (mEq) are used to measure electrolytes (e.g., potassium) and the ionic activity of a medication. The milliequivalent is one thousandth (1/1,000) of the equivalent weight of an ion. The chemist or pharmacist defines milliequivalents as an expression of the number of grams of medication contained in 1 mL of normal solution. Other electrolytes measured in mEq include calcium, magnesium, and sodium.

The nurse does not have to memorize conversions for the international unit, USP unit, or milliequivalent, because medications that are ordered in these measurements are also prepared and administered in the same system. For example, medications that are ordered in units (such as insulin) will be available in units. Potassium is ordered in milliequivalents and available in milliequivalents. Figure 6.2 shows sample labels of medications in milliequivalents and units.

Figure 6.2 Medication labels showing milliequivalents and units.

SAFETY ALERT!

The abbreviations U and IU are prohibited and must be written out (units and international units). The abbreviation U and IU are included on TJC's official "Do Not Use" List (2019) and ISMP's list of Error-Prone Abbreviations, Symbols, and Dose Designations.

POINTS TO REMEMBER

- • Teaspoon and tablespoon are common measures used in the household system.
- • For safety, encourage clients to use the measuring device that comes with the medication or a measuring device purchased from the pharmacy.
- • There are no rules for stating household measures.
- • The household system uses fractions and Arabic numerals.
- • Conversions between metric and household measures are approximate equivalents.
- • Dosages less than a teaspoon should be measured with a syringe-type device that does not have a needle attached.
- • When possible, convert household measures to metric measures.
- • When in doubt about an unfamiliar unit or one that is not used often, consult a reference or an equivalency table.
- • No conversion is necessary for unit, international unit, and milliequivalent. Medications prescribed in these measures are available in the same system.
- • 1 unit = 1,000 milliunits. Nurses may have to convert units to milliunits.

PRACTICE PROBLEMS

Write the abbreviations for the following measures.

- 1. ounce _____
- 2. tablespoon _____
- 3. pint _____
- 4. teaspoon _____
- 5. pound _____
- 6. quart _____

Use Box 6.1 to determine the following equivalents.

- 7.

oz = _____ mL

- 8. 2 tsp = _____ mL
- 9. 45 mL = _____ tbs

- 10. pt = _____ oz
- 11. 90 mL = _____ oz
- 12. 8 oz = _____ cup
- 13. 1 oz = _____ T
- 14. 3 tbs = _____ mL
- 15. 3 pt = _____ mL

Write the following amounts correctly using numerals and abbreviations where indicated.

- 16. 10 ounces _____
- 17. fifteen units _____
- 18. sixty-five pounds _____
- 19. twenty milliequivalents _____
- 20. two and one-half teaspoons _____
- 21. three quarts _____
- 22. fourteen and one-quarter ounces _____
- 23. ten tablespoons _____
- 24. What household measure might be used to give ounce of cough syrup? _____
- 25. The nurse encouraged a client with diarrhea to drink 40 ounces of water per day. How many cups does this represent? _____
- 26. Medications such as penicillin and insulin are commonly measured in _____.
- 27. The unit used to measure the concentration of serum electrolytes such as potassium and sodium is _____ and is abbreviated _____.

Answers on 86

CHAPTER REVIEW

Express the following using numerals and abbreviations where indicated.

- 1. one-third ounce _____
- 2. three million units _____

- 3. five and one-quarter teaspoons _____
- 4. ten thousand units _____
- 5. three and one-half quarts _____
- 6. forty-five milliequivalents _____
- 7. five ounces _____

Complete the following.

- 8. Pound is a unit of _____.
- 9. The abbreviation for drop is _____.
- 10. T is the abbreviation for _____.
- 11. The abbreviation t is used for _____.
- 12. 1 t = _____mL
- 13. 1 oz = _____ mL
- 14. 1 cup = _____ oz
- 15. 1 tbs = _____ mL
- 16. 1 pt = _____ oz
- 17. 1 qt = _____ oz

Express the following notations in words.

- 18. 8¼ oz _____
- 19. 30 mEq _____
- 20. 2 pt _____
- 21. 15

lb _____

- 22. 8 tbs _____
- 23. True or False? The household system of measurement is commonly used for client dosages at home. _____
- 24. True or False? Units can be abbreviated as U. _____
- 25. True or False? Household measures are approximate equivalents. _____

Answers on 87

For additional information, refer to the Conversions and Equivalents section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

ANSWERS

Chapter 6

Answers to Practice Problems

- 1. oz
- 2. T, tbs
- 3. pt
- 4. t, tsp
- 5. lb
- 6. qt
- 7. 15 mL
- 8. 10 mL
- 9. 3 tbs
- 10. 8 oz
- 11. 3 oz
- 12. 1 cup
- 13. 2 T
- 14. 45 mL
- 15. 1,500 mL
- 16. 10 oz, oz 10
- 17. 15 units
- 18. 65 lb
- 19. 20 mEq
- 20. 2½ t, 2½ tsp (varies)
- 21. 3 qt, qt 3
- 22. 14¼ oz, oz 14¼
- 23. 10 T, 10 tbs (varies)
- 24. 1 T, 1 tbs (varies)
- 25. 5 cups
- 26. units
- 27. milliequivalent; mEq

Answers to Chapter Review

- 1.

oz, oz

- 2. 3,000,000 units

- 3. 5

t, 5

tsp (varies)

- 4. 10,000 units
- 5. 3

qt, qt 3

- 6. 45 mEq
- 7. 5 oz, oz 5
- 8. weight
- 9. gtt
- 10. tablespoon
- 11. teaspoon
- 12. 5 mL
- 13. 30 mL
- 14. 8 oz
- 15. 15 mL
- 16. 16 oz
- 17. 32 oz
- 18. eight and onequarter ounces
- 19. thirty milliequivalents
- 20. two pints
- 21. fifteen and one-half pounds

- 22. eight tablespoons
- 23. True
- 24. False
- 25. True

unknown - Section 19 (Page 108)

Equivalents Among Metric and Household Systems

As noted in earlier chapters dealing with the systems of measure, some measures in one system have equivalents in another; however, equivalents are not exact measures, and there are discrepancies. Several tables have been developed illustrating conversions/equivalents. Sometimes drug companies use different equivalents for a measure.

In the health care system, it is imperative that nurses be proficient in converting among the different systems of measure. Nurses are becoming increasingly responsible for administration of medications to clients and teaching clients and family outside of the conventional hospital setting (e.g., home care). Nurses have become more involved in discharge planning and are responsible for ensuring that the client can safely self-administer medications in the correct dosage. Table 7.1 lists some of the equivalents. You may need to convert between systems. Memorize these common equivalents!

TABLE 7.1

Approximate Equivalents to Remember

1t = 5 mL

1 T = 3 t = 15 mL

1 oz = 30 mL (2 T)

1 pt = 16 oz (500 mL)

1 qt = 32 oz (2 pt), (1,000 mL)

1 cup (measuring) = 8 oz

16 oz = 1 lb

2.2 lb = 1 kg (1,000 g)

1 in = 2.5 cm

Note: Equivalents in the table are those used most often. The preferred and accurate unit for liquid measurements is milliliter (mL).

Converting

The term *convert* means to change from one form to another. Converting can mean changing a measure to its equivalent in the same system or changing a measurement from one system to another system, which is called *converting between systems*. The measurement obtained when converting between systems is **approximate, not exact.** Thus, certain equivalents have been established to ensure continuity.

One of the most important skills needed for calculating dosages is the nurse's ability to make conversions when necessary to administer the ordered amount of medication. The nurse therefore must understand the system of measurement and be able to convert within the same system and from one system to another with accuracy.

Before beginning the actual process of converting, the nurse should learn the approximate equivalents in the equivalents to remember in Table 7.1 and apply the following important points to make converting simple.

POINTS TO REMEMBER

- 1. Memorization of the equivalents/conversions is essential.
- 2. Think of memorized equivalents/conversions as essential conversion factors, or as a ratio.
- **Example:** 1,000 mg = 1 g is called a conversion factor.

  1,000 mg:1 g is a ratio.
- 3. Follow basic math principles, regardless of the conversion method used.
- 4. Answers should be expressed by applying specific rules that relate to the system to which you are converting.

  Example: The metric system uses decimals; the household system uses fractions.
- 5. THINK CRITICALLY—select the appropriate equivalent to make conversions (see Table 7.1).

Methods of Converting

Moving the Decimal Point

Moving the decimal point is discussed in Chapter 5. Because the metric system is based on the decimal system, conversions within the metric system can be done easily by moving the decimal point. This method cannot be applied in the household system because decimal points are not often used in the system (with the exception of pounds). **Remember the two rules for moving decimal points:**

RULE

To convert a smaller unit of measure to a larger one in the metric system, divide or move the decimal point three places to the left.

Example:

Solution: After determining that mg is the smaller unit and that you are converting to a larger unit (g), recall the conversion factor that allows you to change milligrams to grams (1 g = 1,000 mg). Therefore 350 is divided by 1,000 by moving the decimal point three places to the left, indicating 350 mg = 0.35 g.

Note: The final answer is expressed in decimal form. Remember to always place a leading zero (0) in front of the decimal point to indicate a value that is less than 1.

RULE

To convert a larger unit of measure to a smaller one in the metric system, multiply or move the decimal point three places to the right.

Example:

Solution: After determining that L is the larger unit and you are converting to a smaller unit (mL), recall the conversion factor that allows you to change liters to milliliters (1 L = 1,000 mL). Therefore 0.85 is multiplied by 1,000 by moving the decimal point three places to the right, indicating 0.85 L = 850 mL.

Note the addition of a zero here to allow movement of the decimal point the correct number of places.

PRACTICE PROBLEMS

For additional practice in converting by decimal movement, convert the following metric measures to the equivalent units indicated.

- 1. 600 mL = _____ L
- 2. 0.016 g = _____ mg
- 3. 15 kg = _____ g
- 4. 3 mcg = _____ mg
- 5. 25 mg = _____ g
- 6. 0.16 kg = _____ g
- 7. 1.9 L = _____ mL
- 8. 0.5 g = _____ kg
- 9. 0.006 mg = _____ mcg
- 10. 650 mL = _____ L

Answers on 106

Using Ratio and Proportion

Using ratio and proportion is one of the easiest ways to make conversions, whether within the same system or between systems. The basics on how to state ratios and proportions and how to solve them when looking for one unknown are presented in Chapter 3. To make conversions using ratio and proportion, a proportion that expresses a numerical relationship between the two systems must be set up. A proportion may be written in linear format or as a fraction when making conversions. Regardless of the format used, there are some basic rules to follow when using this method.

RULE

Rules for Ratio and Proportion

- 1. State the known equivalent first (memorized equivalent).
- 2. Add the incomplete ratio on the other side of the equal sign, making sure the units of measurement are written in the same sequence.
- **Example:** mg : g = mg : g
- 3. Label all terms in the proportion, including *x*. (These labels are not carried when multiplying or dividing.)
- 4. Solve the problem by using the principles for solving ratios and proportions. (The product of the means equals the product of the extremes.)
- 5. The final answer for *x* should be labeled with the appropriate unit of measure or desired unit.

When the method of ratio and proportion are used to make conversions, as with any method used, the known equivalents must be memorized. Stating the proportion in the fraction format may be a way of avoiding confusion with the terms (means and extremes). However, regardless of the format used, the terms must correspond to each other in value and have a relationship. Division should always be carried at least two decimal places to ensure accuracy.

Example: 8 mg = _____ g

Solution: State the known equivalent first, then add the incomplete ratio, making sure the units are in the same sequence. Label all the terms in the proportion, including *x*.

1,000 mg :1 g = 8 mg : *x* g
(known equivalent) = (unknown)

Read as "1,000 mg is to 1 g as 8 mg is to *x* g."

Once the proportion is stated, solve it by multiplying the means (inner terms) and then the extremes (outer terms). Place the "*x*" product on the left side of the equation.

Result:

Because the measure you are converting to is metric, the fraction is changed to a decimal by dividing 8 by 1,000 to obtain an answer of 0.008 g. However, because the measures are metric in this example, perhaps moving the decimal point would be the preferred method as opposed to actual division.

An alternate way of stating the problem illustrated in the previous example would be stating it as a fraction and cross-multiplying to solve for *x*.

Another way of writing a ratio and proportion to eliminate errors is to set up the conversion problem in a fraction format.

Place the conversion factor first (numerator), and place the problem underneath matching up the units (the denominator); then cross-multiply to solve for *x*.

Example:

The remainder of this chapter will show examples of the methods used in converting within the same system and between systems.

Converting Within the Same System

Converting within the same system is often seen with metric measures; however, it can be done using the household system of measurement, such as one household measure being converted to an equivalent within the household system. Any one of the methods discussed can be used, but movement of decimal points is limited to the metric system as shown in previous examples. Ratio and proportion can be used for all systems set up in a fraction or linear format as illustrated.

Dimensional Analysis. Dimensional analysis is a conversion method that has been used in chemistry and other sciences and will be discussed in more detail in Chapter 15. Dimensional analysis involves manipulation of units to get the desired unit. This method can be used for conversion in all systems. As with other methods discussed, you must know the conversion factor (equivalent).

Steps for Converting Using Dimensional Analysis:

- 1. Identify the desired unit you are converting to.
- 2. Write the conversion factor (equivalent) in fraction format so that the desired unit is in the numerator of the fraction. This is written first in the equation, followed by a multiplication sign (×). (Notice the unit in the numerator is the same as the unit you desire.)
- 3. Write the unit in the successive numerator to match the unit of measure in the previous denominator.
- 4. Cancel the alternate denominator/numerator units to leave the unit desired (being calculated).
- 5. Perform the mathematical process indicated.

Example:

Solution: You want to cancel the kilograms and obtain the equivalent amount in grams. Begin by identifying the unknown, in this case, g. Because 1 kg = 1,000 g, the fraction that will allow you to cancel kg is

.

Note: The unit you want to cancel is always written in the denominator of the fraction. Then proceed by placing as the next numerator the same label as the first denominator, in this case, kg.

Note: Placing a 1 under a number does not change its value.

Answer: 0.12 kg is equivalent to 120 g.

PRACTICE PROBLEMS

Convert the following measures to the equivalent units indicated.

- 11. 1,700 mL = _____ L

- 12. 4 kg = _____ g
- 13. 1.4 L = _____ mL
- 14. 1 mL = _____ L
- 15. 4.5 mg = _____ mcg
- 16. 0.004 L = _____ mL
- 17. 6.5 L = _____ mL
- 18. 60 g = _____ kg
- 19. 600 mg = _____ g
- 20. 0.736 mg = _____ mcg
- 21. 1,600 mL = _____ L
- 22. 0.015 L = _____ mL
- 23. 0.18 g = _____ mg
- 24. 25 mcg = _____ mg
- 25. 5.2 g = _____ kg

Answers on 106

Converting Between Systems

The methods presented previously can be used to change a measure in one system to its equivalent in another, or the conversion factor method can be used. This method requires that you consider the size of units. To convert from a larger unit to a smaller unit of measure, you multiply by the conversion factor as shown in Example 1. To convert from a smaller to a larger unit of measure, you must divide by the conversion factor.

Example 1:

Solution Using Conversion Factor Method

- Equivalent: 1 oz = 30 mL
- Conversion factor is 30.
- An ounce is larger than a milliliter.
- Multiply 4 by 30 to obtain 120.

Answer: 120 mL

Alternative: Express the conversion in proportion format and solve for *x*. (One way to remember this method is to remember that it is the known or have : want to know or have.)

Solution Using Ratio and Proportion

Solution Using Dimensional Analysis

Here you want to cancel oz to find the equivalent amount in mL. Because 1 oz = 30 mL, the fraction you desire so that you can cancel oz is:

Therefore:

Example 2:

Solution Using Conversion Factor Method

- Equivalent: 1 kg = 2.2 lb
- Conversion factor is 2.2.

A pound is smaller than a kilogram; 110 is divided by 2.2.

Answer: 50 kg

Solution Using Ratio and Proportion

or

Solution Using Dimensional Analysis

Here you want to cancel lb to find the equivalent amount in kg. Because 1 kg = 2.2 lb, the fraction you desire so that you can cancel lb is:

Therefore:

Example 3:

Solution Using Conversion Factor Method

- Equivalent: 1 in = 2.5 cm
- Conversion factor is 2.5
- A cm is smaller than an inch (in); 55 is divided by 2.5.

Answer: 22 in

Solution Using Ratio and Proportion

Solution Using Dimensional Analysis

Here you want to cancel cm to find the equivalent amount in inches (in). Because 2.5 cm = 1 in, the fraction you desire so that you can cancel cm is:

Therefore:

Answer: 22 in is equivalent to 55 cm

Calculating Intake and Output

The nurse often converts between systems to calculate a client's **intake and output**. Intake and output is abbreviated **I&O**. *Intake* refers to the monitoring of fluids a client takes orally (p.o.), by feeding tube, or parenterally. Oral intake includes fluids and solids that become liquid at body and room temperature, such as gelatin and Popsicles. Intake also includes water, broth, tea, juice, and coffee. Water taken with medications is also considered intake. Solids such as bread, cereal, or meats are not considered in fluid intake. Intravenous (IV) fluids and continuous and intermittent intravenous piggyback (IVPB) and blood components are considered intake. One of the main purposes of IVPB is to infuse medications on an intermittent basis (e.g., antibiotics q6h). It can also be used to infuse additional fluids. The medication is diluted in a specific volume of IV fluid. The nurse documents the volume of fluid administered in the IVPB as parenteral fluid on the I&O, and the medication administered on the medication record. Liquid output refers to fluids that exit the body, such as diarrhea, vomitus (emesis), gastric suction, urine, and drainage from postsurgical wounds or other tubes. A client's intake and output are usually recorded on a special form called an *intake and output flow sheet* (or I&O flow sheet or record) (Figure 7.1), which varies from institution to institution. In some institutions where the charting is computerized, the I&O may be recorded in the computer. A variety of clients require I&O monitoring, such as those whose fluids are restricted and those who are receiving diuretic or intravenous (IV) therapy.

Figure 7.1 Sample I&O flow sheet.

Intake and output may still be recorded at some institutions using cubic centimeters or milliliters. The preferred term for volume is milliliters. Milliliters will be used throughout this text. When measuring output, the nurse uses a graduated receptacle calibrated in metric measures (mL), and conversions are not necessary. Oral intake usually must be converted from household measures to metric measures before it can be recorded. Each time a client takes oral liquids, even those administered with medications, the amount and time are recorded on the appropriate form. The total intake and output are recorded at the end of each shift and also totaled for a 24-hour period.

Conversion of a client's intake is usually required when recording measurements such as a bowl or coffee cup. Each agency usually has an I&O sheet with a ledger that indicates the standard measurement for the utensils used in its facility. For example, it may indicate that a standard cup is 6 oz or a coffee cup is 180 mL. A client's oral intake is calculated in the same manner as other conversion problems. After each item is converted, the items are added together for the total intake. Intake and output are based on the conversion factor 1 oz = 30 mL.

Example 1: Calculate the client's intake for breakfast in milliliters. Assume that the glass holds 6 oz and the cup holds 8 oz. The client had the following for breakfast at 8 am:

Items	Conversion Factors
⅓ glass of apple juice	1 oz = 30 mL
2 sausages*	1 pint = 500 mL
1 boiled egg*	1 cup = 8 oz
½ cup of coffee	1 glass = 6 oz
½ pint of milk	

*The 2 sausages and 1 boiled egg are not part of fluid intake.

Solution:

- 1.

  glass of apple juice
- 1 glass = 6 oz;

  of 6 oz = 2 oz

Therefore 1 oz = 30 mL, 2 oz × 30 mL = 60 mL

Solution Using Ratio and Proportion

1 oz:30 mL = 2 oz:*x* mL, *x* = 60 mL (ratio and proportion)

Solution Using Dimensional Analysis

- 2. ½ cup of coffee

- 1 cup = 8 oz;

of 8 oz = 4 oz

Therefore 4 oz × 30 = 120 mL

Solution Using Ratio and Proportion

1 oz:30 mL = 4 oz:*x* mL, *x* = 120 mL

Solution Using Dimensional Analysis

- 3. ½ pint of milk
- 1 pint = 500 mL; ½ of 500 mL = 250 mL
- 4. Total mL = 60 mL + 120 mL + 250 mL = 430 mL

Another solution would be to total the number of ounces (6 oz in this example). Convert ounces to milliliters, and add the half pint of milk (expressed in milliliters).

Solution Using Ratio and Proportion

Solution Using Dimensional Analysis

The conversions are recorded on an I&O flow sheet (or record) next to the time ingested. The I&O sheet in Figure 7.1 is filled out with the data for this sample problem.

8:00 am juice, 60 mL coffee, 60 mL milk, 250 mL

Let's look at a more complex I&O calculation. This can be done applying the same principles and methods shown in the previous example:

Example: A client receives 75 mL/hr of IV fluid from 7 am to 3 pm. The client also consumes the following:

Breakfast: 3 oz juice
1½ cups coffee (cup = 8 oz)
Lunch: ¾ bowl of broth (bowl = 6 oz)
4 oz gelatin dessert

At 3 pm the client's foley catheter is emptied of 800 mL of urine and a surgical drain emptied of 75 mL.

- (a) How many milliliters will you record for the intake? _____
- (b) How many milliliters will you record for the output? _____

Solution:

- 1. 75 mL/hr of IV fluid from 7 am to 3 pm
  7 am to 3 pm = 8 hr 75 mL × 8 = 600 mL/8 hr
- 2. **Oral intake:**
  - • 3 oz juice, 1 oz = 30 mL, 3 × 30 mL = 90 mL
  - • 1½ cups coffee, 1 cup = 8 oz; 1½ × 8 oz = 12 oz; therefore 1 oz = 30 mL = 12 × 30 = 360 mL
  - • ¾ bowl of broth, 1 bowl = 6 oz; ¾ of 6 oz = 4½ oz; 1 oz = 30 mL, 4½ × 30 = 135 mL
  - • 4 oz gelatin, 1 oz = 30 mL, 4 × 30 = 120 mL
- 3. Add the milliliters to get the total intake
- 600 mL IV fluid = 705 mL oral intake (90 mL + 360 mL + 135 mL + 120 mL)
-

- ***Note:*** This could have also been done using any of the methods shown in the previous example. Here you could have also gotten the total ounces, which is 23½ in this example (then converted ounces to milliliters and added the IV solution in milliliters to get the total).
- 4. The output is in milliliters; no conversion is needed.
- **Add the mL:** 800 mL (urine) + 75 mL (surgical drain) = 875 mL
- Total intake recorded = 1,305 mL
- Total output recorded = 875 mL

In addition to oral intake, if a client is receiving IV therapy, the amount of IV fluid given is also recorded on the I&O flow sheet (or record). When an IV bottle or bag is hung or added, the nurse indicates the time and the type and amount of fluid in the appropriate column on the sheet (or record). When the IV fluid has infused or the IV is changed, the nurse records the actual amount of fluid **infused,** or **absorbed.**

In a situation in which a bag or bottle of IV fluid is not completed by the end of the shift, the nurse beginning the next shift is informed of how much fluid is left in the bag. At some institutions, the amount is also indicated on the I&O flow sheet (or record) with the abbreviation LIB (left in bag or bottle). As already stated, IV fluids given intermittently such as IVPB are also recorded as parenteral intake and recorded every shift on the I&O indicating the amount of fluid that that has been administered in the IVPB.

Example: The nurse hangs a 1,000 mL bag of DsW at 7 am. The client also receives 1 g of an antibiotic in 100 mL of 0.9% normal saline (NS) at 9 am. The nurse records the 100 mL as being absorbed. At 3 pm, 150 mL is left in the IV bag. The nurse records 850 mL was absorbed from the IV and indicates 150 mL is LIB. Refer to the sample I&O form in Figure 7.2, which shows how this example is charted.

Figure 7.2 Charting IV fluids on an I&O flow sheet. *IVPB,* Intravenous piggyback; *LIB,* left in bag.

I&O flow sheets usually have a place for recording p.o. intake and IV intake and a column or columns for output. Figure 7.3 shows a sample 24-hour I&O flow sheet illustrating the charting of intake.

Figure 7.3 I&O flow sheet (completed 24 hours). *IVPB,* Intravenous piggyback; *LIB,* left in bag.

As discussed, output is also recorded on the I&O form. The most commonly measured output is urine. After a client's output is recorded, sometimes the nurse needs to compute an average. The most important average nurses compute in most health care settings is the hourly urine output. The **hourly** urine output for an adult to maintain proper renal function is 30 mL/hr to 50 mL/hr. Usually, the hourly amount is more significant than each voiding. To find the hourly average of urinary output, take the total and divide by the number of hours.

Example:

The charting of I&O varies at each institution. Always check the policies to ensure compliance with a particular institution.

PRACTICE PROBLEMS

Convert the following to the equivalent measures and express answer to two decimal places as indicated.

- 26. 60 lb = _____ kg
- 27. 187.5 cm = _____ in
- 28. 66 lb = _____ kg

- 29. 3 pt = _____ oz
- 30. 7 oz = _____ mL
- 31. 250 mL = _____ qt
- 32. 45 mL = _____ tbs
- 33. 10 cm = _____ in
- 34. 178.2 lb = _____ kg
- 35. 20 mL = _____ tsp
- 36. 3 oz = _____ T
- 37. 4 qt = _____ mL
- 38. 72 kg = _____ lb
- 39. 3 in = _____ cm
- 40. 2.4 L = _____ mL

Compute how much IV fluid you would document on an I&O form as being absorbed from a 1,000-mL bag if the following amounts remain.

- 41. 300 mL _____
- 42. 450 mL _____
- 43. 100 mL _____

Compute the average hourly urinary output in the following situations (round to nearest whole number).

- 44. 650 mL in 8 hr _____
- 45. 250 mL in 8 hr _____
- 46. 1,000 mL in 24 hr _____
- 47. 1,240 mL in 24 hr _____
- 48. A client's output for the 3 to 11 pm shift was as follows:
  - 325 mL of urine at 4:00 pm
  - 75 mL of vomitus at 7:00 pm
  - 225 mL of urine at 8:00 pm
  - 200 mL of nasogastric (NG) drainage at 11:00 pm
  - 50 mL of wound drainage at 11:00 pm
  - What is the total output in milliliters? _____
- 49. What is the client's output in liters in question 48? _____
- 50. If 375 mL of a 500-mL bag of IV solution were absorbed on the 3 to 11 pm shift, the nurse records that 375 mL was absorbed. How many milliliters are recorded as left in bag (LIB)? _____
- 51. A client had the following during an 8-hour shift:
  - • 125 mL/hr of IV fluid from 7 am to 1 pm
  - • 250 mL of packed red blood cells from 1 pm to 3 pm

Breakfast: 2½ cup of coffee (cup = 6 oz)
½ glass of juice (glass = 4 oz)
Lunch: 1½ bowls of broth (bowl = 6 oz)
3 oz milk

  - The client voided four times during the shift:
  - 350 mL, 275 mL, 450 mL, and 300 mL of urine
  - Calculate the I&O for the 8-hour shift in milliliters
    - a. Intake mL _____
    - b. Output mL _____

Answers on 106

POINTS TO REMEMBER

- • Regardless of the method used for converting, memorizing equivalents is a necessity.
- • Answers stated in fraction format should be reduced as necessary.
- • When more than one equivalent is learned for a unit of measure, use the most common equivalent for the measure or use the number that divides equally without a remainder.
- • Division should be carried to the hundredths place or two decimal places to ensure accuracy, and it is not rounded.
- • Decimal point movement as a method for converting is limited to the metric system; ratio and proportion, dimensional analysis, and conversion factor method can be used for all systems of measure.
- • Oral intake is converted before placing data on an I&O flow sheet (or record). The amount is usually recorded in cubic centimeters at some institutions; however, milliliter is the correct unit for volume. Conversion factor for I&O is 1 oz = 30 mL.
- • Always check the policy of the institution regarding I&O and the charting of it.
- • The most common units of measure used to calculate dosages are metric units of measurement.

CHAPTER REVIEW

Convert the following to the equivalent measures indicated.

- 1. 0.007 g = _____ mg
- 2. 1 mg = _____ g
- 3. 6,000 g = _____ kg
- 4. 5 mL = _____ L
- 5. 0.45 L = _____ mL
- 6. 45 mL = _____ oz
- 7. 1.8 mg = _____ mcg
- 8. 23 g = _____ kg
- 9. 6.5 mcg = _____ mg
- 10. 3

  oz = _____ mL
- 11. 1,200 mL = _____ oz
- 12. 1.6 L = _____ mL
- 13. 47 kg = _____ lb
- 14. 3 mL = _____ L
- 15. 75 lb = _____ kg

- 16. 36 mg = _____ g
- 17. 4 pt = _____ mL
- 18. 0.25 mg = _____ mcg
- 19. 82 kg = _____ g
- 20. 6,172 g = _____ kg
- 21. 200 mL = _____ tsp
- 22. 102 lb = _____ kg
- 23. 204 g = _____ kg
- 24. 1.5 L = _____ mL
- 25. 200 mcg = _____ mg
- 26. 48.6 L = _____ mL
- 27. 0.7 L = _____ mL
- 28. 9½ oz = _____ T
- 29. 4 tsp = _____ mL
- 30. 1.8 mg = _____ g
- 31. 2 tbs = _____ mL
- 32. 67.5 mL = _____ t
- 33. 66.25 cm = _____ in
- 34. 16 t = _____ mL
- 35. 20 oz = _____ mL
- 36. 16 mcg = _____ mg
- 37. 75 tsp = _____ mL
- 38. 10 mL = _____ oz
- 39. 4 kg = _____ lb
- 40. 3.25 mg = _____ mcg

Calculate the fluid intake in milliliters. Use the following equivalents for the problems below: 1 cup = 8 oz, 1 glass = 4 oz.

- 41. Client had the following at lunch:
  - 4 oz fruit cocktail
  - 1 tuna fish sandwich
  - ½ cup of tea
  - ¼ pt of milk
  - Total mL = _____
- 42. Calculate the following individual items and give the total number of milliliters:
  - 3 Popsicles (3 oz each)
  - ½ qt iced tea
  - 1½ glasses water
  - 12 oz soft drink
  - Total mL = _____
- 43. Client had the following:
  - 8 oz milk
  - 6 oz orange juice
  - 4 oz water with medication
  - Total mL = _____
- 44. Client had the following:
  - 10 oz of coffee
  - 8 oz water
  - 6 oz vegetable broth
  - Total mL = _____

- 45. Client had the following:
  - ¾ glass of milk
  - 4 oz water
  - 2 oz beef broth
  - Total mL = _____
- 46. A client had the following at lunch:
  - ¼ glass of apple juice
  - 8 oz chicken broth
  - 6 oz gelatin dessert
  - 1¾ cups of coffee
  - Total mL = _____

Convert the following amounts of fluid to milliliters.

- 47. 9

  oz = _____ mL
- 48.

  C (8 oz cup) = _____ mL

Compute how much IV fluid you would document on an I&O form as being absorbed from a 1,000-mL bag if the following amounts are left in the bag.

- 49. 275 mL _____
- 50. 550 mL _____
- 51. 75 mL _____

Compute the average hourly urinary output in each of the following situations (round to nearest whole number).

- 52. 500 mL in 8 hr _____
- 53. 640 mL in 24 hr _____
- 54. 700 mL in 8 hr _____

Compute how much IV fluid you would document on an I&O form as being absorbed from a 500-mL bag if the following amounts are left in the bag.

- 55. 125 mL _____
- 56. 225 mL _____
- 57. A client received 1,750 mL of IV fluid. How many liters of IV fluid did the client receive? _____
- 58. A client has an order for 125 mcg of digoxin. How many milligrams will you administer to the client? _____
- 59. The prescriber directs a client to take 15 oz of the laxative agent GoLYTELY. The cup holds 6 oz. How many cups will the client have to drink? _____
- 60. A client has an order for 1,500 mL of water by mouth every 24 hours. How many ounces is this? _____
- 61. A client had an output of 1.1 L. How many milliliters is this? _____

- 62. The prescriber orders 2 ounces of a liquid medication for a client. How many tablespoons should the client take? _____ tbs
- 63. A client is given a prescription for 7.5 mL of a cough suppressant every four hours. The client will be using a measuring device that is calibrated in teaspoons. How much medication should the client take for each dose? _____ tsp
- 64. A client weighed 95 kg on the initial visit to the clinic. When the client reported for the subsequent visit the client reported losing 11 lb. What is the client's current weight in kg? _____ kg
- 65. A client is instructed to drink 2,500 mL of water per day. How many quarts of water should the client be instructed to drink? _____ qt
- 66. An infant's head circumference is 45 cm. The parents ask for the equivalent in inches. You tell the parents their infant's head circumference is _____ in.
- 67. A client drank 24 ounces of water. How many cups did the client drink? _____ cups
- 68. A client needs to drink 1

ounces of an elixir per day. How many tablespoons would this be equivalent to? _____ tbs

- 69. A client consumed 2

pints of water in a day. How many cups of water is this equivalent to? _____ cups

- 70. An infant drinks 4 ounces of a ready-to-feed formula every 3 hours during the day and night. The formula comes in a quart container. How many quarts of formula should the mother buy for a 7-day supply? _____ qt
- 71. Calculate the total fluid intake in mL for 24 hours.

Breakfast:	5 oz milk
	2 oz orange juice
	4 oz water with medication
Lunch:	12 oz ginger ale
Snack:	10 oz hot tea
	2 oz gelatin dessert
Dinner:	4 oz water
	6 oz apple juice
	3 oz chicken broth
Snack:	3 oz Jell-O
	8 oz iced tea
	6 oz water with medication

- Total = _____ mL
- 72. Calculate the client intake for 12 hours (7 am to 7 pm).
- The client receives intravenous fluids at 100 mL/hr from 7 am to 3 pm, 300 mL of packed red blood cells from 3 pm to 5 pm, and 50 mL/hr of IV fluid from 5 pm to 7 pm.

Breakfast:	4 oz orange juice
	8 oz hot tea
Lunch:	8 oz milk

Dinner: 4 oz hot tea

- 73. How many milliliters will you record on the I&O for the intake? _____ A client's intake and output was the following for 8 hours:
  - *Intake:*
  - 1.2 L of IV fluid

  Breakfast: 1½ cups of tea (cup = 6 oz)

  Lunch: 1 can ginger ale (can = 12 oz)

  Dinner: 1 bowl chicken broth (bowl = 6 oz)

  - *Output:*
  - Foley catheter: 1,200 mL of urine
  - Surgical drain: 100 mL

  Calculate the I&O in milliliters.

  - a. Total intake _____
  - b. Total output _____

Answers on 106

ANSWERS

Chapter 7

Answers to Practice Problems

- 1. 0.6 L
- 2. 16 mg
- 3. 15,000 g
- 4. 0.003 mg
- 5. 0.025 g
- 6. 160 g
- 7. 1,900 mL
- 8. 0.0005 kg
- 9. 6 mcg
- 10. 0.65 L
- 11. 1.7 L
- 12. 4,000 g
- 13. 1,400 mL
- 14. 0.001 L
- 15. 4,500 mcg
- 16. 4 mL
- 17. 6,500 mL
- 18. 0.06 kg
- 19. 0.6 g
- 20. 736 mcg
- 21. 1.6 L
- 22. 15 mL
- 23. 180 mg
- 24. 0.025 mg
- 25. 0.0052 kg
- 26. 27.27 kg
- 27. 75 in, in 75

- 28. 30 kg
- 29. 56 oz, oz 56
- 30. 210 mL
- 31. 1/4 qt, qt 1/4
- 32. 3 tbs, tbs 3
- 33. 4 in, in 4
- 34. 81 kg
- 35. 4 tsp, tsp 4
- 36. 6 T, T 6
- 37. 4,000 mL
- 38. 158.4 lb *or*
- 158

lb, lb 158.4

- *or* lb 158

- 39. 7.5 cm
- 40. 2,400 mL
- 41. 700 mL
- 42. 550 mL
- 43. 900 mL
- 44. 81 mL/hr
- 45. 31 mL/hr
- 46. 42 mL/hr
- 47. 52 mL/hr
- 48. 875 mL
- 49. 0.875 L
- 50. 125 mL
- 51.
    - a. 1,870 mL
    - b. 1,375 mL

Answers to Chapter Review

- 1. 7 mg
- 2. 0.001 g
- 3. 6 kg
- 4. 0.005 L
- 5. 450 mL

- 6. oz 1

, 1

oz

- 7. 1,800 mcg
- 8. 0.023 kg
- 9. 0.0065 mg
- 10. 105 mL
- 11. 40 oz, oz 40
- 12. 1,600 mL
- 13. 103.4 lb,
- 103

lb

- 14. 0.003 L
- 15. 34.09 kg
- 16. 0.036 g
- 17. 2,250 mL
- 18. 250 mcg
- 19. 82,000 g
- 20. 6.172 kg
- 21. 40 tsp, tsp 40
- 22. 46.36 kg
- 23. 0.204 kg
- 24. 1,500 mL
- 25. 0.2 mg
- 26. 48,600 mL
- 27. 700 mL
- 28. T 19, 19 T
- 29. 20 mL
- 30. 0.0018 g
- 31. 30 mL

- 32. 13

t, t 13

- 33. 26

in, in 26

- 34. 80 mL
- 35. 600 mL
- 36. 0.016 mg
- 37. 375 mL
- 38.

oz, oz

- 39. 8.8 lb, 8

lb

- 40. 3,250 mcg
- 41. 245 mL
- 42. 1,310 mL
- 43. 540 mL
- 44. 720 mL
- 45. 270 mL
- 46. 870 mL
- 47. 285 mL
- 48. 180 mL
- 49. 725 mL
- 50. 450 mL
- 51. 925 mL
- 52. 63 mL/hr
- 53. 27 mL/hr
- 54. 88 mL/hr
- 55. 375 mL
- 56. 275 mL
- 57. 1.75 L
- 58. 0.125 mg
- 59. 2

cups

- 60. 50 oz, oz 50
- 61. 1,100 mL
- 62. T 4, 4 T

- 63. t 1

, tsp 1

, 1

t, 1

tsp

- 64. 90 kg
- 65. qt 2

, 2

qt

- 66. 18 in, in 18
- 67. 3 cups
- 68. tbs 3, T 3, 3 tbs, 3 T
- 69. 5 cups
- 70. qt 7, 7 qt
- 71. 1,950 mL
- 72. 1,920 mL
- 73.
    - a. 2,010 mL
    - b. 1,300 mL

For additional information, refer to the Conversions and Equivalents section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

unknown - Section 20 (Page 121)

Converting Between Celsius and Fahrenheit

Most health care facilities use electronic digital temperature thermometers, which instantly convert between the two scales (*Celsius* and *Fahrenheit*), rather than mercury thermometers. The mercury in glass thermometers, which was once the standard device, has been eliminated from health care facilities because of the environmental hazards of mercury. However, such devices do not eliminate the need for the nurse to understand the important difference between Celsius and Fahrenheit. In addition, it may be necessary for the nurse to explain to clients or families how to convert from one to another. Another factor is the recognition that all persons involved in client care do not have a "universal" measurement for temperature; therefore Fahrenheit or Celsius may be used.

Let's look first at some general information that will help you understand the formulas used.

Differentiating Between Celsius and Fahrenheit

To differentiate which scale is being used (Fahrenheit or Celsius), the temperature reading is followed by an *F* or *C*. *F* indicates Fahrenheit, and *C* indicates Celsius. (*Note:* Celsius was formerly known as *centigrade*.)

Examples:

The freezing point of water on the Fahrenheit scale is **32°F,** and the boiling point is **212°F.** The freezing point of water on the Celsius scale is **0°C,** and the boiling point is **100°C.**

The difference between the freezing and boiling points on the Fahrenheit scale is **180°,** whereas the difference between these points on the Celsius scale is **100°.**

The differences between Fahrenheit and Celsius in relation to the freezing and boiling points led to the development of appropriate conversion formulas. Figure 8.1 shows two thermometers reflecting the relationship of pertinent values between the two scales. The glass thermometers shown in Figure 8.1 are for illustration purposes only. As previously stated, electronic digital thermometers are commonly used in health care settings.

Figure 8.1 Celsius and Fahrenheit temperature scales. (From Clayton BD, Willihnganz M: *Basic pharmacology for nurses,* ed. 17, St. Louis, 2017, Mosby.)

The **32° difference** between the freezing point on the scales is used for converting temperature from one scale to the other. As previously stated, there is a **180°** difference between the boiling and freezing points on the Fahrenheit thermometer and **100°** between the boiling and freezing points on the Celsius scale. These differences can be set as a ratio, 180 : 100. Therefore consider the following:

The fraction

expressed as a decimal is 1.8; therefore you will see this constant used in temperature conversions.

Formulas for Converting Between Fahrenheit and Celsius Scales

RULE

To convert from Celsius to Fahrenheit, multiply by 1.8 and add 32.

Example: Convert 37.5°C to °F.

RULE

To convert from Fahrenheit to Celsius, subtract 32 and divide by 1.8.

Example: Convert 68°F to °C.

Note: Thermometers are calibrated in tenths when converting between Fahrenheit and Celsius; if necessary, carry the math process to the hundreds and round to tenths.

PRACTICE PROBLEMS

Convert the following temperatures as indicated (round your answer to tenths).

- 1. 4°C = _____ °F
- 2. 101°F = _____ °C
- 3. 38.1°C = _____ °F
- 4. 101.3°F = _____ °C
- 5. 37.5°C = _____ °F

Change the given temperatures in the following statements to their corresponding equivalents in °C or °F (round your answer to tenths).

- 6. Store medication at room temperature: 20° to 25°C. _____ °F
- 7. Notify health care provider for temperature greater than 101°F. _____ °C
- 8. Store vaccine serum at 7°F. _____ °C
- 9. Normal adult body temperature is 37°C. _____ °F
- 10. Do not store IV solutions at less than 46°F. _____ °C

Answers on 120

In addition to temperature conversions, other measures that may be encountered in the health care setting relate to linear measurement. As with temperature conversion, even though there are devices that instantly convert these measures, nurses need to understand the process. For the purpose of this chapter, we will focus on millimeters (mm) and centimeters (cm).

Metric Measures Relating to Length

In health care settings, metric measures relating to length include the following:

- • Diameter of the pupil of the eye may be described in millimeters (mm); the normal diameter of pupils is 3 to 7 mm. Charts may show pupillary size in millimeters.
- • Accommodation of pupils is tested by asking a client to gaze at a distant object (e.g., a far wall) and then at a test object (e.g., a finger or pencil) held by the examiner approximately 10 centimeters (cm) (4 in) from the bridge of the client's nose.
- • A baby's head and chest circumference are expressed in centimeters.
- • Gauze for dressings is available in different size squares measured in centimeters. Example: 10 × 10 cm (4 × 4 in); 5 × 5 cm (2 × 2 in)
- • Length of an incision may be expressed in measures such as centimeters.

Refer to the conversions in Box 8.1.

BOX 8-1 Conversions Relating to Length

1 cm = 10 mm

1 in = 2.54 cm*

---

*The approximate conversion of 1 in = 2.5 cm is used for conversions.

Now let's try some conversions using these equivalents.

Example 1: A client's incision measures 25 mm. How many centimeters is this?

Conversion factor: 1 cm = 10 mm

Solution: Think: mm is smaller and cm is larger. Divide by 10, or move the decimal point one place to the left.

Answer:

Example 2: Convert 30 cm to inches (in).

Conversion factor: 1 in = 2.5 cm

Solution: Think: smaller to larger (divide).

Answer: 12 in

Example 3: An infant's head circumference is 35.5 cm. How many millimeters is this?

Conversion factor: 1 cm = 10 mm

Solution: Think: larger to smaller (multiply). Multiply by 10, or move the decimal point one place to the right.

Answer: 355 mm

*Any methods presented in previous chapters may be used for converting. Decimal movement, however, is limited to conversions of one metric measure to another.

PRACTICE PROBLEMS

Convert the following to the equivalent indicated.

- 11. A gauze pad for a dressing is
- 10 cm _____ in
- 12. A client's incision measures
- 45 mm _____ cm
- 13. An infant's head circumference is
- 37.5 cm _____ mm
- 14. A newborn is 20

  in long
- _____ cm
- 15. 14.8 in = _____ cm

- 16. 6.5 cm = _____ in
- 17. 100 in = _____ cm
- 18. An infant's chest circumference is
- 32 cm _____ in
- 19. An infant's head circumference is
- 38 cm _____ in
- 20. A newborn is 20 in long _____ cm

Answers on 120

Conversions Relating to Weight

Determination of body weight is important for calculating dosages in adults, children, and, because of the immaturity of their systems, even more so in infants and neonates. This chapter focuses on converting weights for adults and children. Medications such as heparin are more therapeutic when based on weight in kilograms. The most frequently used calculation method for pediatric medication administration is milligrams per kilogram. Some medications are calculated in micrograms per kilogram.

Because medication dosages in drug references are usually based on kilograms, it is essential to be able to convert from pounds to kilograms. However, the nurse also needs to know how to do the opposite (convert from kilograms to pounds). In addition, because a child's weight may be in pounds and ounces, conversion of these units to kilograms is also important. Knowledge of weight conversions is an important part of general nursing knowledge.

Converting Pounds to Kilograms

RULE

Equivalent: 2.2 lb = 1 kg

To convert lb to kg, divide by 2.2 (think smaller to larger).

The answer is rounded to the nearest tenth.

Example 1: A child weighs 65 lb. Convert to kilograms.

Example 2: An adult weighs 135 lb. Convert to kilograms.

Converting Weight in Pounds and Ounces to Kilograms

Step 1: Convert the ounces to the nearest tenth of a pound, and **add** this to the total pounds.

Equivalent: 16 oz = 1 lb

Step 2: Convert the total pounds to kilograms, and round to the nearest tenth.

Equivalent: 2.2 lb = 1 kg

Example 1: A child's weight is 10 lb, 2 oz.

- Think: smaller to larger.
- 2 oz ÷ 16 = 0.12 = 0.1 lb
- 10 lb + 0.1 lb = 10.1 lb
- Think: smaller to larger.
- 10.1 ÷ 2.2 = 4.59 = 4.6 kg

Example 2: A child's weight is 7 lb, 4 oz.

- 4 oz ÷ 16 = 0.25 = 0.3 lb
- 7 lb + 0.3 lb = 7.3 lb
- 7.3 ÷ 2.2 = 3.31 = 3.3 kg

PRACTICE PROBLEMS

Convert the following weights to kilograms (round to the nearest tenth).

- 21. 6 lb, 5 oz = _____ kg
- 22. 12 lb, 2 oz = _____ kg
- 23. 10 lb, 4 oz = _____ kg
- 24. 7 lb, 12 oz = _____ kg

Convert the following weights in pounds to kilograms (round to the nearest tenth where indicated).

- 25. 20 lb = _____ kg
- 26. 64 lb = _____ kg
- 27. 22 lb = _____ kg
- 28. 121 lb = _____ kg
- 29. 85 lb = _____ kg

Answers on 120

Converting Kilograms to Pounds

RULE

Equivalent: 2.2 lb = 1 kg

To convert kilograms to pounds, multiply by 2.2. (Think: larger to smaller.)

Answer is expressed to the nearest tenth.

Example 1: A child weighs 24.7 kg. Convert to pounds.

Example 2: An adult weighs 72.2 kg. Convert to pounds.

Any of the methods presented in Chapter 7 can be used for converting pounds to kilograms and kilograms to pounds, except decimal movement. Remember, pounds can be expressed using a decimal.

PRACTICE PROBLEMS

Convert the following weights in kilograms to pounds (round to the nearest tenth where indicated).

- 30. 20 kg = _____ lb
- 31. 46 kg = _____ lb
- 32. 98.2 kg = _____ lb
- 33. 10.4 kg = _____ lb
- 34. 34.9 kg = _____ lb
- 35. 5.8 kg = _____ lb

Answers on 120

Military Time

Another conversion that is necessary for the nurse to know because it is being used more frequently is the conversion of traditional time using the 24-hour clock. The 24-hour clock is commonly referred to as *military time, international time,* or *24-hour time*. Although some watches and clocks are manufactured with traditional time and military time visible on the face to eliminate confusion, it is important to understand how to read and write military time for avoiding errors.

Traditional Time 12-Hour Clock

- • Provides a source for error in medication administration.
- • Uses 12 numbers (1–12) to represent morning and evening hours (Figure 8.2).

Figure 8.2 Traditional 12-hour clock.

- • Each time occurs twice a day. For example, the hour 7:00 is recorded as both 7:00 AM and 7:00 PM. The abbreviation “AM” means ante meridian or before noon; “PM” means post meridian or after noon. The times 7 AM and 7 PM may look very similar if the A and P are not clear or not written, which could result in errors and the client receiving the medication at the wrong time.
- • The use of the colon (:) to separate hours from minutes. Hours are represented by Arabic numbers to the left of the colon, and minutes are to the right of the colon. For example, 11:30 (11 = hours, 30 = minutes).
- • Day starts at 12:00 AM, and ends at 11:59 PM.

Military Time 24-Hour Clock

- • Military time is a 24-hour clock. Uses 0 to 24 to represent the hours of the day (Figure 8.3).

Figure 8.3 24-hour clock.

- • Main advantage of using military time is that it prevents errors in documentation and medication errors because numbers are not repeated. Each time occurs once per day. Example 7:00 AM is written as 0700, whereas 7:00 PM is written as 1900.
- • Use of a four-digit number without the colon and AM and PM. The first two digits represent the hours; the last two digits, the minutes. For example, 1130 (11 = hours, 30 = minutes).
- • The day begins after 0000 (midnight); the first minute of the day is 0001, and the day ends at 2400 (midnight). The minutes between 2400 (midnight) and 0100 (1:00 AM) are written as 0001, 0002…0058, 0059.
- • Both 0000 and 2400 represent midnight. The time 0000 is commonly used by the military and read as “zero hundred”; 2400 is read as “twenty-four hundred.”
- • Although still referred to as military time, a more accurate term is “international time.”

Many health care facilities are using military time in documentation such as nursing notes and medication administration records and to document treatments. Use of military time prevents misinterpretation about when a therapeutic measure is due, such as medications, and is less problematic.

Rules for Conversion to Military Time (International Time)

RULE

To convert am time: omit the colon and am and ensure that a 4-digit number is written, adding a zero in the beginning as needed.

Example: 8:45 am = 0845

RULE

To convert pm time: omit the colon and pm; add 1200 to time.

Example: 7:50 pm = 750 + 1200 = 1950

Rules for Converting to Traditional Time

RULE

To convert am time: insert the colon, add am, and delete any zero in front of number.

Example: 0845 = 8:45 am

RULE

To convert pm time: subtract 1200, insert the colon, and add pm.

Example: 1950 = 1950 – 1200 = 7:50 pm

PRACTICE PROBLEMS

Convert the following traditional times to military (international) time.

- 36. 7:30 am = _____
- 37. 10:30 am = _____
- 38. 8:10 pm = _____
- 39. 5:45 pm = _____

- 40. 12:16 am = _____
- 41. 6:20 am = _____
- 42. 1:30 pm = _____
- 43. 11:45 am = _____
- 44. 11:58 pm = _____
- 45. 2:10 am = _____

Convert the following military (international) times to traditional (am/pm) time.

- 46. 0207 = _____
- 47. 1743 = _____
- 48. 0004 = _____
- 49. 0240 = _____
- 50. 1259 = _____
- 51. 0525 = _____
- 52. 1620 = _____
- 53. 1050 = _____
- 54. 1830 = _____
- 55. 1200 = _____

Answers on 120

Calculating Completion Times

As you will see in Chapter 21, the nurse can determine the time an intravenous (IV) bag will be completed or empty using military time (international time) or traditional time depending on institutional policy. Now that we have discussed the conversion of time, let's briefly look at how to determine completion times in military and traditional time. This will be discussed in more detail in Chapter 21.

Determining Completion Time in Military (International Time). Calculation of completion time is easier when military time is used to set up and work the problem.

- • Identify the start time of the IV using military time.
- • Add the infusion time in hours and minutes to the start time.
- • If the added infusion time exceeds 2400, subtract 2400 from the total. As the saying goes, there are only 24 hours in a day, and the day ends at 2400. Subtracting 2400 will give you the correct completion time, which would be the next day.
- • When calculating the completion time, if the minutes are equal to or greater than 60 minutes, subtract 60 from the number of minutes and then add the equivalent 1 hour (60 minutes = 1 hour) to the hours.

Example 1: An IV is started at 0800 to be completed in 6 hours. Determine the completion time.

- • Add the infusion time to the 0800-start time.

Completion time: 1400 or 2:00 pm.

Example 2: An IV is started at 0650 to be completed in 4 hours and 30 minutes. Determine the completion time.

- • Add the infusion time to the 0650-start time.

- **Completion time:** 1120 or 11:20 am

Example 3: An IV is started at 2100 to be completed in 10 hours. Determine the completion time.

- • Add the infusion time to the 2100-start time.

- **Completion time:** 0700 or 7:00 am (the next day)

Traditional Time Calculations

Example 1: An IV medication is to infuse in 30 minutes that was started at 6:15 pm. Determine the completion time.

- • Add the 30-minutes infusion time to the 6:15 pm start time.

- **Completion time:** 6:45 pm

Example 2: An IV with an infusion time of 12 hours is started at 2:00 am. Determine the completion time.

- • Add the 12-hour infusion time to the 2:00 am start time.

- **Completion time:** 2:00 pm

PRACTICE PROBLEMS

Calculate the following completion times in military (international) time.

- 56. An IV started at 0215 to infuse in 2 hr 30 min _____
- 57. An IV started at 0250 to infuse in 5 hr 10 min _____
- 58. An IV started at 0900 is to infuse in 6 hr 30 min _____
- Calculate the following completion times in traditional time.
- 59. An IV started at 6:30 am that has an infusion time of 45 min _____
- 60. An IV started at 7:05 pm that has an infusion time of 8 hr _____

Answers on 120

POINTS TO REMEMBER

Use these formulas to convert between Fahrenheit and Celsius temperature.

- • To convert from °C to °F: °F = 1.8 (°C) + 32 *or*

.

- • To convert from °F to °C:

or (°F – 32)

.

- • When converting between Fahrenheit and Celsius, carry math to hundredths and round to tenths.

Conversions Relating to Length

- • Conversions can be made by using any of the methods presented in the chapter on conversions; however, moving of decimals is limited to converting between metric measures.
-

Conversions Relating to Weight

- • Weight conversion of pounds to kilograms is done most often because many medications are based on kilograms of body weight.
- • Body weight is essential for determining dosages in infants and neonates.
- • To convert pounds to kilograms, divide by 2.2. Round answer to the nearest tenth.
- • To convert pounds and ounces to kilograms, convert the ounces to the nearest tenth of a pound; add this to the total pounds. Convert the total pounds to kilograms and round answer to the nearest tenth.
- • To convert kilograms to pounds, multiply by 2.2. Round answer to the nearest tenth.

Conversions Relating to Time

- • The 24-hour clock is also referred to as military time, international time, or 24-hour time.
- • To change traditional am time to military time, omit the colon and am and make sure that a 4-digit number is written, adding a zero in the beginning as needed.
- • To change traditional pm time to military time, omit the colon and pm and add 1200 to the time.
- • To convert military time to traditional am time, insert a colon and add am. Delete any zero in front of numbers.
- • To convert military time to traditional pm time, subtract 1200, insert the colon, and add pm.
- • When calculating completion times in military (international time):
    - • If the added infusion time exceeds 2400, subtract 2400 from the total. There are only 24 hours in a day, and the day ends at 2400. Subtracting 2400 will give you the correct completion time, which would be the next day.
    - • When calculating the completion time, if the minutes are equal to or greater than 60 minutes, subtract 60 from the number of minutes and then add the equivalent 1 hour (60 minutes = 1 hour) to the hours.

CHAPTER REVIEW

For each of the following statements, change the given temperature to its corresponding equivalent in °C or °F. (Round to the nearest tenth.)

- 1. Notify health care provider for temperature greater than 101.4°F. _____ °C
- 2. Store medication at room temperature, 77°F. _____ °C
- 3. Store medication within temperature range of 15°C to 30°C. _____ °F
- 4. An infant has a body temperature of 36.5°C. _____ °F
- 5. Store vaccine at 6°C. _____ °F
- 6. A nurse reports a temperature of 37.8°C. _____ °F
- 7. Do not expose a medication to temperatures greater than 84°F. _____ °C
- 8. A medication contains a crystalline substance with a melting point of about 186°C. _____ °F
- 9. Store vaccine at 4°C. _____ °F
- 10. Do not expose medication to temperatures greater than 88°F. _____ °C

Convert temperatures as indicated. Round your answer to the nearest tenth.

- 11. –10°C = _____ °F
- 12. 0°F = _____ °C
- 13. 102.8°F = _____ °C
- 14. 29°C = _____ °F
- 15. 106°C = _____ °F
- 16. 70°F = _____ °C
- 17. 39.6°C = _____ °F
- 18. 64.4°F = _____ °C
- 19. 35°C = _____ °F
- 20. 50°F = _____ °C
- 21. 39.8°C = _____ °F
- 22. 86°F = _____ °C
- 23. 41°C = _____ °F

Convert the following to the equivalent indicated. Do NOT round off.

- 24. 18 in = _____ cm
- 25. 31 cm = _____ in
- 26. 44.5 cm = _____ mm
- 27. 32 in = _____ cm
- 28. 3 cm = _____ mm
- 29. 7.9 cm = _____ mm
- 30. 4 in = _____ cm
- 31. 36.6 cm = _____ mm
- 32. 6.2 in = _____ cm
- 33. 350 mm = _____ in
- 34. 21½ in = _____ cm
- 35. 2 in = _____ mm

Convert the following weights in pounds to kilograms (round to the nearest tenth where indicated).

- 36. 63 lb = _____ kg
- 37. 150 lb = _____ kg
- 38. 78 lb = _____ kg
- 39. 81 lb = _____ kg
- 40. 27 lb = _____ kg

Convert the following weights in kilograms to pounds (round to the nearest tenth of a pound where indicated).

- 41. 77.3 kg = _____ lb
- 42. 7 kg = _____ lb
- 43. 4.5 kg = _____ lb
- 44. 9 kg = _____ lb
- 45. 56.1 kg = _____ lb
- 46. A child weighs 70 lb during a pediatric clinic visit. How many kilograms does the child weigh? (Round to the nearest tenth.) _____
- 47. A client's wound measures 41 mm. How many centimeters is this? _____ cm
- 48. A client weighs 99.2 kg. How many pounds does the client weigh? (Round to the nearest tenth.) _____ lb
- 49. An infant's head circumference is 40 cm. How many inches is this? _____ in
- 50. An infant's head circumference is 40.6 cm. How many millimeters is this? _____ mm
- Convert the following weights to kilograms. (Round to the nearest tenth as indicated.)
- 51. 7 lb, 1 oz = _____ kg
- 52. 9 lb, 3 oz = _____ kg
- 53. 10 lb, 12 oz = _____ kg
- 54. 8 lb, 10 oz = _____ kg
- 55. 5 lb, 5 oz = _____ kg

Convert the following military (international) times to traditional times (am/pm).

- 56. 0032 = _____
- 57. 0220 = _____
- 58. 1345 = _____
- 59. 2122 = _____

Convert the following traditional times to military (international) times.

- 60. 5:20 am = _____
- 61. 12:00 midnight = _____
- 62. 4:30 pm = _____
- 63. 1:35 pm = _____

State the following completion times as indicated.

- 64. An IV started at 1905 that has an infusion time of 8 hr _____ (military time).
- 65. An IV with a start time of 1245 that has an infusion time of 5 hr 30 min _____ (military time).
- 66. An IV started at 1900 that has an infusion time of 12 hr _____ (military time).
- 67. An IV started at 0245 to infuse over 5 hours and 30 minutes _____ (military time, and traditional).
- 68. An IV started at 11:50 pm with an infusion time of 3 hr 30 min _____ (traditional).
- 69. An IV started at 0025 with an infusion time of 1 hr 15 min _____ (military time and traditional time).
- 70. An IV started at 4:45 am that has an infusion time of 9 hr 40 min _____ (traditional time).

Answers on 121

ANSWERS

Chapter 8

Answers to Practice Problems

- 1. 39.2°F
- 2. 38.3°C
- 3. 100.6°F
- 4. 38.5°C
- 5. 99.5°F

- 6. 68°F to 77°F
- 7. 38.3°C
- 8. −13.9°C
- 9. 98.6°F
- 10. 7.8°C
- 11. 4 in
- 12. 4.5 cm
- 13. 375 mm
- 14. 51.25 cm
- 15. 37 cm
- 16. 2.6 in
- 17. 250 cm
- 18. 12.8 in
- 19. 15.2 in
- 20. 50 cm
- 21. 2.9 kg
- 22. 5.5 kg
- 23. 4.7 kg
- 24. 3.5 kg
- 25. 9.1 kg
- 26. 29.1 kg
- 27. 10 kg
- 28. 55 kg
- 29. 38.6 kg
- 30. 44 lb
- 31. 101.2 lb
- 32. 216 lb
- 33. 22.9 lb
- 34. 76.8 lb
- 35. 12.8 lb
- 36. 0730
- 37. 1030
- 38. 2010
- 39. 1745
- 40. 0016
- 41. 0620
- 42. 1330
- 43. 1145
- 44. 2358
- 45. 0210
- 46. 2:07 am
- 47. 5:43 pm
- 48. 12:04 am
- 49. 2:40 am
- 50. 12:59 pm
- 51. 5:25 am
- 52. 4:20 pm
- 53. 10:50 am
- 54. 6:30 pm
- 55. 12:00 pm (noon)
- 56. 0445
- 57. 0800
- 58. 1530
- 59. 7:15 am
- 60. 3:05 am

For additional information, refer to the Conversions and Equivalents section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

Answers to Chapter Review

- 1. 38.6°C
- 2. 25°C
- 3. 59°F to 86°F
- 4. 97.7°F
- 5. 42.8°F
- 6. 100°F
- 7. 28.9°C
- 8. 366.8°F
- 9. 39.2°F
- 10. 31.1°C
- 11. 14°F
- 12. −17.8°C
- 13. 39.3°C
- 14. 84.2°F
- 15. 222.8°F
- 16. 21.1°C
- 17. 103.3°F
- 18. 18°C
- 19. 95°F
- 20. 10°C
- 21. 103.6°F
- 22. 30°C
- 23. 105.8°F
- 24. 45 cm
- 25. 12.4 in
- 26. 445 mm
- 27. 80 cm
- 28. 30 mm
- 29. 79 mm
- 30. 10 cm
- 31. 366 mm
- 32. 15.5 cm
- 33. 14 in
- 34. 53.75 cm
- 35. 50 mm
- 36. 28.6 kg
- 37. 68.2 kg
- 38. 35.5 kg
- 39. 36.8 kg
- 40. 12.3 kg
- 41. 170.1 lb
- 42. 15.4 lb
- 43. 9.9 lb
- 44. 19.8 lb
- 45. 123.4 lb
- 46. 31.8 kg
- 47. 4.1 cm

- 48. 218.2 lb
- 49. 16 in
- 50. 406 mm
- 51. 3.2 kg
- 52. 4.2 kg
- 53. 4.9 kg
- 54. 3.9 kg
- 55. 2.4 kg
- 56. 12:32 am
- 57. 2:20 am
- 58. 1:45 pm
- 59. 9:22 pm
- 60. 0520
- 61. 2400 (0000 used in military)
- 62. 1630
- 63. 1335
- 64. 0305
- 65. 1815
- 66. 0700
- 67. 0815, 8:15 am
- 68. 3:20 am
- 69. 0140, 1:40 am
- 70. 2:25 pm

chapter - Section 21 (Page 132)

Unit Three

Methods of Administration and Calculation

unknown - Section 22 (Page 136)

UNIT THREE

Introduction to Methods of Administration and Calculation

Note: The safe and accurate administration of medications to a client is an important and primary responsibility of a nurse. Being able to read and interpret an order correctly and calculate medication dosages is necessary for accurate administration.

Chapter 9 Medication Administration

Chapter 10 Understanding and Interpreting Medication Orders

Chapter 11 Medication Administration Records and Drug Distribution Systems

Chapter 12 Reading Medication Labels

Chapter 13 Dosage Calculation Using the Ratio and Proportion Method

Chapter 14 Dosage Calculation Using the Formula Method

Chapter 15 Dosage Calculation Using the Dimensional Analysis Method

Medication Errors

Medications are therapeutic measures aimed at improving a client's health and are a primary form of treatment for most illnesses. Safe medication administration is not just a nursing responsibility, it requires the collaborative effort of all health care providers, drug manufacturers, health care organizations, clients, and their families. To promote safety in medication administration, everyone must be vigilant in embracing safety as a priority. According to the Emergency Care Research Institute (ECRI), numerous studies show a link between a positive safety culture (where safety is a shared priority) and improved patient safety within a health care organization. A safety culture is viewed as an organization's shared perceptions, beliefs, values, and attitudes that combine to create a commitment to safety and effort to minimize harm (ECRI Institute, 2019). When medication errors occur, the consequences can be harmful and threatening to the life of a client. According to the National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP), a medication error is defined as follows:

A medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing, order communication, product labeling, packaging, and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use.

Outcomes from medication errors include increased hospital stay, increased health care costs, acute or chronic disability, and even death. Additional indirect consequences can affect the nurse involved both emotionally and professionally and could result in loss of position, legal consequences, or loss of license to practice.

According to NCCMERP, experts estimate that as many as 98,000 people die in any given year from medical errors that occur in hospitals. A significant number of these deaths are due to medication errors. In addition, NCCMERP believes there is no acceptable incidence rate for medication errors. Every health care organization's goal should be to continually improve systems to prevent harm to patients resulting from medication errors.

With the increased focus on client safety and creating a "culture of safety," it is no surprise that medication safety is linked to a health organization's ability to attract clients, meet the requirements of accreditation, and obtain reimbursement for services. Publications regarding the numerous medication errors have caused astonishment among members of the health care profession, national organizations, and society as a whole. According to current literature, despite considerable effort, technological advances, preventive strategies, and systematic methods of reporting errors, medication errors continue to be one of the most prevailing causes of client harm.

To Err is Human: Building a Safer Health System, published by the Institute of Medicine (IOM, 1999), brought awareness to the number of annual deaths ascribed to preventable medical errors, including medication errors. Information concerning medication errors has serious implications for the health and safety of clients and warrants a collaborative approach with numerous strategies to prevent future errors. A focus on safety has implications for those involved in the education of nurses as well, with safety being a central concept. The critical role of nurses in medication safety (prevention of errors) is a primary focus of this text and is based on the knowledge and understanding of careful, correct, and safe medication administration.

Reporting of significant or sentinel events that result in client harm has become an expectation from those involved in health care delivery. Promotion of a "culture of safety" has become a focus and priority to prevent harm to those entrusted to the health care system.

Organizations Involved in Safe Medication Practices

There are many health care groups, government and nongovernment agencies, and professional organizations that address patient safety issues, establish standards, and make recommendations in health care to advance client safety and create a culture of safety. Discussion of these organizations helps further reinforce the importance of safety in medication administration and the avoidance of harm to clients in our care across health care settings. This text will provide a brief discussion of some of the organizations.

The IOM, affiliated with the National Academies of Science, is a nonprofit organization that serves as a resource on health care issues. Based on research studies, the IOM provides reliable information and makes recommendations for best practices. The IOM became involved in the promotion of client safety and published reports that included data on medication errors and prevention. The IOM (2006) landmark report *Identifying and Preventing Medication Errors* presented an agenda for reduction of medication errors, including collaboration among doctors, nurses, pharmacists, the Food and Drug Administration and other government agencies, hospitals and other health care organizations, and patients. The prevention of patient harm is a priority. The most effective way to reduce errors was identified as the establishment of a partnership between patients and their health care provider. Although *To Err is Human* is more than 20 years old and *Identifying and Preventing Medication Errors* is more than 10 years old, they are still relevant today. Efforts to increase awareness of and reduce medication errors and improve client safety continue, but there is more work needed.

The Institute for Safe Medication Practices (ISMP) is a nonprofit organization devoted to the causes of medication errors and strategies for their prevention. ISMP serves as a resource for medication safety information for health care professionals, hospitals, and other health care entities. Many initiatives by ISMP have changed medication practices in health care settings. ISMP published a list of abbreviations, symbols, and dose designations that were prone to cause medication errors if misread or misinterpreted, and therefore should not be used. This list has become well known, supported

by patient safety organizations, and has become standard practice. The list can be found on ISMP's website: http://www.ismp.org. It is included in Appendix D of this text and will be referred to in later chapters. Among its many initiatives, ISMP runs a National Medication Errors Reporting Program (ISMP MERP), which is a voluntary confidential practitioner medication error reporting program. Other initiatives include publication of newsletters with real-time error information, a list of High-Alert Medications (medications that have an increased risk of causing significant harm), and a list of drug names that look alike or sound alike (Confused Drug Names). All of the resources mentioned can be found on ISMP's website.

The Joint Commission (TJC) is an independent, not-for-profit organization. TJC provides accreditation to U.S. hospitals and health care facilities and has worked to achieve high standards in the U.S. health care system. One of its goals has been in the area of medication errors. TJC implemented National Patient Safety Goals, one of which is aimed at assisting health care facilities in the prevention of devastating medication errors. In 2002, TJC launched a *Speak Up* campaign to urge patients to take a larger role in preventing errors by becoming active participants in their care. This includes posters and brochures that are displayed in health care facilities that provide patients with questions and strategies to use to avoid medication errors in hospitals or clinics. Information regarding *Speak Up* can be found on TJC's website, https://www.jointcommission.org/speakup.aspx. TJC also developed a "Do Not Use" list of abbreviations as a national safety patient goal, which emphasizes the importance of not using several abbreviations that can cause misinterpretation and lead to medication errors. The list also includes some abbreviations that are found on ISMP's list of Error-Prone Abbreviations, Symbols, and Dose Designations. The TJC official list can be found on TJC's website, https://www.jointcommission.org/assets/1/18/Do_Not_Use_List_6_28_19.pdf, and in Appendix C of this text. TJC addressed the practice of medication reconciliation in a National Patient Safety Goal (NPSG) (#8). Reconciling medications continues to be important in medication safety and is addressed in the 2020 NPSG Goal #3-Hospital 2020 NPSG (NPSG.03.06.01) (https://www.jointcommission.org/standards/national-patient-safety-goals/). This process requires verification of clients' medications beginning on admission and following the client through transfers within the healthcare facility and from one institution to another. Adherence to this prevents medication errors that include omission and drug interactions. In addition to reconciling medications, other aspects related to improving medication safety are included in Goal #3 (e.g., labeling of medications, reduction of harm for clients receiving anticoagulant therapy).

The U.S. Food and Drug Administration (FDA) recognized the potential of barcoding to improve client safety. In 2004, the FDA issued a regulation that required all new pharmaceuticals to be barcoded upon launch into the market (FDA, 2004). The barcodes are used with a barcode-scanning system and computerized database. Some hospitals have barcode scanners that are linked to the hospital's electronic medical records. The barcoding allows the health care provider to scan the client's barcode prior to administering medications, which allows access to the client's medication record. The FDA is also responsible for the placement of the "black box" warning on certain medications. A black box warning appears on the label of a prescription medication to alert consumers and health care providers to safety concerns, such as serious adverse effects or life-threatening risks. In addition, the ISMP and FDA suggested the use of "Tall Man" lettering to differentiate drugs with look-alike names. To prevent errors the drug name is highlighted by various methods, which include uppercase letters and boldface to call attention to differences between lookalike drug names. This list is included in Appendix B of this text.

A Risk Evaluation and Mitigation Strategy (REMS) is a drug safety program that the FDA can require for certain medications with serious safety concerns to help ensure the benefits of the medication outweigh its risks. The purpose of REMS is to reinforce medication use behaviors and actions that support the safe use of that medication. Part of the program also includes the provision of a medication guide or package insert each time the medication is dispensed.

National Quality Forum (NQF) is a nonprofit, voluntary, consensus standard-setting organization established in 1999. To ensure that all patients are protected from injury while receiving care, NQF developed and endorsed a set of Serious Reportable Events (SREs). According to NQF, SREs are a compilation of serious, largely preventable, and harmful clinical events; this compilation is designed to help the health care field assess, measure, and report performance in providing safe care. According to NQF the purpose of the SREs is to facilitate uniform and comparable public reporting to enable systematic learning across health care organizations and systems and to drive systematic national improvements in patient safety based on what is learned both about the events and about how to prevent recurrence. SREs go beyond the hospital setting and address patient safety across a range of settings in which patients receive care, including office-based settings and ambulatory surgery centers. An SRE that has particular reference to this text is listed under the area of Care Management Events. It is indicated as 4A, patient death or serious injury associated with a medication error (e.g., errors involving the wrong drug, wrong dose, wrong patient, wrong time, wrong rate, wrong preparations, or wrong route of administration). Notice this SRE includes the "rights" of medication administration, which has been cited as one of the reasons for medication error when they are not consistently followed by nurses in medication administration.

The Quality and Safety Education for Nurses (QSEN) project has the goal of preparing student nurses with the knowledge, skills, and attitudes (KSAs) that are needed to improve the quality and safety of client care. QSEN looks at six (6) competencies (patient-centered care, teamwork and collaboration, evidence-based practice quality improvement, safety, and informatics). Relevant to medication administration is safety and informatics, which relates to technology to mitigate errors, and teamwork and collaboration, since the prevention of medication errors requires collaboration of all members of the health care team to create a culture of safety that also includes active participation of the client in a partnership with health care providers. Reference to QSEN will be referred to in areas in which it is applicable in this text.

Overview of Medication Errors

Medication errors can occur anywhere in the medication process from the prescribing of the medication by the health care provider to the dispensing of the medication from the pharmacy to the administering of the medication by the nurse. The causes of medication errors can involve

multiple factors, including lack of information about the medication and lack of information about the client to whom the medication is being administered to (e.g., allergies, other medications the client is taking, the reason for the medication being administered), and confusing medication names (look-alike or sound-alike). Other causes of medication errors include errors in mathematical calculations of dosages, incomplete orders, failure to observe "rights" of medication administration when administering medications, and miscommunication of orders. Miscommunication of medication orders can involve poor handwriting, misuse of zeros and decimal points, confusion of metric and other dosing units, use of inappropriate abbreviations and errors in computer order entry. Other contributing factors to medication errors include failure to educate clients properly about medications they are taking, administration of medications without critical thought, and failure to comply with the required policy or procedure related to medication administration. With the shortage of nursing personnel, factors such as shift changes, floating staff, double shifts, and workload increases have contributed to errors. A nurse who is chronically overworked can make errors because of exhaustion. Adaptations to the demands of new technology in health care can also contribute to errors. Distractions and interruptions as contributory factors to medication errors have been found to be plausible in the literature. Systemic errors (e.g., medications that are not properly labeled, medications with similar names placed in close proximity to one another) can lead to medication errors.

SAFETY ALERT!

Focus solely on the task at hand, medication administration (when the actual act of medication occurs). Distractions can result in error during medication administration, jeopardize the client's safety, and may cause harm.

Certain medications, referred to as high-alert medications, have also been identified as contributing to harmful errors. Medications on this list include concentrated electrolyte solutions (such as potassium chloride), insulin, heparin, and chemotherapy drugs. These medications require double verification before administering. Failure to conduct double verification can result in errors.

Preventing Medication Errors

The best solution to the problem of medication errors is prevention. To prevent medication errors, personnel involved in the administration of medications must do meticulous planning and implement the task properly, paying close attention to detail. Technological advances in terms of medication (e.g., use of barcode medication administration, automated dispensing cabinets [ADC], computer prescriber order entry [CPOE]) have been instituted in many facilities as a means of preventing and decreasing medication errors; however, computer technology cannot replace human intellect or negate the need to follow various steps in medication administration to ensure client safety. These advances are useful only if the systems are effective and efficient.

Medication administration is more than just giving the medication because it is ordered. The nurse should be knowledgeable about the action, uses, side effects, expected response, contraindications, and range of dosage for the medication being administered. Consult a valid and current drug reference about any medication that is unfamiliar.

It is not possible to completely eliminate distractions and interruptions in health care facilities, however; safety is essential during the preparation of medications. Best practice strategies include the preparation of medications in a designated "No Interruption Zone" and educating staff on the importance of avoiding interruption of the nurse administering medications. The nurse can also ensure safety when administering medications to clients by attending to the "rights" of medication administration. The rights of medication administration are essential safety checks that should be performed each time with the administration of each and every medication. These rights include administering the right medication to the right client, in the right dosage, by the right route, at the right time, followed by the right documentation. We will discuss these rights and additional rights in this chapter that enhance client safety.

High-alert medications can have devastating consequences if not administered properly. Double-check high-alert medications with another nurse to prevent errors that could result in overdose or other errors that can cause fatal harm to a client. Avoid workarounds, or shortcuts; these are signs of errors waiting to happen.

Medication administration involves using the nursing process, which includes assessment, nursing diagnosis/nursing problem, planning, implementation, and evaluation. The nursing process is a systematic, rational method of planning individualized nursing care, which begins with the assessment of the client.

SAFETY ALERT!

Failure to think about what you are doing and why you are doing it and failure to assess a client can result in errors. You are accountable for your actions.

In the 2018-2019 *Targeted Medication Safety Best Practices for Hospitals* (TMSBP), ISMP identified the following new best practice (#14) in terms of preventing medication errors: Seek out and use information about medication safety risks and errors that have occurred in other organizations outside of your facility and take action to prevent similar errors. According to ISMP, errors that occur in an institution can be a learning process for another to identify risks or practices in their institution to prevent the occurrence of similar errors. According to ISMP, the TMSBP was developed to identify, inspire, and mobilize widespread, national adoption of best practices for specific medication safety issues that continue to cause fatal and harmful errors in patients, despite repeated warnings in ISMP publications. The best practices were set forth in 2016-2017. The 2018-2019 has revisions of two previous practices and the addition of three new best practices, which include the previous one discussed here.

The prevention of medication errors and decreasing their rate of occurrence require adherence to medication administration policies and guidelines at your institution and adherence to standards and guidelines developed by organizations that include ISMP and TJC.

The Nurse's Role in Medication Error Prevention

In addition to the consistent use of the basic six rights of medication administration, nurses are essential to reducing medication errors and improving client outcomes. An effective way to reduce medication errors as identified in a report by the IOM's *Identifying and Preventing Medication Errors*, is a partnership between clients and their health care providers. Emphasis is placed on open communication between nurses and clients, which included not only talking to clients but also listening. As noted previously, TJC's *Speak Up* campaign also urged clients to take an active role in preventing errors by becoming more active in their care. When a nurse is administering medications, clients should be encouraged to ask questions about their medications, and they should receive clear and complete responses to the questions. Questions raised by the client in regard to the medication keep the client informed and can sometimes be a warning to the nurse regarding medications the client is receiving, or alert the nurse to a possible error. Always stop and listen; do not disregard questions. This may prevent an error from occurring and may require further questioning of the client. When questions are encouraged, it maintains open communication between the client and nurse and can prevent medication errors.

By way of brochures and posters displayed in health care facilities, clients are encouraged to use strategies to avoid medication mistakes. These include tips such as check your medications; ask questions; and make sure your doctors, nurses, and other caregivers check your wristband and ask your name before giving you medicine (Figure 9.1). Nurses can reduce errors by making more use of information technologies when administering medications. Using reference information provided by a reliable source or downloaded content on personal digital assistants (PDAs), smartphones, or iPads will enhance the nurse's ability to apply critical thinking when making judgments related to medication administration. With the increasing technology in health care, nurses must be able to identify safety risks and prevent adverse events when using it.

Figure 9.1 Sample of Speak Up poster. (Copyright © The Joint Commission, 2013.)

When medication errors occur, they should be reported following the organization's procedure for reporting. Not reporting an error violates the ethical principle of beneficence, which is the moral obligation to prevent harm. Not reporting an error also does not prioritize the client's safety. When an error occurs, after the safety of the client is ensured, the next step should be reporting the error. Nurses need to use information sources that provide vital information related to medication errors and prevent their occurrence (e.g., ISMP, TJC). The prevention of medication errors, the use of technology in prevention, and the education of nurses with an emphasis on maintaining the safety of the client coincide with the Quality and Safe Education for Nurses (QSEN) goal to improve the quality and safety of client care. Medication administration and strategies to prevent errors (e.g.,

consistent use of the six basic rights, analyzing the causes of medication errors, discouraging the use of unsafe abbreviations, and the benefits of safety-enhancing technologies such as barcoding) can be placed under competency 5, which is Safety. Also relevant here is the use of Informatics under competency 6, to mitigate errors. Note, only some strategies are presented here for the prevention of medication errors. Throughout the text there will be further discussion regarding the prevention of medication errors and recommendations to prevent their occurrence based on safety standards established by organizations that include TJC, ISMP, and the FDA.

Critical Thinking and Medication Administration

There are numerous definitions for *critical thinking*. The best way to define critical thinking is as a process of purposeful, intentional thinking that includes being reasonable and rational. Thinking is based on reason. Critical thinking is important to all phases of nursing but is particularly relevant in the discussion of medication administration. Critical thinking is necessary to the development of clinical reasoning skills and clinical judgment.

Critical thinking encompasses several skills relevant to medication administration. One such skill is the ability to identify an organized approach to the task at hand. For example, in medication administration, calculating dosages in an organized, systematic manner (formula, ratio and proportion, dimensional analysis) decreases the likelihood of errors.

A second skill characteristic of critical thinking is the ability to be an autonomous thinker—for example, challenging a medication order that is written incorrectly rather than passively accepting the order. Critical thinking also involves the ability to distinguish irrelevant information from that which is relevant. For example, when reading a medication label, the nurse is able to decipher from the label the information necessary for calculating the correct dosage. Critical thinking involves reasoning and the application of concepts—for example, choosing the correct type of syringe to administer a dosage and using concepts learned to decide the appropriateness of a dosage. Critical thinking also involves asking for clarification of what is not understood and not making assumptions. Clarifying a medication order and dosage indicates critical thinking. Checking the accuracy and reliability of information decreases the chance of medication errors. The ability to validate information requires a high level of thinking and decreases the chance of medication errors that could be harmful to the client.

Critical thinking is essential to the safe administration of medications. This process allows a nurse to think before doing, translate knowledge into practice, and make appropriate judgments. To safely administer medication, the nurse must base decisions on rational thinking and thorough knowledge of medication administration. Proper medication administration involves evaluation of the client and the medication's effects, which requires critical thinking and skills of assessment. A nurse who administers medication in a routine manner, rather than with thought and reasoning, is not using critical thinking skills.

SAFETY ALERT!

Remember that the nurse who administers a medication is legally liable for the medication error regardless of the reason for the error occurrence.

Factors That Influence Medication Dosages and Action

Several factors influence medication dosages and the way they act, including the following:

- 1. Route of administration
- 2. Time of administration
- 3. Age of the client
- 4. Nutritional status of the client
- 5. Absorption and excretion of the medication
- 6. Health status of the client
- 7. Gender of the client
- 8. Ethnicity and culture of the client
- 9. Genetics

All these factors affect how clients react to a medication and the dosage they receive, and all must be considered when medications are prescribed and administered. Because of differences in the actions and types of medications, clients respond in various ways, and therefore dosages must be

individualized. No two clients will respond to a medication in the same manner. Nurses must keep these factors in mind when administering medications. These factors can account for individuals responding differently to the same medication.

Special Considerations for the Elderly

Elderly individuals can be considered high-risk medication consumers. Approximately two-thirds of older adults use both prescription and nonprescription medications, and one-third of all prescriptions are written for older adults. The growing older population represents a special challenge for health care professionals. With the number of individuals over the age of 65 rapidly increasing, the use of medications in this age group will also increase. According to the Administration on Aging (AOA) *2018 Profile of Older Americans,* over the past 10 years, the population age 65 and over increased from 37.8 million in 2007 to 50.9 million in 2017 (a 34% increase) and is projected to reach 94.7 million in 2060. Between 2007 and 2017 the population age 60 and over increased 35% from 52.5 million to 70.8 million. The 85 and over population is projected to more than double from 6.5 million in 2017 to 14.4 million in 2040 (a 123% increase). According to the U.S. Census Bureau, older Americans will make up more than 20% of the U.S. population starting in 2030.

Because of medical advances and focus on healthier lifestyles, people are now living longer. As with children (see Chapter 24), special considerations should be given to the client who is older. The elderly population experiences more chronic conditions and co-morbidities (including degenerative diseases, physical disabilities); consequently there is more use of and demand for health care services, which include specialty care in some cases and increased use of medications. With the aging process come physiological changes that have a direct effect on medications and their action in the elderly individual. Aging causes the slowing down of the body's functions. Other physiological changes include a decrease in circulation, slower absorption, slower metabolism, a decrease in excretory functions, and a decrease in the ability to respond to stress, such as the stress of medications on the system. Other changes with aging include a decrease in body weight, which can affect the dosage of medications, and changes in mental status, possibly caused by the effects of physical illness or physiological changes in the neurological system that can occur with aging. These physiological changes can cause unexpected medication reactions and make the elderly person more sensitive to the effects of many medications.

According to Willihnganz, Gurevitz, and Clayton (2020), although people who are more than 65 years old represent about 14% of the U.S. population, they consume more than 25% of all prescription medicines and 33% of all nonprescription medicines sold. A recent study of the U.S. noninstitutionalized adult population has indicated that more than 90% of persons 65 years old or older use at least one medication per week. More than 40% use five or more medications, and 12% use 10 or more different medications per week. Because the elderly are often taking more than one medication (polypharmacy), problems such as medication interactions, severe adverse reactions, medication and food interactions, and an increase in medication errors occur. The Beers criteria is a list of medications that are used to evaluate quality and safety in nursing homes. According to Willihnganz, Gurevitz, and Clayton (2020), these medications are considered to be potentially inappropriate for older patients. It is thought that the medications on this list cause adverse effects more commonly and should be avoided in older adult patients unless treatment with other medicines has failed. It is recommended that practitioners be aware of the medications on this list and educate clients regarding prescription and nonprescription medications. The 2019 updated Beers Criteria can be found on the American Geriatrics website: https://www.americangeriatrics.org. The Centers for Medicare and Medicaid Services has incorporated the Beers criteria into federal safety regulations for long-term care facilities. As the senior population continues to increase, there is a need to focus on reducing medication errors in this group.

As a rule, the elderly client will require smaller dosages of medications (as dosage size increases, the number of adverse effects and their severity increase), and the dosages should be given farther apart to prevent accumulation of medications and toxic effects. With aging, visual and hearing problems may develop. Special attention must be given when teaching clients about their medications to help prevent medication errors. Develop a relationship with the client; building rapport and trust is important for the elderly. Take time and talk to the elderly, listen to what they say, and never assume they do not know how much or what medications they are taking. Ascertain that all instructions are written as clearly as possible, choosing fonts that are friendly to older eyes. Make sure the client has appropriate measuring devices to facilitate ease and accuracy when measuring (e.g., a dropper or measuring cup with calibrated lines to indicate small dosages [0.2 mg, 0.4 mg, etc.]). To lessen the chance of taking too much medication or forgetting a dosage, try to establish specific times compatible with the client's routine for taking medications.

Omission of medications is a common cause of error for the elderly at home. This may be due to the cost of medication or forgetfulness. Establishing medication times when possible to coincide with the client's routine and engaging a family member or friend if possible in the teaching process may help in preventing omission of medications. Help the client recognize tablets by the name on the bottle, not by color. If the print on medications is too small for the client to read, encourage the use of a magnifying glass. Other measures might include providing a simple chart that outlines the medications to be taken, times they are to be taken, and special instructions if needed. Such a chart should be geared to the client's visual ability and comprehension level. Encourage the elderly client to request that childproof containers not be used; some older people will have difficulty opening child-resistant containers. Recommend medication aids for the client, such as special medication containers divided into separate compartments for storing daily or weekly medication dosages. (Figure 9.2 shows examples of medication containers.) As the aging population increases, the need for safer medication administration has become even more of a priority. Currently there are services available through the pharmacy that package medications for the client according to the time of the day they are taken. The pharmacy sorts the medications and places them in an easy-to-open package. A 30-day supply of medications is provided to the client based on the medications ordered by the health care provider. This eliminates the need for clients to pour their medications daily. This service is referred to as multi-dose drug dispensing (MDD). Examples include the services provided by CVS Pharmacy (referred to as multidose medications) (https://www.cvs.com/content/multidose?); Amazon (referred to as Pill Pack) (https://www.pillpack.com/how-itworks); and some community pharmacies.

Figure 9.2 (A) Container that holds a week's medications. (B) The Pill Timer beeps, flashes, and automatically resets every time it is closed. (A, From Perry AG, Potter PA, Elkin MK, Ostendorf WR: *Nursing interventions and clinical skills,* ed 6, St Louis, 2016, Mosby.)

A careful and complete medication history, including illicit drugs, should be obtained from the elderly client. This should include over-the-counter medications, alternative medicines, and vitamins. The elderly client may think that these products are safe; however, they may cause dangerous interactions with prescribed medications. Encourage clients to check with their health care provider before taking over-the-counter medications.

When teaching the elderly, it is important to remember that they are mature adults who are capable of learning; they may need and deserve additional time for learning to take place. Be patient, use simple language, and maintain the independence of the elderly as much as possible. Always allow ample time for processing, individualize the teaching, and remember to always foster feelings of self-worth. Always have your clients demonstrate back to you what you have taught them. Correct teaching can decrease misunderstandings and errors in medication.

The Rights of Medication Administration

The "rights" of medication administration can be looked at as being standards. By definition, standards are actions that ensure safe nursing practice. The "rights" of medication administration are a set of safety checks that serve as guidelines for the practitioner to follow when administering medications to prevent errors and ensure client safety. The "rights" must be consistently followed when administering medications to a client. There have been many medication errors linked to inconsistency in following the "rights." Over the years there have been five, then six, and now, in many places, eight or more rights. There are six basic rights of medications administration that are required safety checks that must be performed with the administration of each and every medication to a client. The six basic rights include the right client, right medication, right dose, right route, right time, and right documentation. **A violation of any of the six basic rights constitutes a medication error.** Additional rights include right indication, right to know, and right to refuse. A new right being considered is the right response (Box 9.1).

BOX 9-1 The Rights of Medication Administration

- 1. Right client
- 2. Right medication
- 3. Right dose
- 4. Right route
- 5. Right time
- 6. Right documentation
- 7. Right indication
- 8. Right to know
- 9. Right to refuse
- 10. Right response

- 1. **The right client**—Always make sure you are administering medications to the right client. Failure to correctly identify the right client has been cited as one of the three most common causes of medication errors. Since 2003, TJC has required that clients be identified with at least two unique client identifiers (e.g., client's full name, birthdate, medical record number, but not the client's room number). This requirement was initiated as a National Patient Safety Goal; it has been a standard since 2004 and applies to both inpatient and outpatient settings. It is permissible to check the two identifiers with the client's armband, medication administration record, or chart and ask the client to state his or her name or parent to state the child's name.
- In institutions that use barcode medication administration (BCMA), the client's identification bracelet is scanned as well as the medication being administered. In basic nursing education programs, emphasis is placed on establishing the correct identification of the client prior to medication administration. Students are required to compare two client-specific identifiers with the client's armband, medication administration record (MAR), or chart and by asking the client to state her or his name (as a third identifier). To avoid administering medications to the wrong client, the steps identified need to be consistently implemented regardless of how familiar the nurse is with the client. Always know and use the unique identifiers recognized and required by the facility. Advanced technology does not eliminate your responsibility to correctly identify a client. Misidentification can result in the wrong client receiving the wrong medication.

SAFETY ALERT!

Always verify your client's identity by using the two identifiers designated by your institution each time medications are administered. This will help ensure you have the right client and avoid an error.

- 2. **The right medication**—When medications are ordered, the nurse should compare the MAR (medication administration record) or computer record with the actual order. When administering medications, the nurse should check the label on the medication container against the order. Medications should be checked three times: before preparing, after preparing, and before administration to the client. With unit dosages (each medication dosage is prepared in the prescribed dosage, packaged, labeled, and ready to use), the label should still be checked three times. Remember, regardless of the medication distribution system, the medication label should be checked three times. Errors frequently occur because of similarity in medication names and similar packaging.
- Many medications have names that sound alike, or have names or packaging that is similar. ISMP and the FDA recommend the use of "Tall Man" lettering to alert health professionals to the potential for error with look-alike names. In the use of this method, the medication name is mixed-case or enlarged, bolded, or in italics to emphasize the differing portions of the two names. Tall Man lettering is being used at many institutions. See Appendix B, which shows a listing of the FDA and ISMP lists of look-alike drug names with recommended Tall Man lettering. The right medication also includes checking the expiration date on the medication label. If the medication has expired, contact the pharmacy for an updated supply and discard according to the institution policy. In institutions that use BCMA, the client's identification band is scanned, and each medication is scanned and electronically checked against the electronic medication administration record (eMAR).
- Administer only medications that you have prepared and that are clearly labeled. Avoid distractions when preparing medications; do not multitask. Some institutions have instituted "no interruption zones" in areas such as the medication room to prevent distractions.

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If the medication name is not clear or the medication does not seem to be appropriate for the client, question the order. Always double-check that you have the correct medication. If you are unfamiliar with a medication, refer to a reference to ensure you have the correct medication and prevent errors.

- 3. **The right dose**—Always perform and check calculations carefully, without ignoring decimal points. If you misread a decimal point, the client could receive a dose significantly different from the one ordered. Risk of harm from dosage errors in the pediatric population is great. Caution should be taken when administering medications to children. Errors can occur because of the frequency of weight-based calculations, the need for decimal points, and fractional dosages. Many errors have occurred with infusion pumps and calculations involving administration of parenteral fluids and medications. Electronic infusion pumps have reduced medication errors. Although infusion pump technology has increased administration safety, the nurse cannot rely fully on these devices. It is a nursing responsibility to be trained in the use of infusion pumps and to be alert for potential problems.
- To ensure the right dose of medication, interpret abbreviations correctly. Factors such as illegible handwriting, miscalculation of the amount, and use of inappropriate abbreviations can result in administration of the wrong dose. Always have someone else check a dosage that causes concern. In some agencies, certain medication dosages are required to be checked by two nurses (e.g., insulin, heparin). These medications have been a common source of errors in administration. If a dosage or abbreviation in a written order is not clear, call the prescriber for verification; do not assume.
- Computer entry does not eliminate the use of incorrect dosing symbols. Nurses should always consult a reference to confirm the dosage when in doubt. After dosages are calculated, they should be administered using standard measuring devices, such as calibrated medicine droppers and cups. Always double-check a dosage and confirm pump settings. Before administering medications, it is the responsibility of the nurse to question orders thought to be inappropriate. Examples of questionable orders include a single dose to be composed of more than two or three dosage units (e.g., tablets, capsules, vials) and orders for atypically high doses. In order to recognize unusual dosages, the nurse has the responsibility to become familiar with the usual medication dosages for the clients they care for. The same principle of questioning applies to

the preparation of IV solutions. If more than two or three dosage units are needed to prepare the solution, this could signal an error. Always ask the question, Does this dose seem reasonable?

- In later chapters you will learn to calculate the amount to administer to a client. Thinking what is reasonable and using a common sense approach when calculating dosages is imperative to prevent errors. Full attention to accurate dosage calculation ensures that you avoid error and harm to a client when administering medications.
- 4. **The right route**—Route refers to how a medication is administered (e.g., by mouth, injection). A medication intended for one route is unsafe if administered by another route. Oral medications (e.g., tablets, capsules, caplets) are administered by mouth. Nurses should always consult a reliable reference to confirm the correct route for a medication that is unfamiliar. Always check that the route, if listed on the medication label, matches the route ordered. If the route is not indicated, use a reference to identify the correct route. The route of the medication should be stated on the order. Do not assume which route is appropriate. Orders to administer medications by a feeding tube that should not be crushed (e.g., enteric coated) require that the nurse seek clarification of the order or have the order changed by the prescriber to ensure safe medication administration.
- 5. **The right time**—Medications should be given at the correct time of day and interval (e.g., three times a day [t.i.d.] or every 6 hours [q6h]). Judgment should be used as to when medications should be given or not given. If several medications are ordered, set priorities and administer medications that must act at a certain time. For example, insulin should be given at an exact time before meals. The right time should also include the right time sequence! For example, a client may be receiving a diuretic b.i.d., and the institution may have b.i.d. as 9:00 am and 9:00 pm. The nurse will need to know that the diuretic should not be given in the late evening so that the individual is not going to the bathroom all night. This requires critical thinking. The nurse must know whether a time schedule can be altered or requires judgment in determining the proper time to be administered. Know the institutional policy concerning medication times.
- Factors such as the purpose of the medication, medication interactions, absorption of the medication, and side effects must be considered when medication times are scheduled. Administer medications at the right time. In most cases, this means the medication must be administered within 30 minutes of the scheduled time. (Up to 30 minutes before or after the scheduled time.) This is referred to as the "30-minute rule."
- The "30-minute rule" for medication administration, enacted by the Centers for Medicare & Medical Services (CMS), required that medications be given within 30 minutes before or 30 minutes after their scheduled time. According to the ISMP, who conducted a survey of nurses in response to the 30-minute rule, many nurses developed unsafe practices and workarounds that threatened client safety and increased the potential for medication errors. Some of the unsafe practices that resulted from time pressures included taking risky shortcuts including deception (e.g., medication documented as being given at a certain time when it was delayed or given beforehand); administering medications without performing assessments and/or checking vital signs, lab values, weight and allergy status; skipping barcode scanning; and skipping important double checks to save time.
- As a result of the survey findings, CMS provided hospitals the flexibility to establish policies and procedures for the timing of medication, which includes establishing policies for identification of medications that require exact or precise timing for administration and are not eligible for scheduled dosing times. CMS defines time-critical scheduled medications as those in which early or late administration longer than 30 minutes may cause harm or have a significant impact on the intended therapeutic or pharmacological effect. Non–time-critical scheduled medications are those in which a longer or shorter interval of time since the prior dose does not significantly alter the medication's therapeutic effect or otherwise cause harm, and therefore the hospitals may establish, as appropriate, either a 1- or 2-hour window of administration.
- ISMP, in collaboration with a panel and organizations including TJC and the American Nurses Association (ANA), developed Acute Care Guidelines for Timely Administration of Scheduled Medications. These guidelines can be reviewed on the ISMP website: https://www.ismp.org/node/361. Currently, this is the most well-vetted set of guidelines on the ISMP website. Hospitals are recommended to use the ISMP guidelines as a resource and to develop their own medication administration policies. Nurses are therefore expected to be familiar with and competent in their agency's policy regarding medication administration.
- Before administering prn (when required, whenever necessary) medications, check to ascertain that adequate time has passed since the previous dose, or severe consequences may occur because the medication was administered to the client too soon.
- All medication orders should include the frequency that a medication is to be administered. Administration of a medication at the prescribed time or right time is important to maximize the therapeutic effect and maintain therapeutic blood levels. Errors have occurred in medication administration because of misinterpretation of time and frequency in medication orders. TJC has taken steps to prevent errors by prohibiting the use of certain abbreviations related to dosing frequency (e.g., qod and qd have been mistaken for each other; instead of qod, write "every other day" and instead of qd write "daily" or "every day"). These abbreviations are included on TJC's "Do Not Use" list (see Appendix C).
- 6. **The right documentation**—Correct documentation is referred to as the sixth right of medication administration. Medications should be charted accurately as soon as they are given—on the right client's medication record, under the right date, and next to the right time. If a medication is refused, it should be documented as such with a notation on the medication record or in the nurse's notes. Never chart a medication as given before administering it or without documentation as to why it was not given. Follow the policy of the institution when documenting. All documentation should be legible. Unintentional overmedication of a client could result if a nurse fails to document a medication that was given and a nurse on a following shift also gives the medication to the client.
- Documentation of medications administered is done on the client's medication administration record (MAR), which is a paper form or electronic record that tracks the medications a client receives. A computerized record is used as a working document that records medications as they are administered and is referred to as an electronic medication administration record (eMAR). This system allows electronic tracking of medications administered to help reduce errors. With some of the electronic medication systems, the medication barcode and the client's identification band is scanned, and the information is documented into the client's eMAR. **Remember: "If it's not documented, it's not done."**

- The six basic rights that have been discussed should always be consistently followed when administering medications. In addition to the six rights, the nurse should always view the client receiving medications as an important and valuable asset in the prevention of medication errors. Always listen to concerns verbalized by the client when administering medications regardless of the checks that you have performed before administration (e.g., "The other nurse just gave me medication," "I have never taken this medication before"). Statements such as these by a client should not be ignored. Always listen carefully and be attentive to the concerns of a client. Consider what the client verbalizes as correct and investigate concerns before administering the medication; this can be valuable in preventing medication errors.

SAFETY ALERT!

When a client questions a medication, **STOP** and **LISTEN**. This may be the opportunity to identify an error before a client is harmed.

- 7. **The right indication**—This is also referred to as the right reason. The nurse has the responsibility for knowing the reason a medication is being administered to ensure it is being given for the right reason. If the nurse understands the reason for a medication that is ordered, it will help in the identification of when to hold or not give a medication that may cause harm if administered. Knowing why prevents errors. If in doubt about the reason for a medication that is ordered, verify the order with the prescriber before administering.
- 8. **The right to know—All clients have a right to be educated regarding the medication they are taking.** Clients are more likely to be compliant if they understand why they are taking a medication, and education allows them to make an informed decision. Information that clients should receive includes dose, reason, effect, and side effects of the medication. Clients should also be provided information regarding drug-drug interactions, drug-food interactions, and the use of herbal medications, dietary supplements, and drug interactions. Clients knowing about their medication helps to foster medication safety.
- 9. **The right to refuse**—In addition to the six basic rights of medication administration, another right is **a client has the right to refuse medications.** When this occurs, the nurse needs to document the refusal correctly and make appropriate persons aware of the refusal. The right to refuse may be denied to the client who has a mental illness. A client deemed to be dangerous to self or others can be taken to court and mandated to take medication. Though the client has the right to refuse medication or treatment, the law referred to as Kendra's Law in New York state may provide some exception to a client's right to refuse treatment (e.g., medication). Kendra's Law is legislation designed to protect the public and individuals living with mental illness by ensuring that potentially dangerous mentally ill outpatients are safely and effectively treated.
- Kendra's Law is court-ordered assisted outpatient treatment (AOT). It authorizes the courts to issue orders that would require mentally ill persons who are unlikely to survive safely in the community without supervision to accept medications and other needed mental health services. In other words, if a client is in the community and noncompliant with the treatment regimen (e.g., medication), the client can be petitioned to court by an individual (e.g., spouse, parent, adult roommate).
- Nurses should always be aware of the state laws, policies, and procedures for their jurisdiction relative to the administration of medications to refusing clients. It is extremely important for nurses to check frequently for side effects related to medications and to listen carefully to client complaints. The reason for the refusal of medications should be carefully analyzed and documented in all cases. Education of the client and a reassuring therapeutic relationship can assist in diminishing a client's refusal.
- 10. **The right response**—This is a new right that is being considered by some facilities. This right applies to making certain the medication has the effect intended and includes monitoring the client and documenting. For example, if a sleep medication is ordered, is the client able to sleep?

According to *Fundamentals of Nursing* (Potter, Perry, Stockert, & Hall, 2017), in accordance with The Patient Care Partnership (American Hospital Association, 2003) and because of the potential risks related to medication administration, a patient has the following rights, which include: to refuse a medication regardless of the consequences; to not receive unnecessary medications; to have qualified nurses or physicians assess a medication history, including allergies and use of herbs; and to receive labeled medications safely without discomfort in accordance with the six rights of medication administration.

In addition to some specific mandates mentioned by TJC to ensure client safety and prevent the occurrence of medication errors, another National Patient Safety Goal focused on medications that clients may be taking, including herbals, vitamins, and nonprescription products. Patients and families may not accurately report all their medications and dosages, as well as home remedies. This can lead to errors in medication administration and adverse effects. Nurses need to get a thorough history of medications being taken by a client to prevent medication interactions that may be fatal to the client.

Medication Reconciliation

According to TJC, communication is vital, and it is the root cause of many sentinel events, including medication errors. In response to this, TJC focused on medication reconciliation as a National Patient Safety Goal to reduce the risk of errors during transition points. This National Patient Safety Goal requires hospitals to reconcile medications across the continuum of care. This also includes transfer within the institution (i.e., from one unit to another unit). Medication reconciliation is a requirement for ambulatory care, assisted living, behavioral health, home care, and long-term organizations. Medication reconciliation is to be applied in any setting or service where medications are to be used or the client's response to treatment or service could be affected by medications that the client has been taking.

In the context of the goal, reconciliation is the process of comparing the medications that the client/patient/resident has been taking before the time of admission or entry into a new setting with the medications that the organization is about to provide. The purpose of the reconciliation is to avoid errors of transcription, omission, duplication of therapy, or drug-drug and drug-disease interactions.

Medication reconciliation is an important step in the prevention of medication errors and can assist in obtaining accurate medication histories and ensure continuity of appropriate therapy. This process should begin on admission; discharge orders should be compared and reconciled with the most recent inpatient medication orders and the original list of medications taken at home. Nurses can play a major role in the reconciliation process. This must become an important focus to prevent errors and misunderstanding regarding medications that a client may be taking, especially when discharged. Ensuring client knowledge regarding prehospital medications and posthospital medications may be a step in preventing errors and medication interactions. For additional information about medication reconciliation, refer to TJC's National Patient Safety Goals (http://www.jointcommission.org).

Client Education

One of the most important nursing functions is educating the client. Educating clients about their medications is imperative in preventing errors and improving the quality of health care. Educating clients regarding medications plays a role in preventing adverse reactions and achieving adherence to prescribed therapy; taking the correct dosage of the right medication at the right time helps prevent problems with medication administration. Remember that clients cannot be expected to follow a medication regimen—taking the correct dosage of the right medication at the right time—if they have not been taught. Not knowing what to do results in noncompliance, inaccurate dosages, and other problems. Nurses are in a unique position to teach clients, and this has been a traditional activity of nursing practice. Education should begin in the hospital and be a major part of discharge planning because, once discharged, clients need to have been educated about their medications to continue taking them safely and correctly at home. With today's emphasis on outpatient treatment and early discharge, thorough client education regarding medications is necessary.

When the nurse is teaching a client, it is important to thoroughly assess the needs of the client. Determine what the client knows about the medication prescribed; how to take the medication; and the frequency, time, and dosage. Identify the client's learning needs, including literacy level and language most easily and clearly understood. Identify relevant ethnic, cultural, and socioeconomic factors that may influence medication use; consider factors such as age and physical capabilities. A variety of teaching strategies may have to be used to facilitate and enhance learning. Return demonstrations on proper use of medication equipment and reading dosages, in addition to repeated instructions and directions, may be necessary, especially regarding management at home.

What a client needs to know about a medication varies with the medication. There may be numerous pieces of information clients should learn regarding their medications. The items discussed here relate particularly to dosage administration. To ensure that the client takes the right medication in the right dosage, by the right route at the right time, client education should include the following:

- • Both the brand and generic names of the medication or medications being taken
- • Clear explanation of the amount of the medication to be taken (e.g., one tablet, 1/2 tablet)
- • Clear explanation of when to take the medication (Prepare a chart created with the client's lifestyle in mind. For example, if the medication is to be taken with meals, perhaps the chart can indicate the client's mealtime and the medication scheduled accordingly.)
- • Clear demonstration of measuring oral dosages, such as liquids (encourage the use of appropriate measuring devices)
- • Clear explanation of the route of administration (e.g., place under the tongue)

In addition to teaching clients about prescription medications they are taking, it is imperative that nurses question clients about any other over-the-counter medications they might be taking at home, including herbal medications and dietary supplements. Some herbal medications might interact with medications they are taking (e.g., ephedra can accelerate heart rate, ginkgo and garlic may inhibit blood clotting). Nurses must be alert to any factors that may interfere with client safety.

Though nurses cannot ensure that clients will act on or retain everything they are taught, nurses are responsible for providing information to the client that will prevent error-prone situations and enable safe medication administration. Nurses evaluate retention by providing follow-up, and, if necessary, finding alternative ways of dealing with a client who has a "no way" attitude.

Home Care Considerations

Home health nursing has become a large part of the health care delivery system and continues to grow. This is due to factors such as the promotion of cost-effective health care and early discharge. Home care nursing may involve many activities, such as providing treatments, dressing changes,

hospice care, client/family teaching, and medication administration. Medication administration involves administration of medications in various ways (e.g., IV, p.o., injection). The increased movement of nursing into the home of the client, which is not a controlled setting, has some important nursing implications. Home health nursing increases the autonomy of practice. The nurse must conduct a thorough assessment, communicate effectively, problem solve, and use expert critical thinking skills. Thinking must be rational, reasonable, and based on knowledge.

The principles regarding medication administration are the same as in a structured setting (e.g., hospital, acute care facility, nursing home). The six basic rights are still guidelines for the nurse to follow to ensure safe administration. It is imperative that the client be well educated about safe administration. Depending on the client's condition, home nursing services may be provided on a scheduled or intermittent basis to monitor the status of a client. Not all clients have a health aide, family member, or continuous nursing services in the home (around the clock). It is essential that the nurse calculate medication administration in a systematic, organized manner and adhere to the six rights of medication administration. For example, according to TJC, in all initial visits in the home care setting, two identifiers should occur. The correct address is an acceptable identifier when used in conjunction with another person-specific indicator. Thereafter, direct facial recognition is acceptable if there is continuing one-on-one care in which the nurse "knows" the individual. The sixth right—documentation—is essential everywhere, including home health care. Documentation of medications is not just for legal purposes; it plays a significant role in cost reimbursement and payments. Correct interpretation of medication orders and validation are imperative. Proper education of the client concerning the medication, dosage, and route of administration is crucial in order for the client to manage in the home environment. Some may look at it as "the client being totally at your mercy." Clients depend on the nurse to provide direction for them to ensure safe medication administration at home. The nurse must be able to teach the client to use appropriate measuring devices for measuring prescribed dosages and determining the accuracy of the dosage.

When possible, encourage clients to use devices that are readily available in many pharmacies, such as calibrated oral syringes or plastic cups with measurements. Use of these devices can help prevent errors that often occur when clients measure their medication with household utensils. (As discussed in the chapters on systems of measure, the nurse must be able to convert dosages among the various systems.) The nurse providing services to the client in the home must be innovative and knowledgeable and demonstrate excellent critical thinking skills. Open communication with the client is essential. It is crucial to know what clients are taking and how. Remember that clients have to be taught. They may not know that they cannot resume previously taken medications or herbal remedies.

The Nurse's Role in Medication Error Prevention

In addition to the consistent use of the basic six rights of medication administration, nurses are essential to reducing medication errors and improving client outcomes. An effective way to reduce medication errors as identified in the IOM report *Identifying and Preventing Medication Errors*, is a partnership between clients and their health care providers. Emphasis was placed on open communication between nurses and clients, which included not only talking to clients but also listening. In response to this, TJC launched a *Speak Up* campaign that urged clients to take an active role in preventing errors by becoming more active in their care. When administering medications, client questions should be encouraged, and the nurse should be prepared to answer them.

Routes of Medication Administration

Route refers to how a medication is administered or the method of delivery by which the medication enters into the body. The nurse is responsible for ensuring that the client receives the medication by the right route. Medications can be administered by several routes.

Oral (p.o.)

Oral medications are administered by mouth (e.g., tablets, capsules, caplets, liquid solutions). The information contained on a medication label for (e.g., tablets, capsules) will not specify oral as the route of administration; however, unless another route is specified on the label, tablets and capsules are administered by the oral route. Liquid solutions for oral use will specify the route oral.

Sublingual (SL)

Sublingual medications are placed under the tongue and are designed to be readily absorbed through the blood vessels in this area. Medications designed to be administered by the sublingual route should not be swallowed. Nitroglycerin used for relief of angina (chest pain) is a medication commonly administered by the sublingual route (tablet, or metered spray referred to as nitroglycerin lingual aerosol, which can be sprayed onto or under the tongue). Another medication administered sublingually is Suboxone, which is used for opioid dependence.

Buccal

Buccal tablets are placed in the mouth between the gums and inner lining of cheek (buccal pouch) absorbed by buccal mucosa. Clients should be instructed not to chew, swallow, or take with liquids. Fentora (fentanyl buccal tablet), used in the management of breakthrough pain in cancer patients already receiving opioid therapy for persistent cancer pain, is an example of a medication administered by the buccal route.

Other forms of medications administered by the oral route will be discussed in more detail in Chapter 16, Calculation of Oral Medications.

Parenteral

Parenteral medications are administered by a route other than by mouth or gastrointestinal tract. Parenteral medications are administered by injection. Parenteral routes include intravenous (IV), intramuscular (IM), subcutaneous (subcut), and intradermal (ID). Labels on parenteral medications specify the route, (e.g., IM and IV use).

Insertion

Medication is placed into a body cavity, where the medication dissolves at body temperature (e.g., suppositories). Vaginal medications, creams, and tablets may also be inserted by using special applicators provided by the manufacturer.

Instillation

Medication is introduced in liquid form into a body cavity. It can also include placing an ointment into a body cavity, such as erythromycin eye ointment, which is placed in the conjunctiva of the eye. Nose drops and ear drops are also instillation medications.

Inhalation

Medication is inhaled through the mouth or nose into the respiratory tract (e.g., through nebulizers used by clients for asthma). Bronchodilators and corticosteroids may be administered by inhalation through the mouth using an aerosolized, pressurized metered-dose inhaler (MDI). In some institutions, these medications are administered to the client with special equipment, such as positive pressure breathing equipment or the aerosol mask. Other medications in inhalation form include pentamidine isethionate, which is used to treat *Pneumocystis jiroveci*, (previously classified as *Pneumocystis carinii*) a type of pneumonia found in clients with acquired immunodeficiency syndrome (AIDS). Another example is Trelegy Ellipta (inhalation powder) used to treat chronic obstructive pulmonary disease (COPD). Devices such as “spacers” or “extenders” have been designed for use with inhalers to allow all of the metered dose to be inhaled, particularly in clients who have difficulty using inhalers.

Intranasal

A medicated solution is instilled into the nostrils. This route is used to administer medications that include the antidiuretic hormone vasopressin and a nasal mist influenza vaccine. Another example is a new medication, Onzetra Xsail (nasal powder), used for the acute treatment of migraines.

Topical

The medication is applied to the external surface of the skin. It can be in the form of lotion, ointment, or paste.

Percutaneous. Medications are applied to the skin or mucous membranes for absorption. This includes ointments, powders, and lotions for the skin; instillation of solutions onto the mucous membranes of the mouth, ear, nose, or vagina; and inhalation of aerosolized liquids for absorption through the lungs. The primary advantage is that the action of the medication, in general, is localized to the site of application.

Transdermal. Transdermal medication, which is becoming more popular, is contained in a patch or disk and applied topically. The medication is slowly released and absorbed through the skin and enters the systemic circulation. These topical applications may be applied for 24 hours or for as long as 7 days and have systemic effects. Examples include nitroglycerin for angina, nicotine transdermal (Nicoderm) for smoking cessation, clonidine for hypertension, Duragesic (fentanyl) for moderate to severe chronic pain in opioid-tolerant patients, and birth control patches.

Forms of oral medications (tablets, capsules), oral solutions, and routes for parenteral medications are discussed in more detail in later chapters.

Some medications are supplied in multiple forms and therefore can be administered by several routes. For example, Zofran (ondansetron hydrochloride is used to prevent nausea and vomiting associated with cancer chemotherapyand radiation therapy and to prevent and treat nausea and vomiting after surgery. Zofran is supplied as film-coated tablets, orally disintegrating tablets, oral solution, and solution for injection.

Equipment Used for Medication Administration

Medicine Cup

Equipment used for oral administration includes a 30-mL or 1-oz medication cup made of plastic, used to measure most liquid medications. The cup has measurements in all three systems of measure (Figure 9.3). By looking at the medicine cup, you can see that 30 mL = 1 oz, 5 mL = 1 tsp, and so forth. Remember that any volume less than 1 tsp (5 mL) should be measured with a more accurate device, such as an oral syringe, dropper, or calibrated spoon.

Figure 9.3 Medicine cup. (Modified from Turner SJ: *Mulholland's the nurse, the math, the meds: drug calculations using dimensional analysis,* ed 4, St Louis, 2019, Elsevier.)

Although the medicine cup is commonly used for administering liquid medications, many facilities still use medicine cups that have measures such as drams (dr), cubic centimeter (cc), and household measures. It is important to note that units of measure such as dr and cc are no longer used in clinical practice. There have been medication errors made because of confusion with different dosing scales on the medication cup. To avoid dosing errors, the recommendations that have been made include that health care institutions purchase cups that have printed, rather than embossed, measurements so that they are easier to read, and ideally the measuring cups should be printed with milliliters (mL) only. To avoid confusion with different measurement systems, organizations such as the American Academy of Pediatrics (AAP), the Institute for Safe Medication Practices (ISMP), and the Centers for Disease Control and Prevention (CDC) have called for adoption of the metric system (mL) as the standard for prescribing and measuring doses of liquid medications.

Soufflé Cup

A soufflé cup is a small paper or translucent plastic cup used for solid forms of medication, such as tablets and capsules (Figure 9.4).

Figure 9.4 (A) Plastic medicine cup. (B) Soufflé cup. (Courtesy of Chuck Dresner. From Willihnganz M, Gurevitz S, Clayton BD: *Clayton's basic pharmacology for nurses,* ed 18, St Louis, 2020, Elsevier.)

Calibrated Dropper

A calibrated dropper may be used to administer small amounts of medication to an adult or child (Figure 9.5). The calibrations are usually in milliliters but can be in drops. Droppers are also used to dispense eye, nose, and ear medications in a squeeze drop bottle and designed for that purpose. The amount of the drop, abbreviated gtt, and size vary according to the diameter of the opening at the tip of the dropper. For this reason, it is important to remember that droppers should not be used as a medication measure unless they are calibrated. Also, because of variation, a properly calibrated dropper is often packaged with the medication (see Figure 9.5) and calibrated for the specified dose. Examples include children's vitamins; nystatin oral solution; and furosemide oral solution. Use the calibrated dropper only with the medicine for which it is designed or packaged with.

Figure 9.5 Medicine droppers.

CRITICAL THINKING

BE SAFE. THINK: Drops from a dropper with a large opening provide more medication than drops from a smaller opening.

SAFETY ALERT!

Droppers are accurate when used to measure the specific medication they are calibrated to, not for measuring other medications. Do not interchange droppers that are packaged with medications. Using a dropper for the wrong medication could result in a serious medication error.

Nipple

An infant feeding nipple with additional holes may be used for administering oral medications to infants (Figure 9.6).

Figure 9.6 Nipple. (Modified from Willihnganz M, Gurevitz S, Clayton BD: *Clayton's basic pharmacology for nurses,* ed 18, St Louis, 2020, Elsevier.)

Oral Syringe

An oral syringe may be used to administer liquid medications orally to adults and children. No needle is attached (Figure 9.7A). An oral syringe is often in color and has an eccentric (off-center) tip to differentiate it from a parenteral syringe. In addition, it usually indicates for oral use on the barrel.

Figure 9.7 A, Oral syringes. B, Calibrated spoon. (Courtesy of Chuck Dresner. From Willihnganz M, Gurevitz S, Clayton BD: *Clayton's basic pharmacology for nurses,* ed 18, St Louis, 2020, Elsevier.)

Calibrated Spoon

A device that is calibrated usually holds up to 10 mL. Often household and metric units are indicated on the spoon. Designed with a spoon-end shape to make it easier to administer oral medications. Many of the calibrated spoons designed for pediatrics are often in color and may be in the shape of animals (Figure 9.7B).

Parenteral Syringe

A parenteral syringe is used for IM, subcut, ID, and IV medications. These syringes come in various sizes and are marked in milliliters or units. The specific types of syringes are discussed in more detail in Chapter 17. **The barrel** of the syringe holds the medication and has calibrations on it that indicate the capacity of the syringe. The **plunger** is used to pull medication into the syringe or to inject medication out of the syringe (Figure 9.8). The needle is attached to the **tip** of the syringe. The size of the needle depends on how the medication is given (e.g., subcut or IM), the viscosity of the medication, and the size of the client. See Figure 9.9 for samples of the types of syringes.

Figure 9.8 Parts of a syringe. (From Potter PA, Perry AG, Stockert P, Hall A: *Fundamentals of nursing,* ed 9, St Louis, 2017, Mosby.)

Figure 9.9 Types of syringes. (A) 3-mL syringe marked in 0.1 (tenths). (B) Tuberculin syringe marked in 0.01 (hundredths) and 0.1 (tenths) of a mL. (C) Insulin syringe marked in units (100). (D) Lo-Dose Insulin syringe marked in units (50). (From Potter PA, Perry AG, Stockert P, Hall A: *Fundamentals of nursing,* ed 9, St Louis, 2017, Mosby.)

Equipment for Administering Oral Medications to a Child

Various types of calibrated equipment are on the market for administering medications to children. Most of the available equipment is for oral use. Caregivers should be instructed to always use calibrated measuring devices that are appropriate for measuring prescribed dosages when administering medications to a child. Household spoons vary in size and are not reliable devices for accurate dosing. Figure 9.10 presents samples of equipment used to administer oral medications to a child.

Figure 9.10 (A) Acceptable devices for measuring and administering oral medication to children *(clockwise)*: measuring spoon, plastic syringes, calibrated nipple, plastic medicine cup, calibrated dropper, hollow-handled medicine spoon. (B) Medibottle used to deliver oral medication via a syringe. (A, From Hockenberry MJ, Wilson D: *Wong's nursing care of infants and children,* ed 9, St Louis, 2011, Mosby. B, Courtesy Paul Vincent Kuntz, Texas Children's Hospital, Houston.)

SAFETY ALERT!

Remember, to prevent errors in medication administration, the device or equipment you use must be calibrated for the dose you need to administer in order to accurately measure the dose.

POINTS TO REMEMBER

- • The basic six rights of medication administration serve as guidelines for nurses when administering medications (the right client, the right medication, the right dose, the right route, the right time, and the right documentation). Additional rights include the right indication, the right to know, the right to refuse, and the right response.
- • Medication administration includes using critical thinking and the nursing process.
- • There are numerous reasons for medication errors.
- • Medication errors can harm clients physically and economically and can be fatal.
- • Nurses are accountable for medications administered regardless of the reason for the error.
- • Nurses are responsible for ensuring the client's safety when administering medications. This includes ensuring that the right client receives the right medication in the right dose, by the right route, at the right time, followed by the right documentation.
- • Nurses play a critical role in the prevention of medication errors.
- • Talking to clients and listening to them can prevent errors. Encourage client questions.
- • Know the policy of the institution regarding timely administration of medications.
- • QSEN (The Quality and Safety Education for Nurses) goal is to improve the quality and safety of client care.
- • Technology to prevent errors and medication safety is relevant to the QSEN safety competency and informatics.
- • The elderly and children require special considerations with medication administration.
- • Medication errors should be reported immediately.
- • A calibrated dropper should be used when administering medications with a dropper.
- • Dosages less than 1 teaspoon should be measured with a device such as an oral syringe, dropper, or calibrated spoon.
- • A medication cup has the capacity of 30 mL. A soufflé cup is used to dispense solid forms of medications.
- • Medications are administered by various routes.

PRACTICE PROBLEMS

Answer the following questions by filling in the correct word or words to complete the sentence.

- 1. A dose for oral use that is less than 5 mL should not be measured in a _____.
- 2. The _____ and _____ need special considerations regarding medication dosages.
- 3. _____ refers to the way in which a medication is administered.
- 4. _____ medications have an increased risk of causing significant client harm.

- 5. A _____ cup is used for dispensing solid forms of medication.
- 6. Application of medication to the external surface of the skin is referred to as the _____ route.
- 7. Medication administration is a process that requires critical thinking and the nursing process, which includes:
  - a. _____
  - b. _____
  - c. _____
  - d. _____
  - e. _____
- 8. Being an autonomous thinker is an example of _____.
- 9. _____ droppers should be used for medication administration.
- 10. When medications are placed between the gums and inner lining of the cheek, they are administered by the _____ route.

Answers on 147

CHAPTER REVIEW

- 1. Name the six basic rights of medication administration.
- Right _____
- Right _____
- Right _____
- Right _____
- Right _____
- Right _____
- 2. The Joint Commission requires that clients be identified using _____ client identifiers, neither of which can be the _____.
- 3. A medication label should be read _____ times.
- 4. Medications should be charted _____ you have administered them.
- 5. Name three routes of medication administration. _____
- 6. The medicine cup has a (an) _____ capacity.
- 7. Droppers are calibrated to administer standardized drops regardless of what type of dropper is used. True or False? _____
- 8. The syringe used to administer a dosage by mouth is referred to as a (an) _____.
- 9. Parenteral syringes are marked in _____ or units.
- 10. The medicine cup indicates that 2 tablespoons are approximately _____ mL.
- 11. The _____ lists medications that should be avoided in elderly clients.
- 12. ISMP is an abbreviation for _____.
- 13. TJC is an abbreviation for _____.
- 14. The route by which medicated solutions are instilled into the nostrils is _____.
- 15. REMS is an abbreviation for _____.
- 16. QSEN is an abbreviation for _____.
- 17. True or False. Black box warnings are placed on all prescription medications. _____
- 18. True or False. Medication errors should be reported immediately. _____
- 19. True or False. Establishing a partnership between the client and the health care provider can help in the prevention of medication errors. _____
- 20. True or False. Clients do not have the right to refuse medications. _____
- For questions 21-25, read the statements carefully and indicate which right of medication administration has been violated.
- 21. The medication label indicated for optic use, and the medication was instilled into the client's ears. The right _____.
- 22. The prescriber ordered Glipizide and the client received Glyburide. The right _____.
- 23. The nurse charted all her medications on the medication record before she administered them. The right _____.
- 24. The nurse administers a medication at 10 pm that was scheduled for 10 am. The right _____.
- 25. The dosage to be administered was 1½ tsp. The client received 15 mL. The right _____.
- For questions 26-27, identify the right that is violated.

- 26. A client asks why she is receiving a medication. The nurse knows why, does not tell the client, and administers the medication. The right _____
- 27. A client with a history of low blood pressure (hypotension) has an order for an antihypertensive medication. The right _____
- 28. An organization's shared perceptions, beliefs, values, and attitudes that combine to create a commitment to safety and effort to minimize arm is referred to as _____.
- 29. When a nurse is unfamiliar with a medication that has been ordered, the nurse should consult a _____.
- 30. SREs is an abbreviation for_____, which are endorsed by NQF. NQF is an abbreviation for_____.

Answers on 148

ANSWERS

Chapter 9

Answers to Practice Problems

- 1. medicine cup
- 2. elderly and children
- 3. route
- 4. High-alert
- 5. soufflé
- 6. topical
- 7. assessment, nursing diagnosis/nursing problem, planning, implementation, evaluation
- 8. critical thinking
- 9. calibrated
- 10. buccal

Answers to Chapter Review

- 1. medication, dose, client, route, time, documentation
- 2. two unique, client's (patient's) room number
- 3. three
- 4. after
- 5. parenteral, oral, inhalation, insertion, topical, percutaneous, intranasal, instillation, sublingual, buccal, transdermal
- 6. 30 mL or 1 oz
- 7. False
- 8. oral syringe
- 9. milliliters (mL)
- 10. 30 mL
- 11. Beers criteria
- 12. Institute for Safe Medication Practices
- 13. The Joint Commission
- 14. intranasal
- 15. Risk Evaluation and Mitigation Strategy
- 16. Quality and Safety Education for Nurses
- 17. False
- 18. True
- 19. True
- 20. False
- 21. Route
- 22. Medication
- 23. Documentation

- 24. Time
- 25. Dose
- 26. Right to know
- 27. Right indication or right reason
- 28. Safety culture
- 29. Reputable drug reference
- 30. Serious Reportable Events, National Quality Forum

unknown - Section 24 (Page 159)

Medication administration begins with a medication order. Before the nurse can administer any medication, there must be a written legal order written by a licensed health care professional who is authorized to prescribe medication, granted by the state in which they are licensed. Health care professionals authorized to prescribe medications include physicians, physician's assistants, dentists, nurse midwives, and nurse practitioners, depending on state law. Health care providers use medication orders to convey the therapeutic plan for a client, which includes medications. Medication orders communicate to the nurse or designated health care worker which medication or medications to administer to a client. Health care agency policies can vary regarding medication orders. Nurses must be aware of and follow the policies.

In the acute care setting, there are different types of medication orders that can be written:

- • **Standing order.** Sometimes referred to as a routine order, a standing order may be written to indicate a medication is to be given for a specified number of doses. For example, ampicillin 1 g IV q6h for 4 doses. A standing order can also indicate that a medication should be administered until it is discontinued or is replaced by another order. For example, Colace 100 mg po tid. Most health care facilities have policies relating to automatic cancellation of an order after a certain time period. For example, 72 hours for narcotics; 30 days for standing orders.
- • **prn order.** This order is administered as needed. This type of order allows for the client to receive the medication at their request and allows for the use of nursing judgment on when a medication should be administered based on the client's need and safety. Medications that are ordered on a prn basis need a time interval and reason included in the order, such as "q6h prn for pain." This means a medication can be administered every 6 hours as needed for pain. Examples of prn orders, Tylenol 650 mg po q4h prn for temperature greater than 101°F, Zofran (ondansetron hydrochloride) 4 mg po q6h prn for nausea and vomiting.
- • **Stat order.** This means a medication is to be given immediately but only once unless it is re-ordered. For example, Ativan 2 mg IM stat.
- • **Single (one-time) order.** This order specifies a medication to be given only once at a specified time. For example, Demerol 50 mg IM and atropine 0.4 mg IM on call to the operating room.

Medication orders are written as prescriptions in private practice or in clinics. The medication the health care provider is ordering in these settings is written on a prescription form that usually comes as a pad and is filled by a pharmacist at a drugstore (pharmacy) or the hospital. Medication orders can be oral (verbal) or written.

Regardless of the mechanism used for a medication order, the nurse has responsibilities relating to the order to ensure safe administration. The nursing responsibilities include the interpretation of common medication abbreviations, identification of the components of a medication order, selecting the correct medication and dosage, administering the medication by the correct route at the right time to the right client, educating the client regarding the medication, monitoring the client's response to the medication, and documenting the medication administered. **Although the nurse is not the originator of the medication order, it is important to remember the nurse is the point person before the client receives the medication ordered. If a calculation or double check of an order is not done, the nurse who administers the medication shares the liability for the injury, even if the order was incorrect, and is responsible for the medication error.**

Verbal Orders

Usually, medication orders must be written and signed by the prescribing practitioner or directly entered into the computer by the prescriber. Verbal orders are discouraged as a routine policy. Most health care agencies have policies regarding who may accept verbal orders and under what circumstances they can be accepted. Nurses must know the policy of the institution and follow it. However, certain situations or emergencies may require a verbal order that is stated directly in person or by telephone from a licensed physician or another qualified practitioner who is licensed to prescribe. In most health care institutions, the nurse or other authorized personnel can receive a verbal order. Such orders, however, are usually received by the nurse. Verbal orders can be particularly error prone for several reasons, including the order being misheard, poor phone reception, sound-alike drug names, and the nurse assuming the intended order when the order given is incomplete.

Recognizing the errors that can occur with verbal orders and wanting to decrease the potential errors when an oral or telephone order is taken, The Joint Commission (TJC) requires that only "designated qualified staff" may accept verbal or telephone orders. TJC requires that the authorized individual receiving a verbal or telephone order first **write it down** in the patient's chart or enter it into the computer record; second, **read it back** to the prescriber; and then third, **receive confirmation** from the prescriber who gave the order that it is correct. For the nurse to only repeat back the order is not sufficient to prevent errors and is not allowed by TJC. Any questions or concerns relating to the order should be clarified with the prescriber during the conversation. A verbal order must contain the same elements as a written order and be accurate: the date of the order, name and dosage of the medication, route, frequency, any special instructions, and the name of the individual giving the order. TJC advises that in emergency situations, such as a code, doing a formal "read-back" is not feasible, and a "repeat-back" is acceptable to avoid compromising client safety.

It must be noted that it was a verbal or telephone order, and the signature of the nurse taking the order is required. Many institutions require that the order must be signed by the prescriber within 24 hours. Some institutions may require that medication orders written by a person other than a physician be countersigned by designated personnel.

TIPS FOR CLINICAL PRACTICE

It is important to be familiar with specific policies regarding verbal or telephone medication orders and responsibilities in this regard because they vary according to the institution or health care facility.

SAFETY ALERT!

Acceptance of a verbal order is a major responsibility and can lead to medication errors. Accept a verbal order only in an emergency situation. If you accept a verbal order, follow the policy of TJC. Always clarify questions about the order during the conversation. If you are unsure of the medication or the spelling, spell it back to the prescriber and get confirmation. NEVER ASSUME.

Depending on the institution, the medication order may be written on a sheet labeled “physician’s order sheet” or “order sheet.” After the medication order has been written, the nurse or, in some institutions, a trained unit clerk transcribes the order. This means the order is written on the medication administration record (MAR). In an instance in which the nurse does not transcribe the order, the nurse is accountable for what is written and for verifying the order, initialing it, and checking it before administering.

At some institutions, computers are used for processing medication orders. Medication orders are either electronically transmitted or manually entered directly into the computer from an order form. Computerized provider order entry (CPOE) is also referred to as computerized physician order entry, computerized practitioner order entry, and computerized provider order management (CPOM). CPOE systems are used in many institutions to transmit orders electronically. The use of CPOE has decreased the number of medication order errors and has decreased the problems that have been identified from handwritten orders, which has been repeatedly identified as a contributing factor in medication errors. The use of the computer allows immediate transmission of the order to the pharmacy. The computerized medication record can be seen directly on the computer screen or on a printed copy. Medication orders done by computer entry allow the prescriber to make changes if indicated, and the orders are signed by the prescriber with an assigned electronic code. Once the medication is received on the unit, the medication order is implemented and the client receives the medication.

Transcription of Medication Orders

Incorrect transcription of medication orders, misinterpretation of medical abbreviations and symbols, and illegible handwriting have been well documented in the literature as contributing factors to medication errors. The advent of technology for prescribing medications has resulted in medication orders being more legible and a decrease in medication errors. However, there are still some institutions that still have handwritten orders.

Whether a medication order is electronically transmitted or handwritten, the order must be clearly understood to ensure safe administration and prevent errors. Before transcribing an order or preparing a dosage for administration, the nurse must be familiar with reading and interpreting an order. To interpret a medication order, the nurse must know the components of a medication order, the standard abbreviations and symbols used in writing a medication order, as well as those abbreviations and symbols that should not be used. In an effort to prevent errors that occur as a result of misinterpretation of abbreviations and symbols, organizations such as The Joint Commission (TJC) and the Institute for Safe Medication Practices (ISMP) developed a list of abbreviations, symbols, and dose designations that should not be used because they can cause misinterpretation, which results in medication errors. TJC developed a list called the “Do Not Use” List (https://www.jointcommission.org/-/media/tjc/documents/resources/patient-safety-topics/do_not_use_list_6_28_19.pdf? and also Appendix C), and ISMP published a list of Error-Prone Abbreviations, Symbols and Dosage Designations (see Appendix D), which includes the abbreviations and symbols on TJC’s “Do Not Use” List. ISMP has recommended that these abbreviations, symbols, and dose designations be strictly prohibited when communicating medication information, including medication orders. The nurse must have knowledge of error-prone abbreviations, symbols, and dose designations in addition to abbreviations that should not be used to prevent misinterpretation, promote safe medication administration, and

prevent errors with medication orders that can be fatal to the client (QSEN Competency 5-Safety). The nurse therefore must recognize those abbreviations that are error prone and memorize the abbreviations and symbols commonly used in medication administration. The abbreviations include units of measure, route, and frequency for the medication ordered. The common abbreviations and symbols used in medication administration are listed in Tables 10.1 and 10.2.

TABLE 10.1

Symbols and Abbreviations for Units of Measure Used in Medication Administration

Abbreviation/Symbol	Meaning
c, C	cup
g	gram
gtt	drop
kg	kilogram
L	liter
mcg	microgram
mEq*	milliequivalent
mg	milligram
mL	milliliter
oz	ounce
pt	pint
qt	quart
T, tbs	tablespoon
t, tsp	teaspoon

*mEq (milliequivalent) is a drug measure in which electrolytes are measured; it expresses the ionic activity of a medication.

TABLE 10.2

Commonly Used Medication Abbreviations

Abbreviation	Meaning
	before
aa, aa	of each
a.c., ac	before meals
ad lib.	as desired, freely
am, am	morning, before noon
amp	ampule
aq	aqueous, water
b.i.d., bid	twice a day
b.i.w.	twice a week

Abbreviation	Meaning
c̄	with
c, C	cup
cap, caps	capsule
CD	controlled dose
CR	controlled release
dil.	dilute
DS	double strength
EC	enteric coated
elix.	elixir
ER	extended release
fl, fld.	fluid
GT	gastrostomy tube
gtt	drop
h, hr	hour
ID	intradermal
IM	intramuscular
IV	intravenous
IVPB	intravenous piggyback
IVSS	intravenous Soluset
KVO	keep vein open (a very slow infusion rate)
LA	long acting
LOS	length of stay
min	minute
mix	mixture
NAS	intranasal
NG, NGT	nasogastric tube
noc, noct	at night
n.p.o., NPO	nothing by mouth
NS, N/S	normal saline
ODT	orally disintegrating tablet
p̄	after
p.c., pc	after meals

Abbreviation	Meaning
per	through or by
pm, pm	evening, before midnight
p.o.	by mouth, oral
p.r.	by rectum
p.r.n., prn	when necessary/required, as needed
q.	every
q.a.m.	every morning
q.h., qh	every hour
q2h, q4h, q6h,	every 2 hours,
q8h, q12h	every 4 hours, every 6 hours, every 8 hours, every 12 hours
q.i.d., qid	four times a day
q.s.	a sufficient amount/as much as needed
rect	rectum
s^{-}	without
sl, SL	sublingual
sol, soln	solution
s.o.s., SOS	may be repeated once if necessary
SR	sustained release
S&S	swish and swallow
stat, STAT	immediately, at once
subcut	subcutaneous
supp	suppository
susp	suspension
syp, syr	syrup
tab	tablet
t.i.d., tid	three times a day
tr., tinct	tincture
ung., oint	ointment
vag, v	vaginally
XL	long acting
XR	extended release

Note: Abbreviations may be written with or without the use of periods; this does not alter the meaning.

TIPS FOR CLINICAL PRACTICE

The use of abbreviations, acronyms, and symbols in the writing of medication orders can have safety implications, and certain abbreviations can mean more than one thing. Care must be taken to use only abbreviations, acronyms, and symbols that have been approved.

CLINICAL **REASONING**

It is important for you to concentrate on understanding what abbreviations or symbols mean in the context of the order.

Writing a Medication Order

The health care provider writes a medication order on a form called the *physician's order sheet*. Order sheets vary from institution to institution. The order sheet should have the client's name on it. A prescription blank is used to write medication orders for clients who are being discharged from the hospital or are seeing the health care provider in an outpatient facility. Nurses often have to explain these orders to clients so that they understand the dosages and other relevant information relating to their medications to ensure safety.

Components of a Medication Order

When a medication order is written, it must contain the following seven important parts or it is considered invalid or incomplete: (1) client's full name, (2) date and time the order was written, (3) name of the medication, (4) dosage of the medication, (5) route of administration, (6) frequency of administration, and (7) signature of the person writing the order. These parts of the medication order are discussed in detail in the following sections.

SAFETY ALERT!

If any of the components of a medication order are missing, the order is not complete and not a legal medication order. When in doubt, clarify the order with the prescriber.

Client's Full Name

Using the client's full name helps prevent confusion between one client and another, thereby preventing administration of the wrong medication to a client. Many institutions use a nameplate to imprint the client's name and record number on the order sheet; in addition, there is usually a place to indicate allergies. In institutions that use computers, the computer screen may also show identifying information for the client, such as age and known medication allergies.

Date and Time the Order Was Written

The date and time of the order include the month, day, year, and the time the order was written. This will help in determining the start and stop of the medication order. A record of the time the order was written is preferred in many institutions, but omission does not invalidate the order. This same information is required in computer entry of medication orders. In many institutions, the health care provider (or person legally authorized to write a medication order) is required to include the length of time the medication is to be given (e.g., 7 days); or he or she may use the abbreviation LOS (length of stay), which means the client is to receive the medication during the entire stay in the hospital. Even when not written as part of the order, LOS is implied unless stated otherwise. The policy of indicating the length of time a medication is to be given varies from institution to institution. At some institutions, if there is no specified time period for particular medications, it is assumed to be continued until otherwise stopped by the health care provider or a protocol in place for certain medications, such as controlled substances (narcotics). Some medications have automatic stop times according to the facility (e.g., narcotics, certain antibiotics).

Name of the Medication

The medication may be ordered by the generic or brand name (Figure 10.1). To avoid confusion with another medication, the name of the medication should be written clearly and spelled correctly.

Figure 10.1 Rubraca label. Notice the two names. The first, *Rubraca*, is the trade name, identified by the registration symbol®. The name in smaller and different print is *rucaparib*, the generic or official name.

- **Trade name**—The brand name or proprietary name is the name under which a manufacturer markets the medication. The brand or trade name is followed by the registration symbol, ®. The name may be written all in capital letters or may have a combination of capital and lowercase letters. It is generally the largest printed information on the label. The same medication may be made by different drug manufacturers, which assign a trade name to that drug. Therefore a medication can have several trade names. It is important to note that some medications may not have trade names.
- **Generic name**—The proper name, chemical name, or nonproprietary name of the medication. It is a name given by the manufacturer that first created the medication. It is usually designated in lowercase letters or a different typeface. Sometimes the generic name is also placed in parentheses. When a medication label has both the trade name and generic name on the label, the generic name is usually found under the trade name (Figure 10.1). Occasionally, only the generic name will appear on the label (Figure 10.2). Each medication has only one generic name. A medication is licensed under its generic name. **By law, the generic name must appear on all medication labels**. The generic name is also registered with the United States Pharmacopeia (USP). USP is an organization that promotes public health by establishing standards to ensure the quality of medicines and other health care technologies. The name is also recorded with a national listing of medications: the United States Pharmacopeia-National Formulary (USP-NF), a book that includes standards for medications, dosage forms, and drug substances. The letters USP after a generic name on a medication label indicates that the medication complies with the USP standards (see Figure 10.2). This name is not specific to the manufacturer. Therefore a medication label **must** indicate the generic name, and some labels may include a trade name. The prescriber may order medications using the generic name. Information found on a medication label with examples of labels is further discussed in Chapter 12, Reading Medication Labels.

Figure 10.2 Metformin hydrochloride is the generic name on the label. Notice the abbreviation USP that appears after the generic name on the label.

TIPS FOR CLINICAL PRACTICE

Nurses must be familiar with both the generic name and the trade name for a medication. To ensure correct medication identification, nurses should crosscheck trade and generic names as needed with a medication reference.

Checking the names of medications even when they are generic is essential in preventing errors. Some very different medications have similar generic names, such as pyridostigmine bromide (Mestinon), which is used to treat myasthenia gravis, and pyrimethamine (Daraprim), which is used to treat parasitic disorders, such as toxoplasmosis.

When reading the name of a medication, never assume. Sometimes orders may be written with abbreviated medication names. This has been discouraged unless the abbreviation is common and approved. Some abbreviations used for medications can cause confusion with another medication; for example, $MgSO_4$ (intended use: magnesium sulfate) and MSO_4 (intended use: morphine sulfate). These two are cited on TJC's "Do Not Use" List because they have often been mistaken for each other.

For example, the acronym AZT may be used. "AZT 100 mg p.o." (intended medication order zidovudine [Retrovir], 100 mg, which is used for HIV) can be misread as azathioprine (Imuran), an immunosuppressant. The use of acronyms in writing medication orders is not recommended by TJC; the prescriber must write the complete medication name to avoid misinterpretation.

There are many medications on the market that have names that are similar, that look alike, and sound alike but have very different actions. To minimize confusion and the risk of medication errors ISMP published a list of look-alike, sound-alike (LASA) medication names and instituted the use of "tall man" lettering to decrease the confusion between medication names. Both the FDA-approved and the ISMP-recommended tall man (mixed case) letters have been included in this list. "Tall-man" lettering uses mixed-case (capital and lowercase) or enlarged letters, and bolding of sections of the medication name to emphasize differing portions of the medication name from other similar medication names. The list can be viewed on the ISMP website (https://www.ismp.org/sites/default/files/attachments/2017-11/tallmanletters.pdf) and is included in Appendix B of this text.

SAFETY ALERT!

A case of mistaken identity with medications can have tragic results.

Dosage of the Medication

The amount and strength of the medication should be written clearly to avoid confusion. Dosage indicates the amount or weight provided in the form (e.g., per tablet, per milliliter). The dosage includes the strength of the medication with the unit of measurement (e.g., 40 mg).

To avoid misinterpretation, “U,” which stands for units, should not be used when insulin, heparin, or any other medication order that uses units is written. The word *units* should be written out. This would also include “mU” (milliunits). Errors have occurred as a result of confusion of “U” with an “O” in a handwritten order. The abbreviation “U” for units is on TJC’s Official “Do Not Use” List and on ISMP’s List of Error-Prone Abbreviations, Symbols, and Dose Designations.

Example:

subcut stat of Humulin Regular Insulin. The U is almost completely closed and could be misread as 60 units. The word *units* should be written out. The handwritten letters “q.d.,” when used in prescription writing, can be misinterpreted as “q.i.d.” if the period is raised and the tail of the “q” interferes. Example: Lasix 40 mg

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Route of Administration

The route of administration is a very important part of a medication order because medications can be administered by several routes. As already stated, route refers to how a medication is administered or the method of delivery by which the medication enters into the body. Never assume that you know which route is appropriate. Standard and acceptable abbreviations should be used to indicate the route.

Examples:

- p.o. (oral, by mouth)
- ID (intradermal)
- IM (intramuscular)
- IV (intravenous)

SAFETY ALERT!

Administering a medication by a route other than what the form indicates constitutes a medication error. Regardless of the source of an error, if you administer the wrong dosage, or give a medication by a route other than what it is intended for, you have made a medication error and are legally responsible for it.

Time and Frequency of Administration. Standard abbreviations should be used to indicate when and what times a medication is to be administered.

Examples: q.i.d. (four times a day), stat (immediately)

The time intervals at which a medication is administered are determined by the institution, and most health care facilities have routine times for administering medications.

Example: t.i.d. (three times a day) may be 9 am, 1 pm, and 5 pm, or 10 am, 2 pm, and 6 pm

Factors such as the purpose of the medication, medication interactions, absorption of the medication, and side effects should be considered when medication times are scheduled. It is important to realize that when abbreviations such as b.i.d. and t.i.d. are used, the amount you calculate is for one dosage and not for the day's total. The frequency indicates the dosage (amount) of medication given at a single time.

Signature of the Person Writing the Order

For a medication order to be legal, it must be signed by the health care provider. The health care provider writing the order must include his or her signature on the order, and it should be legible. At some institutions, in addition to the signature of the physician or other person licensed to write orders, to ensure legibility the prescriber must stamp the order with a rubber stamp that has his or her name clearly printed on it after an order has been written. Orders that are done by computer entry require a signature created by using an assigned electronic code or electronic signature. In some institutions, depending on the rank of the physician or the person writing the order, an order may have to be co-signed by a senior physician.

Example: Residents or interns and persons other than a physician writing an order must secure the signature of an attending physician.

In addition to the seven required components of a medication order already discussed, any special instructions or parameters for certain medications need to be clearly written.

Examples:

- 1. Hold if blood pressure (BP) is below 100 systolic.
- 2. Administer a half-hour before meals (½ hour a.c.).

Medications ordered as needed or whenever necessary (p.r.n.) should indicate the purpose of administration as well. In addition, a frequency must be written to state the minimum time allowed between dosages. Example: q4h prn.

Examples:

- 1. For chest pain
- 2. Temperature above 101°F
- 3. For blood pressure (BP) greater than 140 systolic and 90 diastolic

In instances in which specific instructions are not stated, nursing judgment must be used to determine whether it is appropriate to administer a medication.

For dosage calculations, the nurse is usually concerned with the medication name, dosage of the medication, route, and time or frequency of administration. This information is necessary in determining a safe and reasonable dosage for a client.

SAFETY ALERT!

Never assume what an order states! Clarify an order when in doubt. If an order is not clear, or if essential components are omitted, it is not a legal order and should not be implemented. The nurse is accountable!

Interpreting a Medication Order

Medication orders should be written following a specific sequence:

- 1. Name of the medication
- 2. The dosage, expressed in standard abbreviations or symbols
- 3. Route
- 4. Frequency

Example:

This order means the prescriber wants the client to receive Colace (name of medication), which is a stool softener, 100 milligrams (dosage) by mouth (route), three times a day (frequency). The use of abbreviations in a medication order is a form of shorthand. For the purpose of interpreting orders, it is important for nurses to commit to memory common medical abbreviations, abbreviations related to the systems of measure, as well as recognizing error-prone abbreviations, symbols, and dosage designations that should not be used. Refer to Tables 10.1 and 10.2 for medical abbreviations and symbols used in medication administration. Be systematic when interpreting the order to avoid an error. The medication order follows a specific sequence when it is written correctly (the name of the medication first, followed by the dosage, route, and frequency); interpret the order in this manner as well; avoid "scrambling the order." Let's look at some medication orders for practice reading and interpreting.

Example 1: Buspar 15 mg po b.i.d.

This order means: Give Buspar 15 milligrams orally (by mouth) two times a day.

Example 2: Procaine Penicillin G 250,000 units IV q6h.

This order means: Give Procaine Penicillin G 250,000 units by intravenous injection every 6 hours.

Example 3: Motrin 400 mg po q6h prn for pain.

This order means: Give Motrin 400 milligrams orally (by mouth) every 6 hours whenever necessary (as required) for pain.

SAFETY ALERT!

p.r.n. must have a frequency that designates the minimum time allowed between doses.

Orders are transcribed in some institutions where unit dose (a system that uses single-unit packages of medications that are dispersed to fill each dose requirement) is used. In some institutions, more transcribing may be necessary because the MAR may have the capacity to be used for only a limited period (e.g., 3 days, 5 days). It is therefore necessary to transcribe orders again at the end of the designated period.

In facilities in which computers are used, the medication order is entered into the computer, and a printout lists the currently ordered medications. The computer is able to scan for information such as medication incompatibilities, safe dosage ranges, recommended administration times, and allergies; it can also indicate when a new order for a medication is required.

Computerized order entry and charting do not eliminate the nurse's responsibility for double-checking medication orders before administering. Nurses need to be aware that the use of certain abbreviations, acronyms, and symbols can cause misinterpretation that may result in the potential for or actual error and cause significant harm to clients.

For the safety of clients and to prevent errors in misinterpretation, prescribers responsible for writing medication orders ***must*** pay attention to what they write; it could save a life. In addition to knowing correct medication notations, those who administer medications must know the safe dosage and be able to recognize discrepancies in a dosage that can sometimes be caused by misinterpretation of an order.

SAFETY ALERT!

Acceptable abbreviations and medical notations are subject to change. Stay abreast of the guidelines and recommendations of TJC, ISMP, and your health care institution regarding acceptable abbreviations and medical notations.

When writing orders, prescribers should avoid nonstandard abbreviations and avoid abbreviations and symbols that have been identified as error prone. It is important to note that CPOE can still result in errors in medication orders. Therefore all forms of communicating medical information, whether a written order or CPOE according to organizations that include ISMP, TJC, and the National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP), should avoid the use of error-prone abbreviations, symbols, and dose designations that have led to medication errors.

SAFETY ALERT!

The consequences of misinterpreting abbreviations, symbols, and dosages may be fatal.

POINTS TO REMEMBER

- • A primary responsibility of the nurse is the safe administration of medications to a client.
- • Interpret medication orders systematically, the way in which they are written (the name of the medication, the dosage, the route, and frequency).
- • The seven components of a medication order are as follows:
    - 1. The full name of the client
    - 2. Date and time the order was written
    - 3. Name of the medication to be administered
    - 4. Dosage of the medication
    - 5. Route of administration
    - 6. Time or frequency of administration
    - 7. Signature of the person writing the order
- • All medication orders must be legible, and standard abbreviations and symbols must be used.
- • Memorize the meaning of common abbreviations and symbols.
- • The nurse needs to be aware of acronyms, symbols, and abbreviations that should not be used. Their use can increase the potential for errors in medication administration.
- • Oral (verbal) orders must be written down, read back to the prescriber, and confirmed with the prescriber that the order is correct.
- • If any of the seven components of a medication order are missing or seem incorrect, the medication order is not legal. Do not assume—clarify the order!
- • If you are in doubt as to the meaning of an order, clarify it with the prescriber before administering.
- • Always crosscheck medications; misidentification can result in a medication error.

PRACTICE PROBLEMS

Interpret the following abbreviations.

- 1. p.c. _____
- 2. h _____
- 3. q12h _____
- 4. b.i.d. _____
- 5. p.r.n. _____

Interpret the following orders. Use either *administer* or *give* at the beginning of the sentence.

- 6. Zidovudine 200 mg p.o. q4h. _____
- 7. Procaine Penicillin G 400,000 units IV q8h. _____
- 8. Gentamicin sulfate 45 mg IVPB q12h. _____
- 9. Regular Humulin insulin 5 units subcut, a.c. at 7:30 am and at bedtime. _____
- 10. Vitamin B_{12} 1,000 mcg IM, every other day. _____
- 11. Prilosec 20 mg p.o. bid. _____
- 12. Tofranil 75 mg p.o. at bedtime. _____
- 13. Restoril 30 mg p.o. at bedtime. _____
- 14. Mylanta 30 mL p.o. q4h p.r.n. _____
- 15. Synthroid 200 mcg p.o. daily. _____
- **Answers on** 163

CHAPTER **REVIEW**

List the seven components of a medication order.

- 1. _____
- 2. _____
- 3. _____
- 4. _____
- 5. _____
- 6. _____
- 7. _____

Write the meaning of the following abbreviations.

- 8. ODT _____
- 9. ad. lib. _____
- 10. subcut _____
- 11.

_____

- 12. a.c. _____
- 13. q.i.d. _____
- 14. b.i.w. _____
- 15. SR _____
- 16. syr _____
- 17. n.p.o. _____
- 18. sl _____

Write the abbreviations for the following:

- 19. after meals _____
- 20. three times a day _____
- 21. intramuscular _____
- 22. every eight hours _____
- 23. suppository _____
- 24. intravenous _____
- 25. may be repeated once if necessary _____
- 26. without _____
- 27. immediately _____
- 28. ointment _____
- 29. milliequivalent _____
- 30. by rectum _____

Interpret the following orders. Use either *administer* or *give* at the beginning of the sentence.

- 31. Methergine 0.2 mg p.o. q4h for 6 doses. _____
- 32. Digoxin 0.125 mg p.o. once a day. _____
- 33. Regular Humulin insulin 14 units subcut daily at 7:30 am. _____
- 34. Demerol 50 mg IM and atropine 0.4 mg IM on call to the operating room. _____
- 35. Ampicillin 500 mg p.o. stat, and then 250 mg p.o. q.i.d. thereafter. _____
- 36. Lasix 40 mg IM stat. _____
- 37. Librium 50 mg p.o. q4h p.r.n. for agitation. _____
- 38. Tylenol 650 mg p.o. q4h p.r.n. for pain. _____
- 39. Mylicon 80 mg p.o. p.c. and bedtime. _____
- 40. Otezla 30 mg p.o. b.i.d. _____
- 41. Nembutal 100 mg p.o. at bedtime p.r.n. _____
- 42. Flomax 0.4 mg p.o. daily. _____
- 43. Dilantin 100 mg p.o. t.i.d. _____
- 44. Minipress 2 mg p.o. b.i.d.; hold for systolic BP less than 120. _____
- 45. Aimovig 70 mg subcut once a month. _____
- 46. Ampicillin 1 g IVPB q6h for 4 doses. _____
- 47. Heparin 5,000 units subcut q12h. _____
- 48. Dilantin susp 200 mg by NGT q am and 300 mg by NGT at bedtime. _____
- 49. Benadryl 50 mg p.o. stat. _____
- 50. Epogen 3,500 units subcut three times a week. _____
- 51. Zofran 8 mg p.o. q12h for 2 days following chemotherapy. _____
- 52. Septra DS 1 tab p.o. daily. _____
- 53. Neomycin ophthalmic ointment 1% in the right eye t.i.d. _____

Indicate whether the statement is True or False.

- 54. The trade name will always be indicated on the medication label. _____

- 55. A medication can have several trade names. _____
- 56. Tall man lettering is used for all medications. _____
- 57. Some medication labels only indicate the generic name on the label. _____

Identify the missing part from the following medication orders. Assume that the date, time, and signature are included on the orders.

- 58. Dicloxacillin 250 mg q.i.d. _____
- 59. Synthroid 0.05 mg p.o. _____
- 60. Nitrofurantoin p.o. q6h for 10 days. _____
- 61. 25 mg p.o. q12h, hold if BP less than 100 systolic. _____
- 62. Solu-Cortef 100 q6h. _____
- 63. Describe what your action would be if the following order was written: Prilosec 20 mg daily. _____

Using the discussion on medication abbreviations, symbols, and acronyms that should not be used, identify the mistake in the following orders and correct each order.

- 64. Inderal20mg p.o. daily. _____
- 65. Lasix 10.0 mg p.o. b.i.d. _____
- 66. Humulin Regular insulin 4U IV stat. _____
- 67. Haldol .5 mg p.o. t.i.d. _____

Answers below and on 164

ANSWERS

Chapter 10

Answers to Practice Problems

- 1. after meals
- 2. hour
- 3. every 12 hours
- 4. twice daily, twice a day
- 5. when necessary/required, as needed
- 6. Give or administer zidovudine 200 milligrams orally (by mouth) every 4 hours.
- 7. Give or administer Procaine Penicillin G 400,000 units by intravenous injection every 8 hours.
- 8. Give or administer gentamicin sulfate 45 milligrams by intravenous piggyback injection every 12 hours.
- 9. Give or administer regular Humulin insulin 5 units by subcutaneous injection before the morning meal at 7:30 am and at bedtime.
- 10. Give or administer vitamin B_{12} 1,000 micrograms by intramuscular injection every other day.
- 11. Give or administer Prilosec 20 milligrams orally (by mouth) twice a day (two times a day).
- 12. Give or administer Tofranil 75 milligrams orally (by mouth) at bedtime.
- 13. Give or administer Restoril 30 milligrams orally (by mouth) at bedtime.
- 14. Give or administer Mylanta 30 milliliters orally (by mouth) every 4 hours when necessary (when required).
- 15. Give or administer Synthroid 200 micrograms orally (by mouth) daily.

Answers to Chapter Review

- 1. name of the client
- 2. date and time the order was written
- 3. name of the medication
- 4. dosage of medication
- 5. route by which medication is to be administered
- 6. time and/or frequency of administration
- 7. signature of the person writing the order
- 8. orally disintegrating tablet

- 9. as desired
- 10. subcutaneous
- 11. with
- 12. before meals
- 13. four times a day
- 14. twice a week
- 15. sustained release
- 16. syrup
- 17. nothing by mouth
- 18. sublingual
- 19. p.c. *or* pc
- 20. t.i.d. *or* tid
- 21. I.M. *or* IM
- 22. q.8.h. *or* q8h
- 23. supp
- 24. I.V. *or* IV
- 25. s.o.s. *or* sos
- 26.

- 27. stat *or* STAT
- 28. ung *or* oint
- 29. mEq
- 30. p.r. *or* pr
- 31. Give or administer Methergine 0.2 milligrams orally (by mouth) every 4 hours for 6 doses.
- 32. Give or administer digoxin 0.125 milligrams orally (by mouth) once a day.
- 33. Give or administer regular Humulin insulin 14 units by subcutaneous injection daily at 7:30 am.
- 34. Give or administer Demerol 50 milligrams by intramuscular injection and atropine 0.4 milligrams by intramuscular injection on call to the operating room.
- 35. Give or administer ampicillin 500 milligrams orally (by mouth) immediately (at once) and then 250 milligrams orally (by mouth) four times a day thereafter.
- 36. Give or administer Lasix 40 milligrams by intramuscular injection immediately (at once).
- 37. Give or administer Librium 50 milligrams orally (by mouth) every 4 hours when necessary (when required) for agitation.
- 38. Give or administer Tylenol 650 milligrams orally (by mouth) every 4 hours when necessary (when required) for pain.
- 39. Give or administer Mylicon 80 milligrams orally (by mouth) after meals and at bedtime.
- 40. Give or administer Otezla 30 milligrams orally (by mouth) twice a day (two times a day).
- 41. Give or administer Nembutal 100 milligrams orally (by mouth) at bedtime when necessary (when required).
- 42. Give or administer Flomax 0.4 milligrams orally (by mouth) daily.
- 43. Give or administer Dilantin 100 milligrams orally (by mouth) three times a day.
- 44. Give or administer Minipress 2 milligrams orally (by mouth) two times a day (twice a day). Hold for systolic blood pressure less than 120.
- 45. Give or administer Aimovig 70 milligrams by subcutaneous injection once a month.
- 46. Give or administer ampicillin 1 gram by intravenous piggyback injection every 6 hours for 4 doses.
- 47. Give or administer heparin 5,000 units by subcutaneous injection every 12 hours.
- 48. Give or administer Dilantin suspension 200 milligrams by nasogastric tube every morning and 300 milligrams by nasogastric tube at bedtime.
- 49. Give or administer Benadryl 50 milligrams orally (by mouth) immediately (at once).
- 50. Give or administer Epogen 3,500 units by subcutaneous injection three times a week.
- 51. Give or administer Zofran 8 milligrams orally (by mouth) every 12 hours for 2 days following chemotherapy.
- 52. Give or administer Septra double-strength 1 tablet orally (by mouth) daily.
- 53. Give or administer neomycin ophthalmic ointment 1% to the right eye three times a day.
- 54. False
- 55. True

- 56. False
- 57. True
- 58. route of administration
- 59. frequency of administration
- 60. dosage of medication (drug)
- 61. name of medication (drug)
- 62. dosage of medication (drug) and route of administration
- 63. Notify the prescriber that the order is incomplete; route is missing from the order; do not administer, order not legal. Never assume.
- 64. Inderal 20 mg p.o. daily. There should be adequate spacing between the medication name, dosage, and unit of measure. Could be misread as 120 mg, which is 6 times the dosage ordered.
- 65. Lasix 10 mg p.o. bid. Trailing zeros could cause dosage to be interpreted as 100 mg, which is 10 times the intended dose.
- 66. Humulin Regular Insulin 4 units IV stat. The abbreviation for units here could be misread as a zero, which could result in 10 times the dose being administered. Write out units.
- 67. Haldol 0.5 mg p.o. tid. Omission of the leading zero before the decimal point could result in the dosage being read as 5 mg, which would be 10 times the dosage ordered.

unknown - Section 25 (Page 173)

Medication Orders

As already discussed, before any medication can be administered or transcribed there must be an order. Health care facilities usually have a special form for recording medication orders. The terms *medication orders* and *doctor's orders* are used interchangeably, and the forms vary from institution to institution. As technology becomes a central component of health care and health care facilities transition to the electronic medical record, handwritten medication order forms are gradually being replaced by computerized provider order entry (CPOE), which is also referred to as computerized physician/practitioner/prescriber order entry. CPOE relates to the process in which the prescriber enters and sends orders (medications and treatments) electronically using a computer application. A medication order, whether handwritten or electronically generated (computer), must have the following components:

- • Client identification information, which includes information such as the client's full name, the client's date of birth, allergies, and other identifying information
- • Name of the medication
- • Dosage of medication
- • Route of administration
- • Frequency of administration and any special instructions related to administration if needed: for example, for moderate pain, hold for apical pulse less than 60
- • Date and time the order was written
- • Signature of the prescriber

Medication Administration Record

Medication administration records (MARs) are legal documents that contain a record of medications a client has received and is currently receiving. MARs may be handwritten (Figure 11.1) or electronically generated (Figure 11.2). In institutions in which handwritten orders are still used, after the medication order has been verified, the order is transcribed to an MAR in a paper format according to the institution policy for transcription of medication orders. The person responsible for transcription of orders to a handwritten MAR depends on the institution. If the order is not transcribed by the nurse, the nurse is still responsible for double-checking the transcription against the prescriber's order to make certain the order is complete and that there are no discrepancies. In institutions where orders are generated electronically, the orders are transcribed to the electronic medication administration record (eMAR) by the computer. Medication orders are viewed and charted on the computer. Even though the system is computerized, the nurse still has the responsibility of verifying the order before administering medications.

Figure 11.1 Handwritten medication administration record (MAR). Note: This MAR is intended to show the basic information that would be included on an MAR.

Figure 11.2 Electronic medication administration record (eMAR). (Used with permission of Epic Systems Corporation.)

There is no standard form for MARs, and they vary from institution to institution. The various MAR forms used at different institutions represent differences in form only. Whether the MAR is electronic or handwritten, it contains the same information indicated on a medication order and specifies

the actual time to administer the medication or the actual time of administration, as well as the essential information (the name of each medication, the dosage, route, and frequency) that is common to all and to their purpose. The MAR is used to determine what medications are ordered and the dosage, route, and time at which each is to be given and is also verified with the prescriber's orders.

Different forms may be used in the home care setting for the charting of medications that are administered. Sample MARs are included in this chapter. As you look at the sample MARs, it is important to locate and identify the information common to all MARs. Your clinical instructor will orient you to actual MARs used in the clinical setting for your clinical experience.

TIPS FOR CLINICAL PRACTICE

Regardless of whether the MAR is handwritten or electronic, the nurse or health care provider uses the record to check the medication order, prepare the correct dosage, and record the medication administered to a client.

Essential Components on a Medication Administration Record

If a handwritten MAR is used, the information on the medication record must be legible and transcribed carefully to avoid errors. In addition to client information (name, date of birth, medical record number, allergies), the following information is necessary on all MARs regardless of the format:

- 1. **Dates**. This information usually includes the date the order was written, the date the medication is to be started (if different from the order date), and when to discontinue it.
- 2. **Medication information.** This includes the medication's full name, the dosage, the route, and the frequency. Abbreviations used on the medication record should be standard abbreviations and follow the guidelines and restrictions of The Joint Commission (TJC), ISMP, and the health care institution.
- 3. **Time of administration.** This will be based on the desired administration ordered by the prescriber, such as t.i.d. and the institution's standard times for scheduled or routine medications. (Thus t.i.d. may mean 9 am, 1 pm, and 5 pm at one institution and 10 am, 2 pm, and 6 pm at another.) A nurse should always become familiar with the hours for medication administration designated by a specific institution as well as the type of time being used (traditional or military time). Many clinical facilities use military time. Medications that are ordered for p.r.n. and one-time dosages are recorded at the time they are administered. Abbreviations for time and frequency should adhere to TJC and ISMP guidelines.
- 4. **Identification of health care professional administering medications.** Most hand-written MARs have a place for initials of the person transcribing the medications to the MAR, and the person administering the medication. The initials are then written under the signature section to identify who gave the medication. Some MARs may request the title as well as the signature of the person. The policy regarding initialing after each administration varies by institution and by the charting system used. See Figure 11.1 for an example. In institutions that use a computerized eMAR, the person uses their own specific code to log into the system, scans the medication, and administers the medication. It is documented as given, and the name is automatically entered.
- 5. **Special instructions (parameters).** Any special instructions relating to a medication should be indicated on the MAR. For example, "Hold if systolic blood pressure is less than 100" or "p.r.n. for moderate pain."

TIPS FOR CLINICAL PRACTICE

The nurse must stay alert to the guidelines of TJC and ISMP regarding abbreviations and medical notations.

Documentation of Medications

Documentation is the sixth “right of medication administration.” Regardless of the format used to document the administration of medications, the documentation must be accurate, and legally all medications administered must be documented. Regardless of whether the handwritten MAR or eMAR is used, documentation should be done immediately after medications are given. Remember, this practice will prevent forgetting to document, which can result in the administration of the medication by another nurse or health care provider who thought the medication was not administered. No documentation can be interpreted as not being administered. Documentation should include not only medications administered but also documentation regarding refusals, delays in administration, and responses to medication administration (including adverse effects). It is important to remember that the type of notation used and where the notation is done for handwritten MARs can vary from one institution to the other. In institutions that use the eMAR, the documentation is done in the computer. The computerized MAR allows the documentation of comments regarding the medication administration at the computer terminal.

SAFETY ALERT!

Document properly and accurately any medications administered to prevent medication errors caused by overmedicating or undermedicating.

Use of Technology in Medication Administration

In an effort to minimize medication errors, many health care facilities have instituted some form of computer-based medication administration. Some of the technology used has already been discussed. Additional technology designed to prevent medication errors includes computer-based drug administration (CBDA), a technological software system. The purpose of the software is to automate the medication administration process and improve accuracy and efficiency in documentation. This system comprises the computerized prescriber order system, the barcode administration system, and the electronic medication administration record (eMAR), and the pharmacy information systems.

Many institutions have moved to CPOE. The CPOE systems are used to transmit orders electronically. Depending on the institution and the sophistication of the software, information such as medication incompatibilities, medication allergies, range of dosages, and recommended medication times may be part of the system. With the computer used to process medication orders, they can be viewed on the computer screen or on a printout. A corresponding MAR is available at some institutions based on the computerized order entry. Software has also been developed that allows for the use of CPOE and clinical decision-making support systems (CDSSs).

A clinical decision support system is also known as a clinical decision support program (CDS program). The CDS systems may be standalone software programs, or they may be integrated into parts of other systems. A definition of the clinical decision support system according to Robert Hayward of the Centre for Health Evidence is: “Clinical decision support systems link health observations with health knowledge to influence health choices by clinicians for improved health care.” In other words, the CDS health information technology provides the physician and other health professions with support to assist in clinical decision-making.

Despite the fact that use of technology such as CPOE has reduced errors associated with medication errors, according to a news release by ISMP (January 24, 2019), “If the conventions used to communicate medication information electronically are not carefully considered, these technologies may contribute to medication errors rather than mitigate risks. Examples of issues with electronic communication that have resulted in medication errors include misinterpretation of symbols, dose designations, and abbreviations; unsafe defaults used to prepopulate fields with missing data (for example, default to number of teaspoons to administer rather than mL); and restricted character spaces or truncated listings that make it impossible to communicate the full name and dose of a medication.” As a result, to improve safety in communicating about medications when working with electronic formats ISMP developed Guidelines for Safe Electronic Communication of Medication Information. These guidelines can be found on the ISMP website: https://www.ismp.org/node/1322 (ISMP Guidelines for Safe Electronic Communication of Medication Information, 2019). The guidelines developed provide specific recommendations relating to the safe presentation of information electronically regarding medications that include medication names, dosages, and weights and measures.

There are many information technology applications for medication safety, and some of them have been discussed in this text (they include computerized physician order entry, automated dispensing cabinets, and barcoding medication system). Technology will continue to grow, and its use will vary from institution to institution. Technology is only one of many tools that can be used to enhance client safety.

Medication Distribution Systems

The medication distribution system varies from one institution to the next. The various distribution systems are discussed in the following sections.

Unit-Dose System

Many institutions use a system of medication administration referred to as a *unit-dose drug dispensing system* (UDDS). This system has decreased medication preparation time because the medications are prepared daily in the pharmacy and sent to the unit. Medications are dispensed by the pharmacy in individual dosages as prescribed. Packages provide a single dosage of medication. The package is labeled with generic and trade names (and sometimes manufacturer, lot number, and expiration date). Depending on the distribution system, the individual packages may be labeled with the client's name and barcode. The medications are placed in a client-identified drawer in a large unit-dose cabinet at the nurse's station.

Unit dose is also used as part of another medication system in some institutions (e.g., a computerized unit-dose medication cart). In the computerized unit-dose system, each dosage for the client is released individually and recorded automatically. This system is used for monitoring controlled substances and other items used in the unit (e.g., medications used by the unit in large volumes). The type of medication form used for this system varies from one institution to another. In some instances, this system has decreased the amount of time spent transcribing orders or eliminated the need for transcription. In some institutions, however, transcription of medication orders to the MAR is still required. The prescriber's orders are therefore written on a separate order sheet and sent to the pharmacy. Figure 11.1 illustrates the transcription of orders to the MAR.

At some institutions the prescriber's order is done by computer entry, eliminating the need for transcription. Figure 11.3 shows a unit-dose cabinet.

Figure 11.3 Unit-dose cabinet. (From Willihnganz M, Gurevitz S, Clayton BD: *Clayton's basic pharmacology for nurses,* ed 18, St Louis, 2020, Elsevier.)

Computer-Controlled Dispensing System

The use of automated dispensing cabinets (ADCs) is on the rise in health care facilities. This system is gaining increased popularity in many institutions and health care facilities. The computer-controlled dispensing system is supplied by the pharmacy daily with stock medications. Controlled substances are also kept in the cart, and the system provides a detailed record indicating which controlled substances were used and by whom. The medication order is received by the pharmacy for the client and then entered into the system. To access medications in this system, the nurse uses a security code and password or biometric fingerprint scan.

The three most common dispensing systems include the Pyxis Med Station system (Figure 11.4), the Omnicell Omni Rx, and the AcuDose-Rx.

Figure 11.4 Pyxis Med Station. (Courtesy and © Becton, Dickinson and Company, Franklin Lakes, NJ.)

The Omnicell system shown in Figure 11.5 is an automated dispesding cabinet (ADC) that assists in providing for a safer process to get the medication to the client as well as in safer medication management. The ADC includes features such as an integrated medication label printer with barcoded labels, the ability to integrate with major advanced electronic health record (EHR) systems, and management of controlled substances (eliminating the need for count-backs at the ADC). The ADC is enhanced by data intelligence; Omnicell Essentials, the cloud-based Essential dashboard, reveals medication inventory and drug diversion issues and points to areas that need attention.

Figure 11.5 Omnicell XT Automated Dispensing Cabinet. (Used with permission of Omnicell, Inc.)

These systems allow storage of items such as vials and premixed IVs and allow nurses to obtain any medications stored in the device for any client and even to override the system in an emergency. However, overrides eliminate verification of medications by the pharmacy, which could result in an error. Currently, almost 90% of all automated dispensing cabinets are linked to pharmacy information systems, thereby decreasing errors by ensuring that the nurse can only access medications for a specific client.

Some institutions have added barcoding to this process during the administration phase of the medication process. At the client's bedside, the nurse uses a handheld scanner that records the barcode on the client's wristband and the unit-dose medication packet, linking this information to the client database. If there is an error, the administration process is halted; if the information is correct, the medication is administered and documentation in the MAR occurs automatically. Literature supports that use of ADCs has reduced medication errors by dispensing the correct medication.

Recognizing the need to guide health care organizations in the safest use of ADCs, ISMP first issued guidelines for the safe use of ADCs in 2009. Following the review of reported errors occurring with the use of ADCs, the guidelines were revised in 2019. The updated guidelines for the safe use of ADCs can be viewed on the ISMP website at https://www.ismp.org/news/ismp-issues-updated-guidelines-safe-use-automated-dispensing-cabinets. The health care provider must still remember the importance of client safety and follow the "Six Rights of Medication Administration" when using technology.

Barcode Medication Delivery

Barcode medication delivery use is increasing in some health care facilities. The basic system of barcoding verifies that a client receives the right dosage of the right medication by the right route at the right time. This system requires that each client wear an ID with a unique barcode to identify the individual. Each medication must therefore have a barcode. Computers installed at the client's bedside and/or handheld devices enable the nurse to scan the barcode on the client's identification band and the medication to be administered. Once the information has been validated to the client and the client's medication profile, the medication given is documented on an online MAR (see Figure 11.6 showing a barcode for unit medication dose, and Figure 11.7 showing a barcode reader). Barcoding is being added to some medication distribution systems as mentioned in the discussions of automated dispensing systems and unit-dose systems. Many pharmacists are using the barcode system to prepare unit-dose medications. Like other systems, barcode systems with additional features are also available. The complexity or simplicity of the barcode system depends on the institution. The barcode medication administration system allows overrides in cases where medications need to be administered in an emergency. However, literature points out that an override bypasses the important step of order verification by the pharmacist.

Figure 11.6 Barcode for unit drug dose. (From Kee JL, Marshall SM, Woods K, Forrester MC: *Clinical calculations: With applications to general and speciality areas,* ed 8, St Louis, 2017, Elsevier.)

Figure 11.7 Barcode reader. (From Kee JL, Marshall SM, Woods K, Forrester MC: *Clinical calculations: With applications to general and speciality areas,* ed 8, St Louis, 2017, Elsevier.)

Role of the Nurse When Using Technology

The use of computer-based technology in medication administration has been identified as one of the best practices to minimize medication errors. The use of computerized systems as a tool for reducing medication errors speaks to two Quality and Safety Education for Nurses (QSEN) competencies: safety to reduce risk of harm to clients and informatics and the use of technology to mitigate errors.

Even though the use of technology in the health care system has proliferated as stated, it is one tool of many that can be used to decrease medication errors. The use of technology tools such as CPOE, eMAR, and the various medication administration systems are not a total safeguard to the elimination of medication errors, and no system is completely without fault. Regardless of the medication system used, the nurse must recognize the importance of safety first and realize that no system eliminates the need for the nurse to follow the standard administration procedures for medication administration, such as verifying all aspects of the medication order and consistent use of the rights of medication administration when administering medications—the right client, right medication, right dosage, right time, right route, and right documentation. When we lose sight of the importance of checks or omit them, errors can occur from skipping steps.

Literature relating to the use of technology in the health care system reinforces the need for proper education of nurses and other health care providers to its proper use to avoid compromising client safety. The institution of technology into medication administration requires a collaborative approach and commitment by all health care providers involved to client safety as the main focus. Any technology implemented in the health care setting should not substitute for knowledge of the health care provider, eliminate critical thinking, nor eliminate the taking of basic safety precautions. With the influx of new medications, varied medication distribution systems, and increasing technology in the health care system, nurses will be presented with new challenges and different types of errors; therefore nurses must be knowledgeable and prepared to meet their responsibilities, remembering client safety is the main focus to prevent harm to the client. The role and responsibilities of the nurse cannot be negated with the use of technology; the role of the nurse is more enhanced by its use.

Scheduling Medication Times

Many health care facilities have routine schedules for administering medications, which vary from one institution to another. Common abbreviations are used for scheduling and prescribing medications. As previously mentioned in this chapter, the nurse must become familiar with the administration schedule used at a specific institution. Table 11.1 shows some examples of commonly used abbreviations in scheduling of medications. The nurse must be knowledgeable about abbreviations prohibited for use by TJC and ISMP related to dosing frequency (QSEN Competency 5, Safety).

TABLE 11.1

Commonly Used Abbreviations for Scheduling Medications

Abbreviation	Meaning
a.c.*	before meals
b.i.d	twice a day
p.c.*	after meals
p.r.n.	as needed (when necessary/required)
q	every
q.h.	every hour
q2h, q3h, q4h	every 2 hours, 3 hours, 4 hours
q6h, q8h, q12h, q24h	every 6 hours, 8 hours, 12 hours, 24 hours
q.i.d.	four times a day
stat	immediately (at once), now
t.i.d.	three times a day

*Based on mealtimes.

Military Time

Many hospitals and health care agencies use military time (international time). Medication orders may include the time of administration in military time when documenting the administration of medications on the MAR. The FDA recommends the use of military time. The nurse therefore

needs to be familiar with how to convert traditional time to military time. Review content relating to converting time between traditional and military in Chapter 8 if necessary.

POINTS TO REMEMBER

- • The system used for medication administration plays a role in determining the type of medication record used and whether transcription of orders is necessary.
- • Regardless of the type of medication record used at an institution, the nurse should know the data that are essential for the medication record and understand the importance of accuracy and clarity on medication orders.
- • Persons transcribing orders should transcribe them in ink and write legibly to avoid medication errors. All essential notations or instructions should be clearly written on the medication record. Notations used should follow TJC and ISMP regulations.
- • Documentation of medications administered should be done promptly, accurately, and only by the person administering them.
- • To avoid errors in administration, always check transcribed orders against the prescriber's orders.
- • The use of technology has reduced medication errors.
- • Nurses need to be aware of the different distribution systems in use.
- • Regardless of the system used, safety is the priority, and the nurse must still use the process in medication administration of verifying the order, administering the medication to the right client, right dosage, right route, right time, and right documentation.
- • A facility may use traditional or military (international) time to designate administration times. The FDA recommends the use of military time.
- • Technology is only one tool of many that can be used for medication safety.

PRACTICE PROBLEMS

- 1. True or False? Illegible prescribers' handwriting is the most common reason for medication errors on handwritten MARs (medication administration records). _____
- 2. True or False? The use of technology is a foolproof method to prevent medication errors. _____
- 3. True or False? Medication administration forms have information that is common to all, regardless of the form used. _____
- 4. "The right _____ must receive the right _____ in the right _____ by the right _____ at the right _____ followed by the right _____."
- 5. The _____ is responsible for the medication administered, regardless of the reason for the error.
- 6. The Pyxis is an example of _____.
- 7. The ability to _____ a system eliminates _____ by the pharmacy, which increases the likelihood of a medication error.
- 8. True or False? All health care institutions document medications using traditional time. _____
- 9. What is the last step in medication administration? _____
- 10. CPOE is an abbreviation for _____.

Refer to the handwritten MAR (Figure 11.1) to answer the following questions.

- 11. How many times a day is furosemide ordered? _____
- 12. Identify the medications and their doses administered at 0900 _____
- 13. K-Dur 10 mEq is ordered. What does mEq mean? _____
- 14. What action must you take before administering Digoxin? _____
- 15. What is the equivalent of the scheduled administration time for K-Dur in traditional time? _____

- 16. True or False? ADC is an abbreviation for Automated Dispensing Cabinets. _____
- 17. The use of technology eliminates the need to use the rights of medication administration. _____

Answers on 178

NGN Case Study

Learning Outcomes:

- 1. Identify the necessary components of a medication administration record (MAR)
- 2. Read an MAR and identify medications that are to be administered on a routine basis, including the name of the medication, the dosage, the route of administration, and the time of administration

Case Scenario: The nurse is working on the medical surgical unit, and the computerized charting system goes down unexpectedly. The hospital has the ability to print out important information from each client's chart during unexpected downtime. The charge nurse hands you a paper copy of the MAR for each of your clients. The nurse checks the MARs to ensure correctness and prepares to administer the morning medications. **Using the MAR provided below, please complete the statements by choosing the *most likely* options for the missing information from the list of options provided.**

Client Name:

Date of Birth:

Medical Record Number:

Allergies:

Date	Medication Dosage, Frequency, and Route	Time Due	Nurse's Initials
10/24/20	Furosemide 40 mg po daily	0900	
	Atorvastatin 10 mg po daily	2100	
	Lisinopril 20 mg po b.i.d. **Hold if SBP less than 90 mm Hg.	0900 B/P 2100 B/P	
	Lantus Insulin 20 units subcut daily	2100	
	Docusate Sodium 100 mg po b.i.d.	0900 2100	

Nurse's Initials	Printed Name	Nurse's Signature

The nurse will give the client the _____1_____. Before giving the Lisinopril the nurse needs to check the client's_____2_____ . After administering the medications, the nurse would _____3_____. The nurse should make certain to also _____ 4_____ .

1	2	3	4
Furosemide, Atorvastatin, Lisinopril, Lantus Insulin, Docusate Sodium	Heart rate to make sure it is greater than 90 beats per minute	Throw the MAR away	Put initials, printed name, and signature at the bottom of the MAR
Furosemide, Lisinopril, Docusate Sodium	Blood pressure to make sure the SBP is less than 90 mm Hg	Document by initialing in the box next to the time for each medication that was administered	Put name on the bottom of the page without initials
Atorvastatin, Lisinopril, Lantus Insulin, Docusate Sodium	Blood pressure to make sure the SBP is greater than 90 mm	Cross off the medication to indicate it was given	Ask the client to initial the form

1 2 3 4

Hg

Reference: Morris D: *Calculate with confidence,* ed 8, St Louis, Elsevier, copyright 2022.

Case Study answers and rationales can be found on Evolve.

CHAPTER REVIEW

- 1. Who determines the medication administration times? _____
- 2. Do b.i.d. and q2h have the same meaning? _____ Explain: _____
- 3. What is the purpose of barcoding? _____
- 4. The abbreviation *eMAR* stands for _____.
- 5. Times for medication administration can be indicated in _____or _____.
- **Refer to the portion of the transcribed MAR provided to answer questions 6-10.**

- 6. What dosage of Neurontin should be administered? _____
- 7. Are any of the medication orders incomplete? If so, which medication and what information is missing? _____
- 8. Indicate the time of day in traditional time that each medication should be given. _____
- 9. Which order(s) contain(s) error-prone abbreviations? How should the order be corrected? _____
- 10. Why are no times listed for Benadryl? _____

Answers on 178

ANSWERS

Chapter 11

Answers to Practice Problems

- 1. True
- 2. False
- 3. True
- 4. client, medication (drug), dosage (dose), route, time, documentation
- 5. nurse
- 6. automated dispensing cabinet (ADC). Sometimes referred to as computer-controlled dispensing system
- 7. override, verification
- 8. False
- 9. documentation
- 10. Computerized prescriber order entry, computerized provider entry, computerized practitioner order entry
- 11. Once a day
- 12. Colace 100 mg, furosemide 40 mg, K-Dur 10 mEq, Digoxin 0.125 mg
- 13. Milliequivalent
- 14. Check the client's apical pulse
- 15. 9:00 am, 5:00 pm
- 16. True
- 17. False

Answers to Chapter Review

- 1. hospital, institution, or health care facility
- 2. No; b.i.d. means the order will be given two times in 24 hours, whereas a q2h order would be given 12 times in 24 hours.
- 3. to ensure dispensing and administration of the correct medication to the right client
- 4. electronic medication administration record
- 5. traditional time, military time (international time)
- 6. 400 mg
- 7. Yes. For Vasotec, the dosage is missing; for heparin, the route is missing.
- 8. Vasotec 10:00 am; Neurontin 10:00 am, 2:00 pm, 6:00 pm; Heparin 10:00 am.
- 9. Vasotec frequency should be stated as every day or daily. Heparin units should be written out and not abbreviated.
- 10. Benadryl is ordered whenever necessary or required (prn). It is not given on a routine schedule and is charted each time it is given, spaced at 6-hour intervals.

unknown - Section 26 (Page 184)

The safe administration of medications to a client includes the nurse accurately reading and identifying key information found on a medication label. The medication label contains information such as the dosage strength that is necessary to perform dosage calculations, as well as information that is essential to clinical practice. The design of a medication label is unique to the drug manufacturer; however, the essential information on a medication label includes the medication name, form, total volume, total amount in container (for solid forms of medication such as tablets and capsules), route of administration, warnings, storage requirements, and manufacturing information. Additional information includes expiration dates, National Drug Code (NDC) number, and, if applicable, reconstitution information and Control Substance Schedule. Some medication labels make reference to a package insert for additional information relating to a medication, which includes information such as contraindications, dosage and administration, and other information that may not be indicated on the label. It is important to read a medication label carefully and recognize essential information to ensure that the client receives the *right medication in the right dosage by the right route*.

SAFETY ALERT!

Always read the label carefully. Reading the label three (3) times will prevent an error in administration of the wrong medication.

Reading Medication Labels

The nurse should be able to recognize the following pertinent information on a medication label.

Generic Name

Every medication has an official name, referred to as the generic name. Medications have only one generic name. A medication is licensed under its generic name. **By law, the generic name must appear on all medication labels.** If there is only one name on the medication label, it is the generic name. The generic name is given by the manufacturer that first develops the medication, but the name is not specific to the manufacturer. It is also recorded with a national listing of medications: the United States Pharmacopeia (USP) and the National Formulary (NF). Prescribers are ordering medications more often by generic name. In many institutions, pharmacists are dispensing medications by generic name to decrease costs. Nurses therefore need to know the generic name as well as the trade name for medications and crosscheck medications to prevent inaccurate medication identification.

On a medication label that has both the trade name and generic name, the generic name is usually found directly under the brand name and sometimes is enclosed in parentheses. Sometimes only the generic name may appear on the medication label or package. This is common for medications that have been used for many years, are well established, and do not require marketing under a different trade name. Examples include atropine and morphine (Figure 12.1A and B). Another example of a medication commonly used in the clinical setting and often seen only with the generic name on the label is Lasix. Lasix is the trade or brand name; however, it is often seen with the generic name only, furosemide (Figure 12.2). Notice on the labels shown in Figures 12.1 and 12.2 the letters *USP* after the generic name. As stated, this is one of the two official listings of medications. The other is *NF*. *USP* after the generic name indicates the medication complies with the USP standards. Do not confuse these abbreviations (letters) with other initials (letters, abbreviations) that designate a special form of a medication, such as CR, which means controlled release.

Figure 12.1 (A) Atropine label (injectable solution). Dosage strength 0.5 mg per 5 mL or 0.1 mg per mL. (B) Morphine sulfate label. Extended-release capsules. The dosage strength is 20 mg per extended-release capsule.

Figure 12.2 Furosemide label. The dosage strength is 20 mg per 2 mL or 10 mg per mL.

SAFETY ALERT!

It is important to avoid confusing official listings (USP or NF) with other initials (letters) or abbreviations on a medication label, which may serve to identify additional medications or specific actions or reactions to a medication. Use caution with medications that have similar spellings.

Trade Name

The trade name is also referred to as the *brand name* or *proprietary name*; it is the manufacturer's name for the medication. The same medication may be made by different manufacturers, which assign a trade name to that medication. Therefore a medication can have multiple trade names. It is important to note that some medications may not have trade names. The trade name is generally the largest printed information on the label, which makes it very prominent. The name may be written all in capital letters or may have a combination of capital and lowercase letters. The trade name is followed by the ®, which is the registration symbol, or ™ for trademark. The registered mark ® means the trade name has been legally registered with the U.S. Patent and Trademark Office (USPTO) by the manufacturer and cannot be used by another company. ™ indicates the name is the trademark for that company. Once the USPTO formally registers the trademark, the symbol ® then appears on the medication label. In Figures 12.3 and 12.4 notice the trade name is listed before the generic name.

Figure 12.3 Xarelto label.

Figure 12.4 Verzenio label.

Figure 12.3 shows the label for Xarelto. Xarelto is the trade name identified by the ® registration symbol. The name underneath in smaller print and enclosed in parentheses, rivaroxaban, is the generic, or official, name of the medication.

Figure 12.4 shows the label for Verzenio. Notice the ™ symbol after the trade name Verzenio. The name underneath in smaller print and enclosed in parentheses, abemaciclib, is the generic or official name.

SAFETY ALERT!

It is important for the nurse to crosscheck all medications, whether just the generic name or both the trade and generic names are indicated on the label to accurately identify a medication. Failure to crosscheck medications could lead to choosing the wrong medication to administer, a violation of the rights of medication administration (the "right" medication).

The Medication Name and Tall Man Lettering

As already stated (in Chapter 10), there are several medications that have names that look alike and sound alike. Remember that even medications with similar names may have markedly different chemical structures and actions. For example, buspirone (BuSpar) is an antianxiety medication, and bupropion (Wellbutrin) is used to treat major depressive disorders. Although the generic names are similar, the action, composition of the medications, and their use are different.

To minimize confusion and the risk of medication errors, the Food and Drug Administration (FDA) requires the "Tall Man" letters be used in generic name pairs that are associated with errors. ISMP also published a recommended list of additional medication names using "Tall Man" lettering. "Tall Man" uses mixed-case (lower- and uppercase) and bolding to emphasize differing portions of the medication name. For example, the two medications discussed using "Tall Man" letters are shown as: bus**PIR**one and bu**PROP**ion. Notice the letters are bolded and capitalized to indicate the differing portions of the name. The FDA and ISMP Lists of Look-Alike Drug Names with Recommended Tall Man Letters can be found in Appendix B. A complete listing of medications written with Tall Man lettering can be found at https://www.ismp.org/sites/default/files/attachments/2017-11/tallmanletters.pdf. There are also some medication labels that indicate the medication name in Tall Man lettering on the label that are found on the Tall Man list, which provides another safety alert for the health care provider. See Figure 12.5A, Dopamine, 12.5B, Dobutamine. These two medications are indicated on the Tall Man list. (**DOP**amine confused with **DOBUT**amine): Notice the use of uppercase lettering and lowercase with the highlighting of a section of the medication names to help distinguish the names from each other.

Figure 12.5 (A) Medication label for DOPamine (injectable solution) with Tall Man lettering. The dosage strength is 200 mg per 5 mL or 40 mg per mL. (B) Medication label for DOBUTamine (injectable solution) label with Tall Man lettering. The dosage strength is 250 mg per 20 mL or 12.5 mg per mL.

Dosage Strength

Dosage strength refers to the weight or amount of the medication provided in a specific unit of measure (e.g., the weight per tablet, capsule, milliliter). The dosage strength is made up of the strength of the medication with the unit of measurement and the dosage form. For solid forms of medications, the dosage strength is the amount of medication per tablet, capsule, etc. For liquid medications (oral and parenteral) the dosage strength is the amount of medication present in a certain amount of solution. See Figure 12.6, Namenda (oral solution), and Figure 12.7, Penicillin V Potassium (oral solution).

Figure 12.6 Namenda label (oral solution). The dosage strength of this oral solution is 2 mg per mL.

Figure 12.7 Penicillin V Potassium label (oral solution). The dosage strength of this oral solution is 250 mg (per 5 mL) or 400,000 units (per 5 mL).

A medication label may identify more than one dosage strength, which allows the nurse to choose any one of the dosage strengths for calculation purposes. (See Figure 12.1A for Atropine; Figure 12.2 for Furosemide; Figure 12.5A for **DOP**amine and 12.5B for **DOBUT**amine.) There are also medication labels that indicate the equivalent unit of measurement on a label such as mcg and mg, which eliminates the need for conversion when calculating a dosage. See Figure 12.8 for Lanoxin and 12.7 for Penicillin V Potassium, which have two different but equivalent dosage strengths shown on the label as well. Sometimes you may see solutions expressed (dosage) as a ratio or percentage. Refer to labels in Figures 12.9 and 12.10. Notice the labels also express the dosage strength in milligrams per milliliters.

Figure 12.8 Lanoxin label. The label indicates 125 mcg (0.125 mg), which means 125 mcg is equivalent to 0.125 mg. The dosage strength is 125 mcg per tablet or 0.125 mg per tablet.

Figure 12.9 Adrenalin label (injectable solution). Adrenalin contains 1 g of medication per 1,000 mL solution (1 : 1,000) and 1 mg per mL.

Figure 12.10 Lidocaine label (injectable solution). Lidocaine 1% contains 1 g of medication per 100 mL of solution and 500 mg per 50 mL or 10 mg per mL.

Refer to the sample labels, which identify the dosage strengths for the medications.

SAFETY ALERT!

The Institute for Safe Medication Practices (ISMP) recommends that the slash mark (/) not be used to separate two doses to indicate “per” because it can be misread and mistaken as the number 1. Use *per* rather than the slash mark. Example: Use 10 mg *per* 5 mL rather than 10 mg/5 mL, which could be misread as 10 mg and 15 mL. This practice will be followed in this text.

SAFETY ALERT!

Always read a medication label carefully to avoid errors and administration of the wrong medication. Medication names can be deceptively similar. Similarity in name does not mean similarity in action. For example, *Inderal* and *Inderide* are similar names, but the action and the contents of the medication are different. Inderal delivers a certain dose of propranolol hydrochloride. Inderide combines two antihypertensive agents (propranolol hydrochloride and hydrochlorothiazide, a diuretic antihypertensive).

Form

The form specifies the type of preparation contained in the package that contains the strength of the medication. Medications are available in a variety of forms.

- • Examples of forms include solid forms such as tablets, capsules, caplets, and suppositories. There are also liquid forms, which include oral solutions and injectable solutions. Solutions may be indicated by milliliters (mL). Some medications are available in powder or as patches. Other forms include inhalants, drops, creams, and ointments.
- • Labels may also indicate abbreviations or words that describe the form of the medication. Examples include *CR* (controlled release), *LA* (long acting), *DS* (double strength), *SR* (sustained release), *XL* (long acting), *ES* (extra strength), and *XR* (extended release). Some labels may use abbreviations such as *EC* (enteric coated) or just indicate enteric coated. These medications should not be crushed. See the label in Figure 12.11A for Ery tablets.

Figure 12.11 (A) Ery Tab Delayed Release Tablet and Enteric Coated. (B) Rabeprazole Sodium Delayed Release Sprinkle Capsules. (C) Xeljanz XR Extended Release Tablets.

- • Abbreviations that describe the form of a medication indicate the medication has been prepared in a way that allows extended action, or slow release, of the active ingredient. Often these medications are given less frequently. Examples include Procardia XL, Inderal LA, Calan SR, and Metformin extended release. These special forms should be swallowed whole and never crushed unless otherwise indicated. Always read labels carefully. Refer to labels in Figure 12.11A–C for samples of medication labels indicating special forms. Notice Figure 12.11B, the label for Rabeprazole Sodium Delayed Release Sprinkle Capsules, indicates they are delayed release and states, "Open capsule and sprinkle contents on liquid or soft food. Do Not crush or chew capsule contents." Also notice label for Ery Tab; the tablets are enteric coated as well as delayed release.

SAFETY ALERT!

Administering the incorrect form of medication is a medication error!

SAFETY ALERT!

Certain forms should not be crushed nor dissolved for use through a nasogastric, gastrostomy, or jejunostomy tube without first consulting a pharmacist or medication guide for information regarding whether a medication can be crushed or altered. Altering oral medications by crushing may result in an alteration of the medication's action and cause unintended outcomes.

Route of Administration

The route of administration describes how the medication is to be administered, or the method of delivery by which the medication enters the body. Common routes include oral, injection (IV, IM, subcut). Examples of other routes include enteral (into the gastrointestinal tract through a tube), ophthalmic, topical (transdermal patches), inhalation, sublingual, and others. When looking at labels for tablets or capsules, the route of administration is not specified on the medication label. It is understood that such solid forms as tablets, capsules, and caplets are administered orally, unless otherwise specified. Any form intended for oral use should be administered orally.

Because all tablets, capsules, and liquids are not always given orally and swallowed, read the label carefully because any variation from oral administration is indicated on the label. Examples include sublingual tablets, otic suspension for use in ears; some capsules are placed in an inhaler and not swallowed. For example, the label for Nitrostat indicates it is administered sublingually (under the tongue) (Figure 12.12A). Another form for sublingual use is sublingual film. For example, Suboxone, which is used to treat opioid dependence, is a sublingual film. The form allows for rapid absorption of medication, which is desired in the treatment of these clients. See Figure 12.12B.

Figure 12.12 (A) Nitrostat label (sublingual). (B) Suboxone (sublingual film).

Liquid medications may be administered orally or by injection. Labels for oral liquid medications as well as for injection will indicate the route. Oral liquids may indicate oral solution, oral suspension. The route may be indicated on the label for injectable medications such as “for IM, subcut or IV” use. See Figures 12.13 to 12.15. Labels will indicate routes for others as well.

Figure 12.13 Ondansetron label (IV and IM).

Figure 12.14 Dilantin-125 label (oral suspension).

Figure 12.15 Trelegy Ellipta label (oral inhalation).

SAFETY ALERT!

The importance of reading a label carefully and identifying the intended route cannot be overemphasized. Medications should only be administered by the route they are intended for. Fatal errors have occurred from administration of medications by the wrong route. Always read the label to determine the route.

Barcoding Symbols

Dating back to 2004, the U.S. Department of Health and Human Services (HHS) required that barcodes be placed on the medication label (human and biological agents). Barcode symbols appear on medication labels as thin and heavy lines arranged in a group. Barcodes are particularly important at institutions where barcoding is used as part of the medication distribution system. Refer to the barcodes indicated on the labels in Figures 12.1 to 12.9. Barcodes can also be used for stock reorder.

Total Volume

On labels of solutions for injections or oral liquids, total volume, as well as dosage strength, is stated. Total volume refers to the quantity contained in a bottle, vial, or ampule. For liquids, total volume refers to the total fluid volume.

There have been documented medication errors caused by misinterpretation of dosage strength and total volume. In 2009 the Food and Drug Administration (FDA) required that single and multidose injectable product labels indicate the dosage strength of a medication per total volume be prominent on the label, followed in close proximity by the dosage strength per mL enclosed in parentheses. Notice the clindamycin label shown in Figure 12.16 indicates 2 mL is the vial size (total volume). The dosage strength is stated for the entire vial (300 mg per 2 mL) and per mL (150 mg per mL). The ondansetron label shown in Figure 12.17 indicates 20 mL is the vial size (total volume). The dosage strength is stated for the entire vial (40 mg per 20 mL) and per mL (2 mg per mL). In Figure 12.18, Namenda, the total volume is 12 fluid ounces (360 mL), and the solution or liquid contains 2 mg per mL (dosage strength).

Figure 12.16 Clindamycin Injectable label.

Figure 12.17 Ondansetron Injectable label.

Figure 12.18 Namenda Oral Solution label.

Total Amount in Container

For solid forms of medication, such as tablets, capsules, and the like, the total amount is the total number of tablets or capsules, or other solid form, in the container. The dosage strength, as well as the total amount in the container, is included on labels of solid forms of medication, such as tablets or capsules. With **unit dose** for a client's ordered medication, the package contains one dose of the medication.

Examples:

- • In Figure 12.1B (Morphine Sulfate Extended-Release Capsules), the total amount of extended-release capsules in the container is 100 extended-release capsules, whereas the dosage strength is 20 mg per extended-release capsule.
- • In Figure 12.3 (Xarelto tablets), the total amount of tablets in the container is 60 tablets, whereas the dosage strength is 2.5 mg per tablet.

SAFETY ALERT!

It is important to recognize the difference between the amount per milliliter and the total volume to avoid confusion and errors. Do not confuse total volume, total amount in container with dosage strength. Confusion of these items can cause a serious medication error.

Directions for Mixing or Reconstituting a Medication

When medication comes in a powdered form, the directions for how to mix or reconstitute it and with what solution are found on the label or package insert. The directions for reconstitution should be followed exactly as directed for accuracy in administration. See the label in Figure 12.19 for directions for reconstituting Levothyroxine Sodium. Reconstitution is discussed further in Chapter 18.

Figure 12.19 Levothyroxine Sodium label (see directions for reconstituting).

Warnings

Medications may come with warnings, alerts, or precautions that are related to safety, effectiveness, or administration considerations and need to be followed. Storage alerts might also be on the label. These precautions, warnings, and alerts may be printed on the label by the manufacturer or added by the pharmacy that dispenses the medication. Always read precautions or special alerts carefully, and follow the instructions given precisely. Examples of precautions, warnings, or alerts on a label may include the following: shake well, protect from light, may be habit forming. For example, refer to the front of the Famotidine label in Figure 12.20 ("Shake well before using, Not for injection"). Notice on the top right side of the label it states, "Keep container tightly closed." Labels may also carry warnings for specific groups of clients. For example, a label may caution that you should find out which other medications may not be taken with the medication (refer to Norvir label, Figure 12.21). Notice the Norvir label also directs the client to store the medicine at room temperature and take with meals.

Figure 12.20 Famotidine label. (Shake well before using. Not for Injection. Keep container tightly closed.) Discard unused suspension after 30 days.

Figure 12.21 Norvir label. (Store at room temperature, take Norvir with meals, find out about medicines that should not be taken with Norvir.)

Expiration Date

Medication labels contain information such as the expiration date (which may be indicated with the abbreviation *Exp*). Expiration dates indicate the last date on which a medication should be used. Typically, the date appears as the month/year. This information can be found on the back or side of a label. Medications requiring reconstitution provide specific expiration instructions. Refer to the Famotidine label in Figure 12.20. Discard unused portion of reconstituted suspension after 30 days (upper right side of label). In the hospital setting, medications that have expired should be returned to the pharmacy. *Note:* Expiration dates must always be checked on medications, and expiration dates are always present on actual prescriptions. The labels shown in this text may not all have expiration dates because they are used solely for educational purposes.

TIPS FOR CLINICAL PRACTICE

It is imperative that nurses check the expiration dates on medications as a routine habit.

SAFETY ALERT!

Remember to always read the expiration date. After the expiration date, the medication may lose its potency or cause adverse or different effects from the intended. Discard expired medications according to agency policy. For some medications, such as narcotics, disposal must be witnessed. Never give expired medications to a client! Clients must be educated in *all* aspects of medication administration, so teach them to check medications for expiration dates, and discard medications that have expired properly. Teach clients about community medication disposal days or days in some communities when they can take unused or expired medications to the police department. Encourage clients not to flush medications down the drainage system.

Dosage and Administration

The dosage and administration portion on a medication label may state wording such as “usual dosage,” “dosage and use,” or “dosage and administration.” This information may be indicated on the label, or it may state to see the package insert for full prescribing information (see Figure 12.1B, Morphine Sulfate Extended-Release Capsules label, “ package insert for prescribing information;” and Figure 12.7, Penicillin V Potassium label (oral solution) label, “Usual Dosage: 250 or 500 mg every 6 to 8 hours. See package insert”).

Single-Dose and Multi-Dose Packaging

This information is indicated on the label for medications used for injection. The label will indicate single-dose or multi-dose vial. See Figure 12.5A, DOPamine label; 12.5B, DOBUTamine label; and Figure 12.13, Ondansetron label. A single-dose container (vial) holds enough medication for a typical single dose. If the single-dose container holds more than the ordered dose, the excess medication is discarded regardless of the volume remaining. A **single-dose** vial does not contain antimicrobial preservatives to minimize bacterial growth once the vial has been used. A **multi-dose** container (vial) contains enough medication for more than one dose and contains a preservative. Single-dose and multi-dose packaging is discussed further in Chapter 17, Parenteral Medications.

Storage Directions—This section of the medication label provides information as to how a medication should be stored to prevent the medication from losing its potency or effectiveness. Usually, information is given on the label relating to temperature for storing the medication. Refer to the Morphine Sulfate Extended-Release Capsules label, Figure 12.1B, and the Dilantin-125 label, Figure 12.14. When medications come in a powdered form and must be reconstituted, storage information is usually indicated on the label telling how long the medication is effective once it has been reconstituted. Refer to the Levothyroxine Sodium label, Figure 12.19, and the Famotidine label, Figure 12.20.

Lot/Control Numbers—Federal law requires that all medication packages be identified by a lot/control number. This number is important in the event that medications have to be recalled.

National Drug Code (NDC) Number—This is a number required by federal law to be given to all medications. Each medication has a unique NDC number. The NDC number consists of NDC followed by three discrete groups of numbers (example: NDC 0074-3333-30 for Norvir, Figure 12.21).

Manufacturer's Name—All medication labels will indicate the name of the company that manufactured the medication (examples: Pfizer, Parke-Davis, or Teva). Abbvie is the manufacturer's name on the Norvir label in Figure 12.21. This information can be valuable if you have questions about the medication. Refer to the various medication labels provided in the chapter. It is important to not confuse the manufacturer's name with the name of the medication.

Abbreviations such as USP (United States Pharmacopoeia) and NF (National Formulary)—USP and NF are the two official national lists of approved medications. Special guidelines are given to the manufacturer related to use and placement of these initials on medication labels. On the Adrenalin label in Figure 12.9, notice that USP follows Epinephrine Injection. Notice the placement of USP on the lidocaine label (see Figure 12.10).

Controlled Substance Schedule

Controlled substances are medications or therapeutic agents with the potential for abuse and addiction and are regulated by state and federal laws. Controlled substances are regulated under the Controlled Substance Act (CSA). Medications considered controlled substances are classified into schedules that rank them according to their abuse potential and physical and psychological dependence. They are ranked from Schedule I to Schedule V. Medications that have the highest abuse potential are Schedule I, and medications with the lowest or limited abuse potential are Schedule V. Controlled substances are indicated on a medication label with a large "C," indicating the medication is a controlled substance, and a Roman numeral (uppercase) to identify the schedule number (I-V) the medication is classified under, inserted in the center of the letter "C." Refer to the label for Morphine Sulfate Extended-Release capsules in Figure 12.1B, which indicates morphine is Schedule II (notice the letter "C" with II).

Combination Medications

A combination medication is a combination of two or more medications that are in one form. The label indicates the dosage strength for each medication. Combination medications are sometimes ordered by the number of tablets, capsules, or milliliters to be administered rather than by the dosage strength. Combined medications such as Sinemet (trade name) are used in the treatment of Parkinson's disease, come in several dosage strengths, and cannot be ordered without a specific dosage; the number of tablets alone is insufficient to fill the order. **It must include the dosage strength!** Example: Sinemet 25 mg/100 mg 1 tab po t.i.d.

- Example 1: The label for Sinemet indicates that the medication contains carbidopa and levodopa. The first number specifies the amount of carbidopa, and the second number represents the amount of levodopa. This is further indicated on the label. See the label for Sinemet in Figure 12.22.

Figure 12.22 Sinemet 25 mg/100 mg label. The dosage strength of carbidopa is 25 mg, and levodopa is 100 mg.

- Example 2: Percocet, which is used to treat moderate to severe pain, is a combination of oxycodone (narcotic pain reliever) and acetaminophen (Tylenol, non-narcotic pain reliever). The medication comes in varying strengths of oxycodone (2.5 mg to 10 mg) and acetaminophen (325 mg to 650 mg). Orders for this medication must specify the dosage strength. Example: Percocet 2.5 mg/325 mg 1-2 tabs po q6h prn for pain. See the label for Percocet in Figure 12.23.

Figure 12.23 Percocet 2.5 mg/325 mg label. The label indicates the dosage strength of oxycodone hydrochloride as 2.5 mg and acetaminophen (Tylenol) is 325 mg.

- Example 3: Septra, an antibacterial, is also manufactured under the trade name Bactrim, which is a combination of trimethoprim and sulfamethoxazole. For example, a Septra (Bactrim) tablet contains 80 mg of trimethoprim and 400 mg of sulfamethoxazole. DS (double-strength) Septra (Bactrim) contains 160 mg of trimethoprim and 800 mg of sulfamethoxazole. See the label for Bactrim DS in Figure 12.24. Since Bactrim DS is available in one strength, it can be ordered by the number of tablets. **Example:** Bactrim DS 1 tab po q12h for 14 days. See label for Bactrim in Figure 12.24. Note this same order written with medications in their generic name would specify the dosage strength for each medication: for example, sulfamethoxazole/trimethoprim 800 mg/160 mg 1 tab po q12h for 14 days.

Figure 12.24 Bactrim DS 800 mg/160 mg label. The label indicates the dosage strength of sulfamethoxazole as 800 mg and trimethoprim is 160 mg.

- Example 4: Biktarvy is a fixed combination of three (3) medications used to treat HIV type-1 (HIV-1). Biktarvy contains ictegravir, emtricitabine, and tenofovir alafenamide. The first number specifies the amount of bictegravir, the second number represents the amount of emtricitabine, and the third number represents the amount of tenofovir alafenamide. This is also indicated on the label. The medication is ordered by the number of tablets. Example: Biktarvy 1 tab po daily. See the label for Biktarvy in Figure 12.25.

Figure 12.25 Biktarvy 50 mg/200 mg/25 mg label. The dosage strength of bictegravir is 50 mg, 200 mg is the dosage strength of emtricitabine, and 25 mg is the dosage strength of tenofovir alafenamide.

Although tablets and capsules that contain more than one medication are often ordered by the brand name and the number of tablets or capsules to be given (e.g., Bactrim DS 1 tab po q12h), the health care provider may order this medication by another route (e.g., intravenous [IV]). The injectable form, which is for IV infusion, is available in the generic name (see the IV label in Figure 12.26). With the IV order, the nurse calculates the dosage to be given based on the dosage strength of the trimethoprim. The nurse would learn such information described by using appropriate resources, such as a reference medication book (*Physician's Desk Reference [PDR]*), pharmacist, hospital formulary, and available information technology.

Figure 12.26 IV label for Sulfamethoxazole and Trimethoprim. Notice the dosage strength is stated for both medications per total volume of the vial, and directly next to it is the dosage strength for each medication per mL. (Calculation of ordered dosages is based on the Trimethoprim).

SAFETY ALERT!

The numbers following a medication name may be used to identify the dosage strengths of more than one medication in a preparation, and initials may be used to identify a special medication action. Read labels carefully to validate that you have the right medication and dosage for combined medications.

Black Box Warning

The Food and Drug Administration (FDA) mandates that certain prescription medications contain a black box warning. This warning is designed to call attention to serious adverse effects that may cause serious injury or death. The alert or warning is outlined with a black box on the medication label with the text inside describing the serious adverse effects. In order for the FDA to require a black box warning label, the confirmation of the potential adverse effects of the medication is done through research and/or clinical data. In addition to the black box warning appearing on the prescription medication's label, it can also be found on the medication package insert, the FDA website, and on the web page of the drug company, if they have a website. Figure 12.27 shows the black box warning for Vraylar (used to treat schizophrenia and bipolar disorder). Refer to the Latuda label in Figure 12.28; notice the statement that refers to giving the patient the accompanying medication guide each time Latuda is dispensed. The guide being referred to provides more information regarding the adverse effects of the medication. Notice Figure 12.30 on p. 195, an excerpt of the prescribing information for Zyprexa, which also shows a black box warning.

Figure 12.27 Black box warning for Vraylar.

Figure 12.28 Latuda label.

Figure 12.30 Prescribing information for Zyprexa, including a black box warning.

Unit-Dose Packaging

Unit-dose packaging is a method by which the pharmacist prepares and packages a client's ordered medication into a single-unit package that provides enough medication for one dose. The unit-dose system decreases errors associated with administration of medications and decreases the need for large amounts of medications on the unit. Figure 12.29 shows examples of unit-dose packaging.

Figure 12.29 Unit-dose packages. (From Willihnganz, M, Gurevitz SL, Clayton BD: *Clayton's basic pharmacology for nurses,* ed 18, St Louis, 2020, Elsevier.)

Medication Information

To decrease errors and manage the risks of medications and adverse medication effects, the U.S. Food and Drug Administration (FDA) mandates the format in which medication information is provided on Prescription Medication Package Inserts. Since 2016, the FDA has mandated the new format for package inserts, which includes categories such as the highlights of prescribing information, boxed warning, recent major changes, indications and usage, and adverse reactions, which includes the following statement under the section, "To report SUSPECTED ADVERSE REACTIONS, contact (Manufacturer) at (phone # and Web address) or FDA at 1-800-FDA-1088 or www.fda.gov/medwatch." See Figure for an excerpt from the prescribing information for the medication Zyprexa (olanzapine).

Over-the-Counter (OTC) Labels

Over-the-Counter (OTC) medicines are medications that a client can purchase without a prescription. The FDA requirements regarding the format for OTC include Medication Facts (the name of the medication and its purpose), uses of the medication, warnings, and directions of how to take the medication. The information is found on the packaging itself (Figure 12.31, OTC label for Aleve). The OTC label is presented in a simpler format than the format for prescription medications.

Figure 12.31 OTC label for Aleve.

To safely administer medications, it is critical that the nurse be able to identify information on the medication label that is required for calculations and administration of the right medication in the right dosage. Remember that cross-checking medication names prevents errors. Use appropriate resources to verify needed information, and question discrepancies before administering.

The amount of information found on a medication label varies; however, some information is consistent on all labels and includes name of medication, dosage, amount in the package, manufacturer's name, expiration date, and lot/control number.

Encourage clients to carefully read the information relating to medications they are taking. Prescription drug information is accessible on DailyMed, an interagency online health information clearinghouse created cooperatively by the FDA and the National Library of Medicine (NLM), available at http://dailymed.nlm.nih.gov. Clients should be made aware of this resource.

POINTS TO REMEMBER

- • Read medication labels three times.
- • Identify directions for mixing when indicated.
- • Read labels carefully, and do not confuse medication names; they are often deceptively similar. When in doubt, check appropriate resources, such as a reference book or the hospital pharmacist. Always cross-reference medication names to avoid administering the wrong medication.
- • Read the label on combined medications carefully to ascertain whether you are administering the correct medication dosage.
- • Extra abbreviations or initials after a medication name may identify additional medications in the preparation or a special action.
- • Read labels carefully to identify trade and generic names, dosage strength, form, total amount in container, total volume, and route of administration.
- • Do not confuse special forms such as SR (sustained release) and XL (extended release) with USP and NF official listing for medications.
- • A single-dose vial typically holds one medication dose and does not have a preservative. A vial labeled "single dose" indicates the vial should be discarded after the ordered dose of medication is withdrawn, regardless of the volume remaining.
- • A multi-dose vial contains a preservative and may be used to administer multiple doses of a medication.
- • The black box warning is required by the FDA on certain medications. The black box warning that appears on a prescription medication's label is designed to alert the consumer to the adverse effects of a medication that carry a risk for serious injury or death.
- • Dosage and administration may be stated on a label or indicate refer to package insert.
- • Unit dose packages for a client's ordered medication contains enough medication for one dose.
- • Tall Man lettering is used to distinguish the name of a medication from another medication with a similar name.
- • Read directions relating to storage.
- • Carefully read alerts on medication labels.
- • Do not administer expired medications.
- • Controlled medication labels indicate the potential for abuse and are ranked Schedule I to Schedule V.
- • When writing dosages, ISMP recommends using *per* instead of a slash (/) because of misinterpretation and being mistaken as the number *1*.
- • Administering the incorrect form of a medication is a medication error.
- • Be certain that you administer the right medication.

PRACTICE **PROBLEMS**

Use the labels to identify the information requested.

- 1. The label shown is an example of a label for _____
- 2. The medication name on the label is generic and/or trade name _____

- 3. Choose the information that is listed on the label.
  - a. Multi-dose vial
  - b. Tall Man lettering
  - c. IV use
  - d. Trade name
  - e. Controlled substance schedule
  - f. Dosage strength 200 mg per 5 mL, 40 mg per mL
  - g. Total volume is 5 mL

- 4. Trade name _____
- Generic name _____
- Form _____
- Dosage strength _____
- Total amount in container _____
- Controlled substance schedule _____
- Pharmacist directions _____

- 5. Trade name _____
- Generic name _____
- Form _____
- Dosage strength _____
- Total amount in container _____

- 6. Trade name _____
- Generic name _____
- Dosage strength _____
- Total amount in container _____
- Storage _____

- 7. Trade name _____
- Generic name _____
- NDC number _____
- Form _____

- 8. Trade name _____
- Generic name _____
- Form _____
- Dosage strength when constituted _____
- Directions before use _____

Answers on 213

CHAPTER **REVIEW**

Read the label, and identify the information requested.

- 1. Trade name _____
- Generic name _____
- Total amount in container _____
- Form _____
- Dosage strength _____

-

- 2. Trade name _____
- Generic name _____
- NDC number _____
- Form _____
- Dosage strength _____
- Total volume _____

- 3. Trade name _____
- Generic name _____
- Storage conditions _____
- Form _____
- Dosage strength _____
- Total amount in container _____

- 4. Trade name _____
- Generic name _____
- Directions for use _____
- Form _____
- Dosage strength _____

- 5. Generic name _____
- Form _____
- Dosage strength _____
- Total amount in container _____
- Can this medication be crushed? _____

- 6. Trade name _____
- Generic name _____
- Form _____
- Dosage strength _____
- Total amount in container _____
- Administration directions _____
- Directions for use _____

- 7. Trade name _____
- Generic name _____
- Form _____
- Dosage strength _____
- Directions to dispenser _____

- 8. Trade name _____
- Generic name _____
- Dosage strength _____
- Directions for use _____
- Total volume _____
- Is Tall Man lettering used on the label? _____

- 9. Trade name _____
- Generic name _____
- Form _____
- Dosage strength _____
- Type of vial _____
- Dosage and administration _____
- Directions for use _____

- 10. Generic name _____
- Form _____
- Dosage strength _____
- Total volume _____
- Controlled substance schedule _____
- Directions for dispensing _____
- How long is the opened bottle good for? _____
- Directions for administration _____

- 11. Trade name _____
- Generic name _____
- Dosage strength _____

- Total volume _____
- Directions for use _____

- 12. Trade name _____
- Generic name _____
- Form _____
- Dosage strength _____
- Total amount in container _____
- Directions for use _____
- Controlled substance schedule _____

-

- 13. Form _____
- NDC number _____
- Directions for use _____
- Controlled substance schedule _____

- 14. Trade name _____
- Generic name _____
- Form _____
- Dosage strength _____
- Total amount in container _____
- Directions to pharmacist _____

-

- 15. Generic name _____
- Form _____
- Dosage strength _____

- Directions for dispensing _____

- 16. Generic name _____
- Form _____
- Dosage strength _____
- Total volume _____
- Directions for use _____

-

- 17. Form _____
- Dosage of fentanyl in each transdermal system _____
- For what time period is 12 mcg per hour of fentanyl delivered? _____
- Directions for use _____
- Is there a black box warning on the label? _____
- Controlled substance schedule _____

- 18. Trade name _____
- Generic name _____
- Form _____
- Dosage strength _____
- Directions for use

-

- 19. This medication is an example of _____
- This medicine contains _____ of oxycodone and _____ of _____
- Controlled substance schedule _____
- Usual dosage _____
- Directions to pharmacist _____

- 20. The dosage strength of this medication expressed as a percentage is _____
- 21. The dosage strength of this medication in mg per mL is _____

- 22. Trade name _____
- Generic name _____
- Form _____
- Dosage strength _____
- Administration directions _____
- How long can the medication be stored after opening? _____

- 23. Trade name _____
- Generic name _____
- Form _____
- Dosage strength _____
- Total amount in container _____
- Usual dosage _____

- 24. Generic name _____
- Form _____
- Dosage strength _____
- Directions for administration _____

- 25. Generic name _____
- Dosage strength _____
- Form _____
- Directions for use _____
- Drug manufacturer _____

Answers on pp. 213-215

ANSWERS

Chapter 12

Answers to Practice Problems

- 1. Combination medication
- 2. Generic and trade name
- 3.
    - b. Tall Man lettering
    - c. IV use
    - f. Dosage strength 200 mg per 5 mL; 40 mg per mL
    - g. Total volume is 5 mL
- 4. Trade name: no trade name stated
- Generic name: clorazepate dipotassium
- Form: tablets
- Dosage strength: 3.75 mg per tablet (tab)
- Total amount in container: 100 tablets
- Controlled substance schedule: 4, IV
- Pharmacist instructions: Dispense the accompanying medication guide to each patient.
- 5. Trade name: Coreg CR
- Generic name: carvedilol phosphate
- Form: extended-release capsules
- Dosage strength: 10 mg per extended-release capsule
- Total amount in container: 30 extended-release capsules
- 6. Trade name: Gleevec
- Generic name: imatinib mesylate
- Dosage strength: 400 mg per tablet (tab)
- Total amount in container: 30 tablets (tabs)
- Storage: Store at 25°C (77°F) excursions permitted to 15°C–30°C (59°F–86°F).
- Controlled room temperature. Protect from moisture.
- 7. Trade name: none stated
- Generic name: ondansetron
- NDC number: 63304-347-30
- Form: orally disintegrating tablets (tabs)
- 8. Trade name: none stated
- Generic name: cefdinir

- Form: powder; oral suspension when reconstituted
- Dosage strength when reconstituted: 125 mg per 5 mL
- Total volume when mixed: 60 mL
- Directions before use: shake well

Answers to Chapter Review

- 1. Trade name: no trade name stated
- Generic name: paricalcitol
- Total amount in container 90 capsules (caps)
- Form: capsules (caps)
- Dosage strength: 1 mcg per capsule (cap)
- 2. Trade name: no trade name stated
- Generic name: digoxin
- NDC number: 0641-6184-01
- Form: Injectable solution (liquid)
- Dosage strength: 500 mcg per 2 mL, 0.5 mg per 2 mL, 250 mcg per mL
- Total volume: 2 mL
- 3. Trade name: no trade name stated
- Generic name: levothyroxine sodium
- Storage conditions: 20-25°C (68-77°F) with excursions between 15-30°C (59-86°F)
- Form: tablets (tabs)
- Dosage strength: 50 mcg per tablet (tab), 0.05 mg per tablet (tab)
- Total amount in container: 100 tablets (tabs)
- 4. Trade name: Qbrexza
- Generic name: glycopyrronium
- Directions for use: For Topical Use Only. Wipe cloth across one entire underarm one time. A single cloth should be used to apply Qbrexza to both underarms. See package insert for more information.
- Form: cloth
- Dosage strength: 2.8 g of solution per cloth
- 5. Generic name: rabeprazole sodium
- Form: Delayed release sprinkle capsules
- Dosage strength: 10 mg per delayed release sprinkle capsule (cap)
- Total amount in container: 30 delayed release sprinkle capsules (caps)
- Can this medication be crushed? No (label indicates do not crush or chew capsule contents)
- 6. Trade name: Bosulif
- Generic name: bosutinib
- Form: tablet (tab)
- Dosage strength: 100 mg per tablet (tab)
- Total amount in container: 120 tablets (tabs)
- Administration directions: Do not crush or cut tablet.
- Directions for use: For oncology use only
- 7. Trade name: Truvada
- Generic name: emtricitabine and tenofovir disoproxil fumarate
- Form: tablets (tabs)
- Dosage strength: 200 mg of emtricitabine and 300 mg of tenofovir disoproxil fumarate
- Directions to dispenser: Each time Truvada is dispensed, give the patient the attached medication guide.
- 8. Trade name: Depo-Provera
- Generic name: medroxyprogesterone acetate
- Dosage strength: 1,000 mg per 2.5 mL, 400 mg per mL
- Directions for use: For IM use only
- Total volume: 2.5 mL
- Is Tall Man lettering used on the label? Yes, it is used in the generic name (medroxyPROGESTERone acetate)
- 9. Trade name: Zulresso
- Generic name: brexanolone
- Form: injectable solution (liquid)
- Dosage strength: 100 mg per 20 mL, 5 mg per mL
- Type of vial: Single-dose vial
- Dosage and administration: See full Prescribing Information
- Directions for use: For intravenous infusion after dilution

- 10. Generic name: lorazepam
- Form: Oral concentrate
- Dosage strength: 2 mg per mL
- Total volume: 30 mL
- Controlled substance schedule: 4, IV
- Directions for dispensing: Dispense only in this bottle and only with the calibrated dropper provided.
- How long is the opened bottle good for? 90 days
- Directions for administration: Fill dropper to the level of the prescribed dose. For ease of administration, add dose to approximately 30 mL (1 fl oz) or more of juice or other liquid. May also be added to applesauce, pudding, or other semi-solid foods. The drug-food mixture should be used immediately and not stored for future use. Return dropper to bottle after use.
- 11. Trade name: Epogen
- Generic name: epoetin alfa
- Dosage strength: 4,000 units per mL
- Total volume: 1 mL
- Directions for use: For intravenous or subcutaneous use only
- 12. Trade name: Oxycontin
- Generic name: oxycodone hydrochloride
- Form: extended-release tablets (tabs)
- Dosage strength: 80 mg per extended-release tablet (tab)
- Total amount in container: 100 extended-release tablets (tabs)
- Directions for use: For use in opioid-tolerant patients only
- Controlled substance schedule: 2, II
- 13. Form: Rectal gel
- NDC number: 68682-652-20
- Directions for use: For rectal administration only
- Controlled substance schedule: 4, IV
- 14. Trade name: no trade name stated
- Generic name: metformin hydrochloride
- Form: extended-release tablets (tabs)
- Dosage strength: 500 mg per extended-release tablet (tab)
- Total amount in container: 100 extended-release tablets (tabs)
- Directions to pharmacist: Dispense with a patient information leaflet.
- 15. Generic name: sertraline hydrochloride
- Form: tablets (tabs)
- Dosage strength: 25 mg per tablet (tab)
- Directions for dispensing: Always dispense with medication guide
- 16. Generic name: bumetanide
- Form: injectable solution (liquid)
- Dosage strength: 1 mg per 4 mL, 0.25 mg per mL
- Total volume: 4 mL
- Directions for use: Intravenous or intramuscular use
- 17. Form: Transdermal patch
- Dosage of fentanyl in each transdermal system: 1.375 mg of fentanyl per transdermal system
- For what time period is 12 mcg per hour of fentanyl delivered? 72 hours
- Directions for use: For opioid-tolerant patients only
- Is there a black box warning on the label? Yes
- Controlled substance schedule: 2, II
- 18. Trade name: Ilumya
- Generic name: tildrakizumab-asmn
- Form: injectable solution (liquid)
- Dosage strength: 100 mg per mL
- Directions for use: For subcutaneous use only
- 19. This medication is an example of a combined medication.
- This medication contains 4.8355 mg of oxycodone and 325 mg Aspirin
- Controlled substance schedule: 2, II
- Usual dosage: See package insert for complete prescribing information.
- Directions to pharmacist: Dispense the medication guide provided separately to each patient.
- 20. The dosage strength of this medication expressed as a percentage is: 10%
- 21. The dosage strength of this medication in mg per mL is: 100 mg per mL

- 22. Trade name: Pradaxa
- Generic name: dabigatran etexilate
- Form: capsule (cap)
- Dosage strength: 110 mg per capsule (cap)
- Administration directions: Swallow capsule whole.
- How long can the medication be stored after opening? 4 months
- 23. Trade name: Xofluza
- Generic name: baloxavir marboxil
- Form: tablets (tabs)
- Dosage strength: 20 mg per tablet (tab)
- Total amount in container: 2 tablets (tabs)
- Usual dosage: Take both tablets in this package as a single, one-time dose.
- 24. Generic name: dimethyl fumarate
- Form: delayed-release capsules (caps)
- Dosage strength: 240 mg per delayed-release capsule (cap)
- Directions for administration: Swallow capsule whole.
- 25. Generic name: denosumab
- Dosage strength: 60 mg per mL
- Form: injectable solution (liquid)
- Directions for use: For subcutaneous use only
- Drug manufacturer: Amgen

unknown - Section 27 (Page 202)

Several methods are used for calculating dosages. The most common methods are *ratio and proportion* and use of the *formula*. Regardless of the method used the nurse **must** be able to calculate a dose correctly when required to administer medications safely. For the nurse to safely and accurately calculate a dosage, the nurse must demonstrate the ability to utilize a mathematical method that enables the logical set-up of the calculation; solve the problem; and identify whether an answer is rational, applying the principles learned for medication administration. This text covers the various calculation methods (*ratio and proportion, formula, and dimensional analysis*) over the next three (3) chapters. After the various methods have been presented, students can choose the method they find easiest and most logical to use. First, let's discuss calculating using the method of ratio and proportion. If necessary, review Chapter 3 on ratio and proportion.

Use of Ratio and Proportion in Dosage Calculation

When you know three of the four values of a proportion, you can solve the proportion to determine the unknown quantity. In dosage calculation, it is oft en necessary to find only one unknown quantity. As you recall from Chapter 3 (*ratio and proportion*), the proportion can be set up using colons (ratio format). A ratio set up using colons (:) is referred to as the linear format. The colons are used to show the relationship between two numbers. The fraction method can also be used. The fractional ratio and proportion method compares two equivalent fractions. Recall that a proportion is a relationship comparing two ratios. In addition to solving for the unknown quantity, it is essential to also be competent in setting up the proportion correctly.

SAFETY ALERT!

If you set up the proportion incorrectly, you could calculate the dose incorrectly and administer the wrong dose, which could have serious consequences for the client.

Let's look at using ratio and proportion to calculate dosages using the linear format and the fraction format. For example, suppose you had a medication with a dosage strength of 50 mg per 1 mL, and the prescriber ordered a dosage of 25 mg. A ratio and proportion may be used to determine how many milliliters to administer. Remember to include units of measure when writing a ratio and proportion to avoid errors.

Linear Format

When the ratio and proportion are written using colons (ratio format), this can be written in a linear format. The first ratio is termed the *known ratio*; this information is what you have available, or the information from the medication label, and is stated first. The second ratio is the *unknown ratio* and is stated second. It contains the ordered dose and the unknown quantity, which is represented by *x*.

- Example 1: 50 mg : 1 mL = 25 mg : *x* mL
- (*known ratio*) (*unknown ratio*)
- Solution: 50 mg : 1 mL = 25 mg : *x* mL
- (known) (unknown)
- 50*x* = product of extremes
- 25 = product of means
- 50*x* = 25 is the equation

50x50=2550

(Divide both sides by 50, the number in front of *x*.)

- $x = 0.5$ mL

Fraction Format

When you are setting up the ratio and proportion using the fraction format, the *known ratio* is what you have available, or the information from the medication label, and is stated first (placed on the left side of the proportion). The desired, or what is ordered to be administered, is the *unknown ratio* (placed on the right side). The ordered dose and the unknown quantity is represented by *x*. Therefore, using the example, the ratio and proportion would be stated as follows:

- Example 1:

  $$\frac{50\text{mg}}{1\text{mL}} = \frac{25\text{mg}}{x\text{mL}} \quad \text{(known ratio)} \quad \text{(unknown ratio)}$$

- Solution: To solve for *x*, use the principles presented in Chapter 3 on ratio and (fraction format) proportion. (The fraction format is solved by cross-multiplication.)

  $$\frac{50\text{mg}}{1\text{mL}} = \frac{25\text{mg}}{x\text{mL}} \quad \text{(known)} \quad \text{(unknown)}$$

  $$50x = 50 \quad 50x = 0.5\text{mL}$$

SAFETY ALERT!

It is important to remember when stating ratios that the units of measure should be stated in the same sequence (in the examples, mg : mL = mg : mL or

$$\frac{\text{mg}}{\text{mL}} = \frac{\text{mg}}{\text{mL}}$$

. Labeling the terms in the ratios, including *x*, is also essential. These pointers are crucial to preventing calculation errors.

- Example 2: Order: 40 mg p.o. of a medication.
- Available: 20-mg tablets (tab, tabs). How many tabs will you administer?
- Fraction Format With Solution:

  $$\frac{20\text{ mg}}{1\text{ tab}} = \frac{40\text{ mg}}{x\text{ tab}} \quad \text{(known)(unknown)} \quad 20x = 20 \cdot 40 \quad 20x = 2\text{ tabs}$$

  or

- Linear Format With Solution:

  $$20\text{ mg}:1\text{ tab} = 40\text{ mg}:x\text{ tab} \quad \text{(known)(unknown)} \quad 20x = 20 \cdot 40 \quad 20x = 2\text{ tabs}$$

- Example 3: Order: 1 g p.o. of an antibiotic.
- Available: 500-mg capsules (cap, caps). How many caps will you administer?
- Solution: Notice that the dosage ordered is in a different unit from what is available. Proceed first by changing the units of measure so that they are the same. As shown in Chapter 7, ratio and proportion can be used for conversion.
- After making the conversion, set up the problem and calculate the dosage to be given. In this example, the conversion required is within the same system (metric).
- In this example, grams are converted to milligrams by using the equivalent 1,000 mg = 1 g. After making the conversion of 1 g to 1,000 mg, the ratio is stated as follows:

  $$\frac{500\text{ mg}}{1\text{ cap}} = \frac{1{,}000\text{ mg}}{x\text{ caps}} \quad \text{or} \quad 500\text{ mg}:1\text{ cap} = 1{,}000\text{ mg}:x\text{ caps} \quad \text{(known)(unknown)(known)(unknown)} \quad x = 2\text{ caps} \quad x = 2\text{ caps}$$

An alternate method of solving might be to convert milligrams to grams. In doing this, 500 mg would be converted to grams by using the same equivalent: 1,000 mg = 1 g. However, decimals are common when measures are changed from smaller to larger in the metric system: 500 mg = 0.5 g. Even though converting the milligrams to grams would net the same final answer, *conversions that net decimals are often the source of calculation*

errors. Therefore, if possible, avoid conversions that require their use. As a rule, it is best to convert to the measure stated on the medication label. Doing this consistently can prevent confusion. As with the other examples, this proportion could be stated as a fraction as well.

For the purpose of learning to calculate dosages by using ratio and proportion, this chapter emphasizes the mathematics used to calculate the answer. Determining whether an answer is logical is essential and necessary in the calculation of medication. An answer *must make sense*. Determining whether an answer is logical will be discussed further in later chapters covering the calculation of dosages by various routes.

POINTS TO REMEMBER

Important Points When Calculating Dosages Using Ratio and Proportion

- • Make sure all terms are in the same unit and system of measure before calculating. If they are not, a conversion will be necessary before calculating the dosage.
- • When conversion of units is required, conversions can be made by converting what is ordered to the units in which the medication is available or by changing what is available to the units in which the medication is ordered. Be consistent as to how you make conversions. It is usual to convert what is ordered to the same unit and system of measure you have the medication available in.
- • When stating ratios, the known is stated first. The known ratio is what is available or on hand or the information obtained from the medication label.
- • The unknown ratio is stated second. The unknown ratio is the dosage desired, or what the prescriber has ordered.
- • The terms of the ratios in a proportion must be written in the same sequence.
- Example: mg:mL = mg : mL *or*

  mgmL=mgmL

- • Label all terms of the ratios in the proportion, including *x*.
- • Before calculating the dosage, make a mental estimate of the approximate and reasonable answer.
- • Label the value you obtain for *x* (e.g., mL, tabs). Double-check the label for *x* by referring back to the label of *x* in the original ratio and proportion; it should be the same.
- • A proportion can be stated in a linear format using colons (ratio format) or as a fraction.
- • Double-check all work.
- • Be consistent in how ratios are stated and conversions are done.
- • An error in the setup of the ratio and proportion can cause an error in calculation.

PRACTICE **PROBLEMS**

Answer the following questions by indicating whether you need less than 1 tab or more than 1 tab. Refer to Chapter 3 if you have difficulty in answering the questions in this area.

- 1. A client is to receive 0.2 mg of a medication. The tablets available are 0.4 mg. How many tablets do you need? _____
- 2. A client is to receive 1.25 mg of a medication. The tablets available are 0.625 mg. How many tablets do you need? _____
- 3. A client is to receive 7.5 mg of a medication. The tablets available are 15 mg. How many tablets do you need? _____
- 4. A client is to receive 10 mg of a medication. The tablets available are 20 mg. How many tablets do you need? _____
- 5. A client is to receive 100 mg of a medication. The tablets available are 50 mg. How many tablets do you need? _____
- For questions 6-25, solve the problems using ratio and proportion. Express your answer in mL to the nearest tenth where indicated. Indicate whether less or more of the medication is needed to administer the dosage ordered.
- 6. Order: 7.5 mg p.o. of a medication.
- Available: Tablets labeled 5 mg _____
- 7. Order: 45 mg p.o. of a medication.
- Available: Tablets labeled 30 mg _____
- 8. Order: 0.09 g p.o. of a medication.
- Available: Capsules labeled 45 mg _____
- 9. Order: 0.25 mg IM of a medication.
- Available: 0.5 mg per mL _____
- 10. Order: 100 mg p.o. of a liquid medication.
- Available: 125 mg per 5 mL _____
- 11. Order: 20 mEq IV of a medication.
- Available: 40 mEq per 10 mL _____
- 12. Order: 5,000 units subcut of a medication.
- Available: 10,000 units per mL _____
- 13. Order: 50 mg IM of a medication.
- Available: 80 mg per 2 mL _____
- 14. Order: 0.5 g p.o. of an antibiotic.
- Available: Capsules labeled 250 mg _____
- 15. Order: 400 mg p.o. of a liquid medication.
- Available: 125 mg per 5 mL _____
- 16. Order: 50 mg IM of a medication.
- Available: 80 mg per mL _____
- 17. Order: 60 mg IM of a medication.
- Available: 30 mg per mL _____
- 18. Order: 15 mg of a medication.
- Available: Tablets labeled 5 mg _____
- 19. Order: 0.24 g p.o. of a liquid medication.
- Available: 80 mg per 7.5 mL _____
- 20. Order: 20 g p.o. of a liquid medication.
- Available: 10 g per 15 mL _____
- 21. Order: 0.125 mg IM of a medication.
- Available: 0.5 mg per 2 mL _____
- 22. Order: 0.75 mg IM of a medication.
- Available: 0.25 mg per mL _____
- 23. Order: 375 mg p.o. of a liquid medication.
- Available: 125 mg per 5 mL _____
- 24. Order: 10,000 units subcut of a medication.
- Available: 7,500 units per mL _____
- 25. Order: 0.45 mg p.o. of a medication.
- Available: Tablets labeled 0.3 mg _____
- 26. Order: 20 mg IM of a medication.
- Available: 25 mg per 1.5 mL _____
- 27. Order: 150 mg IV of a medication.
- Available: 80 mg per mL _____
- 28. Order: 2 mg IM of a medication.
- Available: 1.5 mg per 0.5 mL _____
- 29. Order: 500 mcg IV of a medication.
- Available: 750 mcg per 3 mL _____
- 30. Order: 0.15 mg IM of a medication.
- Available: 0.2 mg per 1.5 mL _____

- 31. Order: 1,100 units subcut of a medication.
- Available: 1,000 units per 1.5 mL _____
- 32. Order: 0.6 g IV of a medication.
- Available: 1 g per 3.6 mL _____
- 33. Order: 3 g IV of a medication.
- Available: 1.5 g per mL _____
- 34. Order: 35 mg IM of a medication.
- Available: 40 mg per 2.5 mL _____
- 35. Order: 0.3 mg subcut of a medication.
- Available: 1,000 mcg per 2 mL _____
- 36. Order: 200 mg IM of a medication.
- Available: 0.5 g per 2 mL _____
- 37. Order: 10 mEq IV of a medication.
- Available: 20 mEq per 10 mL _____
- 38. Order: 165 mg IV of a medication.
- Available: 55 mg per 1.1 mL _____
- 39. Order: 35 mg subcut of a medication.
- Available: 45 mg per 1.2 mL _____
- 40. Order: 700 mg IM of a medication.
- Available: 1,000 mg per 2.3 mL _____
- Write a proportion and solve for the following unknown quantity.
- 41. If 15 mL of solution contains 75 mg of medication, how many mg of medication are in 60 mL of solution?
- 42. A client must take three tablets per day for 28 days. How many tablets should the pharmacy supply to fill this order?
- 43. A health care provider is instructed to administer 700 mL of a solution every 8 hours. How many hours will be needed to administer 2,100 mL?
- 44. Two tablets contain a total of 6.25 mg of a medication. How many milligrams of medication are in 10 tablets?
- 45. If 80 mg of medication is in 480 mL of solution, how many milliliters of solution contain 60 milligrams?

Answers on pp. 233-237

CHAPTER **REVIEW**

Part I

Read the medication labels where available, and calculate the number of tablets or capsules necessary to provide the dosage ordered.

- 1. Order: Phenobarbital 15 mg p.o. t.i.d.
- Available: Phenobarbital tablets labeled 15 mg _____
- 2. Order: Erythromycin (delayed-release capsules) 0.5 g p.o. q12h for 10 days.
- Available:

- _____
- 3. Order: Brilinta 180 mg p.o. stat.
- Available:

- _____
- 4. Order: Dilatrate-SR 80 mg p.o. q12h.
- Available:

- _____
- 5. Order: Dexamethasone 4 mg p.o. q8h.
- Available:

- _____
- 6. Order: Digoxin 125 mcg p.o. daily.
- Available:

- _____
- 7. Order: Ibrance 125 mg p.o. daily for 21 days.
- Available:

- _____
- 8. Order: Cephalexin 0.5 g p.o. q.i.d.
- Available:

- _____
- 9. Order: Nuplazid 34 mg p.o. daily.
- Available:

- _____
- 10. Order: Rifampin 0.6 g p.o. daily.
- Available: Rifampin capsules labeled 300 mg
- _____
- 11. Order: Xanax 0.5 mg p.o. b.i.d.
- Available: Scored tablets (can be broken in half)

- _____
- 12. Order: Rubraca 600 mg p.o. bid.
- Available:

- _____
- 13. Order: Prandin 2 mg p.o. tid before meals.
- Available:

- _____
- 14. Order: Risperdal 8 mg p.o. daily.
- Available:

- _____
- 15. Order: Lasix 60 mg p.o. daily.
- Available:

- _____
- 16. Order: Latuda 80 mg p.o. daily.
- Available:

- _____
- 17. Order: Calcitrol 0.5 mcg p.o. daily.
- Available:

- _____

Answers on 237

Part II

Calculate the volume necessary (in milliliters) to provide the dosage ordered, using medication labels where available. Express your answer as a decimal fraction to the nearest tenth where indicated.

- 18. Order: Dilantin 100 mg by gastrostomy tube t.i.d.
- Available: Dilantin 125 mg per 5 mL _____
- 19. Order: Benadryl 50 mg p.o. at bedtime.

- Available: Benadryl oral solution labeled 12.5 mg per 5 mL _____
- 20. Order: Gentamicin 50 mg IM q8h.
- Available:

- _____
- 21. Order: Vibramycin 100 mg p.o. q12h.
- Available:

- _____
- 22. Order: Morphine 1.5 mg IM q4h prn for pain.
- Available:

- _____
- 23. Order: Ondansetron 8 mg p.o. q12h for 2 days following chemotherapy.
- Available:

- _____
- 24. Order: Nystatin oral suspension 100,000 units swish and swallow q6h.
- Available: Nystatin oral suspension labeled 100,000 units per mL _____
- 25. Order: Heparin 5,000 units subcut daily.
- Available:

- _____
- 26. Order: Atropine 0.2 mg subcut stat.
- Available:

- _____
- 27. Order: Heparin 7,500 units subcut daily. Express answer in hundredths.
- Available:

- _____
- 28. Order: Lorazepam 2 mg IM q4h p.r.n. for agitation.
- Available:

- _____
- 29. Order: Octreotide Acetate 200 mcg subcut q12h.
- Available:

- _____
- 30. Order: Oxcarbazepine 0.6 g p.o. bid.
- Available:

- _____
- 31. Order: Depo-Provera 0.4 g IM at bedtime once a week on Thursday.
- Available:

- _____
- 32. Order: Lactulose 30 g p.o. t.i.d.
- Available:

- _____
- 33. Order: Dilantin suspension 200 mg per nasogastric tube every day.
- Available:
- _____

Answers on 237

ANSWERS

Chapter 13

Answers to Practice Problems

- 1. Less than 1 tab
- 2. More than 1 tab
- 3. Less than 1 tab
- 4. Less than 1 tab
- 5. More than 1 tab
- 6.

  $$5\text{mg}1\text{tab}=7.5\text{mg}x\text{tab}5x5=7.55$$

- *or*
- 5 mg : 1 tab = 7.5 mg : *x* tab

  $$5x5=7.55x=7.55$$

- *x* = 1.5 tabs or 1½ tabs. 5 mg is less than 7.5 mg; therefore you will need more than 1 tab to administer the dosage.
- 7.

  $$30\text{mg}1\text{tab}=45\text{mg}x\text{tab}30x30=4530x=4530$$

  or

- 30 mg : 1 tab = 45 mg : *x* tab

  $$30x30=4530x=4530$$

- *x* = 1.5 tabs or 1½ tabs. 45 mg is more than 30 mg; therefore you need more than 1 tab to administer the dosage.
- 8. Equivalent: 1,000 mg = 1 g (0.09 g = 90 mg)

45mg1cap=90mgxcap45x45=9045x=9045

- *x* = 2 caps. 90 mg is more than 45 mg; therefore you will need more than 1 cap to administer the dosage.
- 9.

  0.5mg1mL=0.25mgxmL0.5x0.5=0.250.5x=0.250.5

  or

- 0.5 mg : 1 mL = 0.25 mg : *x* mL

  0.5x0.5=0.250.5x=0.250.5

- *x* = 0.5 mL, 0.25 mg is less than 0.5 mg; you will need less than 1 mL to administer the dosage.
- 10.

  125mg5mL=100mgxmL125x125=500125x=500125

  or

- 125 mg : 5 mL = 100 mg : *x* mL

  125x125=500125x=500125

- x = 4 mL. 100 mg is less than 125 mg; therefore you will need less than 5 mL to administer the dosage.
- 11.

  $$40\text{mEq}10\text{mL}=20\text{mEq}x\text{mL}40x40=20040$$

  40 mEq : 10 mL = 20 mEq : x mL

  $$40x40=20040x=20040$$

- x = 5 mL. 20 mEq is less than 40 mEq; you will need less than 10 mL to administer the dosage.
- 12.

  $$10{,}000\text{units}1\text{mL}=5{,}000\text{units}x\text{mL}10{,}000x10{,}000=5{,}00010{,}000x=5{,}00010{,}000$$

  or

- 10,000 units : 1 mL = 5,000 units : x mL

  $$10{,}000x10{,}000=5{,}00010{,}000x=5{,}00010{,}000$$

- x = 0.5 mL, 10,000 units is more than 5,000 units; therefore you will need less than 1 mL to administer the dosage.

- 13.

  80mg2mL=50mgxmL80x80=10080x=10080

  or

- 80 mg : 2 mL = 50 mg : *x* mL

  80x80=10080x=10080

- *x* = 1.25 = 1.3 mL. 50 mg is less than 80 mg; therefore you will need less than 2 mL to administer the dosage.
- 14. Equivalent: 1,000 mg = 1 g (0.5 g = 500 mg)

  250mg1cap=500mgxcap250x250=500250

- *or*
- 250 mg : 1 cap = 500 mg : *x* cap

  250x250=500250x=500250

- *x* = 2 caps. 500 mg is more than 250 mg; therefore you will need more than 1 cap to administer the dosage.
- 15.

  125mg5mL=400mgxmL125x125=2,000125x=2,000125

or

- 125 mg : 5 mL = 400 mg : *x* mL

  125x125=2,000125x=2,000125

- *x* = 16 mL. 400 mg is larger than 125 mg; therefore you will need more than 5 mL to administer the dosage.
- 16.

  80mg1mL=50mgxmL80x80=5080x=5080

or

- 80 mg : 1 mL = 50 mg : *x* mL

  80x80=5080x=5080

- *x* = 0.62 = 0.6 mL. 50 mg is less than 80 mg; therefore you will need less than 1 mL to administer the dosage.
- 17.

  30mg1mL=60mgxmL30x30=6030x=6030

or

- 30 mg : 1 mL = 60 mg : *x* mL

  30x30=6030x=6030

- *x* = 2 mL. 60 mg is more than 30 mg; therefore you will need more than 1 mL to administer the dosage.
- 18.

  5mg1tab=15mgxtab5x5=155

or

- 5 mg : 1 tab = 15 mg : *x* tab

  5x5=155x=155

- *x* = 3 tabs. 15 mg is more than 5 mg; therefore you will need more than 1 tab to administer the dosage.
- 19. Equivalent: 1,000 mg = 1 g (0.24 g = 240 mg)

  80mg7.5mL=240mgxmL80x80=1,80080x=1,80080

- *or*
- 80 mg : 7.5 mL = 240 mg : *x* mL

  80x80=1,80080x=1,80080

- x = 22.5 mL. 240 mg is more than 80 mg; therefore you would need more than 7.5 mL to administer the dosage.
- 20.

  $$\frac{10\text{g}}{15\text{mL}}=\frac{20\text{g}}{x\text{mL}}\qquad 10x=10\times 30\qquad 10x=300\qquad x=30$$

- *or*
- 10 g : 15 mL = 20 g : x mL

  $$10x=10\times 30\qquad 10x=300\qquad x=30$$

- x = 30 mL. 20 g is more than 10 g; therefore you would need more than 15 mL to administer the dosage.
- 21.

  $$\frac{0.5\text{mg}}{2\text{mL}}=\frac{0.125\text{mg}}{x\text{mL}}\qquad 0.5x=0.5\times 0.25\qquad 0.5x=0.25$$

  or

- 0.5 mg : 2 mL = 0.125 mg : x mL

  $$0.5x=0.5\times 0.25\qquad 0.5x=0.25$$

- *x* = 0.5 mL. 0.125 mg is less than 0.5 mg; therefore you will need less than 2 mL to administer the dosage.
- 22.

  0.25mg1mL=0.75mgxmL0.25x0.25=0.750.25

  or

- 0.25 mg : 1 mL = 0.75 mg : *x* mL

  0.25x0.25=0.750.25x=0.750.25

- *x* = 3 mL. 0.75 mg is more than 0.25 mg; therefore you will need more than 1 mL to administer the dosage.
- 23.

  125mg5mL=375mgxmL125x125=1,875125

  or

- 125 mg : 5 mL = 375 mg : *x* mL

  125x125=1,875125x=1,875125

- *x* = 15 mL. 375 mg is more than 125 mg; therefore you will need more than 5 mL to administer the dosage.
- 24.

  7,500units1mL=10,000unitsxmL7,500x7,500=10,0007,500

or

- 7,500 units : 1 mL = 10,000 units : *x* mL

  7,500x7,500=10,0007,500x=10,0007,500

- *x* = 1.33 = 1.3 mL. 10,000 units is more than 7,500 units; therefore you will need more than 1 mL to administer the dosage.
- 25.

  0.3mg1tab=0.45mgxtab0.3x0.3=0.450.3

or

- 0.3 mg : 1 tab = 0.45 mg : *x* tab

  0.3x0.3=0.450.3x=0.450.3

- *x* = 1.5 tabs or 1½ tabs. 0.45 mg is more than 0.3 mg; therefore you will need more than 1 tab to administer the dosage.

NOTE

For questions 26-40 and Chapter Review Parts I and II, answers only are provided. Refer to setup for problems 1-25 and 41-45 for Practice Problems as needed.

- 26. 1.2 mL
- 27. 1.9 mL
- 28. 0.7 mL
- 29. 2 mL
- 30. 1.1 mL
- 31. 1.7 mL
- 32. 2.2 mL
- 33. 2 mL
- 34. 2.2 mL
- 35. 0.6 mL
- 36. 0.8 mL
- 37. 5 mL
- 38. 3.3 mL
- 39. 0.9 mL
- 40. 1.6 mL
- 41.

  $$\frac{75\text{mg}}{15\text{mL}}=\frac{x\text{mg}}{60\text{mL}}$$

- *or*
- 75 mg : 15 mL = *x* mg : 60 mL
- *x* = 300 mg
- 42.

  $$\frac{3\text{tab}}{1\text{day}}=\frac{x\text{tab}}{28\text{days}}$$

  or

- 3 tab : 1 day = *x* tab : 28 days
- *x* = 84 tab
- 43.

  $$\frac{700\text{mL}}{8\text{hr}}=\frac{2{,}100\text{mL}}{x\text{hr}}$$

or

- 700 mL : 8 hr = 2,100 mL : *x* hr
- *x* = 24 hr
- 44.

$$\frac{6.25\text{mg}}{2\text{tab}} = \frac{x\text{mg}}{10\text{tab}}$$

or

- 6.25 mg : 2 tab = *x* mg : 10 tab
- *x* = 31.25 mg
- 45.

$$\frac{80\text{mg}}{480\text{mL}} = \frac{60\text{mg}}{x\text{mL}}$$

or

- 80 mg : 480 mL = 60 mg : *x* mL
- *x* = 360 mL

Answers to Chapter Review Part I

- 1. 1 tab
- 2. 2 delayed-release caps
- 3. 2 tabs
- 4. 2 sustained-release (SR) caps
- 5. 2 tabs
- 6. 1 tab
- 7. 1 cap
- 8. 1 tab
- 9. 2 tabs
- 10. 2 caps
- 11. 2 tabs
- 12. 3 tabs
- 13. 2 tabs
- 14. 2 tabs
- 15. 3 tabs
- 16. 2 tabs
- 17. 2 caps

Answers to Chapter Review Part II

- 18. 4 mL
- 19. 20 mL
- 20. 1.3 mL
- 21. 20 mL

- 22. 0.8 mL
- 23. 10 mL
- 24. 1 mL
- 25. 1 mL
- 26. 0.5 mL
- 27. 0.75 mL
- 28. 1 mL
- 29. 1 mL
- 30. 10 mL
- 31. 1 mL
- 32. 45 mL
- 33. 8 mL

unknown - Section 27 (Page 203)

Several methods are used for calculating dosages. The most common methods are *ratio and proportion* and use of the *formula*. Regardless of the method used the nurse **must** be able to calculate a dose correctly when required to administer medications safely. For the nurse to safely and accurately calculate a dosage, the nurse must demonstrate the ability to utilize a mathematical method that enables the logical set-up of the calculation; solve the problem; and identify whether an answer is rational, applying the principles learned for medication administration. This text covers the various calculation methods (*ratio and proportion, formula, and dimensional analysis*) over the next three (3) chapters. After the various methods have been presented, students can choose the method they find easiest and most logical to use. First, let's discuss calculating using the method of ratio and proportion. If necessary, review Chapter 3 on ratio and proportion.

Use of Ratio and Proportion in Dosage Calculation

When you know three of the four values of a proportion, you can solve the proportion to determine the unknown quantity. In dosage calculation, it is oft en necessary to find only one unknown quantity. As you recall from Chapter 3 (*ratio and proportion*), the proportion can be set up using colons (ratio format). A ratio set up using colons (:) is referred to as the linear format. The colons are used to show the relationship between two numbers. The fraction method can also be used. The fractional ratio and proportion method compares two equivalent fractions. Recall that a proportion is a relationship comparing two ratios. In addition to solving for the unknown quantity, it is essential to also be competent in setting up the proportion correctly.

SAFETY ALERT!

If you set up the proportion incorrectly, you could calculate the dose incorrectly and administer the wrong dose, which could have serious consequences for the client.

Let's look at using ratio and proportion to calculate dosages using the linear format and the fraction format. For example, suppose you had a medication with a dosage strength of 50 mg per 1 mL, and the prescriber ordered a dosage of 25 mg. A ratio and proportion may be used to determine how many milliliters to administer. Remember to include units of measure when writing a ratio and proportion to avoid errors.

Linear Format

When the ratio and proportion are written using colons (ratio format), this can be written in a linear format. The first ratio is termed the *known ratio*; this information is what you have available, or the information from the medication label, and is stated first. The second ratio is the *unknown ratio* and is stated second. It contains the ordered dose and the unknown quantity, which is represented by *x*.

- Example 1: 50 mg : 1 mL = 25 mg : *x* mL
- (*known ratio*) (*unknown ratio*)
- Solution: 50 mg : 1 mL = 25 mg : *x* mL
- (known) (unknown)
- 50*x* = product of extremes
- 25 = product of means
- 50*x* = 25 is the equation

(Divide both sides by 50, the number in front of *x*.)

- x = 0.5 mL

Fraction Format

When you are setting up the ratio and proportion using the fraction format, the *known ratio* is what you have available, or the information from the medication label, and is stated first (placed on the left side of the proportion). The desired, or what is ordered to be administered, is the *unknown ratio* (placed on the right side). The ordered dose and the unknown quantity is represented by x. Therefore, using the example, the ratio and proportion would be stated as follows:

- Example 1:

- Solution: To solve for x, use the principles presented in Chapter 3 on ratio and (fraction format) proportion. (The fraction format is solved by cross-multiplication.)

SAFETY ALERT!

It is important to remember when stating ratios that the units of measure should be stated in the same sequence (in the examples, mg : mL = mg : mL or

. Labeling the terms in the ratios, including *x*, is also essential. These pointers are crucial to preventing calculation errors.

- Example 2: Order: 40 mg p.o. of a medication.
- Available: 20-mg tablets (tab, tabs). How many tabs will you administer?
- Fraction Format With Solution:

or

- Linear Format With Solution:

- Example 3: Order: 1 g p.o. of an antibiotic.
- Available: 500-mg capsules (cap, caps). How many caps will you administer?
- Solution: Notice that the dosage ordered is in a different unit from what is available. Proceed first by changing the units of measure so that they are the same. As shown in Chapter 7, ratio and proportion can be used for conversion.
- After making the conversion, set up the problem and calculate the dosage to be given. In this example, the conversion required is within the same system (metric).
- In this example, grams are converted to milligrams by using the equivalent 1,000 mg = 1 g. After making the conversion of 1 g to 1,000 mg, the ratio is stated as follows:

An alternate method of solving might be to convert milligrams to grams. In doing this, 500 mg would be converted to grams by using the same equivalent: 1,000 mg = 1 g. However, decimals are common when measures are changed from smaller to larger in the metric system: 500 mg = 0.5 g. Even though converting the milligrams to grams would net the same final answer, *conversions that net decimals are often the source of calculation errors*. Therefore, if possible, avoid conversions that require their use. As a rule, it is best to convert to the measure stated on the medication label. Doing this consistently can prevent confusion. As with the other examples, this proportion could be stated as a fraction as well.

For the purpose of learning to calculate dosages by using ratio and proportion, this chapter emphasizes the mathematics used to calculate the answer. Determining whether an answer is logical is essential and necessary in the calculation of medication. An answer *must make sense*. Determining whether an answer is logical will be discussed further in later chapters covering the calculation of dosages by various routes.

POINTS TO REMEMBER

Important Points When Calculating Dosages Using Ratio and Proportion

- • Make sure all terms are in the same unit and system of measure before calculating. If they are not, a conversion will be necessary before calculating the dosage.
- • When conversion of units is required, conversions can be made by converting what is ordered to the units in which the medication is available or by changing what is available to the units in which the medication is ordered. Be consistent as to how you make conversions. It is usual to convert what is ordered to the same unit and system of measure you have the medication available in.
- • When stating ratios, the known is stated first. The known ratio is what is available or on hand or the information obtained from the medication label.
- • The unknown ratio is stated second. The unknown ratio is the dosage desired, or what the prescriber has ordered.
- • The terms of the ratios in a proportion must be written in the same sequence.
- Example: mg:mL = mg : mL *or*

- • Label all terms of the ratios in the proportion, including *x*.
- • Before calculating the dosage, make a mental estimate of the approximate and reasonable answer.
- • Label the value you obtain for *x* (e.g., mL, tabs). Double-check the label for *x* by referring back to the label of *x* in the original ratio and proportion; it should be the same.
- • A proportion can be stated in a linear format using colons (ratio format) or as a fraction.
- • Double-check all work.
- • Be consistent in how ratios are stated and conversions are done.
- • An error in the setup of the ratio and proportion can cause an error in calculation.

PRACTICE **PROBLEMS**

Answer the following questions by indicating whether you need less than 1 tab or more than 1 tab. Refer to Chapter 3 if you have difficulty in answering the questions in this area.

- 1. A client is to receive 0.2 mg of a medication. The tablets available are 0.4 mg. How many tablets do you need? _____
- 2. A client is to receive 1.25 mg of a medication. The tablets available are 0.625 mg. How many tablets do you need? _____
- 3. A client is to receive 7.5 mg of a medication. The tablets available are 15 mg. How many tablets do you need? _____
- 4. A client is to receive 10 mg of a medication. The tablets available are 20 mg. How many tablets do you need? _____
- 5. A client is to receive 100 mg of a medication. The tablets available are 50 mg. How many tablets do you need? _____
- For questions 6-25, solve the problems using ratio and proportion. Express your answer in mL to the nearest tenth where indicated. Indicate whether less or more of the medication is needed to administer the dosage ordered.

- 6. Order: 7.5 mg p.o. of a medication.
- Available: Tablets labeled 5 mg _____
- 7. Order: 45 mg p.o. of a medication.
- Available: Tablets labeled 30 mg _____
- 8. Order: 0.09 g p.o. of a medication.
- Available: Capsules labeled 45 mg _____
- 9. Order: 0.25 mg IM of a medication.
- Available: 0.5 mg per mL _____
- 10. Order: 100 mg p.o. of a liquid medication.
- Available: 125 mg per 5 mL _____
- 11. Order: 20 mEq IV of a medication.
- Available: 40 mEq per 10 mL _____
- 12. Order: 5,000 units subcut of a medication.
- Available: 10,000 units per mL _____
- 13. Order: 50 mg IM of a medication.
- Available: 80 mg per 2 mL _____
- 14. Order: 0.5 g p.o. of an antibiotic.
- Available: Capsules labeled 250 mg _____
- 15. Order: 400 mg p.o. of a liquid medication.
- Available: 125 mg per 5 mL _____
- 16. Order: 50 mg IM of a medication.
- Available: 80 mg per mL _____
- 17. Order: 60 mg IM of a medication.
- Available: 30 mg per mL _____
- 18. Order: 15 mg of a medication.
- Available: Tablets labeled 5 mg _____
- 19. Order: 0.24 g p.o. of a liquid medication.
- Available: 80 mg per 7.5 mL _____
- 20. Order: 20 g p.o. of a liquid medication.
- Available: 10 g per 15 mL _____
- 21. Order: 0.125 mg IM of a medication.
- Available: 0.5 mg per 2 mL _____
- 22. Order: 0.75 mg IM of a medication.
- Available: 0.25 mg per mL _____
- 23. Order: 375 mg p.o. of a liquid medication.
- Available: 125 mg per 5 mL _____
- 24. Order: 10,000 units subcut of a medication.
- Available: 7,500 units per mL _____
- 25. Order: 0.45 mg p.o. of a medication.
- Available: Tablets labeled 0.3 mg _____
- 26. Order: 20 mg IM of a medication.
- Available: 25 mg per 1.5 mL _____
- 27. Order: 150 mg IV of a medication.
- Available: 80 mg per mL _____
- 28. Order: 2 mg IM of a medication.
- Available: 1.5 mg per 0.5 mL _____
- 29. Order: 500 mcg IV of a medication.
- Available: 750 mcg per 3 mL _____
- 30. Order: 0.15 mg IM of a medication.
- Available: 0.2 mg per 1.5 mL _____
- 31. Order: 1,100 units subcut of a medication.
- Available: 1,000 units per 1.5 mL _____
- 32. Order: 0.6 g IV of a medication.
- Available: 1 g per 3.6 mL _____
- 33. Order: 3 g IV of a medication.
- Available: 1.5 g per mL _____
- 34. Order: 35 mg IM of a medication.
- Available: 40 mg per 2.5 mL _____
- 35. Order: 0.3 mg subcut of a medication.

- Available: 1,000 mcg per 2 mL _____
- 36. Order: 200 mg IM of a medication.
- Available: 0.5 g per 2 mL _____
- 37. Order: 10 mEq IV of a medication.
- Available: 20 mEq per 10 mL _____
- 38. Order: 165 mg IV of a medication.
- Available: 55 mg per 1.1 mL _____
- 39. Order: 35 mg subcut of a medication.
- Available: 45 mg per 1.2 mL _____
- 40. Order: 700 mg IM of a medication.
- Available: 1,000 mg per 2.3 mL _____
- Write a proportion and solve for the following unknown quantity.
- 41. If 15 mL of solution contains 75 mg of medication, how many mg of medication are in 60 mL of solution?
- 42. A client must take three tablets per day for 28 days. How many tablets should the pharmacy supply to fill this order?
- 43. A health care provider is instructed to administer 700 mL of a solution every 8 hours. How many hours will be needed to administer 2,100 mL?
- 44. Two tablets contain a total of 6.25 mg of a medication. How many milligrams of medication are in 10 tablets?
- 45. If 80 mg of medication is in 480 mL of solution, how many milliliters of solution contain 60 milligrams?

Answers on pp. 233-237

CHAPTER **REVIEW**

Part I

Read the medication labels where available, and calculate the number of tablets or capsules necessary to provide the dosage ordered.

- 1. Order: Phenobarbital 15 mg p.o. t.i.d.
- Available: Phenobarbital tablets labeled 15 mg _____
- 2. Order: Erythromycin (delayed-release capsules) 0.5 g p.o. q12h for 10 days.
- Available:

- _____
- 3. Order: Brilinta 180 mg p.o. stat.
- Available:

- _____
- 4. Order: Dilatrate-SR 80 mg p.o. q12h.
- Available:

- _____
- 5. Order: Dexamethasone 4 mg p.o. q8h.
- Available:

- _____
- 6. Order: Digoxin 125 mcg p.o. daily.
- Available:

- _____
- 7. Order: Ibrance 125 mg p.o. daily for 21 days.
- Available:

- _____
- 8. Order: Cephalexin 0.5 g p.o. q.i.d.
- Available:

- _____
- 9. Order: Nuplazid 34 mg p.o. daily.
- Available:

- _____
- 10. Order: Rifampin 0.6 g p.o. daily.
- Available: Rifampin capsules labeled 300 mg
- _____
- 11. Order: Xanax 0.5 mg p.o. b.i.d.
- Available: Scored tablets (can be broken in half)

- _____
- 12. Order: Rubraca 600 mg p.o. bid.
- Available:

- _____
- 13. Order: Prandin 2 mg p.o. tid before meals.
- Available:

- _____
- 14. Order: Risperdal 8 mg p.o. daily.
- Available:

- _____
- 15. Order: Lasix 60 mg p.o. daily.
- Available:

- _____
- 16. Order: Latuda 80 mg p.o. daily.
- Available:

- _____
- 17. Order: Calcitrol 0.5 mcg p.o. daily.
- Available:

- _____

Answers on 237

Part II

Calculate the volume necessary (in milliliters) to provide the dosage ordered, using medication labels where available. Express your answer as a decimal fraction to the nearest tenth where indicated.

- 18. Order: Dilantin 100 mg by gastrostomy tube t.i.d.
- Available: Dilantin 125 mg per 5 mL _____
- 19. Order: Benadryl 50 mg p.o. at bedtime.

- Available: Benadryl oral solution labeled 12.5 mg per 5 mL _____
- 20. Order: Gentamicin 50 mg IM q8h.
- Available:

- _____
- 21. Order: Vibramycin 100 mg p.o. q12h.
- Available:

- _____
- 22. Order: Morphine 1.5 mg IM q4h prn for pain.
- Available:

- _____
- 23. Order: Ondansetron 8 mg p.o. q12h for 2 days following chemotherapy.
- Available:

- _____
- 24. Order: Nystatin oral suspension 100,000 units swish and swallow q6h.
- Available: Nystatin oral suspension labeled 100,000 units per mL _____
- 25. Order: Heparin 5,000 units subcut daily.
- Available:

- _____
- 26. Order: Atropine 0.2 mg subcut stat.
- Available:

- _____
- 27. Order: Heparin 7,500 units subcut daily. Express answer in hundredths.
- Available:

- _____
- 28. Order: Lorazepam 2 mg IM q4h p.r.n. for agitation.
- Available:

- _____
- 29. Order: Octreotide Acetate 200 mcg subcut q12h.
- Available:

- _____
- 30. Order: Oxcarbazepine 0.6 g p.o. bid.
- Available:

- _____
- 31. Order: Depo-Provera 0.4 g IM at bedtime once a week on Thursday.
- Available:

- _____
- 32. Order: Lactulose 30 g p.o. t.i.d.
- Available:

- _____
- 33. Order: Dilantin suspension 200 mg per nasogastric tube every day.
- Available:
- _____

Answers on 237

ANSWERS

Chapter 13

Answers to Practice Problems

- 1. Less than 1 tab
- 2. More than 1 tab
- 3. Less than 1 tab
- 4. Less than 1 tab
- 5. More than 1 tab
- 6.

- *or*
- 5 mg : 1 tab = 7.5 mg : *x* tab

- *x* = 1.5 tabs or 1½ tabs. 5 mg is less than 7.5 mg; therefore you will need more than 1 tab to administer the dosage.
- 7.

or

- 30 mg : 1 tab = 45 mg : *x* tab

- *x* = 1.5 tabs or 1½ tabs. 45 mg is more than 30 mg; therefore you need more than 1 tab to administer the dosage.
- 8. Equivalent: 1,000 mg = 1 g (0.09 g = 90 mg)

- x = 2 caps. 90 mg is more than 45 mg; therefore you will need more than 1 cap to administer the dosage.
- 9.

or

- 0.5 mg : 1 mL = 0.25 mg : x mL

- x = 0.5 mL, 0.25 mg is less than 0.5 mg; you will need less than 1 mL to administer the dosage.
- 10.

or

- 125 mg : 5 mL = 100 mg : x mL

- x = 4 mL. 100 mg is less than 125 mg; therefore you will need less than 5 mL to administer the dosage.
- 11.

40 mEq : 10 mL = 20 mEq : *x* mL

- *x* = 5 mL. 20 mEq is less than 40 mEq; you will need less than 10 mL to administer the dosage.
- 12.

or

- 10,000 units : 1 mL = 5,000 units : *x* mL

- *x* = 0.5 mL, 10,000 units is more than 5,000 units; therefore you will need less than 1 mL to administer the dosage.
- 13.

or

- 80 mg : 2 mL = 50 mg : *x* mL

- x = 1.25 = 1.3 mL. 50 mg is less than 80 mg; therefore you will need less than 2 mL to administer the dosage.
- 14. Equivalent: 1,000 mg = 1 g (0.5 g = 500 mg)

- *or*
- 250 mg : 1 cap = 500 mg : x cap

- x = 2 caps. 500 mg is more than 250 mg; therefore you will need more than 1 cap to administer the dosage.
- 15.

or

- 125 mg : 5 mL = 400 mg : x mL

- x = 16 mL. 400 mg is larger than 125 mg; therefore you will need more than 5 mL to administer the dosage.
- 16.

or

- 80 mg : 1 mL = 50 mg : *x* mL

- *x* = 0.62 = 0.6 mL. 50 mg is less than 80 mg; therefore you will need less than 1 mL to administer the dosage.
- 17.

or

- 30 mg : 1 mL = 60 mg : *x* mL

- *x* = 2 mL. 60 mg is more than 30 mg; therefore you will need more than 1 mL to administer the dosage.
- 18.

or

- 5 mg : 1 tab = 15 mg : *x* tab

- x = 3 tabs. 15 mg is more than 5 mg; therefore you will need more than 1 tab to administer the dosage.
- 19. Equivalent: 1,000 mg = 1 g (0.24 g = 240 mg)

- *or*
- 80 mg : 7.5 mL = 240 mg : x mL

- x = 22.5 mL. 240 mg is more than 80 mg; therefore you would need more than 7.5 mL to administer the dosage.
- 20.

- *or*
- 10 g : 15 mL = 20 g : x mL

- x = 30 mL. 20 g is more than 10 g; therefore you would need more than 15 mL to administer the dosage.
- 21.

or

- 0.5 mg : 2 mL = 0.125 mg : *x* mL

- *x* = 0.5 mL. 0.125 mg is less than 0.5 mg; therefore you will need less than 2 mL to administer the dosage.
- 22.

or

- 0.25 mg : 1 mL = 0.75 mg : *x* mL

- *x* = 3 mL. 0.75 mg is more than 0.25 mg; therefore you will need more than 1 mL to administer the dosage.
- 23.

or

- 125 mg : 5 mL = 375 mg : *x* mL

- x = 15 mL. 375 mg is more than 125 mg; therefore you will need more than 5 mL to administer the dosage.
- 24.

or

- 7,500 units : 1 mL = 10,000 units : x mL

- x = 1.33 = 1.3 mL. 10,000 units is more than 7,500 units; therefore you will need more than 1 mL to administer the dosage.
- 25.

or

- 0.3 mg : 1 tab = 0.45 mg : x tab

- x = 1.5 tabs or 1½ tabs. 0.45 mg is more than 0.3 mg; therefore you will need more than 1 tab to administer the dosage.

NOTE

For questions 26-40 and Chapter Review Parts I and II, answers only are provided. Refer to setup for problems 1-25 and 41-45 for Practice Problems as needed.

- 26. 1.2 mL
- 27. 1.9 mL
- 28. 0.7 mL
- 29. 2 mL
- 30. 1.1 mL
- 31. 1.7 mL
- 32. 2.2 mL
- 33. 2 mL
- 34. 2.2 mL
- 35. 0.6 mL
- 36. 0.8 mL
- 37. 5 mL
- 38. 3.3 mL
- 39. 0.9 mL
- 40. 1.6 mL
- 41.

- *or*
- 75 mg : 15 mL = *x* mg : 60 mL
- *x* = 300 mg
- 42.

or

- 3 tab : 1 day = *x* tab : 28 days
- *x* = 84 tab
- 43.

or

- 700 mL : 8 hr = 2,100 mL : *x* hr
- *x* = 24 hr
- 44.

or

- 6.25 mg : 2 tab = *x* mg : 10 tab
- *x* = 31.25 mg
- 45.

or

- 80 mg : 480 mL = 60 mg : *x* mL
- *x* = 360 mL

Answers to Chapter Review Part I

- 1. 1 tab
- 2. 2 delayed-release caps
- 3. 2 tabs
- 4. 2 sustained-release (SR) caps
- 5. 2 tabs
- 6. 1 tab
- 7. 1 cap
- 8. 1 tab
- 9. 2 tabs
- 10. 2 caps
- 11. 2 tabs
- 12. 3 tabs
- 13. 2 tabs
- 14. 2 tabs
- 15. 3 tabs
- 16. 2 tabs
- 17. 2 caps

Answers to Chapter Review Part II

- 18. 4 mL
- 19. 20 mL
- 20. 1.3 mL
- 21. 20 mL
- 22. 0.8 mL
- 23. 10 mL
- 24. 1 mL
- 25. 1 mL
- 26. 0.5 mL
- 27. 0.75 mL
- 28. 1 mL
- 29. 1 mL
- 30. 10 mL
- 31. 1 mL
- 32. 45 mL
- 33. 8 mL

unknown - Section 27 (Page 208)

Several methods are used for calculating dosages. The most common methods are *ratio and proportion* and use of the *formula*. Regardless of the method used the nurse **must** be able to calculate a dose correctly when required to administer medications safely. For the nurse to safely and accurately calculate a dosage, the nurse must demonstrate the ability to utilize a mathematical method that enables the logical set-up of the calculation; solve the problem; and identify whether an answer is rational, applying the principles learned for medication administration. This text covers the various calculation methods (*ratio and proportion, formula, and dimensional analysis*) over the next three (3) chapters. After the various methods have been presented, students can choose the method they find easiest and most logical to use. First, let's discuss calculating using the method of ratio and proportion. If necessary, review Chapter 3 on ratio and proportion.

Use of Ratio and Proportion in Dosage Calculation

When you know three of the four values of a proportion, you can solve the proportion to determine the unknown quantity. In dosage calculation, it is oft en necessary to find only one unknown quantity. As you recall from Chapter 3 (*ratio and proportion*), the proportion can be set up using colons (ratio format). A ratio set up using colons (:) is referred to as the linear format. The colons are used to show the relationship between two numbers. The fraction method can also be used. The fractional ratio and proportion method compares two equivalent fractions. Recall that a proportion is a relationship comparing two ratios. In addition to solving for the unknown quantity, it is essential to also be competent in setting up the proportion correctly.

SAFETY ALERT!

If you set up the proportion incorrectly, you could calculate the dose incorrectly and administer the wrong dose, which could have serious consequences for the client.

Let's look at using ratio and proportion to calculate dosages using the linear format and the fraction format. For example, suppose you had a medication with a dosage strength of 50 mg per 1 mL, and the prescriber ordered a dosage of 25 mg. A ratio and proportion may be used to determine how many milliliters to administer. Remember to include units of measure when writing a ratio and proportion to avoid errors.

Linear Format

When the ratio and proportion are written using colons (ratio format), this can be written in a linear format. The first ratio is termed the *known ratio*; this information is what you have available, or the information from the medication label, and is stated first. The second ratio is the *unknown ratio* and is stated second. It contains the ordered dose and the unknown quantity, which is represented by *x*.

- Example 1: 50 mg : 1 mL = 25 mg : *x* mL
- (*known ratio*) (*unknown ratio*)
- Solution: 50 mg : 1 mL = 25 mg : *x* mL
- (known) (unknown)
- 50*x* = product of extremes
- 25 = product of means
- 50*x* = 25 is the equation

(Divide both sides by 50, the number in front of *x*.)

- x = 0.5 mL

Fraction Format

When you are setting up the ratio and proportion using the fraction format, the *known ratio* is what you have available, or the information from the medication label, and is stated first (placed on the left side of the proportion). The desired, or what is ordered to be administered, is the *unknown ratio* (placed on the right side). The ordered dose and the unknown quantity is represented by x. Therefore, using the example, the ratio and proportion would be stated as follows:

- Example 1:

- Solution: To solve for x, use the principles presented in Chapter 3 on ratio and (fraction format) proportion. (The fraction format is solved by cross-multiplication.)

SAFETY ALERT!

It is important to remember when stating ratios that the units of measure should be stated in the same sequence (in the examples, mg : mL = mg : mL or

. Labeling the terms in the ratios, including *x*, is also essential. These pointers are crucial to preventing calculation errors.

- Example 2: Order: 40 mg p.o. of a medication.
- Available: 20-mg tablets (tab, tabs). How many tabs will you administer?
- Fraction Format With Solution:

or

- Linear Format With Solution:

- Example 3: Order: 1 g p.o. of an antibiotic.
- Available: 500-mg capsules (cap, caps). How many caps will you administer?
- Solution: Notice that the dosage ordered is in a different unit from what is available. Proceed first by changing the units of measure so that they are the same. As shown in Chapter 7, ratio and proportion can be used for conversion.
- After making the conversion, set up the problem and calculate the dosage to be given. In this example, the conversion required is within the same system (metric).
- In this example, grams are converted to milligrams by using the equivalent 1,000 mg = 1 g. After making the conversion of 1 g to 1,000 mg, the ratio is stated as follows:

An alternate method of solving might be to convert milligrams to grams. In doing this, 500 mg would be converted to grams by using the same equivalent: 1,000 mg = 1 g. However, decimals are common when measures are changed from smaller to larger in the metric system: 500 mg = 0.5 g. Even though converting the milligrams to grams would net the same final answer, *conversions that net decimals are often the source of calculation errors*. Therefore, if possible, avoid conversions that require their use. As a rule, it is best to convert to the measure stated on the medication label. Doing this consistently can prevent confusion. As with the other examples, this proportion could be stated as a fraction as well.

For the purpose of learning to calculate dosages by using ratio and proportion, this chapter emphasizes the mathematics used to calculate the answer. Determining whether an answer is logical is essential and necessary in the calculation of medication. An answer *must make sense*. Determining whether an answer is logical will be discussed further in later chapters covering the calculation of dosages by various routes.

POINTS TO REMEMBER

Important Points When Calculating Dosages Using Ratio and Proportion

- • Make sure all terms are in the same unit and system of measure before calculating. If they are not, a conversion will be necessary before calculating the dosage.
- • When conversion of units is required, conversions can be made by converting what is ordered to the units in which the medication is available or by changing what is available to the units in which the medication is ordered. Be consistent as to how you make conversions. It is usual to convert what is ordered to the same unit and system of measure you have the medication available in.
- • When stating ratios, the known is stated first. The known ratio is what is available or on hand or the information obtained from the medication label.
- • The unknown ratio is stated second. The unknown ratio is the dosage desired, or what the prescriber has ordered.
- • The terms of the ratios in a proportion must be written in the same sequence.
- Example: mg:mL = mg : mL *or*

- • Label all terms of the ratios in the proportion, including *x*.
- • Before calculating the dosage, make a mental estimate of the approximate and reasonable answer.
- • Label the value you obtain for *x* (e.g., mL, tabs). Double-check the label for *x* by referring back to the label of *x* in the original ratio and proportion; it should be the same.
- • A proportion can be stated in a linear format using colons (ratio format) or as a fraction.
- • Double-check all work.
- • Be consistent in how ratios are stated and conversions are done.
- • An error in the setup of the ratio and proportion can cause an error in calculation.

PRACTICE **PROBLEMS**

Answer the following questions by indicating whether you need less than 1 tab or more than 1 tab. Refer to Chapter 3 if you have difficulty in answering the questions in this area.

- 1. A client is to receive 0.2 mg of a medication. The tablets available are 0.4 mg. How many tablets do you need? _____
- 2. A client is to receive 1.25 mg of a medication. The tablets available are 0.625 mg. How many tablets do you need? _____
- 3. A client is to receive 7.5 mg of a medication. The tablets available are 15 mg. How many tablets do you need? _____
- 4. A client is to receive 10 mg of a medication. The tablets available are 20 mg. How many tablets do you need? _____
- 5. A client is to receive 100 mg of a medication. The tablets available are 50 mg. How many tablets do you need? _____
- For questions 6-25, solve the problems using ratio and proportion. Express your answer in mL to the nearest tenth where indicated. Indicate whether less or more of the medication is needed to administer the dosage ordered.

- 6. Order: 7.5 mg p.o. of a medication.
- Available: Tablets labeled 5 mg _____
- 7. Order: 45 mg p.o. of a medication.
- Available: Tablets labeled 30 mg _____
- 8. Order: 0.09 g p.o. of a medication.
- Available: Capsules labeled 45 mg _____
- 9. Order: 0.25 mg IM of a medication.
- Available: 0.5 mg per mL _____
- 10. Order: 100 mg p.o. of a liquid medication.
- Available: 125 mg per 5 mL _____
- 11. Order: 20 mEq IV of a medication.
- Available: 40 mEq per 10 mL _____
- 12. Order: 5,000 units subcut of a medication.
- Available: 10,000 units per mL _____
- 13. Order: 50 mg IM of a medication.
- Available: 80 mg per 2 mL _____
- 14. Order: 0.5 g p.o. of an antibiotic.
- Available: Capsules labeled 250 mg _____
- 15. Order: 400 mg p.o. of a liquid medication.
- Available: 125 mg per 5 mL _____
- 16. Order: 50 mg IM of a medication.
- Available: 80 mg per mL _____
- 17. Order: 60 mg IM of a medication.
- Available: 30 mg per mL _____
- 18. Order: 15 mg of a medication.
- Available: Tablets labeled 5 mg _____
- 19. Order: 0.24 g p.o. of a liquid medication.
- Available: 80 mg per 7.5 mL _____
- 20. Order: 20 g p.o. of a liquid medication.
- Available: 10 g per 15 mL _____
- 21. Order: 0.125 mg IM of a medication.
- Available: 0.5 mg per 2 mL _____
- 22. Order: 0.75 mg IM of a medication.
- Available: 0.25 mg per mL _____
- 23. Order: 375 mg p.o. of a liquid medication.
- Available: 125 mg per 5 mL _____
- 24. Order: 10,000 units subcut of a medication.
- Available: 7,500 units per mL _____
- 25. Order: 0.45 mg p.o. of a medication.
- Available: Tablets labeled 0.3 mg _____
- 26. Order: 20 mg IM of a medication.
- Available: 25 mg per 1.5 mL _____
- 27. Order: 150 mg IV of a medication.
- Available: 80 mg per mL _____
- 28. Order: 2 mg IM of a medication.
- Available: 1.5 mg per 0.5 mL _____
- 29. Order: 500 mcg IV of a medication.
- Available: 750 mcg per 3 mL _____
- 30. Order: 0.15 mg IM of a medication.
- Available: 0.2 mg per 1.5 mL _____
- 31. Order: 1,100 units subcut of a medication.
- Available: 1,000 units per 1.5 mL _____
- 32. Order: 0.6 g IV of a medication.
- Available: 1 g per 3.6 mL _____
- 33. Order: 3 g IV of a medication.
- Available: 1.5 g per mL _____
- 34. Order: 35 mg IM of a medication.
- Available: 40 mg per 2.5 mL _____
- 35. Order: 0.3 mg subcut of a medication.

- Available: 1,000 mcg per 2 mL _____
- 36. Order: 200 mg IM of a medication.
- Available: 0.5 g per 2 mL _____
- 37. Order: 10 mEq IV of a medication.
- Available: 20 mEq per 10 mL _____
- 38. Order: 165 mg IV of a medication.
- Available: 55 mg per 1.1 mL _____
- 39. Order: 35 mg subcut of a medication.
- Available: 45 mg per 1.2 mL _____
- 40. Order: 700 mg IM of a medication.
- Available: 1,000 mg per 2.3 mL _____
- Write a proportion and solve for the following unknown quantity.
- 41. If 15 mL of solution contains 75 mg of medication, how many mg of medication are in 60 mL of solution?
- 42. A client must take three tablets per day for 28 days. How many tablets should the pharmacy supply to fill this order?
- 43. A health care provider is instructed to administer 700 mL of a solution every 8 hours. How many hours will be needed to administer 2,100 mL?
- 44. Two tablets contain a total of 6.25 mg of a medication. How many milligrams of medication are in 10 tablets?
- 45. If 80 mg of medication is in 480 mL of solution, how many milliliters of solution contain 60 milligrams?

Answers on pp. 233-237

CHAPTER **REVIEW**

Part I

Read the medication labels where available, and calculate the number of tablets or capsules necessary to provide the dosage ordered.

- 1. Order: Phenobarbital 15 mg p.o. t.i.d.
- Available: Phenobarbital tablets labeled 15 mg _____
- 2. Order: Erythromycin (delayed-release capsules) 0.5 g p.o. q12h for 10 days.
- Available:

- _____
- 3. Order: Brilinta 180 mg p.o. stat.
- Available:

- _____
- 4. Order: Dilatrate-SR 80 mg p.o. q12h.
- Available:

- _____
- 5. Order: Dexamethasone 4 mg p.o. q8h.
- Available:

- _____
- 6. Order: Digoxin 125 mcg p.o. daily.
- Available:

- _____
- 7. Order: Ibrance 125 mg p.o. daily for 21 days.
- Available:

- _____
- 8. Order: Cephalexin 0.5 g p.o. q.i.d.
- Available:

- _____
- 9. Order: Nuplazid 34 mg p.o. daily.
- Available:

- _____
- 10. Order: Rifampin 0.6 g p.o. daily.
- Available: Rifampin capsules labeled 300 mg
- _____
- 11. Order: Xanax 0.5 mg p.o. b.i.d.
- Available: Scored tablets (can be broken in half)

- _____
- 12. Order: Rubraca 600 mg p.o. bid.
- Available:

- _____
- 13. Order: Prandin 2 mg p.o. tid before meals.
- Available:

- _____
- 14. Order: Risperdal 8 mg p.o. daily.
- Available:

- _____
- 15. Order: Lasix 60 mg p.o. daily.
- Available:

- _____
- 16. Order: Latuda 80 mg p.o. daily.
- Available:

- _____
- 17. Order: Calcitrol 0.5 mcg p.o. daily.
- Available:

- _____

Answers on 237

Part II

Calculate the volume necessary (in milliliters) to provide the dosage ordered, using medication labels where available. Express your answer as a decimal fraction to the nearest tenth where indicated.

- 18. Order: Dilantin 100 mg by gastrostomy tube t.i.d.
- Available: Dilantin 125 mg per 5 mL _____
- 19. Order: Benadryl 50 mg p.o. at bedtime.

- Available: Benadryl oral solution labeled 12.5 mg per 5 mL _____
- 20. Order: Gentamicin 50 mg IM q8h.
- Available:

- _____
- 21. Order: Vibramycin 100 mg p.o. q12h.
- Available:

- _____
- 22. Order: Morphine 1.5 mg IM q4h prn for pain.
- Available:

- _____
- 23. Order: Ondansetron 8 mg p.o. q12h for 2 days following chemotherapy.
- Available:

- _____
- 24. Order: Nystatin oral suspension 100,000 units swish and swallow q6h.
- Available: Nystatin oral suspension labeled 100,000 units per mL _____
- 25. Order: Heparin 5,000 units subcut daily.
- Available:

- _____
- 26. Order: Atropine 0.2 mg subcut stat.
- Available:

- _____
- 27. Order: Heparin 7,500 units subcut daily. Express answer in hundredths.
- Available:

- _____
- 28. Order: Lorazepam 2 mg IM q4h p.r.n. for agitation.
- Available:

- _____
- 29. Order: Octreotide Acetate 200 mcg subcut q12h.
- Available:

- _____
- 30. Order: Oxcarbazepine 0.6 g p.o. bid.
- Available:

- _____
- 31. Order: Depo-Provera 0.4 g IM at bedtime once a week on Thursday.
- Available:

- _____
- 32. Order: Lactulose 30 g p.o. t.i.d.
- Available:

- _____
- 33. Order: Dilantin suspension 200 mg per nasogastric tube every day.
- Available:
- _____

Answers on 237

ANSWERS

Chapter 13

Answers to Practice Problems

- 1. Less than 1 tab
- 2. More than 1 tab
- 3. Less than 1 tab
- 4. Less than 1 tab
- 5. More than 1 tab
- 6.

- *or*
- 5 mg : 1 tab = 7.5 mg : *x* tab

- *x* = 1.5 tabs or 1½ tabs. 5 mg is less than 7.5 mg; therefore you will need more than 1 tab to administer the dosage.
- 7.

or

- 30 mg : 1 tab = 45 mg : *x* tab

- *x* = 1.5 tabs or 1½ tabs. 45 mg is more than 30 mg; therefore you need more than 1 tab to administer the dosage.
- 8. Equivalent: 1,000 mg = 1 g (0.09 g = 90 mg)

- x = 2 caps. 90 mg is more than 45 mg; therefore you will need more than 1 cap to administer the dosage.
- 9.

or

- 0.5 mg : 1 mL = 0.25 mg : x mL

- x = 0.5 mL, 0.25 mg is less than 0.5 mg; you will need less than 1 mL to administer the dosage.
- 10.

or

- 125 mg : 5 mL = 100 mg : x mL

- x = 4 mL. 100 mg is less than 125 mg; therefore you will need less than 5 mL to administer the dosage.
- 11.

40 mEq : 10 mL = 20 mEq : *x* mL

- *x* = 5 mL. 20 mEq is less than 40 mEq; you will need less than 10 mL to administer the dosage.
- 12.

or

- 10,000 units : 1 mL = 5,000 units : *x* mL

- *x* = 0.5 mL, 10,000 units is more than 5,000 units; therefore you will need less than 1 mL to administer the dosage.
- 13.

or

- 80 mg : 2 mL = 50 mg : *x* mL

- x = 1.25 = 1.3 mL. 50 mg is less than 80 mg; therefore you will need less than 2 mL to administer the dosage.
- 14. Equivalent: 1,000 mg = 1 g (0.5 g = 500 mg)

- *or*
- 250 mg : 1 cap = 500 mg : x cap

- x = 2 caps. 500 mg is more than 250 mg; therefore you will need more than 1 cap to administer the dosage.
- 15.

or

- 125 mg : 5 mL = 400 mg : x mL

- x = 16 mL. 400 mg is larger than 125 mg; therefore you will need more than 5 mL to administer the dosage.
- 16.

or

- 80 mg : 1 mL = 50 mg : *x* mL

- *x* = 0.62 = 0.6 mL. 50 mg is less than 80 mg; therefore you will need less than 1 mL to administer the dosage.
- 17.

or

- 30 mg : 1 mL = 60 mg : *x* mL

- *x* = 2 mL. 60 mg is more than 30 mg; therefore you will need more than 1 mL to administer the dosage.
- 18.

or

- 5 mg : 1 tab = 15 mg : *x* tab

- x = 3 tabs. 15 mg is more than 5 mg; therefore you will need more than 1 tab to administer the dosage.
- 19. Equivalent: 1,000 mg = 1 g (0.24 g = 240 mg)

- *or*
- 80 mg : 7.5 mL = 240 mg : x mL

- x = 22.5 mL. 240 mg is more than 80 mg; therefore you would need more than 7.5 mL to administer the dosage.
- 20.

- *or*
- 10 g : 15 mL = 20 g : x mL

- x = 30 mL. 20 g is more than 10 g; therefore you would need more than 15 mL to administer the dosage.
- 21.

or

- 0.5 mg : 2 mL = 0.125 mg : *x* mL

- *x* = 0.5 mL. 0.125 mg is less than 0.5 mg; therefore you will need less than 2 mL to administer the dosage.
- 22.

or

- 0.25 mg : 1 mL = 0.75 mg : *x* mL

- *x* = 3 mL. 0.75 mg is more than 0.25 mg; therefore you will need more than 1 mL to administer the dosage.
- 23.

or

- 125 mg : 5 mL = 375 mg : *x* mL

- x = 15 mL. 375 mg is more than 125 mg; therefore you will need more than 5 mL to administer the dosage.
- 24.

or

- 7,500 units : 1 mL = 10,000 units : x mL

- x = 1.33 = 1.3 mL. 10,000 units is more than 7,500 units; therefore you will need more than 1 mL to administer the dosage.
- 25.

or

- 0.3 mg : 1 tab = 0.45 mg : x tab

- x = 1.5 tabs or 1½ tabs. 0.45 mg is more than 0.3 mg; therefore you will need more than 1 tab to administer the dosage.

NOTE

For questions 26-40 and Chapter Review Parts I and II, answers only are provided. Refer to setup for problems 1-25 and 41-45 for Practice Problems as needed.

- 26. 1.2 mL
- 27. 1.9 mL
- 28. 0.7 mL
- 29. 2 mL
- 30. 1.1 mL
- 31. 1.7 mL
- 32. 2.2 mL
- 33. 2 mL
- 34. 2.2 mL
- 35. 0.6 mL
- 36. 0.8 mL
- 37. 5 mL
- 38. 3.3 mL
- 39. 0.9 mL
- 40. 1.6 mL
- 41.

- *or*
- 75 mg : 15 mL = *x* mg : 60 mL
- *x* = 300 mg
- 42.

or

- 3 tab : 1 day = *x* tab : 28 days
- *x* = 84 tab
- 43.

or

- 700 mL : 8 hr = 2,100 mL : *x* hr
- *x* = 24 hr
- 44.

or

- 6.25 mg : 2 tab = *x* mg : 10 tab
- *x* = 31.25 mg
- 45.

or

- 80 mg : 480 mL = 60 mg : *x* mL
- *x* = 360 mL

Answers to Chapter Review Part I

- 1. 1 tab
- 2. 2 delayed-release caps
- 3. 2 tabs
- 4. 2 sustained-release (SR) caps
- 5. 2 tabs
- 6. 1 tab
- 7. 1 cap
- 8. 1 tab
- 9. 2 tabs
- 10. 2 caps
- 11. 2 tabs
- 12. 3 tabs
- 13. 2 tabs
- 14. 2 tabs
- 15. 3 tabs
- 16. 2 tabs
- 17. 2 caps

Answers to Chapter Review Part II

- 18. 4 mL
- 19. 20 mL
- 20. 1.3 mL
- 21. 20 mL
- 22. 0.8 mL
- 23. 10 mL
- 24. 1 mL
- 25. 1 mL
- 26. 0.5 mL
- 27. 0.75 mL
- 28. 1 mL
- 29. 1 mL
- 30. 10 mL
- 31. 1 mL
- 32. 45 mL
- 33. 8 mL

unknown - Section 28 (Page 217)

This chapter shows how to use a commonly used *formula method* to calculate a dosage. Using a *formula method* to calculate requires identifying the components of the formula from the calculation problem and inserting the information from the problem into the formula. With the *formula method*, the dose ordered (by the prescriber), the available dose (what is on hand, indicated on the medication label), the dosage form (tablet, capsule, volume of solution), and the amount of the dosage form is inserted into the formula to determine what to administer.

Total reliance on a formula without thinking and asking yourself whether an answer is reasonable can result in errors in calculation and an administration error.

When using a formula, always use it consistently and in its entirety to avoid calculation errors. Always ask, "Is the answer obtained reasonable?"

You will learn, for example, that the maximum number of tablets or capsules for a single dosage is usually three. Anything exceeding that should be a red flag to you, even if the answer is obtained from the use of a formula. Use formulas to validate the dosage you think is reasonable, not the reverse. **Think** before you calculate. Always estimate **before** applying a formula. Thinking first will allow you to detect errors and alert you to try again and question the results you obtained.

SAFETY ALERT!

Avoid Dosage Calculation Errors

Do not rely solely on formulas when calculating dosages to be administered. Use critical thinking skills such as considering what the answer should be, reasoning, problem solving, and finding rational justification for your answer. Formulas should be used as tools for validating the dosage you THINK should be given.

Formula for Calculating Dosages

The formula method can be used when calculating dosages in the same system of measurement. When the dosage desired and the dosage on hand are in different systems, convert them to the same system using one of the methods learned for conversion, before using the formula. It is important to learn and memorize the following formula and its components:

Let's examine the terms in the formula before using it.

- • D = The dosage desired, or what the prescriber has ordered, including the units of measurement. Examples: mg, g, etc.
- • H = The dosage strength available, what is on hand, or the weight of the medication on the label, including the unit of measurement. Examples: mg, g, etc.
- • Q = The quantity or the unit of measure that contains the dosage that is available, in other words, the number of tablets, capsules, milliliters, etc. that contains the available dosage. "Q" is labeled accordingly as tablet, capsule, milliliter, etc.
- • *x* = The unknown, the dosage you are looking for, the dosage you are going to administer, how many milliliters, tablets, etc. you will give.
- • Always get into the habit of inserting the quantity value for **"Q"** into the formula, even though when solving problems that involve solid forms of medication (tabs, caps), **"Q"** is always 1. This will prevent errors when calculating dosages for medications in solution (oral liquids or injectables) in which the solution quantity can be more or less than 1 (such as per 10 mL). When solving problems for medications in solution, include the amount for **"Q,"** which varies and must always be included.

- • The available dosage on the label for medications in solution may indicate the quantity of medication per 1 milliliter or per multiple milliliters of solution, such as 80 mg per 2 mL, 125 mg per 5 mL. Some liquid medications may also express the quantity in amounts less than a milliliter, such as 2 mg per 0.5 mL.
- • When setting up the formula, notice that **"D,"** which is the dosage desired, is in the numerator, and **"H,"** which is the dosage strength available, is placed in the denominator of the fraction.
- • All terms of the formula, including "*x*," must be labeled to ensure accuracy.

NOTE

The unknown "*x* " and "Q" are always labeled the same (e.g., tabs, mL).

SAFETY ALERT!

Omission of the amount for "Q" can render an error in dosage calculation. Labeling of all terms of the formula, including *"x,"* is a safeguard to prevent errors in calculation. Always think first, what is a reasonable amount to administer, and calculate the dosage using the formula.

Using the Formula Method

Let's review the steps for using the formula (Box 14.1) before beginning to calculate dosages.

BOX 14-1 Steps for Using the Formula

- 1. Memorize the formula, or verify the formula from a resource.
- 2. Place the information from the problem into the formula in the correct position, with all terms in the formula labeled correctly, including "*x*."
- 3. Make sure that all measures are in the same units and system of measure; if not, a conversion must be done *before* calculating the dosage.
- 4. Think logically, and consider what a reasonable amount to administer would be.
- 5. Calculate your answer, using the formula
- 6. Label all answers—tabs, caps, mL, etc

Now we will look at sample problems illustrating the use of the formula.

Example 1: Order: 0.375 mg p.o. of a medication.

Available: Tablets labeled 0.25 mg

Solution: The dosage 0.375 mg is desired; the dosage strength available is 0.25 mg per tablet. No conversion is necessary. What is desired is in the same system and unit of measure as what you have on hand.

FORMULA SETUP

The desired (D) is 0.375 mg. You have on hand (H) 0.25 mg per (Q) 1 tablet. The label on *x* is tablet. Notice that the label on *x* is always the same as Q.

x = 1.5 = 1½ tabs

Therefore *x* = 1.5 tabs, or 1½ tabs. (Because 0.375 mg is larger than 0.25 mg, you will need more than 1 tab to administer 0.375 mg.) *Note:* Although 1.5 tabs is the same as 1½ tabs, for administration purposes, it would be best to state it as 1½ tabs.

Example 2: Order: 7,000 units IM of a medication.

Available: 10,000 units in 2 mL

Solution:

SAFETY ALERT!

Omitting Q here could result in an error. A liquid form of medication is involved; Q must be included because the amount varies and is not always per 1 mL.

RULE

Rule for Different Units or Systems of Measure

Whenever the desired amount and the dosage on hand are in different units or systems of measure, follow these steps:

- 1. Choose the identified equivalent (the conversion factor needed to make the conversion).
- 2. Convert what is ordered to the same units or system of measure as what is available by using one of the conversion methods presented in the chapter on converting.
- 3. Use the formula

to calculate the dosage to administer.

TIPS FOR CLINICAL PRACTICE

The metric system is the principal system used for medications. When converting is required before calculating a dosage, convert measures to their metric equivalent when possible to decrease the chance of error in calculation.

Example 3: Order: 0.1 mg p.o. of a medication daily.

Available: Tablets labeled 50 mcg

Solution: Convert 0.1 mg to mcg. The equivalent to use is 1 mg = 1,000 mcg. Therefore 0.1 mg = 100 mcg.

Now that you have everything in the same system and units of measure, use the formula presented to calculate the dosage to be administered.

Solution:

Therefore x = 2 tabs. (Because 100 mcg is a larger dosage than 50 mcg, it will take more than 1 tab to administer the desired dosage.)

Example 4: Order: 0.2 g p.o. of a liquid medication.

Available: 125 mg per 5 mL

Solution: Convert 0.2 g to mg. The equivalent to use is 1,000 mg = 1 g. Therefore 0.2 g = 200 mg.

Now that everything is in the same system and units of measure, use the formula presented to calculate the dosage to be administered.

Therefore x = 8 mL. (Because 200 mg is a larger dose than 125 mg, it will take more than 5 mL to administer the desired dosage.)

Example 5: Order: 10 mg subcutaneous of a medication.

Available: 30 mg per mL (Express the answer to the nearest tenth.)

Solution: No conversion is required; the dosage ordered is in the same system and unit of measurement as the available.

Therefore x = 0.33 = 0.3 mL rounded to the nearest tenth. (Because 30 mg is larger than 10 mg, it will take less than 1 mL to administer the required dosage.) Milliliter is a metric measure expressed as a decimal number.

CRITICAL THINKING

Use critical thinking before and after formulaic calculating. It is an essential step in estimating what is reasonable and logical in terms of a dosage. This will help prevent errors in calculation caused by setting up the problem incorrectly or careless math and will remind you to double-check your calculation and identify any error.

Remember to memorize the formula presented and follow the steps sequentially.

- • Check **first** to see if a conversion is required; if so, **convert** so that everything is in the same units and system of measure.
- • **Think** critically as to a reasonable answer.
- • Set up terms in the formula and **calculate** to validate the dosage you anticipated was reasonable using the formula.

SAFETY ALERT!

Always double-check your math. Errors can be made in simple calculations because of lack of caution. Always ask yourself whether the answer you have obtained is reasonable and correct.

POINTS TO REMEMBER

- • The formula

  can be used to calculate the dosage to be administered.
- • The Q is always 1 for solid forms of medications (tabs, caps, etc.) but varies when medications are in liquid form. Do not omit "Q" even when 1.
- • Before the dosage to be given is calculated, the dosage desired must be in the same units and system of measure as the dosage available or a conversion is necessary.
- • Set up the terms in the formula labeled correctly, including "Q" and *"x."*
- • Think about what a reasonable answer would be.
- • Calculate the dosage to administer using the formula to validate your answer as to what was reasonable.
- • Double-check all your math, and think logically about the answer obtained.
- • Label all answers obtained (e.g., tabs, caps, mL).
- • The use of a formula does not eliminate the need to think critically.
- • Always systematically follow these steps: Convert if necessary, THINK about what would be a reasonable answer, set up the terms in the formula, Calculate the dosage to administer using the formula.

PRACTICE PROBLEMS

For questions 1-15, calculate the problems using the formula method presented in this chapter. Label the answers correctly (tabs, caps). Indicate whether less or more of the medication is needed to administer the dosage ordered.

- 1. Order: 0.4 mg p.o.
- Available: Tablets labeled 0.2 mg_____
- 2. Order: 0.75 g p.o.
- Available: Capsules labeled 250 mg_____
- 3. Order: 90 mg p.o.
- Available: Tablets labeled 60 mg_____
- 4. Order: 7.5 mg p.o.
- Available: Tablets labeled 2.5 mg_____
- 5. Order: 0.05 mg p.o.
- Available: Tablets labeled 25 mcg_____
- 6. Order: 0.4 mg p.o.
- Available: Tablets labeled 200 mcg_____
- 7. Order: 1,000 mg p.o.
- Available: Tablets labeled 500 mg_____
- 8. Order: 0.6 g p.o.
- Available: Capsules labeled 600 mg_____
- 9. Order: 1.25 mg p.o.
- Available: Tablets labeled 625 mcg_____

Calculate the following in milliliters and round to the nearest tenth where indicated. Label answers in mL.

- 10. Order: 10 mg subcut.
- Available: 15 mg per mL_____
- 11. Order: 400 mg p.o.
- Available: Oral solution labeled 200 mg per 5 mL_____
- 12. Order: 15 mEq p.o.
- Available: Oral solution labeled 20 mEq per10 mL_____
- 13. Order: 125 mg p.o.
- Available: Oral solution labeled 250 mg per 5 mL_____
- 14. Order: 0.025 mg p.o.
- Available: Oral solution labeled 0.05 mg per 5 mL_____
- 15. Order: 375 mg p.o.
- Available: Oral solution labeled 125 mg per 5 mL_____

Answers on pp. 255-256

CHAPTER REVIEW

Calculate the following dosages using the medication label or information provided. Label answers correctly: tabs, caps, mL. Answers expressed in milliliters should be rounded to the nearest tenth where indicated.

- 1. Order: Phenobarbital 30 mg p.o. t.i.d.
- Available:

- 2. Order: Neurontin 0.3 g p.o. bid.
- Available:

- 3. Order: Feldene 20 mg p.o. daily.
- Available:

- 4. Order: Vraylar 3 mg p.o. daily.
- Available:

- 5. Order: Flagyl 0.5 g p.o. b.i.d. for 1 week.
- Available:

- 6. Order: Verapamil 5 mg IV stat.
- Available: Verapamil

- 7. Order: Morphine Sulfate (extended-release) 30 mg p.o. q12h.
- Available:

- 8. Order: Cogentin 1 mg IM at bedtime.
- Available:

- 9. Order: Cosentyx 150 mg subcut every 4 weeks.
- Available:

- 10. Order: Methylprednisolone sodium succinate 35 mg IM daily.
- Available:

- 11. Order: Phenobarbital elixir 45 mg p.o. b.i.d.
- Available:

- 12. Order: Heparin 3,000 units subcut b.i.d.
- Available:

- 13. Order: Gentamicin 70 mg IV q8h.
- Available:

- 14. Order: Atropine 0.3 mg IM stat.
- Available:

- 15. Order: Lorazepam 1.5 mg IM stat.
- Available:

- 16. Order: Lincocin 0.5 g IM q12h.
- Available:

- 17. Order: Lithium Carbonate (extended-release) 900 mg p.o. q12h.
- Available:

- 18. Order: Sinemet CR (sustained-release) 50-200 p.o. bid.
- Available:

- 19. Order: Sunosi 37.5 mg p.o. daily for a client with renal impairment.
- Available: Scored tablets (can be broken in half)

- 20. Order: Vasotec 5 mg p.o. daily.
- Available:

- 21. Order: Clozaril 50 mg p.o. b.i.d.
- Available:

- 22. Order: Inderal LA 80 mg p.o. daily.
- Available:

- 23. Order: Targretin 150 mg p.o. daily ac.
- Available:

- 24. Order: Verzenio 150 mg p.o. bid.
- Available:

- 25. Order: Aricept 10 mg p.o. every day at bedtime.
- Available:

- 26. Order: Entresto 49/51 p.o. bid.
- Available:

Answers on 256

ANSWERS

Chapter 14

Answers to Practice Problems

- 1.

  x = 2 tabs. 0.4 mg is greater than 0.2 mg; therefore you will need more than 1 tab to administer the dosage.

- 2. Equivalent: 1,000 mg = 1 g (0.75 g = 750 mg)

- x = 3 caps. 750 mg is larger than 250 mg; therefore you will need more than 1 cap to administer the dosage.
- 3.

. 90 mg is larger than 60 mg; therefore you will need more than 1 tab to administer the dosage.

- 4.

x = 3 tabs. 7.5 mg is larger than 2.5 mg; therefore you will need more than 1 tab to administer the dosage.

- 5. Equivalent: 1,000 mcg = 1 mg
- (0.05 mg = 50 mcg)

- x = 2 tabs. 50 mcg is larger than 25 mcg; therefore you will need more than 1 tab to administer the dosage.
- 6. Equivalent: 1,000 mcg = 1 mg
- (0.4 mg = 400 mcg)

- x = 2 tabs. 400 mcg is larger than 200 mcg; therefore you will need more than 1 tab to administer the dosage.
- 7.

x = 2 tabs. 1,000 mg is more than 500 mg; therefore you will need more than 1 tab to administer the dosage.

- 8. Equivalent: 1,000 mg = 1 g (0.6 g = 600 mg)

- x = 1 cap. 0.6 g = 600 mg. 600-mg caps are available; therefore give 1 cap to administer the dosage.
- 9. Equivalent: 1,000 mcg = 1 mg
- (1.25 mg = 1,250 mcg)

- x = 2 tabs. 1,250 mcg is more than 625 mcg; therefore you will need more than one tab to administer the dosage.
- 10.

  x = 0.66 = 0.7 mL. 10 mg is less than 15 mg; therefore you will need less than 1 mL to administer the dosage.

- 11.

  x = 10 mL. 400 mg is more than 200 mg; therefore you will need more than 5 mL to administer the dosage.

- 12.

  x = 7.5 mL. 15 mEq is less than 20 mEq; therefore you will need less than 10 mL to administer the dosage.

- 13.

x = 2.5 mL. 125 mg is less than 250 mg; therefore you will need less than 5 mL to administer the dosage.

- 14.

x = 2.5 mL. 0.025 mg is less than 0.05 mg; therefore you will need less than 5 mL to administer the dosage.

- 15.

x = 15 mL. 375 mg is more than 125 mg; therefore you will need more than 5 mL to administer the dosage.

Answers to Chapter Review

NOTE

For Chapter Review problems, only answers are shown. If needed, review the setup of problems in Practice Problems 1 to 15.

- 1. 2 tabs
- 2. 3 caps
- 3. 2 caps
- 4. 2 caps
- 5. 1 tab
- 6. 2 mL
- 7. 1 extended-release tab
- 8. 1 mL
- 9. 1 mL
- 10. 0.9 mL
- 11. 11.3 mL
- 12. 0.6 mL

- 13. 1.8 mL
- 14. 0.8 mL
- 15. 0.8 mL
- 16. 1.7 mL
- 17. 2 extended-release tabs
- 18. 1 sustained-release tab
- 19.

tab or 0.5 tab

- 20. 2 tabs
- 21. 2 tabs
- 22. 1 long-acting caps
- 23. 2 caps
- 24. 1 tab
- 25. 2 tabs
- 26. 1 tab

unknown - Section 28 (Page 222)

This chapter shows how to use a commonly used *formula method* to calculate a dosage. Using a *formula method* to calculate requires identifying the components of the formula from the calculation problem and inserting the information from the problem into the formula. With the *formula method*, the dose ordered (by the prescriber), the available dose (what is on hand, indicated on the medication label), the dosage form (tablet, capsule, volume of solution), and the amount of the dosage form is inserted into the formula to determine what to administer.

Total reliance on a formula without thinking and asking yourself whether an answer is reasonable can result in errors in calculation and an administration error.

When using a formula, always use it consistently and in its entirety to avoid calculation errors. Always ask, "Is the answer obtained reasonable?"

You will learn, for example, that the maximum number of tablets or capsules for a single dosage is usually three. Anything exceeding that should be a red flag to you, even if the answer is obtained from the use of a formula. Use formulas to validate the dosage you think is reasonable, not the reverse. **Think** before you calculate. Always estimate **before** applying a formula. Thinking first will allow you to detect errors and alert you to try again and question the results you obtained.

SAFETY ALERT!

Avoid Dosage Calculation Errors

Do not rely solely on formulas when calculating dosages to be administered. Use critical thinking skills such as considering what the answer should be, reasoning, problem solving, and finding rational justification for your answer. Formulas should be used as tools for validating the dosage you THINK should be given.

Formula for Calculating Dosages

The formula method can be used when calculating dosages in the same system of measurement. When the dosage desired and the dosage on hand are in different systems, convert them to the same system using one of the methods learned for conversion, before using the formula. It is important to learn and memorize the following formula and its components:

Let's examine the terms in the formula before using it.

- • D = The dosage desired, or what the prescriber has ordered, including the units of measurement. Examples: mg, g, etc.
- • H = The dosage strength available, what is on hand, or the weight of the medication on the label, including the unit of measurement. Examples: mg, g, etc.
- • Q = The quantity or the unit of measure that contains the dosage that is available, in other words, the number of tablets, capsules, milliliters, etc. that contains the available dosage. "Q" is labeled accordingly as tablet, capsule, milliliter, etc.
- • *x* = The unknown, the dosage you are looking for, the dosage you are going to administer, how many milliliters, tablets, etc. you will give.
- • Always get into the habit of inserting the quantity value for **"Q"** into the formula, even though when solving problems that involve solid forms of medication (tabs, caps), **"Q"** is always 1. This will prevent errors when calculating dosages for medications in solution (oral liquids or injectables) in which the solution quantity can be more or less than 1 (such as per 10 mL). When solving problems for medications in solution, include the amount for **"Q,"** which varies and must always be included.

- • The available dosage on the label for medications in solution may indicate the quantity of medication per 1 milliliter or per multiple milliliters of solution, such as 80 mg per 2 mL, 125 mg per 5 mL. Some liquid medications may also express the quantity in amounts less than a milliliter, such as 2 mg per 0.5 mL.
- • When setting up the formula, notice that **"D,"** which is the dosage desired, is in the numerator, and **"H,"** which is the dosage strength available, is placed in the denominator of the fraction.
- • All terms of the formula, including "*x*," must be labeled to ensure accuracy.

NOTE

The unknown "*x* " and "Q" are always labeled the same (e.g., tabs, mL).

SAFETY ALERT!

Omission of the amount for "Q" can render an error in dosage calculation. Labeling of all terms of the formula, including *"x,"* is a safeguard to prevent errors in calculation. Always think first, what is a reasonable amount to administer, and calculate the dosage using the formula.

Using the Formula Method

Let's review the steps for using the formula (Box 14.1) before beginning to calculate dosages.

BOX 14-1 Steps for Using the Formula

- 1. Memorize the formula, or verify the formula from a resource.
- 2. Place the information from the problem into the formula in the correct position, with all terms in the formula labeled correctly, including "*x*."
- 3. Make sure that all measures are in the same units and system of measure; if not, a conversion must be done *before* calculating the dosage.
- 4. Think logically, and consider what a reasonable amount to administer would be.
- 5. Calculate your answer, using the formula
- 6. Label all answers—tabs, caps, mL, etc

Now we will look at sample problems illustrating the use of the formula.

Example 1: Order: 0.375 mg p.o. of a medication.

Available: Tablets labeled 0.25 mg

Solution: The dosage 0.375 mg is desired; the dosage strength available is 0.25 mg per tablet. No conversion is necessary. What is desired is in the same system and unit of measure as what you have on hand.

FORMULA SETUP

The desired (D) is 0.375 mg. You have on hand (H) 0.25 mg per (Q) 1 tablet. The label on *x* is tablet. Notice that the label on *x* is always the same as Q.

x = 1.5 = 1½ tabs

Therefore *x* = 1.5 tabs, or 1½ tabs. (Because 0.375 mg is larger than 0.25 mg, you will need more than 1 tab to administer 0.375 mg.) *Note:* Although 1.5 tabs is the same as 1½ tabs, for administration purposes, it would be best to state it as 1½ tabs.

Example 2: Order: 7,000 units IM of a medication.

Available: 10,000 units in 2 mL

Solution:

SAFETY ALERT!

Omitting Q here could result in an error. A liquid form of medication is involved; Q must be included because the amount varies and is not always per 1 mL.

RULE

Rule for Different Units or Systems of Measure

Whenever the desired amount and the dosage on hand are in different units or systems of measure, follow these steps:

- 1. Choose the identified equivalent (the conversion factor needed to make the conversion).
- 2. Convert what is ordered to the same units or system of measure as what is available by using one of the conversion methods presented in the chapter on converting.
- 3. Use the formula

to calculate the dosage to administer.

TIPS FOR CLINICAL PRACTICE

The metric system is the principal system used for medications. When converting is required before calculating a dosage, convert measures to their metric equivalent when possible to decrease the chance of error in calculation.

Example 3: Order: 0.1 mg p.o. of a medication daily.

Available: Tablets labeled 50 mcg

Solution: Convert 0.1 mg to mcg. The equivalent to use is 1 mg = 1,000 mcg. Therefore 0.1 mg = 100 mcg.

Now that you have everything in the same system and units of measure, use the formula presented to calculate the dosage to be administered.

Solution:

Therefore x = 2 tabs. (Because 100 mcg is a larger dosage than 50 mcg, it will take more than 1 tab to administer the desired dosage.)

Example 4: Order: 0.2 g p.o. of a liquid medication.

Available: 125 mg per 5 mL

Solution: Convert 0.2 g to mg. The equivalent to use is 1,000 mg = 1 g. Therefore 0.2 g = 200 mg.

Now that everything is in the same system and units of measure, use the formula presented to calculate the dosage to be administered.

Therefore x = 8 mL. (Because 200 mg is a larger dose than 125 mg, it will take more than 5 mL to administer the desired dosage.)

Example 5: Order: 10 mg subcutaneous of a medication.

Available: 30 mg per mL (Express the answer to the nearest tenth.)

Solution: No conversion is required; the dosage ordered is in the same system and unit of measurement as the available.

Therefore x = 0.33 = 0.3 mL rounded to the nearest tenth. (Because 30 mg is larger than 10 mg, it will take less than 1 mL to administer the required dosage.) Milliliter is a metric measure expressed as a decimal number.

CRITICAL THINKING

Use critical thinking before and after formulaic calculating. It is an essential step in estimating what is reasonable and logical in terms of a dosage. This will help prevent errors in calculation caused by setting up the problem incorrectly or careless math and will remind you to double-check your calculation and identify any error.

Remember to memorize the formula presented and follow the steps sequentially.

- • Check **first** to see if a conversion is required; if so, **convert** so that everything is in the same units and system of measure.
- • **Think** critically as to a reasonable answer.
- • Set up terms in the formula and **calculate** to validate the dosage you anticipated was reasonable using the formula.

SAFETY ALERT!

Always double-check your math. Errors can be made in simple calculations because of lack of caution. Always ask yourself whether the answer you have obtained is reasonable and correct.

POINTS TO REMEMBER

- • The formula

  can be used to calculate the dosage to be administered.
- • The Q is always 1 for solid forms of medications (tabs, caps, etc.) but varies when medications are in liquid form. Do not omit "Q" even when 1.
- • Before the dosage to be given is calculated, the dosage desired must be in the same units and system of measure as the dosage available or a conversion is necessary.
- • Set up the terms in the formula labeled correctly, including "Q" and *"x."*
- • Think about what a reasonable answer would be.
- • Calculate the dosage to administer using the formula to validate your answer as to what was reasonable.
- • Double-check all your math, and think logically about the answer obtained.
- • Label all answers obtained (e.g., tabs, caps, mL).
- • The use of a formula does not eliminate the need to think critically.
- • Always systematically follow these steps: Convert if necessary, THINK about what would be a reasonable answer, set up the terms in the formula, Calculate the dosage to administer using the formula.

PRACTICE PROBLEMS

For questions 1-15, calculate the problems using the formula method presented in this chapter. Label the answers correctly (tabs, caps). Indicate whether less or more of the medication is needed to administer the dosage ordered.

- 1. Order: 0.4 mg p.o.
- Available: Tablets labeled 0.2 mg_____
- 2. Order: 0.75 g p.o.
- Available: Capsules labeled 250 mg_____
- 3. Order: 90 mg p.o.
- Available: Tablets labeled 60 mg_____
- 4. Order: 7.5 mg p.o.
- Available: Tablets labeled 2.5 mg_____
- 5. Order: 0.05 mg p.o.
- Available: Tablets labeled 25 mcg_____
- 6. Order: 0.4 mg p.o.
- Available: Tablets labeled 200 mcg_____
- 7. Order: 1,000 mg p.o.
- Available: Tablets labeled 500 mg_____
- 8. Order: 0.6 g p.o.
- Available: Capsules labeled 600 mg_____
- 9. Order: 1.25 mg p.o.
- Available: Tablets labeled 625 mcg_____

Calculate the following in milliliters and round to the nearest tenth where indicated. Label answers in mL.

- 10. Order: 10 mg subcut.
- Available: 15 mg per mL_____
- 11. Order: 400 mg p.o.
- Available: Oral solution labeled 200 mg per 5 mL_____
- 12. Order: 15 mEq p.o.
- Available: Oral solution labeled 20 mEq per10 mL_____
- 13. Order: 125 mg p.o.
- Available: Oral solution labeled 250 mg per 5 mL_____
- 14. Order: 0.025 mg p.o.
- Available: Oral solution labeled 0.05 mg per 5 mL_____
- 15. Order: 375 mg p.o.
- Available: Oral solution labeled 125 mg per 5 mL_____

Answers on pp. 255-256

CHAPTER REVIEW

Calculate the following dosages using the medication label or information provided. Label answers correctly: tabs, caps, mL. Answers expressed in milliliters should be rounded to the nearest tenth where indicated.

- 1. Order: Phenobarbital 30 mg p.o. t.i.d.
- Available:

- 2. Order: Neurontin 0.3 g p.o. bid.
- Available:

- 3. Order: Feldene 20 mg p.o. daily.
- Available:

- 4. Order: Vraylar 3 mg p.o. daily.
- Available:

- 5. Order: Flagyl 0.5 g p.o. b.i.d. for 1 week.
- Available:

- 6. Order: Verapamil 5 mg IV stat.
- Available: Verapamil

- 7. Order: Morphine Sulfate (extended-release) 30 mg p.o. q12h.
- Available:

- 8. Order: Cogentin 1 mg IM at bedtime.
- Available:

- 9. Order: Cosentyx 150 mg subcut every 4 weeks.
- Available:

- 10. Order: Methylprednisolone sodium succinate 35 mg IM daily.
- Available:

- 11. Order: Phenobarbital elixir 45 mg p.o. b.i.d.
- Available:

- 12. Order: Heparin 3,000 units subcut b.i.d.
- Available:

- 13. Order: Gentamicin 70 mg IV q8h.
- Available:

- 14. Order: Atropine 0.3 mg IM stat.
- Available:

- 15. Order: Lorazepam 1.5 mg IM stat.
- Available:

- 16. Order: Lincocin 0.5 g IM q12h.
- Available:

- 17. Order: Lithium Carbonate (extended-release) 900 mg p.o. q12h.
- Available:

- 18. Order: Sinemet CR (sustained-release) 50-200 p.o. bid.
- Available:

- 19. Order: Sunosi 37.5 mg p.o. daily for a client with renal impairment.
- Available: Scored tablets (can be broken in half)

- 20. Order: Vasotec 5 mg p.o. daily.
- Available:

- 21. Order: Clozaril 50 mg p.o. b.i.d.
- Available:

- 22. Order: Inderal LA 80 mg p.o. daily.
- Available:

- 23. Order: Targretin 150 mg p.o. daily ac.
- Available:

- 24. Order: Verzenio 150 mg p.o. bid.
- Available:

- 25. Order: Aricept 10 mg p.o. every day at bedtime.
- Available:

- 26. Order: Entresto 49/51 p.o. bid.
- Available:

Answers on 256

ANSWERS

Chapter 14

Answers to Practice Problems

- 1.

  x = 2 tabs. 0.4 mg is greater than 0.2 mg; therefore you will need more than 1 tab to administer the dosage.

- 2. Equivalent: 1,000 mg = 1 g (0.75 g = 750 mg)

- x = 3 caps. 750 mg is larger than 250 mg; therefore you will need more than 1 cap to administer the dosage.
- 3.

. 90 mg is larger than 60 mg; therefore you will need more than 1 tab to administer the dosage.

- 4.

x = 3 tabs. 7.5 mg is larger than 2.5 mg; therefore you will need more than 1 tab to administer the dosage.

- 5. Equivalent: 1,000 mcg = 1 mg
- (0.05 mg = 50 mcg)

- x = 2 tabs. 50 mcg is larger than 25 mcg; therefore you will need more than 1 tab to administer the dosage.
- 6. Equivalent: 1,000 mcg = 1 mg
- (0.4 mg = 400 mcg)

- x = 2 tabs. 400 mcg is larger than 200 mcg; therefore you will need more than 1 tab to administer the dosage.
- 7.

x = 2 tabs. 1,000 mg is more than 500 mg; therefore you will need more than 1 tab to administer the dosage.

- 8. Equivalent: 1,000 mg = 1 g (0.6 g = 600 mg)

- x = 1 cap. 0.6 g = 600 mg. 600-mg caps are available; therefore give 1 cap to administer the dosage.
- 9. Equivalent: 1,000 mcg = 1 mg
- (1.25 mg = 1,250 mcg)

- x = 2 tabs. 1,250 mcg is more than 625 mcg; therefore you will need more than one tab to administer the dosage.
- 10.

  x = 0.66 = 0.7 mL. 10 mg is less than 15 mg; therefore you will need less than 1 mL to administer the dosage.

- 11.

  x = 10 mL. 400 mg is more than 200 mg; therefore you will need more than 5 mL to administer the dosage.

- 12.

  x = 7.5 mL. 15 mEq is less than 20 mEq; therefore you will need less than 10 mL to administer the dosage.

- 13.

x = 2.5 mL. 125 mg is less than 250 mg; therefore you will need less than 5 mL to administer the dosage.

- 14.

x = 2.5 mL. 0.025 mg is less than 0.05 mg; therefore you will need less than 5 mL to administer the dosage.

- 15.

x = 15 mL. 375 mg is more than 125 mg; therefore you will need more than 5 mL to administer the dosage.

Answers to Chapter Review

NOTE

For Chapter Review problems, only answers are shown. If needed, review the setup of problems in Practice Problems 1 to 15.

- 1. 2 tabs
- 2. 3 caps
- 3. 2 caps
- 4. 2 caps
- 5. 1 tab
- 6. 2 mL
- 7. 1 extended-release tab
- 8. 1 mL
- 9. 1 mL
- 10. 0.9 mL
- 11. 11.3 mL
- 12. 0.6 mL

- 13. 1.8 mL
- 14. 0.8 mL
- 15. 0.8 mL
- 16. 1.7 mL
- 17. 2 extended-release tabs
- 18. 1 sustained-release tab
- 19.

  tab or 0.5 tab
- 20. 2 tabs
- 21. 2 tabs
- 22. 1 long-acting caps
- 23. 2 caps
- 24. 1 tab
- 25. 2 tabs
- 26. 1 tab

unknown - Section 29 (Page 229)

In this chapter, you will learn how to use *dimensional analysis* (DA) as a method for calculating dosages. It was first introduced as a conversion method in Chapter 7. You may prefer *dimensional analysis to ratio and proportion or formula method*.

Using *dimensional analysis* has advantages, which include the following:

- • Applicable to all dosage calculation problems and other required clinical calculations that the nurse may encounter
- • No required memorization of a formula
- • Setup of one equation to solve a problem even if conversions are required
- • Consistent format for setting up the equation

However, as with other methods of calculating dosages (*ratio and proportion or formula method*) previously discussed, memorization of the common equivalents is still a **must**.

Dimensional analysis is a method that has been in use in the sciences for many years and is also referred to as the *factor-label method or the unit factor method*. Dimensional analysis can be viewed as a problem-solving method. It involves the process of manipulating units. By manipulating units, you are able to eliminate or cancel unwanted units of measurement, leaving only the desired unit for the answer. Although some may find the formalism of the term *dimensional analysis* intimidating at first, you will find it is simple once you have used it to solve a few problems. As already stated, dimensional analysis can be used for all calculations you may encounter once you become comfortable with the process. One of the primary advantages of dimensional analysis is the reduction in the number of steps in calculations to the use of a single equation. Dimensional analysis will be demonstrated as we proceed through the chapters in this text. *Note*: Remember, as previously stated in the discussion of calculation methods, it is important that you choose a method of calculation you are comfortable with and use it consistently.

Understanding the Basics of Dimensional Analysis

Let's begin by reviewing making conversions using dimensional analysis before we look at using it to calculate dosages. As you recall from previous chapters, you learned what were referred to as *equivalents* or *conversion factors*: for example, 1 g = 1,000 mg, 1 kg = 1,000 g. In dimensional analysis, the equivalent or conversion factor is written so that the unwanted unit(s) are cancelled (or eliminated) to leave the desired unit.

Performing Conversions Using Dimensional Analysis

The equivalents (or conversion factors) you learned can be written in a fraction format without changing the value of the unit. This is important to understand when using dimensional analysis. Let's look at the equivalent 1 kg = 1,000 g.

This can be written as:

Now let's look at the basics in using dimensional analysis for converting units of measure. It is necessary to state the equivalent (conversion factor) in fraction format, maintaining the desired unit in the numerator. In dimensional analysis, how the fraction is written is important. How the fraction is written is based on the unit you want to cancel (or eliminate) to get the unit desired. An equivalent (conversion factor) will give you two fractions:

Examples:

To Make Conversions Using Dimensional Analysis

- 1. Identify the desired unit.
- 2. Identify the equivalent (conversion factor) needed.
- 3. Write the equivalent (conversion factor) in fraction format, keeping the desired unit in the numerator of the fraction. This is written first in the equation. (Notice the unit in the numerator is the same as the unit you desire.)
- 4. Label all factors in the equation, and label what you desire *x* (unit desired).
- 5. Identify unwanted or undesired units, and cancel them. Reduce to lowest terms if possible.
- 6. If all the labels except the answer label (unit desired) are not eliminated, recheck the equation.
- 7. Perform the mathematical process indicated.

SAFETY ALERT!

Stating the equivalent correctly is crucial. If the equivalent is stated incorrectly, it will not allow you to cancel unit(s) to get the unit desired. Knowing when the equation is set up correctly is an important part of the concept of dimensional analysis.

Let's look at conversion examples to demonstrate the dimensional analysis process.

Example 1: 1.5 g = _____ mg

- 1. The desired unit is mg.
- 2. Equivalent (conversion factor): 1,000 mg = 1 g
- 3. Write the equivalent (conversion factor), keeping mg in the numerator to allow you to cancel the unwanted unit, g. (Notice the unit in the numerator of the first fraction is the same as the unit you are looking for.)
- 4. Write the equivalent (conversion factor) first stated as a fraction, followed by a multiplication sign (×).
- 5. Perform the indicated mathematical operations.

Setup:

NOTE

Placing a 1 under a value does not alter the value of the number

Example 2: 110 lb = _____ kg

- 1. The desired unit is kg.
- 2. Equivalent (conversion factor): 2.2 lb = 1 kg
- 3. Proceed to set up the problem as outlined.

Setup:

RULE

All factors entered in the equation must always include the quantity and unit of measure. What you desire or are looking for is "*x* " and is labeled with the unit desired. State all answers following the rules of the system. When there is more than one equivalent (conversion factor) for a unit of measure, use the equivalent (conversion factor) used most often.

PRACTICE PROBLEMS

Set up the following problems using the dimensional analysis format; cancel the units. Do not solve.

- 1. 8

  tsp = _____ mL
- 2. 15 mg = _____ g
- 3. 400 mcg = _____ mg
- 4. 2 tbs = _____ mL

- 5. 0.007 g = _____ mg
- 6. 0.5 L = _____ mL
- 7. 529 mg = _____ g
- 8. 1,600 mL = _____ L
- 9. 46.4 kg = _____ lb
- 10. 5 cm = _____ in

Answers on pp. 272-273

POINTS TO REMEMBER

- • State the equivalent (conversion factor) in fraction format with the desired unit in the numerator.
- • Label all factors in the equation, including "*x*."
- • State the equivalent first in the equation, followed by a multiplication sign (×).
- • Remember the rules relating to conversions.
- • Cancel the undesired units to obtain the unit desired for the answer.

Dosage Calculation Using Dimensional Analysis

As stated, dimensional analysis can be used to calculate dosages with the use of a single equation. A single equation can also be used to calculate the dosage when the dosage desired is in units that differ from what is available (or on hand). When using dimensional analysis to calculate dosages, extract the essential information. To set up a dosage calculation problem using dimensional analysis, you need to know the following information:

- • *What is ordered*. This comes from the prescriber's order and contains the strength of the medication and a unit of measurement.
- • ***The available dosage strength*** or what is on hand. This information comes from the medication label. As you recall the dosage strength refers to the weight or amount of the medication provided in a specific unit of measure. The dosage strength is made up of the strength of the medication with the unit of measurement and the dosage form. For solid forms of medications, the dosage strength is the amount per tablet, capsule, etc. **Examples:** 100 mg per tablet (tab), 500 mg per capsule (cap)
- • For liquid medications (oral and parenteral) the dosage strength is the amount of medication present in a certain amount of solution. **Examples:** 40 mg per 1 mL, 125 mg per 5 mL
- • The desired unit of measure being calculated, which contains the unknown quantity represented by "*x*" with the unit of measurement. **Examples:** *x* tab, *x* mL

When dimensional analysis is used to calculate dosages, the above information become crucial factors in the equation. Dosage strengths, for example, are entered as fractions with a numerator and denominator.

Steps in Calculating Dosages Using Dimensional Analysis

- 1. Identify the unit of measure desired in the calculation. With solid forms, the unit will be tab or cap. For parenteral and oral liquids, the unit is milliliter.
- 2. On the left side of the equation, place the name or appropriate abbreviation for *x*, what you desire or are looking for (e.g., tab, cap, mL).
- 3. On the right side of the equation, place the available information from the problem in a fraction format. The abbreviation or unit matching the desired unit must be placed in the numerator.
- 4. Enter the additional factors from the problem, usually what is ordered. Set up the numerator so that it matches the unit in the previous denominator.
- 5. Cancel out the like units of measurement on the right side of the equation. The remaining unit should match the unit on the left side of the equation and be the unit desired. Reduce to lowest terms if possible.
- 6. Solve for the unknown *x*.

Let's look at examples using these steps.

Example 1: Order: Lasix 40 mg p.o. daily.

Available: Tablets labeled 20 mg

- 1. Place the unit of measure desired in the calculation on the left side of the equation, and label it *x*.
- *x* tab =
- 2. Place the information from the problem on the right side of the equation in a fraction format with the unit matching the desired unit in the numerator. (In this problem each tab contains 20 mg.) You must always think about what is a reasonable answer.

- 3. Enter the additional factors from the problem, what is ordered, matching the numerator in the previous denominator (in the problem the order is 40 mg). Placing a 1 under it does not change the value.

- 4. Cancel the like units of measurement on the right side of the equation. The remaining unit of measurement should be what is desired. Match the unit of measurement on the left side. Proceed with the mathematical process. Notice that after cancellation of units (mg), the desired unit of measure to be administered remains (e.g., tabs in this problem).

Now let's look at an example with parenteral medications. You would follow the same steps illustrated in Example 1.

Example 2: Order: Gentamicin 55 mg IM q8h.

Available: Gentamicin 80 mg per 2 mL (round answer to the nearest tenth)

- 1. On the left side of the equation, place the unit desired in this problem (mL).
- *x* mL =
- 2. On the right side, place the available information from the problem in fraction format, placing the unit matching the unit desired in the numerator. Think what is reasonable to administer.

- 3. Enter the additional factors from the problem, what is ordered matching the numerator in the previous denominator (in this problem, the order is 55 mg).

- 4. Cancel out the like units of measurement on the right side of the equation. The remaining unit of measurement should match the unit on the left side of the equation and be the unit desired.

Setting up the Dimensional Analysis Equation When a Conversion Is Required

As already mentioned, dimensional analysis can be used when a medication is ordered in one unit of measurement and is available in a different unit of measurement, thereby necessitating a conversion. To solve the dosage calculation when there are different units, an additional conversion factor is incorporated into the equation. One of the major advantages of dimensional analysis is that it allows multiple factors to be entered in one equation. However, you can also perform the conversion before setting up the equation. Let's look at the steps for incorporating the needed conversion factor (equivalent) into the equation.

The same steps for setting up the equation are followed as previously shown, and the needed conversion factor is incorporated into the equation as follows:

- • An additional fraction is inserted into the equation as the second fraction. This fraction is the equivalent (or conversion factor) needed. The numerator must match the unit of the previous denominator.
- • The last fraction is the medication ordered. This is written so that the numerator of the fraction matches the unit in the denominator of the fraction immediately before.

Let's look at examples:

Example 3: Order: Ampicillin 0.5 g p.o. q6h.

Available: Ampicillin capsules labeled 250 mg

- 1. On the left side of the equation, place the unit of measure desired in the calculation, and label it *x*.
- *x* caps =
- 2. Place the information from the problem on the right side of the equation in a fraction format, placing the unit matching the unit desired in the numerator. Think about what is a reasonable amount to administer.

- 3. The order is for 0.5 g, and the medication is available in 250 mg; a conversion is therefore needed.
- From previous chapters, we know 1 g = 1,000 mg; this conversion factor is placed next in the form of a fraction (the numerator of the fraction must match the denominator of the immediately previous fraction).

- 4. Next, place the amount of medication ordered in the equation. This will match the denominator of the fraction immediately before. In this problem, it is 0.5 g.

- 5. Cancel out like units of measurement on the right side of the equation; the remaining unit of measurement should match the unit on the left side of equation and be the desired unit. Notice that mg and g cancel, leaving the desired unit, caps.

Example 4: Order: Enalaprilat 625 mcg IV stat.

Available: Enalaprilat 2.5 mg per 2 mL

- 1. On the left side of the equation, place the unit of measure desired in the calculation, and label it *x*.
- *x* mL =
- 2. Place the information from the problem on the right side of the equation in a fraction format, placing the unit matching the unit desired in the numerator. Think about what is a reasonable amount to administer.

- 3. The order is for 625 mcg, and the medication available is 2.5 mg per 2 mL; a conversion is therefore needed. From previous chapters, we know 1 mg = 1,000 mcg; this conversion factor is placed next in the form of a fraction (the numerator of the fraction must match the denominator of the immediately previous fraction).

- 4. Next, place the amount of medication ordered in the equation. This will match the denominator of the fraction immediately before, in this problem, it is 625 mcg.

- 5. Next cancel out like units of measurement on the right side of the equation; the remaining unit of measurement should match the unit on the left side of the equation and be the desired unit. Notice that mg and mcg cancel, leaving the desired unit, mL.

SAFETY ALERT!

Incorrect placement of units of measure into the equation will not allow cancellation of units and can result in an error in calculation. Dimensional analysis does not eliminate thinking about what a reasonable answer should be.

POINTS TO REMEMBER

When using dimensional analysis to calculate dosages:

- • First determine units of the medication you want to administer; for example, tabs, caps, mL, and so on. The unit desired is written FIRST to the left of the equation followed by an equal sign (=).
- • The units in the numerator on the left of the equal sign are the same units placed in the numerator of the first fraction on the right side of the equation.
- • If a conversion is necessary, the conversion factor is also entered into the right side of the equation, as the second fraction.
- • The ordered dosage is added at the end as the final fraction.
- • Cancel the like units. When all the cancellations have been made, only the units desired remain (e.g., tab, caps, mL).
- • Always determine the units and THINK about what a reasonable answer is, set up the equation, and cancel the units.
- • All factors entered into the equation must include the quantity and unit of measure.
- • Incorrect placement of units of measurement will not allow you to cancel units and can result in an incorrect answer.
- • Thinking and reasoning are essential even with dimensional analysis.

PRACTICE PROBLEMS

Set up the following problems using dimensional analysis. Do not solve.

- 11. A dose strength of 0.3 g has been ordered.
- Available: 0.4 g per 1.5 mL_____
- 12. A dose strength of 15 mg is ordered.
- Available: 15 mg per mL_____
- 13. Order: Ampicillin 1 g p.o. stat.
- Available: Ampicillin capsules labeled 500 mg_____
- 14. Order: Cefaclor 250 mg p.o. t.i.d.
- Available: Cefaclor oral suspension labeled 125 mg per 5 mL_____
- 15. Order: Methyldopa 0.5 g p.o. daily.
- Available:

- 16. Order: Digoxin 0.125 mg p.o. daily.
- Available: Scored tablets (can be broken in half)

- 17. Order: Dilantin 300 mg p.o. t.i.d.
- Available:

- 18. Order: Cipro 0.5 g p.o. q12h for 10 days.
- Available: Cipro tablets labeled 250 mg_____
- 19. Order: Clindamycin 0.3 g IV q6h.
- Available: Clindamycin labeled 150 mg per mL_____

Answers on 273

CHAPTER REVIEW

Calculate the following medication dosages using the dimensional analysis method. Use medication labels or information provided. Label answers correctly: tab, caps, mL. Answers expressed in milliliters should be expressed to the nearest tenth, except where indicated.

- 1. Order: Antivert 50 mg p.o. daily.
- Available:

- 2. Order: Vibramycin calcium 100 mg p.o. q12h.
- Available:

- 3. Order: Enalaprilat 0.625 mg IV stat.
- Available:

- 4. Order: Linzess 290 mcg p.o. daily for a client with irritable bowel syndrome with constipation (IBS-C).
- Available:

- 5. Order: Captopril 25 mg p.o. b.i.d.

- Available:

- 6. Order: Ondansetron 7 mg p.o. q12h for 2 days following chemotherapy.
- Available:

- 7. Order: Heparin 6,500 units subcut q12h.
- Available: (Express answer in hundredths)

- 8. Order: Invega 6 mg p.o. daily
- Available:

- 9. Order: Solu-Medrol 175 mg IV daily.
- Available: Solu-Medrol 125 mg per mL_____
- 10. Order: Clarithromycin 0.5 g p.o. q12h for 7 days.
- Available:

- 11. Order: Clonazepam 1 mg p.o. b.i.d.
- Available:

- 12. Order: Lyrica CR 165 mg p.o. daily.
- Available:

- 13. Order: Methotrexate 15 mg IM daily for 5 days.
- Available:

- 14. Order: Calcitrol 0.5 mcg p.o. daily
- Available:

- 15. Order: Cefaclor 0.4 g p.o. q8h.
- Available:

- 16. Order: Haloperidol decanoate 0.05 g IM every 4 weeks.
- Available:

- 17. Order: Dexamethasone 1.5 mg IV stat.
- Available:

- 18. Order: Rubraca 500 mg p.o. b.i.d.
- Available:

- 19. Order: Erythromycin Ethylsuccinate oral suspension 0.4 g p.o. q6h.
- Available:

- 20. Order: Clindamycin 0.6 g IV q12h.
- Available:

Answers on pp. 273-274

ANSWERS

Chapter 15

Answers to Practice Problems

NOTE

The following problems could be set up without placing 1 under a value; placing a 1 under the value as shown in the setup for problems 1-19 does not alter the value of the number.

- 1.
- 2.
- 3.
- 4.

- 5.
- 6.
- 7.
- 8.
- 9.

- 10.
- 11.
- 12.
- 13.
- 14.
- 15.

- 16.

- 17.

- 18.

- 19.

NOTE

Placing a 1 under the value does not alter the value of the number.

Answers to Chapter Review

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.

- 7.
- 8.
- 9.
- 10.
- 11.

- 12.
- 13.
- 14.
- 15.
- 16.
- 17.

- 18.
- 19.
- 20.

unknown - Section 29 (Page 234)

In this chapter, you will learn how to use *dimensional analysis* (DA) as a method for calculating dosages. It was first introduced as a conversion method in Chapter 7. You may prefer *dimensional analysis to ratio and proportion or formula method*.

Using *dimensional analysis* has advantages, which include the following:

- • Applicable to all dosage calculation problems and other required clinical calculations that the nurse may encounter
- • No required memorization of a formula
- • Setup of one equation to solve a problem even if conversions are required
- • Consistent format for setting up the equation

However, as with other methods of calculating dosages (*ratio and proportion or formula method*) previously discussed, memorization of the common equivalents is still a **must**.

Dimensional analysis is a method that has been in use in the sciences for many years and is also referred to as the *factor-label method or the unit factor method*. Dimensional analysis can be viewed as a problem-solving method. It involves the process of manipulating units. By manipulating units, you are able to eliminate or cancel unwanted units of measurement, leaving only the desired unit for the answer. Although some may find the formalism of the term *dimensional analysis* intimidating at first, you will find it is simple once you have used it to solve a few problems. As already stated, dimensional analysis can be used for all calculations you may encounter once you become comfortable with the process. One of the primary advantages of dimensional analysis is the reduction in the number of steps in calculations to the use of a single equation. Dimensional analysis will be demonstrated as we proceed through the chapters in this text. *Note*: Remember, as previously stated in the discussion of calculation methods, it is important that you choose a method of calculation you are comfortable with and use it consistently.

Understanding the Basics of Dimensional Analysis

Let's begin by reviewing making conversions using dimensional analysis before we look at using it to calculate dosages. As you recall from previous chapters, you learned what were referred to as *equivalents* or *conversion factors*: for example, 1 g = 1,000 mg, 1 kg = 1,000 g. In dimensional analysis, the equivalent or conversion factor is written so that the unwanted unit(s) are cancelled (or eliminated) to leave the desired unit.

Performing Conversions Using Dimensional Analysis

The equivalents (or conversion factors) you learned can be written in a fraction format without changing the value of the unit. This is important to understand when using dimensional analysis. Let's look at the equivalent 1 kg = 1,000 g.

This can be written as:

Now let's look at the basics in using dimensional analysis for converting units of measure. It is necessary to state the equivalent (conversion factor) in fraction format, maintaining the desired unit in the numerator. In dimensional analysis, how the fraction is written is important. How the fraction is written is based on the unit you want to cancel (or eliminate) to get the unit desired. An equivalent (conversion factor) will give you two fractions:

Examples:

To Make Conversions Using Dimensional Analysis

- 1. Identify the desired unit.
- 2. Identify the equivalent (conversion factor) needed.
- 3. Write the equivalent (conversion factor) in fraction format, keeping the desired unit in the numerator of the fraction. This is written first in the equation. (Notice the unit in the numerator is the same as the unit you desire.)
- 4. Label all factors in the equation, and label what you desire *x* (unit desired).
- 5. Identify unwanted or undesired units, and cancel them. Reduce to lowest terms if possible.
- 6. If all the labels except the answer label (unit desired) are not eliminated, recheck the equation.
- 7. Perform the mathematical process indicated.

SAFETY ALERT!

Stating the equivalent correctly is crucial. If the equivalent is stated incorrectly, it will not allow you to cancel unit(s) to get the unit desired. Knowing when the equation is set up correctly is an important part of the concept of dimensional analysis.

Let's look at conversion examples to demonstrate the dimensional analysis process.

Example 1: 1.5 g = _____ mg

- 1. The desired unit is mg.
- 2. Equivalent (conversion factor): 1,000 mg = 1 g
- 3. Write the equivalent (conversion factor), keeping mg in the numerator to allow you to cancel the unwanted unit, g. (Notice the unit in the numerator of the first fraction is the same as the unit you are looking for.)
- 4. Write the equivalent (conversion factor) first stated as a fraction, followed by a multiplication sign (×).
- 5. Perform the indicated mathematical operations.

Setup:

NOTE

Placing a 1 under a value does not alter the value of the number

Example 2: 110 lb = _____ kg

- 1. The desired unit is kg.
- 2. Equivalent (conversion factor): 2.2 lb = 1 kg
- 3. Proceed to set up the problem as outlined.

Setup:

RULE

All factors entered in the equation must always include the quantity and unit of measure. What you desire or are looking for is "*x* " and is labeled with the unit desired. State all answers following the rules of the system. When there is more than one equivalent (conversion factor) for a unit of measure, use the equivalent (conversion factor) used most often.

PRACTICE PROBLEMS

Set up the following problems using the dimensional analysis format; cancel the units. Do not solve.

- 1. 8

  tsp = _____ mL
- 2. 15 mg = _____ g
- 3. 400 mcg = _____ mg
- 4. 2 tbs = _____ mL

- 5. 0.007 g = _____ mg
- 6. 0.5 L = _____ mL
- 7. 529 mg = _____ g
- 8. 1,600 mL = _____ L
- 9. 46.4 kg = _____ lb
- 10. 5 cm = _____ in

Answers on pp. 272-273

POINTS TO REMEMBER

- • State the equivalent (conversion factor) in fraction format with the desired unit in the numerator.
- • Label all factors in the equation, including "*x*."
- • State the equivalent first in the equation, followed by a multiplication sign (×).
- • Remember the rules relating to conversions.
- • Cancel the undesired units to obtain the unit desired for the answer.

Dosage Calculation Using Dimensional Analysis

As stated, dimensional analysis can be used to calculate dosages with the use of a single equation. A single equation can also be used to calculate the dosage when the dosage desired is in units that differ from what is available (or on hand). When using dimensional analysis to calculate dosages, extract the essential information. To set up a dosage calculation problem using dimensional analysis, you need to know the following information:

- • *What is ordered*. This comes from the prescriber's order and contains the strength of the medication and a unit of measurement.
- • ***The available dosage strength*** or what is on hand. This information comes from the medication label. As you recall the dosage strength refers to the weight or amount of the medication provided in a specific unit of measure. The dosage strength is made up of the strength of the medication with the unit of measurement and the dosage form. For solid forms of medications, the dosage strength is the amount per tablet, capsule, etc. **Examples:** 100 mg per tablet (tab), 500 mg per capsule (cap)
- • For liquid medications (oral and parenteral) the dosage strength is the amount of medication present in a certain amount of solution. **Examples:** 40 mg per 1 mL, 125 mg per 5 mL
- • The desired unit of measure being calculated, which contains the unknown quantity represented by "*x*" with the unit of measurement. **Examples:** *x* tab, *x* mL

When dimensional analysis is used to calculate dosages, the above information become crucial factors in the equation. Dosage strengths, for example, are entered as fractions with a numerator and denominator.

Steps in Calculating Dosages Using Dimensional Analysis

- 1. Identify the unit of measure desired in the calculation. With solid forms, the unit will be tab or cap. For parenteral and oral liquids, the unit is milliliter.
- 2. On the left side of the equation, place the name or appropriate abbreviation for *x*, what you desire or are looking for (e.g., tab, cap, mL).
- 3. On the right side of the equation, place the available information from the problem in a fraction format. The abbreviation or unit matching the desired unit must be placed in the numerator.
- 4. Enter the additional factors from the problem, usually what is ordered. Set up the numerator so that it matches the unit in the previous denominator.
- 5. Cancel out the like units of measurement on the right side of the equation. The remaining unit should match the unit on the left side of the equation and be the unit desired. Reduce to lowest terms if possible.
- 6. Solve for the unknown *x*.

Let's look at examples using these steps.

Example 1: Order: Lasix 40 mg p.o. daily.

Available: Tablets labeled 20 mg

- 1. Place the unit of measure desired in the calculation on the left side of the equation, and label it *x*.
- *x* tab =
- 2. Place the information from the problem on the right side of the equation in a fraction format with the unit matching the desired unit in the numerator. (In this problem each tab contains 20 mg.) You must always think about what is a reasonable answer.

- 3. Enter the additional factors from the problem, what is ordered, matching the numerator in the previous denominator (in the problem the order is 40 mg). Placing a 1 under it does not change the value.

- 4. Cancel the like units of measurement on the right side of the equation. The remaining unit of measurement should be what is desired. Match the unit of measurement on the left side. Proceed with the mathematical process. Notice that after cancellation of units (mg), the desired unit of measure to be administered remains (e.g., tabs in this problem).

Now let's look at an example with parenteral medications. You would follow the same steps illustrated in Example 1.

Example 2: Order: Gentamicin 55 mg IM q8h.

Available: Gentamicin 80 mg per 2 mL (round answer to the nearest tenth)

- 1. On the left side of the equation, place the unit desired in this problem (mL).
- *x* mL =
- 2. On the right side, place the available information from the problem in fraction format, placing the unit matching the unit desired in the numerator. Think what is reasonable to administer.

- 3. Enter the additional factors from the problem, what is ordered matching the numerator in the previous denominator (in this problem, the order is 55 mg).

- 4. Cancel out the like units of measurement on the right side of the equation. The remaining unit of measurement should match the unit on the left side of the equation and be the unit desired.

Setting up the Dimensional Analysis Equation When a Conversion Is Required

As already mentioned, dimensional analysis can be used when a medication is ordered in one unit of measurement and is available in a different unit of measurement, thereby necessitating a conversion. To solve the dosage calculation when there are different units, an additional conversion factor is incorporated into the equation. One of the major advantages of dimensional analysis is that it allows multiple factors to be entered in one equation. However, you can also perform the conversion before setting up the equation. Let's look at the steps for incorporating the needed conversion factor (equivalent) into the equation.

The same steps for setting up the equation are followed as previously shown, and the needed conversion factor is incorporated into the equation as follows:

- • An additional fraction is inserted into the equation as the second fraction. This fraction is the equivalent (or conversion factor) needed. The numerator must match the unit of the previous denominator.
- • The last fraction is the medication ordered. This is written so that the numerator of the fraction matches the unit in the denominator of the fraction immediately before.

Let's look at examples:

Example 3: Order: Ampicillin 0.5 g p.o. q6h.

Available: Ampicillin capsules labeled 250 mg

- 1. On the left side of the equation, place the unit of measure desired in the calculation, and label it *x*.
- *x* caps =
- 2. Place the information from the problem on the right side of the equation in a fraction format, placing the unit matching the unit desired in the numerator. Think about what is a reasonable amount to administer.

- 3. The order is for 0.5 g, and the medication is available in 250 mg; a conversion is therefore needed.
- From previous chapters, we know 1 g = 1,000 mg; this conversion factor is placed next in the form of a fraction (the numerator of the fraction must match the denominator of the immediately previous fraction).

- 4. Next, place the amount of medication ordered in the equation. This will match the denominator of the fraction immediately before. In this problem, it is 0.5 g.

- 5. Cancel out like units of measurement on the right side of the equation; the remaining unit of measurement should match the unit on the left side of equation and be the desired unit. Notice that mg and g cancel, leaving the desired unit, caps.

Example 4: Order: Enalaprilat 625 mcg IV stat.

Available: Enalaprilat 2.5 mg per 2 mL

- 1. On the left side of the equation, place the unit of measure desired in the calculation, and label it *x*.
- *x* mL =
- 2. Place the information from the problem on the right side of the equation in a fraction format, placing the unit matching the unit desired in the numerator. Think about what is a reasonable amount to administer.

- 3. The order is for 625 mcg, and the medication available is 2.5 mg per 2 mL; a conversion is therefore needed. From previous chapters, we know 1 mg = 1,000 mcg; this conversion factor is placed next in the form of a fraction (the numerator of the fraction must match the denominator of the immediately previous fraction).

- 4. Next, place the amount of medication ordered in the equation. This will match the denominator of the fraction immediately before, in this problem, it is 625 mcg.

- 5. Next cancel out like units of measurement on the right side of the equation; the remaining unit of measurement should match the unit on the left side of the equation and be the desired unit. Notice that mg and mcg cancel, leaving the desired unit, mL.

SAFETY ALERT!

Incorrect placement of units of measure into the equation will not allow cancellation of units and can result in an error in calculation. Dimensional analysis does not eliminate thinking about what a reasonable answer should be.

POINTS TO REMEMBER

When using dimensional analysis to calculate dosages:

- • First determine units of the medication you want to administer; for example, tabs, caps, mL, and so on. The unit desired is written FIRST to the left of the equation followed by an equal sign (=).
- • The units in the numerator on the left of the equal sign are the same units placed in the numerator of the first fraction on the right side of the equation.
- • If a conversion is necessary, the conversion factor is also entered into the right side of the equation, as the second fraction.
- • The ordered dosage is added at the end as the final fraction.
- • Cancel the like units. When all the cancellations have been made, only the units desired remain (e.g., tab, caps, mL).
- • Always determine the units and THINK about what a reasonable answer is, set up the equation, and cancel the units.
- • All factors entered into the equation must include the quantity and unit of measure.
- • Incorrect placement of units of measurement will not allow you to cancel units and can result in an incorrect answer.
- • Thinking and reasoning are essential even with dimensional analysis.

PRACTICE PROBLEMS

Set up the following problems using dimensional analysis. Do not solve.

- 11. A dose strength of 0.3 g has been ordered.
- Available: 0.4 g per 1.5 mL_____
- 12. A dose strength of 15 mg is ordered.
- Available: 15 mg per mL_____
- 13. Order: Ampicillin 1 g p.o. stat.
- Available: Ampicillin capsules labeled 500 mg_____
- 14. Order: Cefaclor 250 mg p.o. t.i.d.
- Available: Cefaclor oral suspension labeled 125 mg per 5 mL_____
- 15. Order: Methyldopa 0.5 g p.o. daily.
- Available:

- 16. Order: Digoxin 0.125 mg p.o. daily.
- Available: Scored tablets (can be broken in half)

- 17. Order: Dilantin 300 mg p.o. t.i.d.
- Available:

- 18. Order: Cipro 0.5 g p.o. q12h for 10 days.
- Available: Cipro tablets labeled 250 mg_____
- 19. Order: Clindamycin 0.3 g IV q6h.
- Available: Clindamycin labeled 150 mg per mL_____

Answers on 273

CHAPTER REVIEW

Calculate the following medication dosages using the dimensional analysis method. Use medication labels or information provided. Label answers correctly: tab, caps, mL. Answers expressed in milliliters should be expressed to the nearest tenth, except where indicated.

- 1. Order: Antivert 50 mg p.o. daily.
- Available:

- 2. Order: Vibramycin calcium 100 mg p.o. q12h.
- Available:

- 3. Order: Enalaprilat 0.625 mg IV stat.
- Available:

- 4. Order: Linzess 290 mcg p.o. daily for a client with irritable bowel syndrome with constipation (IBS-C).
- Available:

- 5. Order: Captopril 25 mg p.o. b.i.d.

- Available:

- 6. Order: Ondansetron 7 mg p.o. q12h for 2 days following chemotherapy.
- Available:

- 7. Order: Heparin 6,500 units subcut q12h.
- Available: (Express answer in hundredths)

- 8. Order: Invega 6 mg p.o. daily
- Available:

- 9. Order: Solu-Medrol 175 mg IV daily.
- Available: Solu-Medrol 125 mg per mL_____
- 10. Order: Clarithromycin 0.5 g p.o. q12h for 7 days.
- Available:

- 11. Order: Clonazepam 1 mg p.o. b.i.d.
- Available:

- 12. Order: Lyrica CR 165 mg p.o. daily.
- Available:

- 13. Order: Methotrexate 15 mg IM daily for 5 days.
- Available:

- 14. Order: Calcitrol 0.5 mcg p.o. daily
- Available:

- 15. Order: Cefaclor 0.4 g p.o. q8h.
- Available:

- 16. Order: Haloperidol decanoate 0.05 g IM every 4 weeks.
- Available:

- 17. Order: Dexamethasone 1.5 mg IV stat.
- Available:

- 18. Order: Rubraca 500 mg p.o. b.i.d.
- Available:

- 19. Order: Erythromycin Ethylsuccinate oral suspension 0.4 g p.o. q6h.
- Available:

- 20. Order: Clindamycin 0.6 g IV q12h.
- Available:

Answers on pp. 273-274

ANSWERS

Chapter 15

Answers to Practice Problems

NOTE

The following problems could be set up without placing 1 under a value; placing a 1 under the value as shown in the setup for problems 1-19 does not alter the value of the number.

- 1.
- 2.
- 3.
- 4.

- 5.
- 6.
- 7.
- 8.
- 9.

- 10.
- 11.
- 12.
- 13.
- 14.
- 15.

- 16.

- 17.

- 18.

- 19.

NOTE

Placing a 1 under the value does not alter the value of the number.

Answers to Chapter Review

- 1.
- 2.
- 3.
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chapter - Section 30 (Page 241)

Unit Four

Oral and Parenteral Dosage Forms and Insulin

unknown - Section 31 (Page 242)

UNIT FOUR

Introduction to Oral and Parenteral Dosage Forms and Insulin

Oral medications are the easiest, most economical, and most frequently used medications, but sometimes parenteral (nongastrointestinal tract) dosage routes are necessary. Both oral and parenteral medications are available in liquid or powder form. Medications that are available in powdered form must be reconstituted and administered in liquid form. In addition to oral and parenteral dosage forms, this unit examines the varying types of insulin.

- **Chapter 16 Oral Medications**
- **Chapter 17 Parenteral Medications**
- **Chapter 18 Reconstitution of Solutions**
- **Chapter 19 Insulin**

unknown - Section 32 (Page 243)

The term *enteral* is used to describe medications that are administered directly into the gastrointestinal tract. With the enteral route, medications can be administered orally, rectally, or, when the oral route is unavailable, through a tube (e.g., nasogastric tube [NGT] or percutaneous endoscopic gastrostomy [PEG]).

Enteral medications are most commonly administered by the oral route (by mouth, or p.o., an abbreviation for the Latin phrase *per os*). Medications that are administered orally come in several forms, including tablets (tab/tabs), capsules (cap/caps), caplets, and liquid preparations. The administration of medications orally is considered to be the easiest, most convenient, and relatively most economical.

In an effort to increase medication safety and reduce errors, safety organizations have recommended that all medications be available in unit-dose packaging. The Joint Commission (TJC) standards require "medications to be dispensed in the most ready-to-administer forms possible to minimize opportunities for error."

A major nursing responsibility in the administration of medications includes engaging in practices that minimize medication errors and promote safe medication administration. To calculate dosages safely, the nurse must read medication labels carefully, identify information relevant to calculation of dosages, and understand and apply principles that apply to administration of medications by the oral route. Calculations involving solid forms (e.g., tablets, capsules) and their preparation for administration are usually simple. Let's begin with discussion of the various forms of solid oral medications.

Forms of Solid Oral Medications

Solid forms of oral medications come in various forms, which include the most common form, tablets and capsules.

Tablets

Tablets are preparations of powdered medications that have been compressed into various sizes and shapes and are available in many colors and various types. There are tablets designed for chewing and some that can be dissolved in water, resulting in a liquid that the client drinks. For example, medication guide for Brilinta (ticagrelor), used to decrease the risk of stroke and heart problems after a heart attack, indicates that, if the tablet cannot be swallowed whole, it can be crushed and mixed with water. **Always check** the medication label or a reliable drug reference to verify how a tablet can be administered. Let's discuss the various types of tablets.

Caplets. A caplet is a tablet that has an elongated shape (oval) and a smooth coating for ease of swallowing. Examples: Tylenol and Naproxen (used for pain) are available in caplet form.

Scored Tablets. Scored tablets have indentations, grooves, or markings that allow for ease in breaking the tablet in halves or quarters and sometimes thirds. The medication is evenly distributed throughout the tablet and allows the dose to be divided evenly when the tablet is scored. Figure 16.1 shows an example of a scored tablet. It is not safe practice to break a tablet that is not scored. Splitting or breaking tablets that are not scored have been found to result in inaccurate dosages because of a lack of even distribution of medication. Breaking scored tablets to administer an ordered dosage is allowed but **not optimal**. It is safest and most accurate to administer the least number of whole, undivided tablets possible. Splitting tablets in half, even when scored with a line down the middle, leads to medication errors. Always check to see if the tablet is available in another dosage strength before breaking a scored tablet. Breaking tablets should only be done if no other option exists to administer the dosage. **Safety is always first.** Use practices that promote client safety (Quality and Safety Education for Nurses [QSEN]).

Figure 16.1 Clonazepam tablet scored.

To break tablets evenly, the indentation or groove on the tablet should be used as a guide and be done using a tablet (pill) cutter/splitter, which is readily available in most pharmacies. Figure 16.2 shows a pill/tablet cutter. Clients breaking tablets at home should be encouraged to use a pill or tablet cutter. Ensure that the client fully understands how to use the device and has a clear understanding regarding splitting the tablet. If the client cannot split the tablet, the help of a qualified family member may be needed. Examples of scored tablets include Klonopin (clonazepam [used to treat seizures]), Lanoxin (digoxin [used to treat congestive heart failure and heart rhythm problems]), and Synthroid (levothyroxine [used to treat thyroid deficiency]).

Figure 16.2 Pill/tablet cutter. (From Kee JL, Marshall SM: *Clinical calculations: with applications to general and specialty areas,* ed 8, St Louis, 2016, Saunders.)

SAFETY ALERT!

Breaking an unscored tablet is risky and dangerous and can lead to administration of an unintended dosage. Question and/or verify any order and any calculation you perform that indicates administering a portion of a tablet that is not scored.

TIPS FOR CLINICAL PRACTICE

If the calculation of a medication dosage requires that a tablet be cut in half, divide the tablet along the scoring created by the manufacturer. Use a pill or tablet cutter to divide a tablet in half to help ensure acccuracy of a dose.

Enteric-Coated Tablets. Enteric-coated tablets have a special coating that protects them from the effects of gastric secretions and prevents them from dissolving in the stomach. They are dissolved and absorbed in the small intestines. Enseal is also used to indicate enteric coated.

The enteric coating also prevents the medication from becoming a source of irritation to the gastric mucosa, thereby preventing gastrointestinal upset. Examples include enteric-coated aspirin and iron tablets, such as ferrous gluconate. Enteric-coated tablets should never be crushed, broken, or chewed, because crushing, breaking, and chewing them destroys the special coating and defeats its purpose. They must be swallowed whole with their coating intact.

Sublingual Tablets. Sublingual tablets are designed to be placed under the tongue for rapid absorption into the bloodstream by the network of blood vessels in this area. Sublingual tablets should never be swallowed, because this will prevent them from achieving their desired effect. Figure 16.3A shows placement of sublingual tablets. Examples include nitroglycerin, which is used for the relief of acute chest pain, and Abstral (fentanyl), an opioid pain medication used to treat breakthrough cancer pain.

Figure 16.3 Sublingual (A) and buccal (B) tablets.

Buccal Tablets. Buccal tablets are placed between the gums and cheek for absorption from the blood vessels of the cheek. Clients should be instructed not to chew, swallow, or take liquids. Buccal tablets are designed to be absorbed through the mucous membranes of the mouth. Figure 16.3B shows placement of buccal tablets. Examples include Oravig (miconazole), used to treat oropharyngeal candidiasis (OPC), a oral infection caused by the yeast *Candida* and also referred to as thrush; and Fentora (fentanyl), used to control breakthrough cancer pain not controlled by other medicines.

Layered Tablets. Some tablets contain different layers or have cores that separate different medications that may be incompatible with one another; thus incompatible ingredients may be separated and released at different times as the tablet passes through the gastrointestinal tract (Figure 16.4).

Figure 16.4 Layered tablet. (From Potter PA, Perry AG, Stockert P, Hall A: *Fundamentals of nursing,* ed 9, St Louis, 2016, Mosby.)

Medications in a layered form have become available in which one or more medications can be released immediately from the coating, whereas the same or other medications can be released on a sustained basis from the tablet core. An example of this is Ambien CR. Ambien CR is formulated in a two-layer tablet. The first layer of the tablet dissolves quickly to help in falling asleep, and the second layer dissolves slowly over the night to help the person stay asleep. Another example is Concerta (methylphenidate), a CNS stimulant used in the treatment of attention deficit hyperactivity disorder (ADHD). Concerta has two (2) layers. The first layer dissolves within an hour and releases the initial dose of methylphenidate, and the second layer releases the rest of the medication over a duration of 6 to 7 hours.

Film Tab. A film tab is a tablet sealed with a film. The special coating helps protect the stomach. Some medications that come as film tabs include Biaxin (clarithromycin) and E.E.S. 400 (erythromycin).

Orally Disintegrating Tablets. Orally disintegrating tablets dissolve rapidly, usually within seconds of being placed on the tongue. They are used for their rapid onset of action. Examples of use include treatment of migraine headaches, for clients who have difficulty swallowing, and in clients in whom administration must be ensured because the client often attempts to avoid taking their medications (e.g., the mentally ill). Examples include Klonopin (clonazepam), an anticonvulsant, and Zofran (ondansetron), an antiemetic used for the prevention of nausea and vomiting associated with cancer chemotherapy, radiotherapy, and the prevention of postoperative nausea and vomiting.

A **sublingual film** is now available. The film is placed under the tongue for rapid disintegration. Suboxone (used to manage opiate addiction) is an example of this form. The rapid action of the film is advantageous because the client is unable to retrieve the medication for possible sale on the street and ensures compliance. Suboxone film can be abused in the same manner as other opioids.

Chewable Tablets. Chewable tablets are designed to be chewed, and must be chewed to be effective. Examples of medications that come in chewable form include amoxicillin clavulanate potassium tablets (broad spectrum, anti-infective), Tegretol (carbamazepine), an anticonvulsant, and Dilantin Infatabs (phenytoin) used in the treatment and prevention of seizures.

Timed-Release and Extended-Release Tablets. Look for words and abbreviations that are associated with timed-release and extended-release medications. These include SA, LA, XL, SR, and CR. Medication from these types of tablets is not released immediately but released over a period of time at specific intervals. These types of preparations should not be crushed, chewed, or broken; they should be swallowed whole. If a timed-release or extended-release tablet is crushed, chewed, or broken, all of the medication will be administered at one time and absorbed rapidly causing an unintended effect. Examples include Calan SR, Xeljanz XR, Metformin ER, and Sinemet CR.

Capsules

A capsule is oval-shaped or round and has a hard or soft gelatinous covering that contains medication in a dry powder, liquid, oil, or miniature pellets. Capsules are available in a variety of sizes and colors. Capsules are not divided or crushed but are administered whole to achieve the desired effect. There are some capsules that may be opened and mixed with food or mixed in water or juice for ease of administration in clients who have difficulty swallowing. For example, Altace (ramipril) used to treat hypertension can be opened and sprinkled on applesauce or mixed in water or juice. Nurses should always check a reliable drug reference to determine which capsules can be opened and mixed with food or in a liquid. Examples of medications that come in capsule form include ampicillin, tetracycline, and Colace. In addition to capsules indicated on a label, some labels may include the term *Kapseals* (e.g., “Kapseals” is seen on some labels for Dilantin extended-release capsules).

Types of Capsules

Spansules (timed-release, also known as sustained-release) are capsules that contain many tiny beads (or pellets) of medication that dissolve at spaced intervals for long-acting medications. Spansules may be opened and mixed with food; however, the beads (or pellets) cannot be crushed. The beads (or pellets) delay the release of the medication. An example of a medication that comes in spansule form is Dexedrine spansules sustained-release (dextroamphetamine sulfate), used to treat ADHD and narcolepsy.

Gelcaps are soft gelatin shells that contain the medication in a liquid or oil-based form. Gelcaps are not designed to be opened or crushed. Examples include Lanoxicaps (digoxin), used to treat congestive heart failure (CHF) and heart rhythm problems, and PhosLo (calcium acetate), used to prevent phosphate levels from increasing. There are some medications for cold, sinus, and the flu, such as Advil, DayQuil, and NyQuil, which are forms of gelcaps and may use terms that include: “Liquid Gels,” “Liqui-Gels,” or “Liqui-Caps” on the label.

Sprinkle capsules are also available for oral administration and indicate sprinkle capsules on the medication label. Sprinkle capsules can be swallowed whole or opened and sprinkled on food such as applesauce. Examples include Topamax sprinkle capsules (topiramate), used as an anticonvulsant and to treat migraines; Depakote sprinkle capsules (divalproex sodium), used to treat seizure disorders or manic disorders related to bipolar disorder; and Aciphex sprinkle capsules (rabeprazole), which is used to treat symptoms of gastroesophageal reflux disease (GERD).

Medications for oral use are also available as granules (designed to be administered directly into the mouth, taken with food, or liquid) and as powders (designed to be dissolved in a liquid). Other forms of solid preparations for oral administration include lozenges, troches, and pulvules (proprietary capsules containing a dosage of a medication in powdered form). Tablets and capsules are the most common solid forms requiring calculation encountered by the nurse. Figure 16.5 shows various forms of solid oral medications.

Figure 16.5 Forms of oral medications. (A) Scored tablet. (B) Chewable tablet. (C) Sublingual. (D) Timed-release tablet. (E) Capsule. (F) Timed-release capsule. (G) Gelatin capsule.

Crushing Tablets or Opening Capsules

Not all medications can be crushed or opened for administration to clients. The Institute for Safe Medication Practices (ISMP) publishes a list of oral dosage forms that should not be crushed. This list is commonly referred to as the “Do Not Crush” list. The list was first published in July 2007 and updated in 2020. The complete list can be found on ISMP website: https://www.ismp.org/recommendations/do-not-crush Medications may sometimes be ordered for administration into the gastrointestinal tract through a specifically placed tube. For example, a nasogastric tube (NG/NGT) [a tube inserted through the nose into the gastric (stomach) region]. Medications administered by a tube will have to be crushed and dissolved in a small amount of warm water. Determine whether an alternative form of the medication exists if it cannot be crushed, such as oral liquid form.

To maintain safety of the client and prevent an incorrect dose or unintended effect, do not crush or open capsules or tablets that are labeled time-release, sustained-release, delayed release, or extended release. Tablets that are sublingual, buccal, or enteric-coated are never crushed. Capsules are not crushed or opened unless they are designed to be or it is indicated they can be opened. **Always** consult a drug reference, pharmacist, or other reliable resources before crushing a tablet or opening a capsule to ensure that the medication is correctly administered by an approved route, and can be safely administered to avoid harm to a client.

SAFETY ALERT!

Medications such as time-release, sustained-release, extended-release, and delayed-release tablets and capsules have special coatings to prevent the medication from being absorbed too quickly. Altering medications that should be administered whole may result in alteration of the medication action

(e.g., increasing the rate of absorption or causing the medication to be inactivated) and cause unintended effects.

Calculating Dosages Involving Tablets and Capsules

When administering solid forms of oral medications (tablets and capsules), the nurse rarely performs complex calculations to determine the number of tablets or capsules needed to administer the dosage ordered. Accurate and safe dosage calculation includes requiring that the nurse understands the medication order, reads the medication label carefully to identify the dosage strength (also referred to as the dosage strength available, what is on hand or available), which is the amount of medication contained in each tablet or capsule, and accurately calculate the dose to administer. To foster clinical reasoning skills and help determine whether the calculated dosage is sensible, accurate, and safe to administer, and to avoid calculation errors, the nurse **must** integrate the following points as an integral part of calculation of dosages involving tablets and capsules.

POINTS TO REMEMBER

- • Converting medication measures from one system to another and one unit to another to determine the dosage to be administered can result in discrepancies, depending on the conversion factor used.
- • When the precise number of tablets or capsules is determined and you find that administering the amount calculated is unrealistic or impossible, always use the following rule to avoid an error in administration: *No more than 10% variation should exist between the dosage ordered and the dosage administered.* For example, you may determine that a client should receive 0.9 tablet or 0.9 capsule. Administration of such an amount accurately would be impossible. Following the stated rule, if you determined that 0.9 tablet or 0.9 capsule should be given, you could safely administer 1 tab or 1 cap. This variation usually occurs when conversions are made between apothecary and metric measurements because approximate equivalents are used. There should be no conversion to apothecary. If apothecary measure is indicated, the metric conversion will be beside the apothecary measure, which is often in parenthesis. The 10% variation rule is often applied with adults but not necessarily with the pediatric clients.
- • Capsules are not scored and cannot be divided. They are administered in whole amounts only. If a client has difficulty swallowing a capsule, check to see if a liquid preparation of the same medication is available. Never crush or open a timed-release capsule or empty its contents into a liquid or food; this may cause release of all the medication at once. Always use the metric equivalent.
- • Tablets and capsules may be available in different strengths for administration, and you may have a choice when giving a dosage. For example, 75 mg of a medication may be ordered. When you check what is available, it may be in tablet or capsule form as 10, 25, or 50 mg. In deciding the best combination of tablets or capsules to give, the nurse should always choose the strength that would allow the least number of tablets or capsules to be administered without breaking a tablet, if possible, because breaking is found to result in variations in dosage. In the example given, the best combination for administering 75 mg is one 50-mg tablet or capsule and one 25-mg tablet or capsule.
- • Only scored tablets are intended to be divided. It is safest and most accurate not to divide tablets, and give the fewest number of whole, undivided tablets possible.

- RULE

  Three (3) tablets or capsules are typically the maximum administered to achieve a single dose. Always stop, think, and recheck a calculation if a single dose requires more. Question the order before administering if it exceeds three (3).

- • It is important to note that although the maximum number of tablets or capsules given to a client is usually three, there may be exceptions, including calcium tablets and some of the solid forms of HIV medications (e.g., tablets, capsules). Example: ritonavir 600 mg p.o. b.i.d. (recommended dosage) (available 100 mg per tab). Although many HIV medications are available in liquid form, many clients have a preference for tablets or capsules.

- • Remember: Unless the medication is an exception, more than three (3) tablets or capsules to achieve a single dose is unusual and may indicate an error in interpretation of the order, transcription, or calculation. Think! Always question any order that exceeds this amount.
- • When calculating dosages using ratio and proportion, the formula method, or dimensional analysis, remember that each tablet or capsule contains a certain amount of medication per tablet or capsule. Example: 325 mg per tablet, 500 mg per capsule. The dosage strength indicated on a label is per tablet or per capsule. This is particularly important when you are reading a medication label on a bottle or single unit-dose package.
- • In calculating oral dosages, you may encounter measures other than metric measures. For example, electrolytes such as potassium will indicate the number of milliequivalents (mEq) per tablet. Units is another measure you may see for oral antibiotics or vitamins. For example, a vitamin E capsule will indicate 400 units per capsule. Measurements of units and milliequivalents are specific to the medication they are being used for. There is no conversion between these and other systems of measure. (These are discussed in Chapter 17.)
- • Always consult a medication reference or pharmacist when in doubt as to whether a capsule may be opened or whether a tablet can be crushed.

SAFETY ALERT!

Regardless of the source of an error, if you administer the wrong dose or give a medication by a route other than that intended, you have committed a medication error and are legally responsible for the error. Always think of the reasonableness of what you have calculated to administer and double-check the dose and route for a medication before administering.

Remembering the points mentioned will be helpful before starting to calculate dosages. Any of the methods presented in Chapters 13, 14, and 15 can be used to determine the dosage to be administered.

To compute dosages accurately, it is necessary to review a few reminders that were presented in previous chapters:

- 1. Read the order carefully and:
  - a. Identify known factors.
  - b. Identify unknown factors.
  - c. Eliminate unnecessary information that is not relevant.
- 2. Make sure that what is ordered and what is available are in the same system of measurement and units, or a conversion will be necessary. When a conversion is necessary, it is usual to convert what is ordered into what you have available or what is indicated on the medication label. You can, however, convert the measure in which the medication is available into the same units and system of measure as the dosage ordered. The choice is usually based on whichever is easier to calculate. Use any of the methods presented in Chapters 7, 13, and 15 to make conversions consistent to avoid confusion. If necessary, go back and review these methods.
- 3. Consider what would be a reasonable answer based on what is ordered.
- 4. Set up the problem using ratio and proportion, the formula method, or dimensional analysis. Label each component in the setup, including "x."
- 5. Label the final answer (tablet, capsule).
- 6. For administration purposes, for oral dosages that are given in fractional dosages (e.g., scored tablets), state answers to problems in fractions. Example: 1-2 tab or 11-2 tabs, instead of 0.5 tabs or 1.5 tabs.

Let's look at some sample problems calculating the number of tablets or capsules to administer.

Example 1: Order: Digoxin 0.375 mg p.o. daily

Available: Digoxin (scored tablets) labeled 0.25 mg

PROBLEM SETUP

- 1. No conversion is necessary; the units are in the same system of measure.
- Order: 0.375 mg.
- Available: 0.25-mg tablets
- 2. Think critically: Tablets are scored; 0.375 mg is larger than 0.25 mg; therefore you will need more than 1 tab to administer the correct dosage.
- 3. Solve using ratio and proportion, the formula method, or dimensional analysis.

Solution Using Ratio and Proportion

Linear Format: 0.25 mg : 1 tab = 0.375 mg : *x* tab

(known) (unknown)

(what is available) (what is ordered)

Fraction Format:

(It is best to state it as 1½ tabs for administration purposes.) You can administer 1½ tabs because tablets are scored.

Solution Using the Formula Method

Solution Using Dimensional Analysis

Example 2: Order: Flagyl 0.75 g p.o. t.i.d. for 7 days

Available: Flagyl capsules labeled 375 mg per capsule

- 1. Order: 0.75 g
- Available: 375 mg capsules
- 2. After making the necessary conversion, think about what is a reasonable amount to administer. (***Note:*** Before calculating the dosage to be administered, the ordered dosage and the available dosage must be in the same unit of measure.)
- 3. Calculate the dosage to be administered using ratio and proportion, the formula method, or dimensional analysis.
- 4. Label your final answer (capsules).

PROBLEM SETUP

- 1. A conversion is necessary. What the prescriber ordered is in grams and the medication is available in milligrams. Convert g to mg. Equivalent (conversion factor): 1 g = 1,000 mg; 0.75 g = 750 mg. Use any of the methods presented in Chapter 7 for converting. If necessary, review the methods.
    - • Notice converting the grams to milligrams eliminated a decimal, which is often the source of calculation errors. Whenever possible, conversions that result in a decimal should be avoided to decrease the chance of error in calculating.
- 2. After making the conversion, you are now ready to calculate the dosage to be given, using ratio and proportion, the formula method, or dimensional analysis. In this problem we will use the answer obtained from converting what was ordered to what is available (0.75 g = 750 mg). Remember that if dimensional analysis is used, you need only one equation, even if conversion is required. For dimensional analysis, you need

the equivalent (conversion factor) in fraction format:

Solution Using Ratio and Proportion

Linear Format: 375 mg : 1 cap = 750 mg : *x* cap

Fraction Format:

Solution Using the Formula Method

Solution Using Dimensional Analysis

Below shows the problem setup in dimensional analysis to calculate the dosage after making conversion:

- 1. Convert g to mg:

- 2. Set up in dimensional analysis after conversion made to calculate dosage:

Note: It is easier to set up the problem in dimensional analysis using one equation that will allow you to convert and calculate the dosage required. This eliminates the need for multiple-step calculations.

Example 3: Order: Thorazine 100 mg p.o. t.i.d.

Available: Thorazine tablets labeled 25 mg and 50 mg

PROBLEM SETUP

- 1. No conversion is necessary.

- 2. Think critically: 100 mg is larger than 25 or 50 mg. Therefore more than 1 tab is needed to administer the dosage. The client should always be given the strength of tablets or capsules that would require the least number to be taken.
- 3. In this problem, selection of the 50-mg tablets would require the client to receive 2 tabs, whereas using 25-mg tablets would require 4 tabs to be administered.

Solution Using Ratio and Proportion

Linear Format: 50 mg : 1 tab = 100 mg : *x* tab

Fraction Format:

Note: The number of tablets is specified as well as the strength of the tablets.

Solution Using the Formula Method

Solution Using Dimensional Analysis

Example 3 could have been calculated without the use of ratio and proportion, dimensional analysis, or a formula. This is common when problems provide more than one dosage strength. In the case where a conversion is required, you would perform the conversion first, then choose the appropriate dosage strength to administer the least number of tablets or capsules. Add the dosage strengths chosen to ensure that it is equivalent to what is ordered.

Variation of Tablet and Capsule Problems

You will at times find it necessary to decide how many tablets or capsules are needed. This requires knowing the dosage and frequency. Numerous scenarios could arise, but for the purpose of illustration, let's look at two examples. A client is going out of town on vacation and needs to know whether it is necessary to refill the prescription before leaving.

Example 1: A client has an order for Valium 10 mg p.o. q.i.d. and has 5-mg tablets. The client is leaving town for 7 days and asks how many tablets to bring.

Solution: To obtain a dosage of 10 mg, the client requires two 5-mg tablets each time. Therefore eight 5-mg tablets are necessary to administer the dosage q.i.d. (four times a day).

Number of tablets needed per day (8) × Number of days needed for (7) = Total number of tablets needed

8 × 7 = 56

Answer: The total number of tablets needed for 7 days would be 56 tablets.

Example 2: A client is instructed to take 30 mg of a medication stat as an initial dose and 20 mg tid thereafter. The tablets available are 10-mg tablets. What is the total number of tablets the client will need for 3 days?

Solution: To obtain a dose of 30 mg, the client will require three 10-mg tablets for the stat dose, and six 10-mg tablets are needed to administer the dose t.i.d. (three times a day).

Number of tablets needed per day (6) × Number of days needed for (3) = Total number of tablets needed.

6 × 3 = 18 + 3 (stat dose) = 21 tablets

Answer: The total number of tablets needed for 3 days is 21 tablets.

Determining the Dosage to Be Given Each Time

Example: A client is to receive 1 gram of a medication p.o. daily. The medication should be given in four equally divided doses.

How many milligrams should the client receive each time the medication is administered?

Solution:

= Dosage to be administered

Answer:

= 250 mg each time the medication is administered.

POINTS TO REMEMBER

- • The maximum number of tablets and capsules to administer to achieve a single desired dosage is usually three. Question any order for more than this before administering.
- • Before calculating a dosage, make sure that the dosage ordered and what is available are in the same system and units of measurement. When a conversion is required, it is usually best to convert the dosage ordered to what is available.
- • No more than a 10% variation should exist between the dosage ordered and the dosage administered for adults. Remember, this should only occur when you are converting between apothecary and metric systems because of using approximate equivalents. When possible, always convert to a metric measure or use the metric measure indicated on a label.
- • Regardless of the method used to calculate a dosage, it is important to develop the ability to think critically about what is a reasonable amount. Think and question any dosage that seems unreasonable.
- • State dosages as you are actually going to administer them. Example: 0.5 tab = ½ tab.
- • Tablets that are not scored should not be broken.
- • It is safer to administer the least number of whole tablets possible without scoring.
- • Read labels carefully and choose the correct medication to administer to match the order and dosage amount.
- • When there is a choice of tablets or capsules in varying strengths, choose the strength that allows administration of the least number of tablets or capsules.
- • Consult a medication reference or pharmacist when in doubt about a dosage to be administered and whether tablets can be crushed or capsules opened.

PRACTICE **PROBLEMS**

Calculate the correct number of tablets or capsules to be administered in the following problems using the labels or information provided. Use any of the methods presented to calculate the dosage. Remember to label your answers correctly: tabs, caps.

- 1. Order: Synthroid 0.025 mg p.o. every day.
- Available: Scored tablets
- _____
- 2. Order: Xeljanz 10 mg p.o. b.i.d.
- Available:
- _____
- 3. Order: Relafen 1 g p.o. daily.
- Available:
- _____
- 4. Order: Lanoxin 0.125 mg p.o. daily.
- Available: Scored tablets

    - a. What is the appropriate strength tablet to use? _____
    - b. What will you administer? _____
- 5. Order: Ampicillin 1 g p.o. q6h.
- Available: Ampicillin capsules labeled 500 mg and 250 mg
    - a. Which strength capsule is appropriate to use? _____
    - b. How many capsules are needed for one dosage? _____
    - c. What is the total number of capsules needed if the medication is ordered for 7 days? _____
- 6. Order: Fluconazole 150 mg p.o. daily for 2 weeks.
- Available:

- What is the appropriate strength tablet to use? _____
- 7. Order: Bosulif 0.4 g p.o. daily.
- Available:

- 8. Order: Brilinta 180 mg p.o. stat for the initial dose.
- Available:

- 9. Order: Vraylar 3 mg p.o. daily.

- Available:

- _____
- 10. Order: Rexulti 2 mg p.o. daily for 3 days for a client with schizophrenia.
- Available:

- _____
- 11. Order: Phenobarbital 90 mg p.o. at bedtime.
- Available: Phenobarbital 15-mg tabs and 30-mg tabs
  - a. Which strength tablet is best to administer? _____
  - b. How many tablets of which strength will you prepare to administer? _____
- 12. Order: Ziagen 0.6 g p.o. daily.
- Available:

- _____
- 13. Order: Chlorpromazine Hydrochloride 100 mg p.o. t.i.d.
- Available:

- How many tablets are needed for 3 days? _____
- 14. Order: Verapamil 120 mg p.o. t.i.d. Hold for systolic blood pressure less than 100, heart rate less than 55.
- Available:

- How many tablets of which strength will you administer? _____
- 15. Order: OxyContin (extended release) 20 mg p.o. q12h for pain management.
- Available:

- _____
- 16. Order: Depakote ER 1 g p.o. daily.
- Available:

- _____
- 17. Order: Pyridium 0.2 g p.o. t.i.d. after meals.
- Available:

- _____
- 18. Order: Tecfidera DR 240 mg p.o. b.i.d. for a client with multiple sclerosis.
- Available:

- _____
- 19. Order: Cimetidine 400 mg p.o. b.i.d.
- Available:

- _____
- 20. Order: Entresto 49/51 mg p.o. b.i.d. as a starting dose for a client with chronic heart failure.
- Available:

    - a. How many tablets should the client receive? _____
    - b. According to the medication label, Entresto contains how many medications? _____
    - c. Entresto contains _____ mg of sacubitril and _____ mg of valsartan.
- 21. Order: Cymbalta (delayed-release capsules) 60 mg p.o. daily.
- Available:

- _____
- 22. Order: Synthroid 75 mcg p.o. daily.
- Available: Scored tablets

- How many tablets of which strength will you use to administer the dosage? _____

- 23. Order: Captopril 25 mg p.o. t.i.d.
- Available:

- _____
- 24. Order: Clonazepam 1 mg p.o. b.i.d. and at bedtime.
- Available: Scored tablets

- _____
- 25. Order: Rubraca 500 mg p.o. daily.
- Available:

- _____
- 26. Order: Procardia XL 60 mg p.o. daily.

- 27. Order: Calcitriol 0.5 mcg p.o. daily.
- Available:

- _____

- 28. Order: Coreg 6.25 mg p.o. b.i.d. for 2 weeks.
- Available:

- _____

Answers on pp. 326-328

Calculating Oral Liquids

Enteral medications are also available in liquid form for administration orally or through various types of tubes placed into the stomach or intestines. Examples: nasogastric (tube that is introduced through the nose into the stomach), gastrostomy (tube directly into the stomach), or jejunostomy (tube directly into the jejunum [second part of small intestines]). Liquid medications are also desirable for use in:

- • Clients who have dysphagia (difficulty swallowing)
- • Young children, infants, and elderly clients
- • Instances when medications that cannot be crushed for administration are ordered; then the availability of the medication in liquid form should be investigated.

Liquid medications are prepared in different forms. The most common forms are elixirs, suspensions, and syrups.

- 1. **Elixir:** The medication is mixed with water, alcohol, and a sweetener, and is aromatic. Example: Phenobarbital elixir.
- 2. **Suspension**: One or more medications in fine particles in a liquid such as water. The particles cannot be dissolved therefore the suspension must be shaken well before administering for thorough mixing of the particles.
- Example: Penicillin suspension.
- 3. **Syrup:** The medication is dissolved in a concentrated sugar (usually sucrose) and water. Example: Colace.

Liquid medications also come as tinctures, emulsions, and extract preparations for oral use. There are also medications for oral use that are available in powder form and must be mixed prior to administering them to a client. The process of mixing the powder with a liquid so that it can be administered is called **reconstitution**. The nurse may reconstitute the medication by following the directions on the medication label or package insert. The process of reconstitution will be discussed in detail in Chapter 18. Although oral liquids may be administered by means other than by mouth (e.g., nasogastric tube, gastrostomy tube), they should **never** be given by any other route, such as the intravenous (IV) route or by injection.

The labels on medications in liquid form indicate the specific amount or weight of a medication in a given amount of solution. You must calculate the volume or amount of liquid that contains the ordered dosage. The methods presented in Chapters 13 to 15 can be used to calculate the volume or amount to administer the ordered dosage. There are some oral liquid medications that do not require calculation because, when ordered, the specific amount to be administered is stated. Examples: Milk of Magnesia 1 ounce p.o. at bedtime; Robitussin 15 mL p.o. q4h prn; Fer-in-Sol 0.2 mL p.o. daily.

The medication label on oral liquids may indicate the amount of medication per milliliter, ounce, etc. For example, 25 mg per mL, 200 mg per mL (Figure 16.6A). The amount may also be expressed in terms of multiple milliliters of solution, such as 80 mg per 2 mL, 250 mg per 5 mL (Figure 16.6B).

Figure 16.6 (A) CellCept oral suspension 200 mg per mL. (B) Valproic acid oral solution 250 mg per 5 mL.

Oral liquids can be measured in small amounts of volume, and a greater range of dosages can be ordered for administration. When you calculate oral liquid medications, the stock, or what you have available, is in liquid form; therefore the label (unit) on your answer will always be expressed in

liquid measures such as milliliters.

Like other forms of medications, dosing errors can occur with oral liquids. The reason for dosing errors include inaccurate measurement of oral liquids and the use of improper measuring devices, and non-calibrated devices. The use of calibrated measuring devices (e.g., droppers, calibrated spoons) should be used in the hospital and clients educated on the importance of this at home as opposed to using household measuring devices (e.g., spoons). Household measuring devices vary in size and are inaccurate and may deliver more or less medication than ordered. Clients should be encouraged to use the measuring device that comes with their medication if one does, or ask the pharmacist about an appropriate measuring device.

Measuring Oral Liquids

The administration of oral liquids requires careful measurement. There can be a greater range of dosages ordered and administered with oral liquids. Several types of equipment are used to administer oral liquid medications. These include medicine cups, droppers, oral syringes, and calibrated spoons.

- 1. **The standard medicine cup** is usually plastic, has a capacity of 30 milliliters (1 fluid ounce), and is used to measure most liquid medications for oral administration. Most medication cups typically indicate metric, household, and apothecary systems of measurement on the cup. Therefore cups include units such as tablespoons (tbs), teaspoons (tsp), milliliters (mL), drams (dr), and ounces (oz).
- ***Note:*** Dram (dr), a unit of measurement in the apothecary system, and cubic centimeter (cc), formerly used interchangeably with milliliters (mL) may still appear on medicine cups in some health care facilities. These units of measurement are no longer used.
- Because of the reporting of errors that occurred from nurses confusing dosing scales on a plastic oral liquid dosing cup, a recommendation that was set forth was to move toward medicine cups that allow measurement in milliliters only. Figure 16.7 shows one view of a medication cup.

Figure 16.7 Medicine cup.

- When measuring liquid medications, place the medication cup on a flat surface, poured at eye level, and read at the bottom of the meniscus (a curvature made by the solution). See Figure 16.8. Always pour liquid medications with the label facing you to avoid covering the label with your hand or obscuring label information if the medication drips down the side of the container.

Figure 16.8 Reading meniscus. The meniscus is caused by the surface tension of the solution against the walls of the container. The surface tension causes the formation of a concave or hollowed curvature on the surface of the solution. Read the level at the lowest point of the concave.

SAFETY ALERT!

To prevent medication errors, take care and do not confuse the dosing scales on a medication cup when pouring medications.

- 2. **Calibrated droppers** are used for measuring and administering small volumes of liquid medications (Figure 16.9). They may be used to administer certain liquid medications to the eyes, ears, and nose. Another common use is for administration of oral medications especially to children. Droppers have different sized openings that produce different amounts of medication with each drop. Some medications come with a dropper that indicates the dropper is calibrated for the specified dose and can only be used for the medication it is packaged with, to ensure accurate dosing. Some medicine droppers are calibrated in milliliters, drops, teaspoons, or by actual dosage. Clients who are being discharged and taking oral medications at home should **always** be instructed to use only the dropper that comes packaged with the particular medication.

Figure 16.9 Medicine droppers.

SAFETY ALERT!

To avoid medication dosing errors, a calibrated dropper should be used ONLY for the medication for which it is intended; droppers are not interchangeable and drop size varies from one dropper to another.

- 3. **Oral syringes:** Solutions for oral use should be measured by using a specially calibrated oral syringe (Figure 16.10). Oral syringes are calibrated in tenths of a milliliter and may have teaspoon and tablespoon markings and are used to measure and administer oral liquids to ensure accurate and safe dosages. They come in 1 mL, 3 mL, 5 mL, and 10 mL sizes. Syringes for oral use have unique features that distinguish them from syringes used for injections which include:

Figure 16.10 Oral syringes. (Courtesy Chuck Dresner. From Clayton BD, Gurevitz SL, Willihnganz M: *Basic pharmacology for nurses,* ed 18, St Louis, 2020, Elsevier.)

  - • They are needleless
  - • Often come in colors, and are not sterile
  - • Some are labeled on the barrel of the syringe, “for oral use only”
  - • An eccentric or off-center tip alerts the nurse that a needle should not be attached to this syringe
  - • The tip of the oral syringe does not fit adapters and devices made for injectable syringes, such as IV tubing. This prevents medication for oral use from being injected IV or into tissue, which can cause injury or death.

SAFETY ALERT!

To prevent confusion with the route of administration, only use oral syringes to measure and administer oral medications. Oral medications are never injected.

- 4. **Calibrated spoons** are designed with a spoon and a shape for easy administration. They are often used to administer oral liquids to children or elderly clients. Some spoons for children are shaped like animals. They are calibrated in milliliters and equivalent household measures (e.g., teaspoons, tablespoons) (Figure 16.11). Household spoons vary in size and are not reliable for accurate dosing. Always encourage the use of calibrated spoons for measuring medications at home.

Figure 16.11 Calibrated spoons. (From Mulholland JM,Turner SJ: *The nurse, the math, the meds: drug calculations using dimensional analysis,* ed 4, St Louis, 2019, Elsevier.)

Before we proceed to calculate liquid medications, let's review some helpful pointers.

- 1. The label on the medication container must be read carefully to determine the dosage strength in the volume of solution because it varies.

SAFETY ALERT!

Do not confuse dosage strength with total volume. Read labels carefully. Confusing dosage strength with total volume can result in errors when performing calculations and lead to the administration of an unintended dose.

- For example, the label on a medication may indicate a total volume of 100 mL, but the dosage strength may be 125 mg per 5 mL. It must be noted that dosage strength can be written on solutions in several ways to indicate the same thing. For example, 125 mg per 5 mL may be written as 125 mg/5 mL or 125 mg = 5 mL. Other examples of dosage strength are 20 mg per mL, 20 mg/mL, or 20 mg = 1 mL. It should also be noted that many solutions are also expressing dosage strengths on the label using "per" instead of the slash mark.

SAFETY ALERT!

The Institute for Safe Medication Practices (ISMP) (https://www.ismp.org/recommendations/error-proneabbreviations-list) recommends that the "/" (slash mark) not be used to separate doses. The slash mark has been mistaken as the number 1. Use "per" rather than a slash mark to separate doses.

- 2. Answers are labeled using liquid measures. Example: mL.
- 3. Calculations can be done by using the same methods (ratio and proportion, the formula method, or dimensional analysis) and the same steps as for solid forms of oral medications.

Now let's look at some sample problems that involve the calculation of oral liquids.

Example 1: Order: Dilantin 200 mg p.o. t.i.d.

Available: Dilantin suspension labeled 125 mg per 5 Ml

PROBLEM SETUP

- 1. No conversion is required. Everything is in the same units of measure and the same system.
- Order: 200 mg
- Available: 125 mg per 5 mL
- 2. Think critically: What would be a logical answer? Looking at Example 1, you can assume the answer will be greater than 5 mL.
- 3. Set up the problem using ratio and proportion, the formula method, or dimensional analysis.
- 4. Label the final answer with the correct unit of measure. In this case the units will be milliliters. Remember: The answer has no meaning if written without the appropriate unit of measure.

Solution Using Ratio and Proportion

Known Unknown

Linear Format: 125 mg : 5 mL = 200 mg : *x* mL

Fraction Format:

Known Unknown

Note: Reduction of numbers can be done to make them smaller and easier to deal with.

Solution Using the Formula Method

Solution Using Dimensional Analysis

Example 2: Order: Lactulose 30 g p.o. b.i.d.

Available: Lactulose labeled 10 g per 15 mL

Solution Using Ratio and Proportion

Known Unknown

Linear Format: 10 g : 15 mL = 30 g : *x* mL

Fraction Format:

Known Unknown

Solution Using the Formula Method

Solution Using Dimensional Analysis

Example 3: Order: Cefdinir 0.3 g p.o. q 12 h.

Available: Cefdinir oral suspension labeled 125 mg per 5 mL

- 1. A conversion is necessary. What the prescriber ordered is in grams here, and the medication is available in milligrams.
  - • Convert grams to milligrams.
  - • Equivalent (conversion factor) 1,000 mg = 1 g
  - • Use any of the methods presented for converting 0.3 g = 300 mg

Solution Using Ratio and Proportion

Known Unknown

Linear Format: 125 mg : 5 mL = 300 mg : *x* mL

Fraction Format:

Known Unknown

Solution Using the Formula Method

Solution Using Dimensional Analysis

POINTS TO REMEMBER

- • Liquid medications can be calculated using the same methods as those used for solid forms (tabs, caps).
- • Read labels carefully on medications; identify the dosage strength of the medication contained in a certain amount (volume) of solution.
- • Do not confuse dosage strength (amount of medication contained in a certain amount of solution) with total volume (the amount in the container).
- • Administration of accurate dosages of liquid medications requires the use of calibrated devices (calibrated droppers, calibrated spoons, and oral syringes).
- • Oral syringes are designed for oral use only. Use oral syringes to measure and administer oral liquids.
- • When using a medication cup to administer oral liquid medications, pour the medication at eye level and read at eye level at bottom of meniscus on a flat surface.
- • The use of ratio and proportion, the formula method, or dimensional analysis is a means of validating an answer; however, it still requires thinking in terms of the dosage you will administer and applying principles learned to calculate dosages that are sensible and safe.
- • Use “per” to separate dosages when writing, not a slash mark. Example: 125 mg per 5 mL, not 125 mg/5 mL.
- • Do not use the dropper packaged with a particular medication to administer other medications.

PRACTICE **PROBLEMS**

Calculate the following dosages for oral liquids in milliliters using the labels or information provided. Do not forget to label your answer. Round answers to the nearest tenth where indicated.

- 29. Order: Lyrica 75 mg p.o. b.i.d.
- Available:
- _____
- 30. Order: Prednisolone sodium phosphate 40 mg p.o. daily.
- Available:
- _____
- 31. Order: Potassium chloride 20 mEq p.o. b.i.d.
- Available:
- _____
- 32. Order: Calcitriol 2 mcg p.o. daily.
- Available:
- _____
- 33. Order: Clemastine fumarate syrup 2 mg p.o. q12h.
- Available:

- _____
- 34. Order: Dilantin 100 mg p.o. t.i.d.
- Available:

- _____
- 35. Order: Digoxin 125 mcg p.o. every day.
- Available:

- _____
- 36. Order: Amoxicillin 0.5 g p.o. q6h.
- Available: *Reconstituted medication

- _____
- 37. Order: Phenobarbital 60 mg p.o. at bedtime.
- Available:

- _____
- 38. Order: Lithium carbonate 600 mg p.o. t.i.d.
- Available:

- _____
- 39. Order: Erythromycin ethylsuccinate 0.5 g by gastrostomy tube q6h for 10 days.
- Available: *Reconstituted medication

- _____
- 40. Order: Sulfamethoxazole/trimethroprim 200 mg/40 mg 160 mg p.o. q12h for 10 days (calculation based on trimethroprim).
- Available: *Reconstituted medication

- _____
- 41. Order: Tamiflu 75 mg p.o. b.i.d. for 5 days.
- Available: *Reconstituted medication

- _____
- 42. Order: Neurontin 0.3 g p.o. t.i.d.
- Available:

- _____
- 43. Order: Ondansetron 8 mg q12h for 2 days.
- Available:

- _____
- 44. Order: Amoxicillin and Clavulanate Potassium 0.25 g p.o. q8h (ordered according to the dose of amoxicillin).
- Available: *Reconstituted medication

- _____
- 45. Order: Zovirax 200 mg p.o. q4h for 5 days.
- Available:

- _____
- 46. Order: Fluoxetine 30 mg p.o. every day in am.
- Available:

- _____
- 47. Order: Promethazine 12.5 mg p.o. t.i.d.
- Available:

- _____
- 48. Order: Oxycodone Hydrochloride 30 mg p.o. q12h p.r.n. for pain.
- Available:

- _____

Answers on pp. 328-330

CLINICAL **REASONING**

- 1. **Scenario:** Order: Digoxin 0.75 mg p.o. daily. In preparing to administer medications, you find 0.125-mg tabs (scored) in the medication drawer for the client.
  - a. Based on the tablets available, how many would you have to administer? _____
  - b. What action should you take? _____
  - c. What is the rationale for your action? _____
- 2. **Scenario:** Order: Diflucan 150 mg p.o. daily. The pharmacy sends two 100-mg unscored tabs.
  - a. What action should you take to administer the dosage ordered? _____
  - b. What is the rationale for your action? _____
- 3. **Scenario:** Order: Percocet 2 tabs p.o. q4h p.r.n. for pain for a client who is allergic to aspirin. The nurse administers Percodan 2 tabs.

-
  - a. What client right was violated? _____
  - b. What contributed to the error? _____
  - c. What is the potential outcome of the error? _____
  - d. What preventive measures could have been taken to prevent the error? _____

Answers on 331

CHAPTER **REVIEW**

Calculate the following dosages using the medication label or information provided. Express volume answers in milliliters; round answers to the nearest tenth as indicated. Remember to label answers: tab, caps, mL.

- 1. Order: Neurontin 0.6 g p.o. t.i.d.
- Available:
- _____
- 2. Order: Vraylar 4.5 mg p.o. daily.
- Available:
- How many capsules of which strength will you administer? _____
- 3. Order: Bosulif 0.5 g p.o. daily.
- Available:
- _____
- 4. Order: Carvedilol 25 mg p.o. b.i.d.

- Available:

- _____
- 5. Order: Penicillin V Potassium 0.5 g p.o. q6h.
- Available: *Reconstituted medication

- _____
- 6. Order: Dexamethasone 0.75 mg p.o. daily.
- Available:

- _____
- 7. Order: Cialis 10 mg p.o. 1 hr before sexual activity for a client with erectile dysfunction.
- Available:

- _____
- 8. Order: Ativan 1 mg p.o. q4h p.r.n. for agitation.
- Available:

- _____
- 9. Refer to the label for Mavyret to answer the questions.
    - a. Mavyret is a fixed-dose combination medication that contains _____ mg of glecaprevir and _____ mg of pibrentasvir in each tablet.
    - b. If the recommended total daily dosage is 300 mg of glecaprevir and 120 mg of pibrentasvir, how many tablets will the client need to take for the daily dosage? _____
- 10. Order: Aldactone 100 mg p.o. daily.
- Available:

- _____
- 11. Order: Digoxin 0.1 mg p.o. daily.
- Available:

- _____
- 12. Order: Ziagen 0.3 g p.o. b.i.d.
- Available:

- _____
- 13. Order: Theophylline extended-release 0.6 g p.o. daily.
- Available:

- _____
- 14. Order: Xanax 0.75 mg p.o. t.i.d.
- Available:

- How many tablets of which strength will you administer? _____
- 15. Order: Erythromycin (delayed-release) 0.5 g p.o. q12h.
- Available:

- _____
- 16. Order: Ibrance 125 mg p.o. daily for 21 days.
- Available:

- _____
- 17. Order: Metformin (extended-release) 1 g p.o. daily.
- Available:

- _____
- 18. Order: Clozapine 50 mg p.o. daily.
- Available:

    - a. How many tabs will you administer for each dosage? _____
    - b. How many tabs will be needed for 7 days? _____
- 19. Order: Lipitor 30 mg p.o. daily.
- Available:

- What will you administer to the client? _____
- 20. Order: Eliquis 10 mg p.o. b.i.d. for 7 days.
- Available:

    - a. How many tablets will you administer per dose? _____
    - b. How many tablets are needed for 7 days? _____
- 21. Order: Prednisolone 25 mg p.o. daily.
- Available:

- _____
- 22. Order: Ondansetron 24 mg p.o. 30 minutes before start of chemotherapy.
- Available:

- _____
- 23. Order: Latuda 60 mg p.o. daily.
- Available:

- How many tablets of which strength will you administer? _____
- 24. Order: Lasix 40 mg p.o. daily.
- Available:

- _____
- 25. Order: Strattera 0.1 g p.o. daily.
- Available:

- _____
- 26. Order: Inderal LA 120 mg p.o. daily.
- Available:

- _____
- 27. Order: Suboxone 16 mg/4 mg sublingual daily.
- Available:

- _____
- 28. Order: Amoxicillin and clavulanate 0.5 g by gastrostomy tube q8h (ordered according to the dose of amoxicillin).
- Available: *Reconstituted medication

- _____
- 29. Order: Zyprexa 15 mg p.o. daily.
- Available:

- _____
- 30. Order: Entresto 97/103 p.o. b.i.d.
- Available:

- _____
- 31. Order: Zoloft 175 mg p.o. daily.
- Available:

    - a. How much, and what liquids can this medication be mixed with? _____
    - b. How long after mixing the medication should it be administered? _____
    - c. How many mL will you administer? _____
- 32. Order: Cytotec 200 mcg p.o. q.i.d.
- Available:

- _____
- 33. Order: Trileptal 0.6 g p.o. b.i.d.
- Available:

- _____
- 34. Order: Terbutaline 5 mg p.o. q8h.
- Available:

- _____

- 35. Order: Epclusa 400 mg/100 mg p.o. daily.
- Available:

- _____
- 36. Refer to the label for Biktarvy to answer the questions:

  - a. What alert is indicated on the medication? _____
  - b. Biktarvy is a fixed-dose combination medication that contains medications. What are the medications contained in Biktarvy per tablet? _____
  - c. Indicate the dosage strength for each medication. _____

Answers on 331

For additional practice problems, refer to the Oral Dosages section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

ANSWERS

Chapter 16

Answers to Practice Problems

The answers to the practice problems include the rationale for the answer where indicated. Where necessary, the methods for calculation of the dosage are shown as well. Although not shown, dimensional analysis can also be used. If necessary, review setup in this chapter and in Chapter 15. Ratio and proportion could also be set up in fraction format; review Chapter 13 if necessary.

NOTE

Unless stated, no conversion is required to calculate dosage. In problems that required a conversion before calculating the dosage, the problem setup shown illustrates the problem after appropriate conversions have been made.

- 1. 0.025 mg = 25 mcg (1,000 mcg = 1 mg)
- 50 mcg : 1 tab = 25 mcg : *x* tab
- *or*

- Answer: ½ tab. This is an acceptable answer, because the tabs are scored. (For administration purposes, state as ½ tab.) Note that the problem could have been done without converting by using the dosage indicated on the label in mg. This would net the same answer.
- *or*
- 0.05 mg: 1 tab = 0.025 mg: *x* tab

- 2. 5 mg: 1 tab = 10 mg: *x* tab
- *or*

- Answer: 2 tabs. The dosage ordered is greater than what is available; therefore you will need more than 1 tab to administer the dosage.
- 3. Conversion is required. Equivalent: 1,000 mg = 1 *g*.
- Therefore 1 g = 1,000 mg.
- 1,000 mg: 1 tab = 1,000 mg: *x* tab
- *or*

- Answer: 1 tab (DS). The dosage ordered is equivalent to the dosage available. 1 tab is equal to 1,000 mg, which is equivalent to 1 g; therefore only 1 tab is needed to administer the dosage.
- 4.
    - a. 125-mcg tablet is the appropriate strength to use (0.125 mg = 125 mcg).
    - b. 1 125-mcg tab. Even though the tablets are scored, when possible, administer whole tablets.
    - 125 mcg : 1 tab = 125 mcg : *x* tab
    - *or*
    - Answer: 1 tab
- 5.
    - a. 500-mg caps would be appropriate to use.
    - b. 2 caps (500 mg each). 1,000 mg = 1 g; therefore 2 caps of 500 mg each would be the least number of capsules. Using the 250-mg strength capsules would require 4 caps.
    - c. 2 caps q6h = 8 caps. Multiplying the number of caps needed by the number of days gives you the number of capsules required.
    - 8 (number of caps per day) × 7 (number of days) = 56 (total caps needed)
    - 500 mg : 1 cap = 1,000 mg : *x* cap
    - *or*
    - *x* = 2 caps
- 6. It would be best to administer one of the 100-mg tablets and one of the 50-mg tablets. This would allow the client to take 2 tablets to achieve the dosage ordered. Although giving the client three 50-mg tablets would be acceptable, it is not the best choice. The client always should be given the least number of tablets to achieve the desired dosage (100 mg + 50 mg = 150 mg).
- 7. 0.4 g = 400 mg (1 g = 1,000 mg)
- 400 mg : 1 tab = 400 mg : *x* tab
- *or*
- Answer: 1 tab. 1 tab, 400 mg, is equal to 0.4 g; therefore only 1 tab is needed to administer the dosage.

- 8. 90 mg : 1 tab = 180 mg : *x* tab
- *or*

- Answer: 2 tabs. The dosage ordered is greater than what is available; therefore you will need more than 1 tab to administer the dosage.
- 9. 1.5 mg : 1 cap = 3 mg : *x* cap
- *or*

- Answer: 2 caps. The dosage ordered is greater than what is available; therefore you will need more than 1 cap to administer the dosage.
- 10. 1 mg : 1 tab = 2 mg : *x* tab
- *or*

- Answer: 2 tabs. The dosage ordered is more than what is available; therefore you will need more than 1 tab to administer the dosage.
- 11.
  - a. 30-mg tablets
  - b. Three 30-mg tablets. This strength will allow the client to take three tabs to achieve the desired dosage, as opposed to six 15-mg tabs. This dosage is logical because the maximum number of tablets administered is generally three.
  - 30 mg : 1 tab = 90 mg : *x* tab
  - *or*

  - Answer: three 30-mg tabs
- 12. 0.6 g = 600 mg (1 g = 1,000 mg)
- 300 mg : 1 tab = 600 mg : *x* tab
- *or*

- Answer: 2 tabs. The dosage ordered is greater than what is available; therefore you will need more than 1 tab to administer the dosage.
- 13. 50 mg : 1 tab = 100 mg : *x* tab
- *or*

- Answer: You need 2 tabs to administer 100 mg. 2 tabs t.i.d. (3 times a day) = 6 tabs × 3 days = 18 tabs.
- 14. It would be best to administer one 80-mg tablet and one 40-mg tablet (80 + 40 = 120 mg). This would be the least number of tablets.
- 15. 10 mg : 1 tab = 20 mg : *x* tab
- *or*

- Answer: 2 tabs (extended release). The dosage ordered is larger than the available dosage; therefore more than 1 tab will be required.
- 16. Conversion is required. Equivalent: 1,000 mg = 1 g. 500 mg : 1 tab = 1,000 mg : *x* tab
- *or*

- Answer: 2 tabs (extended release). The dosage ordered is greater than what is available; therefore you will need more than 1 tab to administer the dosage.
- 17. Conversion is required. Equivalent: 1,000 mg = 1 g.
- Therefore 0.2 g = 200 mg.
- 100 mg : 1 tab = 200 mg : *x* tab
- *or*

- Answer: 2 tabs. The dosage ordered is larger than what is available; therefore you will need more than 1 tab to administer the dosage.
- 18. 120 mg : 1 cap = 240 mg : *x* cap
- *or*

- Answer: 2 delayed-release capsules. The dosage ordered is greater than what is available. You will need more than 1 cap to administer the dosage.
- 19. 200 mg : 1 tab = 400 mg : *x* tab
- *or*

- Answer: 2 tabs. The dosage ordered is more than what is available. You will need more than 1 tab to administer the dosage.
- 20.
    - a. 1 tablet. The dosage ordered is contained in the one tablet.
    - b. two (2)
    - c. 49 mg of sacubitril and 51 mg of valsartan.
- 21. 30 mg : 1 cap = 60 mg : *x* cap
- *or*

- Answer: 2 caps (delayed release). The dosage ordered is more than what is available. You will need more than 1 cap to administer the dosage.
- 22. It would be best to administer 3 25 mcg tablets. Although the tabs are scored, it is best to administer tabs whole rather than breaking them. Variation in dosage can occur if tablets are broken.
- 23. 12.5 mg : 1 tab = 25 mg : *x* tab
- *or*

- Answer: 2 tabs. The dosage ordered is more than what is available. You will need more than 1 tab to administer the dosage.
- 24. 0.5 mg : 1 tab = 1 mg : *x* tab
- *or*

- Answer: 2 tabs. The dosage ordered is more than what is available; therefore you will need more than 1 tab to administer the dosage.
- 25. 250 mg : 1 tab = 500 mg : *x* tab
- *or*

- Answer: 2 tabs. The dosage ordered is greater than what is available. You will need more than 1 tab to administer the dosage.
- 26. 30 mg : 1 tab = 60 mg : *x* tab
- *or*

- Answer: 2 tabs XL (extended-release). The dosage ordered is greater than what is available. You will need more than 1 tab to administer the dosage.
- 27. 0.25 mcg : 1 cap = 0.5 mcg : *x* cap
- *or*

- Answer: 2 caps. The dosage ordered is greater than what is available. You will need more than 1 cap to administer the dosage.
- 28. 3.125 mg : 1 tab = 6.25 mg : *x* tab

- *or*

- Answer: 2 tabs. The dosage ordered is greater than what is available. You will need more than 1 tab to administer the dosage.

NOTE

The setup shown for problems that required conversions reflects conversion of what the prescriber ordered to what is available. Unless stated in problems 29-35, no conversion is required to calculate the dosage.

- 29. 20 mg : 1 mL = 75 mg : *x* mL
- *or*

- Answer: 3.75 mL = 3.8 mL. The dosage ordered is more than the available strength. You will need more than 1 mL to administer the dosage.
- 30. 25 mg : 5 mL = 40 mg : *x* mL
- *or*

- Answer: 8 mL. The dosage ordered is more than the available strength; therefore you will need more than 5 mL to administer the required dosage.
- 31. 20 mEq : 15 mL = 20 mEq : *x* mL
- *or*

- Answer: 15 mL. The dosage ordered is contained in 15 mL of the medication.
- 32. 1 mcg : 1 mL = 2 mcg : *x* mL
- *or*

- Answer: 2 mL. The dosage ordered is more than the available strength; therefore you will need more than 1 mL to administer the dosage.
- 33. 0.5 mg : 5 mL = 2 mg : *x* mL
- *or*

- Answer: 20 mL. The dosage ordered is greater than the available strength; therefore more than 5 mL will be needed to administer the required dosage.
- 34. 125 mg : 5 mL = 100 mg : *x* mL
- *or*

- Answer: 4 mL. The amount ordered is less than the available strength; therefore less than 5 mL will be needed to administer the required dosage.
- 35. Use the microgram equivalent to calculate the dosage.
- 50 mcg : 1 mL = 125 mcg : *x* mL
- *or*

- Answer: 2.5 mL. (2.5 mL is metric and stated with decimal.) The dosage ordered is larger than the available strength; therefore you will need more than 1 mL to administer the dosage.
- 36. Conversion is required. Equivalent: 1,000 mg = 1 g.
- Therefore 0.5 g = 500 mg.
- 125 mg : 5 mL = 500 mg : *x* mL
- *or*

- Answer: 20 mL. The dosage ordered is four times larger than the available strength; therefore more than 5 mL will be needed to administer the dosage.
- 37. 20 mg : 5 mL = 60 mg : *x* mL
- *or*

- Answer: 15 mL. The dosage ordered is more than the available strength. You will need more than 5 mL to administer the dosage.
- 38. The label indicates that 5 mL = 300 mg of the medication.
- 300 mg : 5 mL = 600 mg : *x* mL
- *or*

- Answer: 10 mL. The dosage ordered is two times more than the available strength. You will need more than 5 mL to administer the required dosage.
- 39. Conversion is required. Equivalent: 1,000 mg = 1 g.
- Therefore 0.5 g = 500 mg.
- *or*
- 400 mg : 5 mL = 500 mg : *x* mL

- Answer: 6.25 = 6.3 mL. The dosage ordered is larger than the available strength. You will need more than 5 mL to administer the dosage.
- 40. 40 mg : 5 mL = 160 mg : *x* mL

- *or*
- Answer: 20 mL. The dosage ordered is more than the available strength; therefore you will need more than 5 mL to administer the dosage.
- 41. 6 mg : 1 mL = 75 mg : *x* mL
- *or*

- Answer: 12.5 mL. The dosage ordered is greater than the available strength. You will need more than 1 mL to administer the dosage.
- 42. Conversion is necessary. Equivalent: 1,000 mg = 1 g.
- Therefore 0.3 g = 300 mg.
- 250 mg : 5 mL = 300 mg : *x* mL
- *or*

- Answer: 6 mL. The dosage ordered is greater than the available strength; therefore you will need more than 5 mL to administer the required dosage.
- 43. 4 mg : 5 mL = 8 mg : *x* mL
- *or*

- Answer: 10 mL. The dosage ordered is greater than the available strength; therefore you will need more than 5 mL to administer the required dosage.
- 44. Conversion is necessary. 1,000 mg = 1 g; therefore 0.25 g = 250 mg.
- 200 mg : 5 mL = 250 mg : *x* mL
- *or*

- Answer: 6.25 = 6.3 mL. The dosage ordered is greater than the available strength. You will need more than 5 mL to administer the dosage.
- 45. 200 mg : 5 mL = 200 mg : *x* mL
- *or*

- Answer: 5 mL. The dosage ordered is equivalent to the available strength. Label indicates 200 mg = 5 mL.
- 46. 20 mg : 5 mL = 30 mg : *x* mL
- *or*

- Answer: 7.5 mL. The dosage ordered is greater than the available strength; therefore you will need more than 5 mL to administer the required dosage.
- 47. 6.25 mg : 5 mL = 12.5 mg : *x* mL
- *or*

- Answer: 10 mL. The dosage ordered is greater than the available strength; therefore you will need more than 5 mL to administer the required dosage.
- 48. 20 mg : 1 mL = 30 mg : *x* mL
- *or*

- Answer: 1.5 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the required dosage.
- *or*
- 100 mg : 5 mL = 30 mg : *x* mL

- This would net the same answer of 1.5 mL. Note when using the dosage strength of 100 mg per 5 mL, the dosage ordered is less than the available strength; therefore you will need less than 5 mL to administer the dosage.

Answers to Clinical Reasoning Questions

- 1.
  - a. 6 tablets
  - b. Question the order before administering. Double-check your calculation with another nurse. If order is correct, check with the pharmacy regarding available dosage strengths for the medication. Check a reliable and reputable medication reference for the usual dosage and action of this medication.
  - c. Any calculation that requires you to administer more than the maximum number of tablets or capsules, which is usually three (3), to achieve a single dose should be questioned and calculation rechecked. An unusual number of tablets or capsules should alert the nurse to a possible error in prescribing, transcribing, or calculation.
- 2.
  - a. After checking a reliable and reputable drug resource for the usual dosage, contact the pharmacy regarding the available dosage strengths for the medication.
  - b. The dosage ordered would require that the tablets be broken to administer the dosage. The tablets are unscored and should not be broken. Unscored tablets will not break evenly, and there is no way to determine the dosage being administered. Breaking an unscored tablet could lead to the administration of an unintended dosage.
- 3.
  - a. The right medication
  - b. In preparing the medication, the nurse did not read the label carefully and administered Percodan, the wrong medication, which has a similar spelling to Percocet. By not reading the label carefully, the nurse did not notice that combination medications contain more than one medication; in this case, Percodan contained aspirin. Percocet contained Tylenol (acetaminophen).
  - c. A medication error occurred because the wrong medication was administered. The client was allergic to aspirin and could have had a reaction from mild to a severe anaphylactic reaction (dyspnea, airway obstruction, shock, and in some cases, death).
  - d. The error could have been prevented by carefully reading the medication label three times while preparing the medication. The nurse must use caution when administering medications that look alike or that have similar spellings. Tablets or capsules that contain more than one medication must be read carefully. (Percocet contains acetaminophen [Tylenol] and Percodan contains aspirin.)

NOTE

Refer to problems 1-48 for setup of problems if needed.

Answers to Chapter Review

- 1. 1 tab
- 2. One 1.5-mg cap and one 3-mg cap
- 3. 1 tab
- 4. 2 tabs

- 5. 10 mL
- 6. 7.5 mL
- 7. 2 tabs
- 8. 2 tabs
- 9.
    - a. 100 mg of glecaprevir and 40 mg of pibrentasvir
    - b. 3 tabs
- 10. 2 tabs
- 11. 2 mL
- 12. 15 mL
- 13. 1 extended-release tab
- 14. One 0.25-mg tab and one 0.5-mg tab
- 15. 2 delayed-release tabs
- 16. 1 cap
- 17. 1 extended-release tab
- 18.
    - a. 2 tabs
    - b. 14 tabs
- 19. One 10-mg tab and one 20-mg tab
- 20.
    - a. 2 tabs
    - b. 28 tabs
- 21. 8.3 mL
- 22. 30 mL
- 23. One 40-mg tab and one 20-mg tab
- 24. 2 tabs
- 25. 1 cap
- 26. 1 long-acting cap
- 27. 2 sublingual films
- 28. 6.3 mL
- 29. 2 tabs
- 30. 1 tab
- 31.
    - a. 4 oz (½ cup) of water, ginger ale, lemon-lime soda, lemonade, or orange juice only
    - b. Immediately
    - c. 8.8 mL
- 32. 2 tabs
- 33. 10 mL
- 34. 2 tabs
- 35. 1 tab
- 36.
    - a. Find out about medications that should not be taken with Biktarvy.
    - b. 3 (three) medications: bictegravir, emtricitabine, and tenofovir alafenamide
    - c. bictegravir 50 mg equivalent to 52.5 mg of bictegravir, emtricitabine 200 mg, and tenofovir alafenamide 25 mg equivalent to 28 mg of tenofovir alafenamide

unknown - Section 33 (Page 269)

The term *parenteral* is used to indicate medications by any route other than through the gastrointestinal (GI) system. Parenteral is commonly used to refer to medications administered by injection with the use of a needle and syringe. Common parenteral routes include intramuscular (IM), subcutaneous (subcut), and intravenous (IV). Of the three routes, the IV route produces the desired effect more rapidly, as the medication is injected directly into the bloodstream. Intradermal (ID) is a less common injection route and is mainly used for skin testing, such as for allergy test or tuberculin skin test.

Medications administered by the parenteral route generally act more quickly than oral medications because they are absorbed more rapidly into the bloodstream. This chapter will focus on calculation of medications administered IM, subcut, and IV.

- • **IM**—Indicates an injection given into a muscle, such as Demerol for pain.
- • **Subcut**—Injection into the subcutaneous tissue, below the skin, such as insulin used in the management of diabetes.
- • **IV**—Injection given directly into the vein. This can be direct (IV push), or the medication can be diluted in a larger volume of intravenous fluid and infused over a period of time (IV infusion). Antibiotics and other medications may be administered IV.
- • **ID**—Injection administered just under the skin, or into the dermis. ID is mainly used for diagnostic purposes. Example: used to administer purified protein derivative (PPD) skin test to test for exposure to tuberculosis.

When the rapid action of a medication is necessary or a client cannot take the medication orally, the parenteral route may be preferred. For example, a client is unable to take a medication orally because of emesis (vomiting) or a nonfunctioning gastrointestinal (GI) tract, or the client is unconscious.

Medications for parenteral use are available as a sterile solution or liquid that can be absorbed and distributed without causing irritation to the tissues. Parenteral medications are also available in powder form that must be diluted with a liquid or solvent (reconstituted) before they can be used. Reconstitution of medications in powder form will be covered in Chapter 18.

Parenteral Medication Packaging

Medications for parenteral use come packaged in a variety of devices, including ampules, vials, mix-o-vials, premeasured (prefilled) syringes, and cartridges.

- 1. **Ampule:** Sealed glass container that contains a typical single dose of medication. It has a constricted neck that is designed to be snapped off to allow for the withdrawal of medication. The neck is snapped off by using a plastic protective sleeve, an alcohol wipe or sterile gauze. Medication is withdrawn from an ampule using a filter needle (a needle with a filter inside) to prevent the withdrawal of glass fragments (Potter et al., 2017). If the entire amount of medication is not administered, the medication remaining must be discarded (Figure 17.1).

Figure 17.1 Medication in ampules. (From Potter PA, Perry AG, Stockert PA, Hall AM: *Fundamentals of nursing*, ed 9, St Louis, 2017, Elsevier.)

- 2. **Vial:** A vial is a plastic or glass container that has a rubber stopper (diaphragm) on the top that is punctured for the withdrawal of medication and can be for single-dose use or multi-dose use. The medication in a vial may be in liquid (solution) form (Figure 17.2) or may contain a powder that must be reconstituted before administration (discussed in Chapter 18) (Figure 17.3). Multi-dose vials contain more than one dose of the medication and contain an antimicrobial preservative to help prevent the growth of bacteria. Single-dose vials contain the amount of medication for a typical single dose and lack the antimicrobial preservative. Even though medication is in a single-dose vial, it should be measured and not just drawn up. The Centers for Disease Control and Prevention (CDC) issued recommendations for safe injection practices, which included that vials labeled “single-dose” or “single use” should be used once and are meant for one patient use (https://www.cdc.gov/injectionsafety/providers/provider_faqs_singlevials.html). When possible, the CDC also recommends multi-dose vials be for single client use and not opened or punctured in the immediate client area (e.g., client room). This practice will prevent contamination of the vial (direct or indirect), which can lead to infections in subsequent clients (https://www.cdc.gov/injectionsafety/providers/provider_faqs_multivials.html).

Figure 17.2 Medication in vials. (From Potter PA, Perry AG, Stockert PA, Hall AM. *Fundamentals of nursing*, ed 9, St Louis, 2017, Elsevier.)

Figure 17.3 Medication in powder form.

TIPS FOR CLINICAL PRACTICE

It is important to note that for both single-dose vials and ampules, there is a little extra medication present; it is important to carefully measure the amount of medication to be withdrawn.

- 3. **Mix-o-vial:** Some medications come in mix-o-vials (Figure 17.4). The vial usually contains a single dosage of medication. The mix-o-vial has two compartments separated by a rubber stopper. The top compartment contains the sterile liquid (diluent), and the bottom compartment contains the powdered medication. When pressure is applied to the top of the vial, the rubber stopper that separates the medication and liquid is released. This allows the liquid and medication to be mixed, thereby dissolving the medication.

Figure 17.4 Mix-o-vial. (From Willihnganz H, Gurevitz S, Clayton BD: *Clayton's Basic pharmacology for nurses*, ed 18, St Louis, 2020, Elsevier.)

- 4. **Cartridge:** A cartridge is a glass or plastic container prefilled with a single dosage of medication. Cartridges require a special holder called a *Tubex* or *Carpuject* to release the medication from the cartridge for administration. The amount of medication is calculated, and if the dosage to be administered is less than the amount contained in the unit, the unneeded portion is discarded (in the presence of another nurse when medication is a controlled substance) and then the dose of medication is administered to the client (Figure 17.5A).

Figure 17.5 (A) Carpuject syringe holder and needleless, prefilled sterile cartridge. (B) EpiPen 2-Pak. (A, From Hospira, Inc., Lake Forest, IL. B, From Mylan Specialty L.P., Basking Ridge, NJ.)

- 5. **Prefilled syringe (premeasured):** The syringe comes from the manufacturer prefilled with medication, single-dose, and designed to be used once. The medication comes prepared for administration with a needle attached or without a needle attached, packaged with a plunger, and does not require a special holder for administration. The amount desired is calculated, the excess disposed of (in the presence of another nurse when medication is a controlled substance), and the calculated dosage is administered. Examples of medications available in prefilled syringes include vaccines, emergency medications such as sodium bicarbonate and atropine, EpiPen, insulin pens, and Amivog (used for migraine headaches) (Figure 17.5B).
- In addition to the packaging discussed for parenteral medications, there are some parenteral medications that come in ***auto-injectors.*** An auto-injector is a medical device designed to deliver a premeasured dose of medication. Auto-injectors allow for self-injection with a single, preloaded dose of a medication that consists of a spring-loaded syringe activated when the device is pushed firmly against the body. Examples of medications that come in auto-injectors include Epinephrine and Amivog.

SAFETY ALERT!

To safely administer the ordered amount of medication from a cartridge and prefilled syringe, the amount of medication in excess of what is needed to administer the dosage should be discarded before administration.

Syringes

Parenteral medications are administered with a syringe. The nurse has the responsibility for choosing the proper equipment required to safely administer the medication. Syringes as well as needles vary in size. The choice of needle size as well as syringe is determined by the nurse, depending on several factors, which include the route of administration, the volume of medication, the viscosity of the medication to be injected, the type of tissue being injected into, and the client's size. Nurses must be able to choose the appropriate syringe, accurately read the calibrations on the syringe, and draw up the correct volume of medication. Syringes are available in various sizes for use, have different capacities, and specific calibrations. They are made of plastic and glass, but plastic syringes are more commonly used. Syringes are disposable and designed for one-time use only. Before discussing the various types of syringes let's begin with the **parts of a syringe** (Figure 17.6).

Figure 17.6 Parts of a syringe.

- 1. **The barrel:** The outer (body) portion of the syringe that holds the medication. The barrel of the syringe is marked with lines that are referred to as calibrations (markings) that measure medication doses in milliliters (mL).

- 2. **The plunger:** The inner device that is moved backward to withdraw and measure the medication and is pushed to eject the medication from the syringe. The plunger fits into the barrel.
- 3. **The tip:** The end of the syringe that holds the needle. The needle can be twisted and locked in place (Luer-Lok) (Figure 17.7A). This design prevents the inadvertent removal of the needle (Potter, Perry, Stockert, Hall, 2017). Or the needle slips on to the tip (non–Luer-Lok) (Figure 17.7B). Some syringes also come with a needle attached that cannot be detached from the syringe.

Figure 17.7 (A) Luer-Lok. (B) Slip tip (non–Luer-Lok).

Needles come in various lengths and diameters. The nurse chooses the needle according to the client's size, the type of tissue being injected into, and the viscosity of the medication to be injected. Some syringes also come with a needle attached that cannot be detached from the syringe.

Types of Syringes

Syringes are available in a variety of sizes. The nurse chooses the syringe to use based on the volume to be administered. The syringes commonly used in the clinical setting include the **3-mL** (small hypodermic) **syringe, 1-mL (tuberculin) syringe**, and the **insulin syringes**. There are larger syringes that include the 5, 6, 10, 12, up to 60 mL and larger. Syringes are calibrated in milliliters (mL) and hold varying capacities, and the calibrations vary with the size of the syringe.

- • **3-mL syringe.** The 3-mL syringe is the most commonly used hypodermic syringe for the administration of medication that is more than 1 mL (Figure 17.8). Notice the calibration lines on the barrel of the 3-mL syringe. The beginning of the barrel (or first line on the syringe) is referred to as the zero line. The first calibration on all syringes is zero. Each calibration (short line) after the zero line is 0.1 mL. The longer lines indicate half (0.5 mL), and full milliliter measures up to 3 mL. Note mL is indicated on the syringe and not cubic centimeter (cc). **Milliliter (mL)** is the correct term for volume. The cubic centimeter is a three-dimensional measure of space and represents the space that a milliliter occupies. Notice also that the small hypodermic syringes up to size 3 mL also have fractions on them. There are, however, some syringes that indicate 0.5 mL, 1.5 mL, etc., instead of fractions. The use of decimals on the syringes correlates with the use of decimals in the metric system; therefore a dosage should be stated in milliliters as a decimal (e.g., 1.2 mL, 0.3 mL).

Figure 17.8 3-mL syringe.

Measuring the Amount of Medication in a Syringe

Refer to the syringe shown in Figure 17.9; notice the rubber ring. When measuring medication and reading the medication withdrawn, the forward edge of the plunger head indicates the amount of medication withdrawn. Do not become confused by the second, bottom ring or by the raised section (middle) of the suction tip. The point where the rubber plunger edge makes contact with the barrel is the spot that should be lined up with the amount desired.

Figure 17.9 Reading measured amount of a medication in a syringe. (From Potter PA, Perry AG, Stockert P, Hall A: *Fundamentals of nursing,* ed 9, St Louis, 2017, Elsevier.)

SAFETY ALERT!

Understanding the calibrations on a syringe and reading them carefully are critical to accurately measuring a medication dosage. Misreading the calibrations could lead to a medication error. The volume of medication represented by the calibrations is different depending on the size of the syringe being used. Never assume what the calibrations on a syringe mean. Check the calibrations carefully. If the medication is not accurately measured, an incorrect dosage can be administered, resulting in serious consequences to the client.

Let's examine the syringes below to illustrate specific amounts in a syringe. (Syringe **A** shows a volume of 0.7 mL filled in, and syringe **B,** 1.7 mL.)

Because the small-capacity syringes are used most often to administer medications, it is very important to know how to read them to withdraw amounts accurately.

POINTS TO REMEMBER

- • Small-capacity hypodermics are calibrated in milliliters; the 3-mL size syringe is used most often to administer dosages greater than 1 mL. Dosages administered with them must correlate to the calibration.
- • Syringes are labeled with the abbreviation mL. More and more syringes are being manufactured using just mL.
- • The milliliter (mL) is the correct measure for volume.
- • The first calibration (line) on all syringes is zero.
- • 3-mL syringe is calibrated in tenths (0.1) of a mL.

PRACTICE **PROBLEMS**

Shade in the indicated amounts on the syringes in milliliters.

- 1. 0.8 mL

- 2. 1.2 mL

- 3. 1.5 mL

- 4. 2.4 mL

Indicate the number of milliliters shaded in on the following syringes.

- 5.

- 6.

- 7.

- 8.

Answers on 377

Large-Capacity Syringes. The larger hypodermics (5, 6, 10, and 12 mL) are used when volumes larger than 3 mL are desired.

- • **5-, 6-, 10-, and 12-mL syringes:** These syringes are used when volumes larger than 3 mL are desired. Of these syringes the 5 mL and 10 mL are seen most often to prepare and administer medications for intravenous (IV) administration. These syringes are sometimes referred to as *intravenous syringes*. With these syringes (5-mL, 6-mL, 10-mL, and 12-mL) each small calibration line is 0.2 mL, with the whole numbers indicated by the long calibration line and is numbered. Figure 17.10A shows 0.8 mL of medication measured in a 5-mL syringe, and Figure 17.10B shows 7.8 mL measured in a 10-mL syringe.

Figure 17.10 Large hypodermics. (A) 5-mL syringe filled with 0.8 mL. (B) 10-mL syringe filled with 7.8 mL.

- • **20-, 30-, and up to 60-mL syringes:** These syringes are used to administer large volumes of IV medication and other clinical uses which includes feeding clients. These syringes have small calibration lines that measure 1 mL, and every fifth mL has a longer calibration line and is numbered. These syringes also measure ounces on the syringe.

TIPS FOR CLINICAL PRACTICE

The larger the syringe, the larger the calibration. Example: In 5-mL and 10-mL syringes, each shorter calibration line measures two-tenths of a milliliter (0.2 mL). To be safe, always examine the calibration of the syringes and use the one best suited for the volume to be administered.

PRACTICE **PROBLEMS**

Indicate the number of milliliters shaded in on the following syringes.

- 9.

- 10.

- 11.

Answers on 377

- • **Tuberculin syringe (1 mL):** The tuberculin (TB) syringe is a narrow syringe that has a capacity of 0.5 mL or 1 mL. The 1-mL size is used most often. The syringe gets its name from its original use, which was the administration of tuberculin skin tests. Tuberculin syringes are used to accurately measure medications given in very small volumes and for medication doses contained in hundredths of a milliliter (mL) (e.g., heparin). Other medications administered with a tuberculin syringe include vaccines and small doses of medications given to children. It is also recommended that dosages less than 0.5 mL be measured and administered with a tuberculin syringe. The calibrations on a 1-mL syringe are small and close together. Dosages such as 0.42 mL and 0.37 mL can be accurately measured using a tuberculin syringe. On the tuberculin syringe each of the shorter calibration lines represent one-hundredth of a milliliter (0.01 mL); the longer calibration lines measure one-tenth of a milliliter (0.1) and are numbered. The numbers on the tuberculin syringe are decimal fractions (Figures 17.11 and 17.12).

Figure 17.11 Tuberculin syringe.

Figure 17.12 Tuberculin syringe. The 0.4 mL calibration *(orange line)* is one of 0.1-increments; the 0.25 mL calibration *(green line)* is one of the 0.01-mL increments on the tuberculin syringe.

SAFETY ALERT!

Reading the calibration lines and measuring the correct dose with a tuberculin syringe requires extreme care. Read the calibrations carefully to avoid error.

SAFETY ALERT!

The calibrations on hypodermic syringes differ. Be careful when measuring medications in a syringe. Being off by even a small amount on the syringe scale can be critical. The syringe you use to administer medication must provide the calibration you need to accurately measure the dose.

Insulin syringes: Insulin syringes are used to administer insulin **only**. Insulin syringes are calibrated in **units**, and not mL. Insulin is ordered by the number of units to administer and not volume. Insulin syringes do not have detachable needles. The needle, hub, and barrel are inseparable. The administration of insulin, insulin orders, and insulin syringes are further discussed in the insulin chapter, Chapter 19. Insulin syringes are available in three sizes: 100 unit (1 mL), 50 unit (0.5 mL), and 30 unit (0.3 mL). The 50-unit and 30-unit insulin syringes are called Lo-Dose insulin syringes; they are designed to precisely deliver low doses (50 units or less) of insulin (Figure 17.13).

Figure 17.13 Insulin syringes. (A) 1-mL size (100 units). (B) Lo-Dose (50 units). (C) Lo-Dose (30 units). (D) U-500. (From Macklin D, Chernecky L, Infortuna H: *Math for clinical practice*, ed 2, St Louis, 2010, Mosby.)

- • **100-unit insulin syringe** (referred to as the standard insulin syringe): A long calibration line identifies every 10 units (i.e., 10, 20, up to 100 units). Each short line calibration is in 2-unit increments (Figure 17.13A).
- • **50-unit insulin syringe:** A long calibration line identifies every 5 units (i.e., 5, 10, up to 50 units). Each short calibration line is in 1-unit increments (Figure 17.13B).
- • **30-unit insulin syringe:** A long calibration line identifies every 5 units (i.e., 5, 10, up to 30 units). Each short line calibration is in 1-unit increments. Note: the calibration lines on the 30-unit insulin syringe has more spacing between the calibrations and is easy to read (Figure 17.13C).
- • ***U-500 insulin syringe:** This syringe has "U-500" indicated on the barrel of the syringe. Each calibration (short line) on the syringe is 5 units. The syringe is designed to administer U-500 insulin (discussed further in Chapter 19) and has a capacity of 250 units (Figure 17.13D).
- • **Dual-scale insulin syringe:** The second type of 100-unit insulin syringe is the dual-scale version, which is calibrated in 2-unit increments. It has a scale with even numbered 2-unit increments on one side (2, 4, etc.) The opposite side is in odd-numbered 2-unit increments (1, 3 etc.). The best method for using this syringe is to measure the odd dosages on the left and even dosages using the scale on the right (Figure 17.14). Care must be taken to use the correct scale for the number of units of insulin ordered.

Figure 17.14 1-mL capacity insulin syringe (100 units) with the dual-scale odd and even calibrations.

SAFETY ALERT!

Insulin is a high-alert medication. All insulin dosages should be checked by another nurse before administration to a client. Insulin is measured in units not mL.

Insulin syringes are used to measure insulin only. Measurement of dosages that are approximate (in between lines) should be avoided. Never measure other medications measured in units in an insulin syringe (e.g., heparin).

- • **Safety syringes:** Needlestick prevention is the only way to prevent transmission of blood-borne pathogens from contaminated needles. Consequently, this has resulted in special prevention techniques (e.g., no recapping of a needle after use) and development of special equipment, which includes needless syringe systems, and safety syringes with a sheath or guard that covers the needle after it is withdrawn from the skin, thereby decreasing the chance of needlestick injury. Safety syringes are available in multiple sizes and styles. An example of the safety needle technology is the safety glide syringe, which contains a protective needle guard that can be activated by a single finger to cover and seal the needle after injection (Figure 17.15). Following the administration of an injection, the nurse should **always** activate the safety device.

Figure 17.15 BD Safety Glide needle. (Courtesy and copyright Becton, Dickinson and Company, Franklin Lakes, NJ.)

POINTS TO REMEMBER

- • When parenteral medications are prepared for administration, it is important to use the correct syringe for accurate administration of the dosage.
- • Dosages must be measurable and appropriate for the syringe used.
- • Milliliters (mL) is the correct term for volume. Cubic centimeters (cc) is the amount of space that a milliliter occupies. Milliliter and cubic centimeter are not equivalent.
- • The 3-mL size syringe is the most common used for medication administration. On the 3-mL size syringe, each calibration is 0.1 mL.
- • The first line on all syringes is “zero” and referred to as the *zero line*.
- • On syringes that are 5, 6, 10, and 12 mL, each small calibration line is 0.2 mL.
- • Syringes that are 20, 30, up to 60 mL are calibrated in mL and have ounce measurements on the syringe.
- • Tuberculin syringe (1-mL) measures 0.01 mL and 0.1 mL; the calibrations are small and close together. Decimal fractions are indicated on the syringe. (Recommended for dosages less than 0.5 mL.)
- • Insulin is a high-alert medication; dosages should be checked by another nurse before administration. The insulin syringe is only used to administer insulin.
- • Insulin is administered in units, not mL.
- • Insulin syringe and tuberculin syringe are different. Confusion of the two can cause a medication error.
- • Dosages involving mL should be expressed as a decimal fraction even if the syringe has fractional markings. Milliliters is a metric measure.
- • If the dosage cannot be accurately measured, do not administer.

Before proceeding to discuss calculation of parenteral dosages, we will review some specifics in terms of reading labels. Reading the label and understanding what information is essential are important in determining the correct dosage to administer.

Reading Parenteral Labels

The information contained on the parenteral label is similar to the information on an oral liquid label. It contains the total volume of the container and the dosage strength (amount of medication in solution) expressed in milliliters (Table 17.1). It is important to read the label carefully to determine the dosage strength and volume. Let’s examine some labels.

TABLE 17.1

Sample Dosage Strengths

Label	Interpretation
Emgality 120 mg/mL	1 mL contains 120 mg of Emgality
Ondansetron HCl 4 mg/2 mL	2 mL contains 4 mg of Ondansetron HCl
Digoxin 500 mcg/2 mL	2 mL contains 500 mcg of Digoxin

The slash (/) mark used here to illustrate expression of the dosage strength as written on label. When expressing dosage strengths, do not use the slash mark. Use “per.” For example, per mL is recommended by ISMP and is on the list of Error-Prone Abbreviations, Symbols, and Dose Designations. The slash mark has been mistaken for the number (1).

The Tigan label in Figure 17.16 tells us the total size of the vial is 2 mL. The dosage strength is stated for the entire vial (200 mg per 2 mL) and per mL (100 mg per mL). The Depo-Provera label shown in Figure 17.17 indicates the total vial size is 2.5 mL. The dosage strength for the entire vial is (1,000 mg per 2.5 mL) and per mL (400 mg per mL).

Figure 17.16 Tigan label.

Figure 17.17 Depo-Provera label.

Dosage strengths for parenteral medications are commonly seen expressed as the amount of medication contained in a volume of solution and expressed in milliliters. Parenteral labels can also express the dosage strength for medications in percentage strengths, ratios, units, or milliequivalents. Read labels carefully to identify the unit of measure as well as the dosage strength.

PRACTICE **PROBLEMS**

Use the labels provided to answer the questions.

Using the chlorpromazine label above, answer the following questions:

- 12.
  - a. What is the total volume of the ampul (ampule)? _____
  - b. What is the dosage strength? _____
  - c. If 50 mg were ordered, how many milliliters would this be? _____

Using the Diazepam label above, answer the following questions:

- 13.
  - a. What is the total volume of the vial? _____
  - b. What is the dosage strength? _____
  - c. What is the controlled substance schedule? _____
  - d. If 2.5 mL were ordered, how many milligrams would this be? _____

Using the Leuprolide acetate label above, answer the following questions:

- 14.
  - a. What is the total volume of the vial? _____
  - b. What is the dosage strength? _____
  - c. What is the route of administration? _____

Using the Bumetanide label above, answer the following questions:

- 15.
  - a. What is the total volume of the vial? _____
  - b. What is the dosage strength? _____
  - c. What are the directions for use? _____

Using the Stelara label above, answer the following questions:

- 16.
  - a. What is the route of administration? _____
  - b. What is the dosage strength? _____

Using the Fentanyl label on the previous page, answer the following questions:

- 17.
  - a. What is the dosage strength? _____
  - b. What is the route of administration? _____
  - c. What is the controlled substance schedule? _____

Using the furosemide label above, answer the following questions:

- 18.
  - a. What is the total volume of the vial? _____
  - b. What is the dosage strength? _____
  - c. What are the directions for use? _____
  - d. What type of vial is the medication packaged in? _____

Using the Amiodarone label above, answer the following questions:

- 19.
  - a. What is the total volume of the vial? _____
  - b. What is the dosage strength? _____
  - c. What is the route of administration? _____

Answers on 377

Medications Labeled in Percentage Strengths

Medications that are labeled as percentage solutions give information such as the percentage of the solution and the total volume of the vial or ampule. Although percentage is used, metric measures are used as well. Example: Notice the label below of lidocaine 1%, notice there are 500 mg per 50 mL (10 mg per mL). As discussed in Chapter 4, percentage solutions express the number of grams of medication per 100 mL of solution. In the lidocaine label shown, lidocaine 1% contains 1 g of medication per 100 mL of solution, 1 g per 100 mL = 1,000 mg per 100 mL = 500 mg per 50 mL (10 mg per mL).

Solutions Expressed in Ratio Strength

A medication that may be seen expressed in ratio strength is Adrenalin (epinephrine). Medications expressed this way include metric measures and are often ordered by the number of milliliters. Example: Adrenalin (epinephrine) may state 1:1,000 and indicate 1 mg per mL. Ratio solutions, as discussed in Chapter 3 on ratio and proportion, express the number of grams of the medication per total milliliters of solution. Adrenalin (epinephrine) 1:1,000 contains 1 g medication per 1,000 mL solution; 1 g: 1,000 mL = 1,000 mg : 1,000 mL = 1 mg : 1 mL. (See the label below.)

Medications Measured in Units

Some medications measured in units for parenteral administration are heparin, Pitocin (oxytocin), insulin, and penicillin. Units measure a medication in terms of its action. Units are specific to the medication for which they are used. For example, a unit of insulin is not the same as a unit of heparin. When dosages with units are calculated, there is no conversion of units, and drugs measured in units are ordered by the number of units to be administered. See labels below, heparin 5,000 units per mL and Pitocin (oxytocin) 10 units per mL.

Medications in Milliequivalents

Potassium and sodium bicarbonate are examples of medications that are expressed in milliequivalents. Like units, milliequivalents are specific measurements that have no conversion to another system and are specific to the medication used. Milliequivalents (mEq) are used to measure electrolytes (e.g., potassium) and the ionic activity of a medication. Milliequivalents are also defined as an expression of the number of grams of a medication contained in 1 mL of a normal solution. This definition is often used by a chemist or pharmacist. Refer to the potassium label below. Notice the dosage strength for the total vial is 20 mEq per 10 mL and (2 mEq per mL).

PRACTICE **PROBLEMS**

Use the labels provided to answer the questions.

Use the sodium bicarbonate label above to answer the following questions:

- 20.
  - a. What is the total volume of the vial? _____
  - b. What is the dosage strength in milliequivalents per milliliter? _____

Use the Epogen label on the previous page to answer the following questions:

- 21.
  - a. What is the total volume of the vial? _____
  - b. What is the dosage strength? _____
  - c. Directions for use _____

Use the potassium acetate label above to answer the following questions:

- 22.
  - a. What is the total volume of the vial? _____
  - b. What is the dosage strength? _____

Answers on 377

TIPS FOR CLINICAL PRACTICE

It is important to read the labels on parenteral medications carefully. Labels on parenteral medications include a variety of units to express dosage strengths. To calculate dosages to administer, it is important to know the dosage strength (the amount of medication contained in a specific volume of solution). Confusing dosage strength with total volume can lead to a medication error.

Guidelines for Calculating and Rounding Parenteral Medications

- • To calculate parenteral dosages, convert if necessary, **THINK,** and calculate using one of the methods presented (ratio and proportion, the formula method, or dimensional analysis).
- • The syringe used should accurately measure the calculated dosage to administer.
- • Dosage calculations sometimes result in an even answer, and you will not need to round the answer for administration. Choose the syringe in this case that allows for the accurate measurement of the calculated dose. Example: 0.35 mL can be accurately measured in a 1-mL (tuberculin) syringe, 2.2 mL can be accurately measured in a 3-mL syringe.
- • When calculating parenteral dosages and the calculation does not net an answer that comes out evenly, use the following guidelines for rounding:
  - a. **The 3-mL syringe** is calibrated in 0.1-increments. Round milliliters to the nearest tenth to measure in a 3-mL syringe; **never round to a whole unit.** If math calculation does not terminate evenly in the tenths place, then carry division to the hundredths place (two decimal places) and round to the nearest tenth. **Example:** 1.75 mL = 1.8 mL
  - b. **The 1-mL (tuberculin) syringe** is recommended for administration of dosages less than 0.5 mL. The syringe is calibrated in 0.01-mL increments. If the math calculation does not work out evenly to the hundredths place, then the division is carried to the thousandths (three decimal places) and rounded to the hundredths place. **Example:** 0.433 mL = 0.43 mL
  - c. **Large syringes (5-, 6-, 10-, and 12-mL)** are calibrated in 0.2-mL increments. Dosages are also expressed to the nearest tenth.
- • Dosages administered should be measured in milliliters and the answer labeled accordingly. The exception is insulin, which is measured in units and administered in units and administered with insulin syringes calibrated in units. (Insulin is discussed in Chapter 19.)

TIPS FOR CLINICAL PRACTICE

It is critical to choose the correct size syringe to ensure accurate measurement.

Guidelines for Volume to Administer in Sites/Routes

For injectable medications, there are guidelines as to the amount of medication that can be administered in a single site/route. (See Table 17.2.) It is recommended that when the amount exceeds the amount that can be administered in a single site, divide the amount into two injections. When administering medications by injection, consider the condition of the client, site selected, and absorption and consistency of the medication. Depending on his or her condition, a client may not be able to tolerate the maximum dosage volumes.

TABLE 17.2

Maximum Volume for Sites/Routes

Route/Site	Maximum Volume
Intramuscular:	
Adult	3 mL
Deltoid muscle	1 mL
Children 6 -12 years	2 mL
Children 0 -5 years	1 mL
Adult: Subcutaneous (subcut)	1 mL
Adult: Intravenous (IV) added to solution	May have a volume greater than 5 mL

SAFETY ALERT!

When the dosage for parenteral administration exceeds the guidelines of volume that can be administered in a single injection site/route, the dosage should be questioned and calculation double-checked. Dosages larger than the maximum volume are rare and can cause harm to a client.

Calculating Injectable Medications

Now that you have an understanding of syringes and guidelines, let's begin calculating dosages. Regardless of the method used to calculate, the following steps are used:

- 1. Check to make sure everything is in the same system and unit of measure.
- 2. Think critically and estimate what the logical volume to administer should be.
- 3. Calculate: use ratio and proportion, the formula method, or dimensional analysis to calculate the dosage.
- 4. Consider the type of syringe being used. **The cardinal rule should always be that any dosage given must be able to be measured accurately in the syringe you are using.** Let's look at some sample problems.

Example 1:

- Order: Gentamicin 75 mg IM q8h.
- Available: Gentamicin labeled 40 mg per mL.

Note: No conversion is necessary here. Think—The dosage ordered is going to be more than 1 mL but less than 2 mL. Set up and solve.

Solution Using Ratio and Proportion

Linear Format: 40 mg : 1 mL = 75 mg : *x* mL

40x40=7540

x=7540

x = 1.87 = 1.9 mL

Fraction Format:

40 mg1 mL=75 mgx mL

40x40=7540

x=7540

$x = 1.87 = 1.9$ mL

Answer: 1.9 mL

The answer here is rounded to the nearest tenth of a milliliter. Remember that you are using a small hypodermic syringe marked in tenths of a milliliter.

Solution Using the Formula Method

(D) 75 mg(H) 40 mg

× (Q) 1 mL = x mL

x=7540

$x = 1.87 = 1.9$ mL

Answer: 1.9 mL

Solution Using Dimensional Analysis

$x=7540$

$x = 1.87 = 1.9$ mL

Answer: 1.9 mL

Refer to the syringe below illustrating 1.9 mL shaded in on the syringe.

Example 2:

- Order: Ceftriaxone 0.25 g IM stat q12h for 5 days.
- Available: Ceftriaxone labeled 350 mg per 1 mL.

In this problem, a conversion is necessary. Equivalent: 1,000 mg = 1 g. Convert what is ordered to what is available: 0.25 g = 250 mg.

Think—The dosage you will need to give is less than 1 mL, and it is being given intramuscularly. The dosage therefore should fall within the range that is safe for IM administration. The solution, after making conversion, is as follows:

Solution Using Ratio and Proportion

Linear Format: 350 mg : 1 mL = 250 mg : x mL

350x350=250350

x=250350

$x = 0.71 = 0.7$ mL

Fraction Format: 350 mg1 mL=250 mgx mL

350x350=250350

x=250350

$x = 0.71 = 0.7$ mL

Answer: 0.7 mL

Solution Using the Formula Method

(D) 250 mg(H) 350 mg

× (Q) 1 mL = *x* mL

x=250350

x = 0.71 = 0.7 mL

Solution Using Dimensional Analysis

$x = 1{,}000 \times 0.25350$

$x = 250350$

$x = 0.71 = 0.7$ mL

Answer: 0.7 mL

Refer to the syringe below illustrating 0.7 mL drawn up.

Example 3:

- Order: Atropine sulfate 0.6 mg subcut stat.
- Available: Atropine sulfate labeled 1 mg per mL.

PROBLEM SETUP

- 1. No conversion is necessary.
- 2. Think—You will need less than 1 mL to administer the required dosage.
- 3. Set up the problem, and calculate the dosage to be administered.

Solution Using Ratio and Proportion

Linear Format: 1 mg : 1 mL = 0.6 mg : *x* mL

1x1=0.61

x=0.61

x = 0.6 mL

Fraction Format: 1 mg1 mL=0.6 mgx mL

1x1=0.61

x=0.61

x = 0.6 mL

Answer: 0.6 mL

Solution Using the Formula Method

(D) 0.6 mg(H) 1 mg

× (Q) 1 mL = x mL

x=0.61

x = 0.6 mL

Answer: 0.6 mL

Solution Using Dimensional Analysis

x=0.61

x = 0.6 mL

Answer: 0.6 mL

Refer to the illustration below showing 0.6 mL shaded in on the syringe.

Calculating Dosages for Medications in Units

As previously mentioned, certain medications are measured in units. Some medications measured in units include vitamins, antibiotics, insulin, and heparin. In determining the dosage to administer when medications are measured in units, use the same steps as with other parenteral medications. Dosages of certain medications such as heparin are administered with a tuberculin syringe. Heparin will also be discussed in more detail in Chapter 22. Let's look at sample problems with units.

Example 1:

- Order: Heparin 750 units subcut daily.
- Available: Heparin 1,000 units per mL
- Using a 1-mL (tuberculin) syringe, calculate the dosage to be administered.

PROBLEM SETUP

- 1. No conversion is required. No conversion exists for units.
- 2. Think—The dosage to be given is less than 1 mL. This dosage can be accurately measured in a 1-mL tuberculin syringe. Heparin is administered in exact dosages.
- 3. Set up the problem, and calculate the dosage to be given.

SAFETY ALERT!

Because of the action of heparin, an exact dosage is crucial; the dosage should not be rounded off.

Solution Using Ratio and Proportion

Linear Format: 1,000 units : 1 mL = 750 units : *x* mL*x* = 0.75 mL

1,000x1,000=7501,000

x=751,000

x = 0.75 mL

Fraction Format: 1,000 units1 mL=750 unitsx mL

1,000x1,000=7501,000

x=7501,000

x = 0.75 mL

Answer: 0.75 mL

Solution Using the Formula Method

(D) 750 units(H) 1,000 units

× (Q) 1 mL = *x* mL

x=7501,000

x = 0.75 mL

Answer: 0.75 mL

Solution Using Dimensional Analysis

x=75100

x = 0.75 mL

Answer: 0.75 mL

Refer to the syringe illustrating 0.75 mL shaded in.

Example 2:

- Order: Penicillin G procaine, 500,000 units IM b.i.d.
- Available: Penicillin G procaine labeled 300,000 units per mL

PROBLEM SETUP

- 1. No conversion is required.
- 2. Think—The dosage ordered is more than the available strength. Therefore more than 1 mL would be required to administer the dosage.

- 3. Set up the problem using ratio and proportion, the formula method, or dimensional analysis to calculate the dosage.

Solution Using Ratio and Proportion

Linear Format: 300,000 units : 1 mL = 500,000 units : *x* mL

300,000x300,000=500,000300,000

x=53

x = 1.66 = 1.7 mL

Fraction Format:

300,000 units1 mL=500,000 unitsx mL

300,000x300,000=500,000300,000

x=53

x = 1.66 = 1.7 mL

Answer: 1.7 mL

Note: Math was carried two decimal places to round to 1.7 mL. Small hypodermic was marked in tenths of a mL.

Solution Using the Formula Method

(D) 500,000(H) 300,000

× (Q) 1 mL = x mL

$x = 1.66 = 1.7$ mL

Answer: 1.7 mL

Solution Using Dimensional Analysis

$x = 1.66 = 1.7$ mL

Answer: 1.7 mL

Refer to the syringe illustrating 1.7 mL shaded in.

SAFETY ALERT!

Read orders carefully when they are expressed in units. Units should NOT be abbreviated in orders. To avoid confusion, The Joint Commission (TJC) has placed the abbreviations for units (U) on the “Do Not Use” list. This abbreviation is also on ISMP’s (Institute for Safe Medication Practices) Error Prone Abbreviations, Symbols, and Dose Designations. Prescribers are required to write out the word units to help prevent misinterpretation of an order—for example, “50 ” as “500 units.” (Notice that the U is almost closed; it could be mistaken for a zero and misinterpreted as 500 units.) This error could be fatal.

Mixing Medications in the Same Syringe

Two medications may be mixed in one syringe if they are compatible with each other and the total amount does not exceed the amount that can be safely administered in a site. Always consult a reliable reference in regard to compatibility of medications before mixing medications.

When mixing two medications for administration in one syringe, calculate the dosage to be administered in milliliters to the nearest tenth for each of the medications ordered. Then add the results to find the total volume to be combined and administered.

Example:

- Order: Demerol 65 mg IM and Vistaril 25 mg IM q4h p.r.n. for pain.
- Available: Demerol 75 mg per mL and Vistaril 50 mg per mL.
- Solution: Demerol dosage 0.86 = 0.9 mL
- Visatril dosage 0.5 mL
- 0.9 mL Demerol + 0.5 mL Vistaril = 1.4 mL (total volume)

Dosage shaded in one syringe:

POINTS TO REMEMBER

- • Read labels carefully. Do not confuse dosage strength with total volume.
- • There is no conversion of units and milliequivalents.
- • Do not exceed the dosage administration guidelines for parenteral administration. (IM—maximum 3 mL for an average-size adult, 1 mL for deltoid, 2 mL for children ages 6–12, 0–5 years 1 mL).
- • Subcut maximum 1 mL for an adult.
- • Calculate parenteral dosage problems using any of the methods presented (ratio and proportion, formula method, or dimensional analysis).
- • 3-mL syringe calibrated in 0.1 mL. Round mL to the nearest tenth.

- • 1-mL syringe calibrated in 0.01-mL and 0.1 increments. Math that does not terminate evenly in hundredths is carried to thousandths and rounded to hundredths.
- • 5-, 6-, and 12-mL syringes are calibrated in 0.2 mL. Dosages are expressed to the nearest tenth.
- • Two medications can be administered in the same syringe if compatible. Calculate the dosage to be administered in mL to the nearest tenth for each of the medications. Add the result to get the total volume to administer.
- • Choose the correct size syringe to accurately administer the dosage. Read the calibrations carefully.

PRACTICE **PROBLEMS**

Calculate the dosages for the problems below, and indicate the number of milliliters you will administer. Shade in the dosage on the syringe provided. Use medication labels or information provided to calculate the volume necessary to administer the dosage ordered. Express your answers in milliliters to the nearest tenth except where indicated.

- 23. Order: Haloperidol 5 mg IM stat.
- Available:
-

- 24. Order: Methylprednisolone 60 mg IM stat.
- Available:

- 25. Order: Meperidine 50 mg IM and Hydroxine 25 mg IM q4h p.r.n. for pain.
- Available:

- 26. Order: Heparin 5,000 units subcut daily.
- Available:

- 27. Order: Morphine sulfate 10 mg IM q4h p.r.n. for pain.
- Available:

- **Answers on p.** 378

CLINICAL **REASONING**

Scenario: Prescriber ordered the following:

Hydroxyzine 50 mg IM q4h p.r.n. for anxiety.

The nurse, in error, administered hydralazine 50 mg IM from a vial labeled 20 mg per mL and administered 2.5 mL.

- a. What client right was violated?
- b. What contributed to the error made?
- c. What is the potential outcome from the error?

- d. What measures could have been taken to prevent the error?

Answers on 378

NGN Case Study

Case Scenario: A client arrives to the postanesthesia care unit after having an appendectomy. The client has a history of postoperative nausea and vomiting. The nurse has an order to give dexamethasone 4 mg IV stat. **Using the label below, complete the following sentences by choosing from the list of options.**

The nurse would first determine the dosage strength of dexamethasone to be _____**1**_____. The nurse would calculate the correct volume to administer as _____**2**_____. The appropriate size syringe to use would be _____**3**_____.

1	2	3
16.5 mg per mL	0.4 mL	5 mL
10 mg per mL	0.25 mL	3 mL
1.5 mg per mL	2.67 mL	1 mL

Reference: Morris D: *Calculate with confidence*, ed 8, St Louis, Elsevier, copyright 2022. *Case Study answers and rationales can be found on Evolve.*

CHAPTER **REVIEW**

Calculate the dosages for the problems that follow, and indicate the number of milliliters you will administer. Shade in the dosage on the syringe provided. Use medication labels or information provided to calculate the volume necessary to administer the dosage ordered. Express your answers to the nearest tenth except where indicated.

- 1. Order: Sandostatin 175 mcg subcut q12h. (Express your answer in hundredths.)
- Available:

- 2. Order: Ketorolac 25 mg IM q6h p.r.n. for pain.
- Available:

- 3. Order: Digoxin 125 mcg IM daily.
- Available:

- 4. Order: Bicillin C-R (900/300) 1,200,000 units IM stat.
- Available:

- 5. Order: Methylprednisolone 100 mg IV q8h for 2 doses.
- Available: *Reconstituted medication

- 6. Order: Ondansetron 4 mg IV q4h.
- Available:

- 7. Order: Phenytoin Sodium 200 mg IV stat.
- Available:

- 8. Order: Famotidine 40 mg IV at bedtime.
- Available:

- 9. Order: Tobramycin 50 mg IM q8h.
- Available:

-

- 10. Order: Solu-Cortef 400 mg IV every day for a severe inflammation for 5 days.
- Available:

- 11. Order: Naloxone 0.2 mg IM stat.
- Available:

- 12. Order: Robinul (glycopyrrolate) 200 mcg IM on call to the O.R.
- Available:

- 13. Order: Aranesp 30 mcg subcut stat. (Express your answer in hundredths.)
- Available:

- 14. Order: Propranolol 250 mcg IV stat.
- Available:

- 15. Order: Ativan 1.5 mg IM b.i.d. p.r.n. for agitation.
- Available:

- 16. Order: Metoclopramide (Reglan) 15 mg IV stat.
- Available:

- 17. Order: Valium (diazepam) 7.5 mg IM stat.
- Available:

- 18. Order: Bumetanide 1 mg IV daily.
- Available:

-

- 19. Order: Gentamicin 55 mg IV q8h.
- Available:

- 20. Order: Granisetron HCl 125 mcg IV 20 minutes before start of chemotherapy.
- Available:

-

- 21. Order: Demerol (meperidine) 65 mg IM and Hydroxyzine HCl 25 mg IM q4h p.r.n.
- for pain.
- Available:

- 22. Order: Decadron (dexamethasone) 9 mg IV daily for 4 days.
- Available:

- 23. Order: Sublimaze (fentanyl) 60 mcg IM 30 minutes before surgery.
- Available:

- 24. Order: Neupogen 300 mcg subcut every day for 2 weeks.
- Available: Prefilled syringe of Neupogen

- a. How many mL will the nurse administer? _____
- b. How many mL will the nurse discard from the prefilled syringe? _____

- 25. Order: Stelara 45 mg subcut as an initial dose.
- Available: Prefilled syringe of Stelara

- a. How many mL will the nurse administer? _____
- b. How many mL will the nurse discard from the prefilled syringe? _____

- 26. Order: Ilumya 100 mg subcut at Week 4 for a client being treated for plaque psoriasis.
- Available: A prefilled syringe of Ilumya

- a. How many mL will the nurse administer? _____
- b. How many mL will the nurse discard from the prefilled syringe? _____

Answers on pp. 379-383

ANSWERS

Chapter 17 Answers to Practice Problems

NOTE

Problems requiring conversion reflect conversion of what the prescriber ordered to what is available.

- 1.
- 2.
- 3.
- 4.
- 5. 1.4 mL
- 6. 1 mL
- 7. 0.9 mL
- 8. 0.4 mL

- 9. 4.4 mL
- 10. 7 mL
- 11. 3.2 mL
- 12.
  - a. 2 mL
  - b. 50 mg per 2 mL, 25 mg per mL
  - c. 2 mL
- 13.
  - a. 10 mL
  - b. 50 mg per 10 mL, 5 mg per mL
  - c. IV, 4
  - d. 12.5 mg
- 14.
  - a. 2.8 mL
  - b. 1 mg per 0.2 mL
  - c. subcut
- 15.
  - a. 4 mL
  - b. 1 mg per 4 mL, 0.25 mg per mL
  - c. For IV or IM use
- 16.
  - a. subcut
  - b. 45 mg per 0.5 mL
- 17.
  - a. 100 mcg per 2 mL, 50 mcg per mL
  - b. IV or IM
  - c. 11, 2
- 18.
  - a. 10 mL
  - b. 100 mg per 10 mL, 10 mg per mL
  - c. For IV or IM use
  - d. Single-dose vial
- 19.
  - a. 3 mL
  - b. 150 mg per 3 mL, 50 mg per mL
  - c. IV use only
- 20.
  - a. 10 mL
  - b. 0.5 mEq per mL
- 21.
  - a. 2 mL
  - b. 20,000 units per 2 mL, 10,000 units per mL
  - c. For IV or subcut use only
- 22.
  - a. 20 mL
  - b. 40 mEq per 20 mL, 2 mEq per mL
- 23. 5 mg : 1 mL = 5 mg : *x* mL
- *or*
- 5 mg20 mg

× 5 mL = *x* mL

- Answer: 1 mL. The dosage ordered is contained in the available strength; therefore you will need 1 mL to administer the dosage.

- 24. 40 mg : 1 mL = 60 mg : *x* mL
- *or*
- 60 mg40 mg

× 1 mL = *x* mL

- Answer: 1.5 mL. The dosage ordered is more than the available strength; therefore you will need more than 1 mL to administer the dosage.

- 25. Meperidine : 50 mg : 1 mL = 50 mg : *x* mL
- *or*
- 50 mg50 mg

× 1 mL = *x* mL

- Answer: 1 mL. The dosage ordered is contained in the available strength; therefore you will need 1 mL to
- administer the dosage.
- Hydroxyzine: 50 mg : 1 mL = 25 mg : *x* mL
- *or*

- 25 mg50 mg

× 1 mL = *x* mL

- Answer: 0.5 mL. The dosage ordered is less than the available strength; therefore you will need less than 1 mL to administer the dosage. The total number of milliliters you will prepare to administer is 1.5 mL (1 mL Meperidine + 0.5 mL Hydroxyzine = 1.5 mL). Medications may be administered in the same syringe as long as they are compatible.

- 26. 10,000 units : 1 mL = 5,000 units : *x* mL
- *or*
- 5,000 units10,000 units

× 1 mL = *x* mL

- Answer: 0.5 mL. The dosage ordered is less than the available strength; therefore you will need less than 1 mL to administer the dosage.

- 27. 10 mg : 1 mL = 10 mg : *x* mL
- *or*
- 10 mg10 mg

× 1 mL = *x* mL

- Answer: 1 mL. The label indicates that the dosage ordered is contained in 1 mL.

Answers to Clinical Reasoning Questions

- a. The right medication. Hydroxyzine and hydralazine have similar names but are two different medications.
- b. Not reading the medication labels carefully and comparing them with the order, or medication administration record (MAR).
- c. Hydralazine is an antihypertensive and could cause a fatal drop in the client's blood pressure.
- d. Carefully comparing the medication label and dosage with the order or MAR three times while preparing the medication. Perhaps if the nurse had consulted a reliable drug reference, it may have alerted the nurse to the fact that hydralazine is used to treat hypertension and hydroxyzine is used for anxiety, which is what the medication was prescribed for.

Answers to Chapter Review

- 1. 500 mcg : 1 mL = 175 mcg : *x* mL
- *or*
- 175 mcg500 mcg

× 1 mL = *x* mL

- Answer: 0.35 mL. The dosage ordered is less than the available strength. Therefore you will need less than 1 mL to administer the dosage.

- 2. 30 mg : 1 mL = 25 mg : *x* mL
- *or*
- 25 mg30 mg

× 1 mL = *x* mL

- Answer: 0.83 mL = 0.8 mL. The dosage ordered is less than what is available. Therefore you will need less than 1 mL to administer the dosage.

- 3. No conversion is required. Label indicates dosage in micrograms.
- 500 mcg : 2 mL = 125 mcg : *x* mL
- *or*
- 125 mcg500 mcg

× 2 mL = *x* mL

- Answer: 0.5 mL. The dosage ordered is less than the available strength. The dosage required would be less than 2 mL.
- Alternate solution:
- 250 mcg : 1 mL = 125 mcg : *x* mL
- *or*
- 125 mcg250 mcg

× 1 mL = *x* mL

- This would net the same answer, 0.5 mL.

- 4. 1,200,000 units : 2 mL = 1,200,000 units : *x* mL
- *or*
- 1,200,000 units1,200,000 units

× 2 mL = *x* mL.

- Answer: 2 mL. The dosage ordered is contained in 2 mL; therefore you will need 2 mL to administer the dosage.

- 5. 40 mg : 1 mL = 100 mg : *x* mL
- *or*
- 100 mg40 mg

× 1 mL = *x* mL

- Answer: 2.5 mL. The amount ordered is more than the available strength; therefore you will need more than 1 mL to administer the required dosage.

NOTE

You would need three (3) vials of the medication to obtain the indicated dose. The total volume available in the vial is 1 mL, which contains 40 mg.

- 6. 2 mg : 1 mL = 4 mg : *x* mL
- *or*

- 4 mg2 mg

× 1 mL = *x* mL

- Answer: 2 mL. The dosage ordered is more than the available strength; therefore you will need more than 1 mL to administer the dosage.
- Alternate solution:
- 4 mg : 2 mL = 4 mg : *x* mL
- *or*
- 4 mg4 mg

× 2 mL = *x* mL

- This setup will give an answer of 2 mL.

- 7. 250 mg : 5 mL = 200 mg : *x* mL
- *or*
- 200 mg250 mg

× 5 mL = *x* mL

- Answer: 4 mL. The dosage ordered is less than the available strength; therefore you will need less than 5 mL to administer the dosage.
- Alternate solution:
- 50 mg : 1 mL = 200 mg : *x* mL
- *or*

- 200 mg250 mg

× 1 mL = *x* mL

- This setup will yield an answer of 4 mL.

- 8. 20 mg : 2 mL = 40 mg : *x* mL
- *or*
- 40 mg20 mg

× 2 mL = *x* mL

- Answer: 4 mL. The dosage ordered is more than the available strength. Therefore you will need more than 2 mL to administer the dosage.
- Alternate solution:
- 10 mg : 1 mL = 40 mg : *x* mL
- *or*
- 40 mg10 mg

× 1 mL = *x* mL

- This setup will yield an answer of 4 mL.

NOTE

You would need two (2) vials of the medication to administer the ordered dose. The total volume available in the vial is 2 mL, which is equal to 20 mg.

- 9. 40 mg : 1 mL = 50 mg : *x* mL
- *or*
- 50 mg40 mg

× 1 mL = *x* mL

- Answer: 1.3 mL. 1.25 mL is rounded to nearest tenth. The dosage ordered is more than the available strength per mL if you use 40 mg per mL. You will need more than 1 mL to administer the dosage.
- Alternate solution:
- 80 mg : 2 mL = 50 mg : *x* mL
- *or*
- 50 mg80 mg

× 2 mL = *x* mL

- This setup still gives an answer of 1.3 mL.

- 10. 250 mg : 2 mL = 400 mg : *x* mL
- *or*

- 400 mg250 mg

× 2 mL = *x* mL

- Answer: 3.2 mL. The dosage ordered is more than the available strength. You will need more than 2 mL to administer the dosage.

- 11. 0.4 mg : 1 mL = 0.2 mg : *x* mL
- *or*
- 0.2 mg0.4 mg

× 1 mL = *x* mL

- Answer: 0.5 mL. The dosage ordered is less than the available strength. You will need less than 1 mL to administer the dosage.

- 12. Conversion is required. Equivalent: 1,000 mcg = 1 mg. Therefore 200 mcg = 0.2 mg.
- 0.2 mg : 1 mL = 0.2 mg : *x* mL
- *or*
- 0.2 mg0.2 mg

× 1 mL = *x* mL

- Answer: 1 mL. Because 200 mcg = 0.2 mg, you will need 1 mL to administer the required dosage.
- Alternate solution:
- 1 mg : 5 mL = 0.2 mg : *x* mL
- *or*
- 0.2 mg1 mg

  × 5 mL = *x* mL
- This setup will give an answer of 1 mL.

- 13. 40 mcg : 1 mL = 30 mcg : *x* mL
- *or*
- 30 mcg40 mcg

  × 1 mL = *x* mL
- Answer: 0.75 mL. The dosage ordered is less than the available strength. You will need less than 1 mL to administer the dosage.

- 14. Conversion is required. Equivalent: 1,000 mcg = 1 mg.
- Therefore 250 mcg = 0.25 mg
- 1 mg : 1 mL = 0.25 mg : *x* mL
- *or*

- 0.25 mg1 mg

× 1 mL = *x* mL

- Answer: 0.25 mL. The dosage ordered is less than the available strength; therefore you will need less than 1 mL to administer the dosage.

- 15. 2 mg : 1 mL = 1.5 mg : *x* mL
- *or*
- 1.5 mg2 mg

× 1 mL = *x* mL

- Answer: 0.75 mL = 0.8 mL. The dosage ordered is less than the available strength; therefore you will need less than 1 mL to administer the dosage.

- 16. 10 mg : 2 mL = 15 mg : *x* mL
- *or*
- 15 mg10 mg

× 2 mL = *x* mL

- Answer: 3 mL. The dosage ordered is greater than the available strength. Therefore you will need more than 2 mL to administer the dosage.
- Alternate solution:
- 5 mg : 1 mL = 15 mg : *x* mL
- *or*
- 15 mg5 mg

  × 1 mL = *x* mL
- This setup will yield an answer of 3 mL.

- 17. 5 mg : 1 mL = 7.5 mg : *x* mL
- *or*
- 7.5 mg5 mg

  × 1 mL = *x* mL
- Answer: 1.5 mL. (State the answer as a decimal; mL is a metric measure.) The dosage ordered is greater than the available strength. Therefore you will need more than 1 mL to administer the dosage.
- Alternate solution:
- 50 mg : 10 mL = 7.5 mg : *x* mL
- *or*
- 7.5 mg50 mg

  × 10 mL = *x* mL
- This setup will yield an answer of 1.5 mL.

- 18. 0.25 mg : 1 mL = 1 mg : *x* mL
- *or*
- 1 mg0.25 mg

× 1 mL = *x* mL

- Answer: 4 mL. The dosage ordered is more than the available strength. Therefore you will need more than 1 mL to administer the dosage.
- Alternate solution:
- 1 mg : 4 mL = *x* mL
- *or*
- 1 mg1 mg

× 4 mL = *x* mL

- This setup will yield an answer of 4 mL.

- 19. 40 mg : 1 mL = 55 mg : *x* mL
- *or*
- 55 mg40 mg

× 1 mL = *x* mL

- Alternate solution:
- 80 mg : 2 mL = 55 mg : *x* mL
- *or*
- 55 mg80 mg

  × 2 mL = *x* mL
- Answer: 1.4 mL, or 1.37 rounded to the nearest tenth.

- 20. Conversion is required. Equivalent: 1,000 mcg = 1 mg. Therefore this should be 125 mcg not 1.25 = 0.125 mg.
- 0.1 mg : 1 mL = 0.125 mg : *x* mL
- *or*
- 0.125 mg0.1 mg

  × 1 mL = *x* mL
- Answer: 1.3 mL, or 1.25 mL rounded to the nearest tenth. The dosage ordered is more than the available strength. Therefore you will need more than 1 mL to administer the dosage.

- 21. Demerol (meperedine):
- 100 mg : 1 mL = 65 mg : *x* mL
- *or*

- 65 mg100 mg

× 1 mL = *x* mL

- Answer: 0.7 mL, or 0.65 mL rounded to the nearest tenth. The dosage ordered is less than the available strength. Therefore less than 1 mL would be required to administer the dosage.
- Hydroxyzine HCl:
- 50 mg : 1 mL = 25 mg : *x* mL
- *or*
- 25 mg50 mg

× 1 mL = *x* mL

- Answer: 0.5 mL. The dosage ordered is less than the available strength. Therefore you need less than 1 mL to administer the dosage. These two medications are often administered in the same syringe (0.7 mL of Demerol + 0.5 mL of Hydroxyzine HCl = 1.2 mL).

- 22. 4 mg : 1 mL = 9 mg : *x* mL
- *or*
- 9 mg4 mg

× 1 mL = *x* mL

- Answer: 2.3 mL, or 2.25 mL rounded to the nearest tenth. The dosage ordered is greater than the available strength. You would need more than 1 mL to administer the dosage.
- Alternate solution:
- 20 mg : 5 mL = 9 mg : *x* mL
- *or*

- 9 mg20 mg

× 5 mL = *x* mL

- This setup would yield the same answer, 2.3 mL, or 2.25 mL rounded to the nearest tenth.

- 23. 50 mcg : 1 mL = 60 mcg : *x* mL
- *or*
- 60 mcg50 mcg

× 1 mL = *x* mL

- Answer: 1.2 mL. The dosage ordered is greater than the available strength when using 50 mcg per mL. You will need more than 1 mL to administer the dosage.
- Alternate solution:
- 250 mcg : 5 mL = 60 mcg : *x* mL
- *or*
- 60 mcg40 mcg

× 1 mL = *x* mL

- This setup will still yield an answer of 1.2 mL.

- 24. 480 mcg : 0.8 mL = 300 mcg : *x* mL
- *or*
- 300 mcg480 mcg

× 0.8 mL = *x* mL

- Answers:
  - a. 0.5 mL. The dosage ordered is less than the available strength; therefore you will need less than 0.8 mL to administer the dosage.
  - b. Discard 0.3 mL
- 25. 90 mg : 1 mL = 45 mg : *x* mL
- *or*
- 45 mg90 mg

× 1 mL = *x* mL

- Answers:
  - a. 0.5 mL. The dosage ordered is less than the available strength; therefore you will need less than 1 mL to administer the dosage.
  - b. Discard 0.5 mL.
- 26. 100 mg : 1 mL = 100 mg : *x* mL
- *or*
- 100 mg100 mg

× 1 mL = *x* mL

- Answer:
  - a. 1 mL. The label indicates that the dosage ordered is contained in 1 mL.
  - b. Zero (0) mL will be discarded.

For additional practice problems, refer to the Parenteral Dosages section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

Some medications come in a powdered form rather than in liquid form. As opposed to medications in powdered form, medications in liquid form retain their potency for a shorter time. When medications come in powdered form, *reconstitution* is necessary before they can be measured and administered to a client. The process of *reconstitution* involves adding a liquid (referred to as a diluent or solvent) to a medication in powdered form to dissolve it and form a solution. Once a medication is reconstituted, some solutions may have to be used within an hour, 1 to 14 days, or longer, depending on the medication. For example, ampicillin must be used within an hour after reconstitution, whereas EryPed, an oral suspension, is good for 35 days after reconstitution.

As a safety precaution in some institutions, the pharmacist reconstitutes most medications; however, the nurse may occasionally need to reconstitute a powdered medication. The nursing responsibility in reconstitution includes accurate interpretation of the directions for reconstitution, choosing the type and amount of diluent, and identifying the dosage strength after reconstitution to use in calculation of the ordered dosage. Medications requiring reconstitution can be for oral or parenteral use; these are not always injectable medications.

The safe preparation and administration of powdered medications require that the nurse have an understanding of the reconstitution process and terminology used:

- • **Solute**—A powdered medication or liquid concentrate to be dissolved or diluted. **Solvent (diluent)**—A liquid that is added to the powder or liquid concentrate. The nurse **must** identify the diluent (solvent) to use. The type of diluent (solvent) varies according to the medication. The package insert or the medication label will indicate the diluent (solvent) to be used and the amount. If the information is not indicated on the label, or the package insert is unavailable, consult appropriate resources, which include the pharmacist and a medication reference (drug manual or computer website for medication, if listed). Sterile solutions (diluent/solvent) are always used to reconstitute medications for injectable use. Special diluents (solvents), when required for reconstitution, are usually packaged with the powdered medication, but medications for oral use can oft en be, but are not always, reconstituted with tap water.
- **Solution**—The liquid that results when the diluent (solvent) dissolves the solute (powdered medication or liquid concentrate).

Basic Principles for Reconstitution

The first step in reconstitution is to find the directions and carefully read the information on the vial or the package insert. Medications labeled and packaged with reconstitution directions may indicate “oral, IM, or IV use only.” Always verify the route of administration ordered **before** reconstituting a medication. This is **critical** for parenteral routes and requires the nurse to read the directions carefully. Directions may be different based on the parenteral route of administration (i.e., IM versus IV). Follow reconstitution directions **exactly** for the route of administration to obtain the correct dosage strength.

SAFETY ALERT!

Before reconstituting a medication, read and follow the directions on the label or package insert. This includes checking the expiration date on the medication and diluent. Never assume the type or amount of diluent to be used. If the information is not available, consult appropriate resources, such as a reliable medication text, the *Physician’s Desk Reference (PDR),* a pharmacist, or the manufacturer’s website, before reconstituting the medication.

- 1. The drug manufacturer provides directions for reconstitution, including information regarding the number of milliliters of diluent or solvent that should be added, as well as the type of solution that should be used to reconstitute the medication. The concentration (or strength) of the medication after it has been reconstituted according to the directions is also indicated on some medications. The directions for reconstitution must be followed exactly.
- 2. Commonly used diluents for parenteral medications include sterile water for injection and sterile sodium chloride (normal saline) for injection. Sterile water and normal saline for injection are available in preservative-free diluent used for single-use reconstitution and in bacteriostatic form with preservatives that prevent the growth of microorganisms for multiple-dose vials. Use only the diluent recommended. Using the wrong diluent can result in an incompatibility that can cause crystallization and/or clumping of the medication in solution. Some medications that require reconstitution may indicate they can be mixed with lidocaine, a local anesthetic, to reduce pain. Some medications may cause pain when injected (e.g., antibiotics). The label or package insert indicates when lidocaine can be used and the percentage. Always check with the prescriber before reconstituting a medication with lidocaine. Because lidocaine is a medication, it necessitates an order from the prescriber. If lidocaine is used, make certain to use only lidocaine. Lidocaine can come combined with epinephrine. Epinephrine causes vasoconstriction (tightening of blood vessels), which delays the absorption of the medication.

SAFETY ALERT!

Always use a sterile solution for injection and for mixing to administer a medication by the parenteral route.

- 3. Once you have located the reconstitution directions on the label or package insert, you need to identify the following information:
  - a. The type of diluent to use for reconstitution.
  - b. The amount of diluent to add. This is essential because directions relating to the amount of diluent can vary according to the parenteral route of administration. (Refer to Figure 18.1, the label for Ceft riaxone; note the amount of diluent to add for IM is 2.1 mL and for IV is 9.6 mL.)

Figure 18.1 Ceftriaxone 1-g vial reconstitution.

SAFETY ALERT!

Always determine both the type and amount of diluent to be used for reconstituting medications. Read and follow the label or package insert directions carefully to ensure that your client receives the intended dosage. Consult a pharmacist or other appropriate resources if there are any questions. Never assume!

- c. The length of time the medication is good for once it is reconstituted. The length of time a medication can be stored once reconstituted can vary depending on how it is stored. When medications are reconstituted, the solution must be used in a timely fashion. The potency (stability) of the medication may be several hours to several days or even a week or longer. Check the medication label, package insert, or appropriate resources for how long a medication may be used after reconstitution.
- d. Directions for storing the medication after mixing. Medications must be stored appropriately once reconstituted per manufacturer's instructions to ensure optimal potency of the medication. Medications can become unstable when stored incorrectly and for long periods. Example: A label may state a medication maintains its potency 96 hours at room temperature or 7 days when refrigerated.
- e. It is essential for the nurse to locate the dosage strength or concentration of the medication after it has been reconstituted as indicated by the drug manufacturer. The dosage strength after the medication is reconstituted is used in the dosage calculation.

Refer to Figure 18.1 showing the label for Ceftriaxone 1 gram. The 1 gram on the Ceftriaxone label represents the total amount of medication in the vial. As you will see, the total amount, once diluted, (reconstituted) provides a specific concentration or dosage strength. Refer to the directions for reconstitution of the Ceftriaxone for IM administration. ***Note*** the directions on the label say to add 2.1 mL of 1% lidocaine hydrochloride injection or sterile water for injection and that each 1 mL contains 350 mg. The **available dosage strength (concentration)** after reconstitution is 350 mg of Ceftriaxone per 1 mL of solution. **(Remember to check with the prescriber before reconstituting a medication with lidocaine.)** Note if you were reconstituting this medication for IV administration, the amount of diluent to add and the dosage strength after reconstitution is different from the IM route.

- 4. If there are no directions for reconstitution on the label or on a package insert, or if any of the information (listed in number 3) is missing, consult appropriate resources such as the *PDR,* a pharmacology text, the hospital drug formulary, the pharmacy, or the manufacturer's website.
- 5. Injectable medications for reconstitution can come in a single-dose vial or a multiple-dose vial. When medications are in single-dose vials, there is only enough medication for **one** dose, and the contents are administered after reconstitution. In the case where the nurse reconstitutes a multiple-dose vial, there is enough medication for more than one dose. Therefore, when a multiple-dose vial is reconstituted, it is important to clearly label the vial after reconstitution with the following information:
    - a. The date and time prepared, dosage strength prepared, the expiration date for the medication once reconstituted, and the time. *Note:* If all of the solution that is mixed is used, this information is not necessary. Information regarding the date and time of preparation and date and time of expiration is crucial when all of the medication is not used.
    - b. Storage directions such as "Refrigerate."
    - c. Your initials.

If the medication label does not have room to clearly write the required information, add a label to the vial and indicate important information. Make certain the label is applied so that it does not obscure the medication name and dosage.

TIPS FOR CLINICAL PRACTICE

When reconstituting a multiple-dose medication vial, label it with the required information and store it appropriately. If the vial is not labeled with a date and time the medication was reconstituted and the dosage strength after reconstitution and expiration date, the medication must be discarded. The nurse should never use an unlabeled reconstituted vial.

- 6. When some powdered medications are reconstituted, the powdered medication takes up space as it dissolves and results in an increase in the amount of total (fluid) volume once it has dissolved. This is sometimes referred to as just *displacement* or as the *displacement factor*. For example, directions for 1 g of powdered medication may state to add 2.5 mL of sterile water for injection to provide an approximate volume of 3 mL (330 mg per mL). The displacement volume is 0.5 mL. The available dosage strength after reconstitution, however, is 330 mg per mL of solution. The displacement volume may not be indicated on all medication labels.

Types of Reconstituted Medications

There are two types of powdered medications for parenteral use that require reconstitution. They are single-strength reconstitution and multiple-strength reconstitution.

Single-strength reconstitution medications usually have one amount of diluent to add and provide only one dosage strength. See the 1-g Ceftriaxone label shown in Figure 18.1. Notice there is only one amount of diluent to add for IM use and one dosage strength indicated after the diluent is added. For IV there is only one amount of diluent indicated and one dosage strength after the diluent is added.

Multiple-strength reconstitution medications have several directions for reconstitution to different dosage strengths. In other words, different amounts of diluent are indicated, allowing for the mixing of different concentrations of a medication. A multiple-strength reconstitution requires the nurse be even more attentive to the directions to select the best concentration to administer the required dosage.

Powdered Medications for Oral Administration

Like parenteral medications, medications for oral use that come in a powder form must be reconstituted (mixed with a liquid) before administration. The diluent used to reconstitute powdered medications for oral use include tap water, distilled water, and purified water. The directions for mixing, which include the amount and type of diluent, are found on the medication label. The amount of diluent added to powdered medications for oral use provides one dosage strength. The label indicates the dosage strength after reconstitution as well as the volume of medication after reconstitution. The nurse must follow the reconstitution directions as indicated on the medication label to obtain the correct dosage strength of the medication. Reconstitution directions vary according to the medication. Other pertinent information the nurse needs to identify in addition to the dosage strength after reconstitution includes storage information for the medication once it is reconstituted, and the expiration date of the reconstituted medication (identified by the time period when the reconstituted medication will need to be discarded). The reconstitution of powdered medications for oral use usually results in multiple doses; therefore the nurse who initially mixes the medication must include the following information on the medication bottle without obscuring the label: the date and time the medication was reconstituted and the initials of the preparer.

In some institutions the nurse may be required to indicate the date and time of expiration. Always follow the policy of the institution regarding the required information on reconstituted oral medications. Refer to Figure 18.2 (label for Cefaclor Oral Suspension 125 mg per 5 mL).

Figure 18.2 Directions for mixing Cefaclor Oral Suspension 125 mg per 5 mL. Notice the **directions for mixing** indicate to add 106 mL of water in two portions to the dry mixture and shake well after each addition. **The reconstituted solution** will provide a dosage strength of 125 mg per 5 mL. **The total volume** when mixed is 150 mL. **Storage directions:** Store in refrigerator. **Expiration:** Discard unused portion after 14 days.

Let's begin with practice problems answering questions relating to single-strength reconstitution.

PRACTICE PROBLEMS

Using the label for Gemcitabine, answer the following questions.

- 1. What is the total dosage strength of Gemcitabine in this vial? _____
- 2. How much diluent is added to the vial to prepare the medication for IV use? _____
- 3. What diluent is recommended for reconstitution? _____
- 4. What is the final dosage strength (concentration) of the prepared solution for IV administration? _____
- 5. How long will the reconstituted material retain its potency? _____
- 6. 100 mg IV is ordered for day one of treatment. How many milliliters will you give? Shade the dosage in on the syringe provided. _____

Using the label for Leucovorin calcium, answer the following questions.

- 7. What is the total dosage strength of Leucovorin calcium in the vial? _____
- 8. How much diluent is added to the vial to reconstitute the medication? _____
- 9. What diluent is recommended for reconstitution? _____
- 10. What is the dosage strength (concentration) of the reconstituted solution? _____
- 11. Routes of administration _____
- 12. Where can you find directions for complete prescribing information? _____
- 13. 15 mg IM q6h is ordered. How many milliliters will you give? Shade the dosage on the syringe provided. _____

Using the label for Methylprednisolone sodium succinate, answer the following questions.

- 14. What is the total dosage strength of Methylprednisolone sodium succinate in the vial?_____
- 15. What diluent is recommended to prepare an IV dosage?_____
- 16. How many milliliters of diluent are needed to prepare an IV dosage?_____
- 17. What is the dosage strength (concentration) of the solution prepared for IV administration?_____
- 18. Methylprednisolone sodium succinate 35 mg IV daily is ordered. How many milliliters will you give? Shade the dosage on the syringe provided._____

Using the label for Cefaclor, answer the following questions.

- 19. How much diluent must be added to prepare the solution? _____
- 20. What type of solution is used for the diluent? _____
- 21. What is the final dosage strength (concentration) of the prepared solution? _____
- 22. How should the medication be stored after it is reconstituted? _____

Using the label for Erythromycin ethylsuccinate, answer the following questions.

- 23. How much diluent must be added to prepare the solution? _____
- 24. What is the volume of the solution after it is mixed? _____
- 25. What is the final dosage strength (concentration) of the prepared solution? _____
- 26. For how long is the reconstituted solution good? _____

Using the label for Ceftriaxone, answer the following questions.

- 27. What is the total dosage strength of Ceftriaxone in this vial? _____
- 28. How much diluent must be added to the vial to prepare the medication for IM use? _____
- 29. How much diluent must be added to the vial to prepare the medication for IV use? _____
- 30. What diluent is recommended for IV reconstitution? _____
- 31. What is the final dosage strength (concentration) of the prepared solution for IV use? _____

Using the label for Zithromax, answer the following questions.

- 32. What is the total dosage strength of Zithromax in this vial? _____
- 33. How many milliliters of diluent are needed to prepare an IV dosage? _____
- 34. What diluent is recommended for reconstitution? _____
- 35. What is the final dosage strength (concentration) of the prepared solution? _____
- 36. Directions for use? _____

Answers on pp. 421-422

Calculation of Medications When the Final Concentration (Dosage Strength) Is Not Stated

Sometimes a medication comes with directions for only one way to reconstitute it, and the label does not indicate the final dosage strength (concentration) with the reconstitution information provided on the label. The dosage strength is determined by the total amount of medication in the vial and the amount of diluent added. Refer to Figure 18.3 label for Acyclovir 500 mg.

Figure 18.3 Acyclovir 500 mg per vial. Notice there is no dosage strength stated with the reconstitution information. The dosage strength is 500 mg per 10 mL. This was determined by using the total amount of medication in the vial (500 mg) and the amount of diluent added (10 mL).

Reconstituting Medications With More Than One Direction for Mixing (Multiple Strength Reconstitution)

Some powdered medications may come with directions for reconstitution to different solution strengths. Different volumes of diluent may be added, as specified by the drug manufacturer. The amount of diluent added determines the final dosage strength (concentration). In this case the nurse must choose the concentration or dosage strength appropriate for the dosage ordered and the individual client. The dosage strength chosen should result in a reasonable amount of solution administered to the client by the route ordered. A common medication that has directions for reconstitution to different dosage strengths is penicillin. To determine which dosage strength to use, the following guidelines may be used.

Guidelines for Choosing Appropriate Concentrations

- 1. Route of administration. It is essential to verify the route of administration before reconstituting.
  - a. IM—You are concerned that the amount does not exceed the maximum injection amount allowed for IM administration. However, you do not want to choose a concentration that will result in irritation when injected into a muscle. When a choice of strengths can be made, do not choose an amount that would exceed the amount allowed for IM administration or one that is very concentrated. Consider the muscle site being used and the age of the client.
  - b. IV—Keep in mind that this medication is usually further diluted because, once reconstituted, the medication is then placed in additional fluid of 50 to 100 mL or more, depending on the medication being administered.
- 2. Choose the concentration or dosage strength that comes closest to what the prescriber has ordered. The dosage strengths are given for the amount of diluent used. Example: If the prescriber orders 300,000 units of a particular medication IM, and the choices of strength are 200,000 units per mL, 250,000 units per mL, and 500,000 units per mL, the strength closest to 300,000 units per mL is 250,000 units per mL. It allows you to administer a dosage within the range allowed for IM administration, and it is not the most concentrated.

SAFETY ALERT!

When multiple directions are given for reconstituting medications, the smaller the amount of diluent used to reconstitute the medication, the more concentrated the resulting solution will be. Consider the route of administration when reconstituting medications. Always check the route and the directions related to reconstitution.

- 3. The word *respectively* may sometimes be used on a medication label for directions on reconstitution. For example, reconstitute with 23 mL, 18 mL, 8 mL of diluent to provide concentrations of 200,000 units per mL, 250,000 units per mL, 500,000 units per mL, respectively. The

word *respectively* means in the order given. In terms of the directions for reconstitution, this means that if you add 23 mL diluent, it will provide 200,000 units per mL, 18 mL diluent will provide 250,000 units per mL, etc. In other words, the amounts of diluent correspond to the order in which the concentrations are written.

Remember: **When you are mixing a medication that is a multiple-strength solution, the dosage strength that you prepare must be written on the vial.**

Let's look at a sample label showing multiple reconstitution options. Refer to the label for Pfizerpen (penicillin G potassium) See Figure 18.4.

Figure 18.4 Pfizerpen (penicillin G potassium).

Notice the label indicates the total amount of medication in the vial is 5,000,000 units. The Pfizerpen label has three choices of diluent amounts (18.2 mL, 8.2 mL, and 3.2 mL). The dosage strength (concentration) of the reconstituted medication depends on the amount of diluent used. If the nurse adds 18.2 mL of diluent, the dosage strength is 250,000 units per mL; if the nurse adds 8.2 mL of diluent, the dosage strength is 500,000 units per mL; and if the nurse adds 3.2 mL of diluent, the dosage strength is 1,000,000 units per mL. Once the nurse has chosen the amount of diluent to use and the corresponding dosage strength, the dosage strength is used to calculate the problem.

Let's assume the order is for 400,000 units IM for an adult. The best concentration in this case would be 500,000 units per mL. Refer to the label and notice to make this concentration (dosage strength), you will need to add 8.2 mL of diluent. When calculated, the client would receive 0.8 mL (3 mL is the maximum for a large adult muscle). Remember the condition of the intramuscular site and the client (age and muscle mass) **must** be considered. Depending on the status of the client, a different dosage strength may be a better choice. Notice also when you reconstitute the medication using 8.2 mL, the total volume will be 8.2 mL, which means you have enough left over for at least 9+ doses. Because this is a multiple-strength solution, the dosage strength must be indicated on the vial after you reconstitute it. Other information would include date and time prepared, expiration date and time, and initials of the preparer. This will help to ensure that the nurse using the medication after you knows the essential information (dosage strength, when the medication was reconstituted and by whom, and the expiration date).

SAFETY ALERT!

Proper labeling is a crucial detail on a multiple-strength solution that has been reconstituted. For safe practice, never administer a reconstituted medication that lacks the appropriate information on the medication label. Instead, discard the medication. You have no way of knowing how and when the medication was mixed!

PRACTICE PROBLEMS

Using the label for Penicillin G potassium, answer the following questions.

- 37. What are the directions for use? _____
- 38. If you add 33 mL of diluent to the vial, what dosage strength (concentration) will you print on the label? _____
- 39. If 2,000,000 units IV is ordered, which dosage strength (concentration) would be appropriate to use? _____
- 40. How many milliliters will you administer if 2,000,000 units are ordered? _____
- 41. How long will the medication maintain its potency if refrigerated? _____

Using the label for Penicillin G potassium, answer the following questions.

- 42. What are the directions for use? _____
- 43. Where would the usual dosage for IV administration be found? _____
- 44. Where will you store any unused medication? _____
- 45. How long will the medication maintain its potency? _____
- 46. What concentration strength would be obtained if you added 18.2 mL of diluent? (Write out in numbers.) _____

Answers on 422

Reconstitution From Package Insert Directions and Medications With Different Reconstitution Directions Depending on Route of Administration

If the label does not contain reconstitution directions, you must obtain directions from the information insert or package insert that accompanies the vial. Sometimes the drug manufacturer may print reconstitution directions for the size of the vial as well as the route of administration. The nurse must pay attention to the amount in the vial and the route; there may be different directions based on the route of administration. Reading the directions carefully is **critical** to identification of the correct directions for reconstitution. Refer to the Ceftazidime (Tazicef) label (Figure 18.5) and insert. For example, note that the directions for mixing the Ceftazidime 1-gram vial for IM injection are different from mixing the 1-gram vial for IV infusion. Note that although the same amount of diluent is indicated for a 1-gram vial and a 2-gram vial for IV infusion, the final dosage strengths (concentrations) are different.

Figure 18.5 (A) Tazicef 1 gram. (B) Portion of Tazicef package insert.

SAFETY ALERT!

Carefully check the route ordered before reconstituting a medication and follow the directions corresponding to that route. Do not interchange the dilution instructions for IM or IV because you can harm a client.

Medications With Instructions to "See Accompanying Literature" (Package Insert) for Reconstitution and Administration

Some medications that require reconstitution may indicate the dosage strength contained in the vial and do not provide the information necessary to reconstitute the medication or information relating to administration. To prepare the powdered medication, you must see the package insert or accompanying literature. Refer to the Olanzapine (Zyprexa) label (Figure 18.6A) and the accompanying package insert information (Figure 18.6B). The label instructs you to see "accompanying literature for dosage, reconstitution instructions; method of administration, and storage conditions."

Figure 18.6 (A) Olanzapine 10-mg label. (B) Olanzapine package insert.

To reconstitute the medication and calculate a dosage you will need to refer to the package insert. The directions instruct you to add 2.1 mL of sterile water for injection to provide a solution containing approximately 5 mg per mL of Olanzapine and indicate the number of mL to withdraw to administer specific dosages of the medication IM. Notice, for example, that if you had to administer 5 mg of Olanzapine IM, when the medication has been reconstituted, you would withdraw 1 mL of the medication to administer the ordered dosage of 5 mg.

PRACTICE PROBLEMS

Use the Olanzapine label and package insert in Figure 18.6A and B to answer problems 47-52.

- 47. What is the dosage strength of the total vial?_____
- 48. How much diluent must be added to this vial to prepare the medication for IM use?_____
- 49. What diluent is recommended for reconstitution?_____
- 50. For how long will the reconstituted solution be good?_____
- 51. How much would you withdraw for a 7.5-mg dose?_____
- 52. How much would you withdraw for a 2.5-mg dose?_____

Answers on 422

Powdered Medication Delivery Systems

There has been an increase in the use of more manufacturer-prepared IV medication systems. One such system is the ADD-Vantage system. This system has two components: (1) an ADD-Vantage diluent container (e.g., an IV bag) and (2) an ADD-Vantage medication vial that contains the medication. The medication, which is in a vial, is attached to the IV bag. When this system is used, the IV solution becomes the diluent. The stopper in the vial is pulled, which allows the medication to mix with the IV fluid prior to administration (Figure 18.7).

Figure 18.7 The ADD-Vantage drug delivery system. (Courtesy Bruce Clayton.)

Examples of medications that come in the ADD-Vantage System include Vancomycin, Tazicef, and Ampicillin. The steps that are required in preparing the ADD-Vantage delivery system for IV administration can be found online and in a nursing skills textbook.

In addition to the ADD-Vantage system there are other systems used to mix powdered medications that include the Mix-O-Vial. This system was discussed in the previous chapter. A Mix-O-Vial allows for the mixing of a powdered medication (there are two compartments, the lower contains the medication in a powder, and the upper chamber contains the sterile diluent). Between the two compartments is a rubber stopper. When pressure is applied to the top of the vial (rubber diaphragm), this causes the diluent to mix with powder and produce a liquid for administration.

Calculation of Dosages

If you are using ratio and proportion, the known ratio is also the dosage strength (concentration) obtained after you mix the medication.

- • In

  Q is the volume of solution that contains the dosage strength.
- • In dimensional analysis, the first fraction written is the solution (volume) that contains the dosage strength.

Before we proceed to calculate dosages, let's review the steps to use with medications that have been reconstituted.

- 1. Ratio and proportion, the formula method, or dimensional analysis may be used to calculate the dosage. However, the H (have or what is available) is the dosage strength you obtain after you mix the medication according to directions.
- 2. When the final concentration is not stated, the total weight of the medication in powdered form is used, and the number of milliliters diluent added.
- 3. As with all calculation problems, check to make sure that the ordered and the available medications are in the same system of measurement and the same units.
- 4. Do not forget to label your answer.

Example 1: To illustrate, let's calculate the dosage you would administer if you mixed penicillin and made a solution containing 1,000,000 units per mL. Order: 2,000,000 units IM q6h.

Solution Using Ratio and Proportion

Linear Format: 1,000,000 units : 1 mL = 2,000,000 units : *x* mL

Answer: 2 mL

Solution Using the Formula Method

Answer: 2 mL

Solution Using Dimensional Analysis

Answer: 2 mL

Example 2: Order: 0.2 g of a medication IV q6h

Available: 500 mg of the medication in powdered form that states, “Add 8 mL of diluent to yield a solution 500 mg per 8 mL.”

PROBLEM SETUP

- 1. A conversion is necessary. Equivalent: 1,000 mg = 1 g. Therefore 0.2 g = 200 mg.
- 2. Think: What would a logical answer be?
- You will need more than 1 mL but less than 8 mL.

Solution Using Ratio and Proportion

- Linear Format: 500 mg : 8 mL = 200 mg : *x* mL
-

- Fraction Format:

Answer: 3.2 mL

Solution Using the Formula Method

Answer: 3.2 mL

Solution Using Dimensional Analysis

Answer: 3.2 mL

POINTS TO REMEMBER

- • Directions for reconstituting medications are provided by the drug manufacturer.
- • The directions for reconstituting medications can be found on the vial, the medication container, or a package insert. If there are no instructions on the vial, container, or the package insert is not available, consult other reliable resources (pharmacy, medication reference book, *PDR*).
- • Read directions carefully for reconstitution, and reconstitute the medication specific to the route of administration ordered (e.g., IM, IV). Interchanging dilution instructions for routes can have serious outcomes for client.
- • The type and amount of diluent to be used for reconstitution must be followed exactly.
- • Lidocaine should not be used to reconstitute a medication without an order from the prescriber.
- • Read directions relating to storage and the time period for maintaining potency of medication once it is reconstituted.
- • If a medication is not used in its entirety after it is reconstituted and medication remains for future use, clearly label medication with the following:
    - 1. Date and time of preparation
    - 2. Date and time of expiration
    - 3. Initials of the preparer
    - 4. Dosage strength or concentration of reconstituted solution

Reconstitution of Noninjectable Solutions

The principles of reconstitution can be applied to nutritional liquids. Enteral feeding solutions are formulated to be administered in full strength; however, the nurse may, on occasion, need to dilute the enteral solution before administering it. Before beginning calculations, let's discuss enteral feedings.

Enteral Feeding

Enteral nutrition involves the provision of nutrients to the gastrointestinal tract. This nutrition is provided to clients who are unable to ingest food safely or have eating difficulties. Enteral nutrition may be provided with a nasogastric, jejunal, or gastric tube. It may consist of blended foods or tube feeding formulas. Tube feedings can be administered in several ways. Depending on the client's needs, they may be given as a bolus (administration of a single large dose) by means of gravity several times per day by using a large-volume syringe, as a continuous gravity drip over a period of ½ to 1 hour several times per day by using a pouch to hang the feeding, or as a continuous drip by infusion pump. When clients are receiving a continuous feeding, the feeding is placed in a special pouch or container and attached to a feeding pump. A common feeding pump is the Kangaroo pump (Figure 18.8). When the feeding pump is used, the feeding is delivered at a rate expressed in milliliters per hour. For the purpose of this chapter, we will focus on administering a feeding by the continuous drip method with an enteral infusion pump.

Figure 18.8 Kangaroo pump. (From Potter PA, Perry AG, Stockert P, Hall A: *Fundamentals of nursing,* ed 9, St Louis, 2017, Elsevier.)

When an order is written for feedings by continuous infusion, the nurse attaches the feeding to a special pump and administers it at the prescribed rate in milliliters per hour. A sample order is Jevity at 65 mL per hour by PEG (percutaneous endoscopic gastrostomy) or by NG (nasogastric) tube. The feeding order also includes a certain volume of water with feeding (100 to 250 mL). The amount of water given with a tube feeding and how it is administered vary from one institution to the next. Check the institution's policy relating to administering enteral feedings. Some orders may be written as follows: Pulmo Care 400 mL over 8 hours followed by 100 mL of water after each feed. When the prescriber does not indicate milliliters per

hour, the nurse divides the number of milliliters ordered by the number of hours and rounds answer to the nearest whole number, to determine the milliliters per hour to set the pump. In pediatrics, the order often specifies the formula and the rate. Example: Similac 24 at 20 mL per hr continuously by NG tube.

Example 1: Order: Pulmocare 400 mL over 8 hours followed by 100 mL of water after each feed. Determine the rate in milliliters per hour.

The pump would be set at 50 mL/hr.

Example 2: Order: Nepro 1,200 mL over 16 hours. Determine the rate in milliliters per hour.

The pump would be set to deliver 75 mL/hr.

In addition to nutrients, medications may be given through a tube. Liquid medications are preferred; however, some tablets may be crushed, dissolved in water, and administered.

Never assume. Not all medications are designed for administration through a tube, so check with the pharmacist or other appropriate resources. A medication's effectiveness could depend on the location of the tube (e.g., stomach, jejunum).

SAFETY ALERT!

Always verify that the medications to be administered are not sublingual, enteric-coated, or timed-release medications because such medications are absorbed differently and the effects of the medication may be altered. Consult the pharmacist or medication guide before tablets are crushed and before capsules are opened and dissolved for tube feeding administration.

PRACTICE PROBLEMS

Determine the rate in milliliters per hour for the following continuous feedings. Round answers to the nearest whole number.

- 53. Ensure 480 mL by NG tube over 8 hr. Follow with 100 mL of water after each feeding._____

- 54. Perative 1,600 mL over 24 hr by gastrostomy. Follow with 250 mL of water._____

Answers on 422

Determining the Strength of a Solution

Nurses or other health care professionals may be required to dilute a concentrated liquid or powder (solute) with a solution such as water or saline (solvent) so as to make a less concentrated solution. Water is a common solvent used to dilute solutions and has been referred to as the **universal solvent.** This may include preparation of irrigating solutions, soaks, and nutritional liquids. When reconstituting solutions that are noninjectable, nurses must understand that the amount of liquid (solvent) that is used to make a substance less concentrated is determined by the desired strength of the solution.

Therefore, if you add more solvent, the final solution strength will be less concentrated; the less solvent that is added, the more concentrated the final solution strength will be. An example to illustrate this concept is the directions for making one quart of ice tea from a powder. Directions call for 4 cups of water to 1 packet of powdered ice tea. If you prefer a stronger tea taste, you might add 2 cups of water (solvent) to the powder (solute), making it more concentrated. However, if you add 4 cups of water (solvent) to the powder (solute), the final solution will be more diluted and less concentrated because you added more water (solvent).

The strength of a solution can be expressed using ratios, fractions, or percents. The fraction format is usually preferred to explain the ratio of solute to the total solution. For example, a

strength solution indicates 1 part solute for 3 parts of the total solution. This could be expressed as 1:3 solution or 33

% solution.

Calculation of Solutions

Because of special circumstances in both adults and children, nutritional liquids may require dilution before they are used. These nutritional liquids may be administered orally or through feeding tubes. Nutritional solutions can be supplied in ready-to-use form, powder for reconstitution, or liquid concentrate. Nutritional formulas may be diluted with sterile or tap water. **Always consult a reference or institutional policy regarding what should be used to reconstitute a nutritional formula.**

To prepare a prescribed solution of a certain strength from a solute, first let's review some basic terms.

Solute—A concentrated liquid or solid substance to be dissolved or diluted

Solvent—A liquid substance that dissolves another substance. Commonly used solvents are sterile water and normal saline.

Solution—A solute plus a solvent

To prepare a solution of a specific strength, use the following steps:

- 1. Desired solution strength × Amount of desired solution = Solute (substance/concentrated liquid to be dissolved)
- *Note:* The strength of the desired solution is written as a fraction; the amount of desired solution is expressed in milliliters or ounces, depending on the problem. This will give you the amount of solute you will need to add to the solvent to prepare the desired solution.
- 2. Amount of desired solution – Solute = Amount of liquid needed to dissolve substance (solvent)

Example 1: Order:

-strength Ensure 900 mL by NG tube over 8 hr

Solution:

Step 1:

You need 300 mL of the formula (solute).

Step 2:

Therefore you would add 600 mL water to 300 mL of Ensure to make 900 mL of

-strength Ensure.

Example 2: ¾-strength Isomil 4 oz p.o. q4h for 24 hr

- *Note:* 4 oz q4h = 6 feedings; 4 oz × 6 = 24 oz
    - 1 oz = 30 mL; therefore 24 oz = 720 mL

    - x = 540 mL of the formula (solute)

Therefore you would add 180 mL water to 540 mL of Isomil to make 720 mL of ¾-strength Isomil for a 24-hour period.

Irrigating Solutions and Soaks

Nurses or other health care professionals may need to dilute solutions for use as a topical solution, or for irrigating body cavities or wounds. Normal saline is the preferred solution for cleaning wounds, for the application of moist dressings and packing of wounds. The use of cytotoxic solutions is discouraged. Current practice for wound irrigation recommends the use of non-cytotoxic wound cleaners such as normal saline, potable (tap) water, and sterile water. Normal saline solution is the preferred and frequently used solution for wound irrigation. Normal saline is the common term for 0.9% NaCl (full-strength) and is an isotonic solution (the same tonicity or osmolarity as blood and other body serums) and does not harm tissues. According to *Fundamentals of Nursing,* 9th edition (Potter et al., 2017), agents such as Dakin's Solution (sodium hypochlorite solution), acetic acid, povidone-iodine, and hydrogen peroxide are cytotoxic solutions. Cytotoxic solutions are toxic to cells and may interfere with healing. However, the health care provider providing wound care must always take into account the solution ordered and the nature of the wound.

Example 1: Using full-strength normal saline (0.9%), prepare 180 mL of ¼-strength normal saline solution diluted with sterile water for wound care.

Solution: The fraction represents the desired solution strength: ¼-strength means 1-part solute (normal saline) to 4 total parts solution.

- 1. No conversion required.
- 2.

You need 45 mL of solute (normal saline) to prepare the desired solution (180 mL of ¼ strength). The total you want to make is 180 mL. The amount of solvent you need is therefore:

- 180 mL – 45 mL = 135 mL (solvent/sterile water)
- To make 180 mL of ¼-strength normal saline, mix 45 mL of full-strength normal saline and 135 mL of sterile water.

Think: 45 mL is ¼ of the total volume (180 mL) and 135 mL + 45 mL = 180 mL.

Example 2: The prescriber orders a sacral wound irrigated with

-strength normal saline and sterile water tid. 75 mL is needed for each irrigation (tid means three times a day). You will need to prepare 75 mL × 3 irrigations = 225 mL total solution.

How much normal saline (full-strength) and sterile water will you need?

Solution: The fraction represents the desired solution strength:

means 1-part solute (normal saline) to 3 total parts solution.

- 1. No conversion required.
- 2.

You need 75 mL of solute (normal saline) to prepare the desired solution (225 mL of

strength). The total you want to make is 225 mL. The amount of solvent you need is therefore:

- 225 mL – 75 mL = 150 mL (solvent/sterile water)
- To make 225 mL of

-strength normal saline, mix 75 mL of full-strength normal saline and 150 mL of sterile water.

Think: 75 mL is

of the total volume (225 mL) and 150 mL + 75 mL = 225 mL.

SAFETY ALERT!

Think and calculate with accuracy. Errors can be made in determining the dilution for a solution if you incorrectly calculate the amount of solute and solvent for a required solution strength.

PRACTICE PROBLEMS

Prepare the following strength solutions. (Express answers in mL.)

- 55.

-strength Sustacal 300 mL p.o. q.i.d. _____

- 56. ¾-strength Ensure 16 oz by nasogastric (NG) tube over 8 hr _____
- 57. ½-strength Ensure 20 oz by gastrostomy tube (GT) over 5 hr _____

For each of the following, indicate how you would prepare the following solutions using full-strength normal saline as the solute and sterile water as the solvent.

- 58. 8 oz of ¼ strength for wound cleansing _____

- 59. 480 mL of

strength for wound irrigation _____

- 60. 120 mL of ¾ strength for skeletal pain care _____
- 61. 160 mL of

-strength solution _____

Answers on 422

POINTS TO REMEMBER

- • Enteral feedings (continuous) are placed on an infusion pump and administered at a rate expressed in milliliters per hour. The prescriber usually orders the feeding rate in milliliters per hour. If not, the nurse must calculate the rate at which to deliver the feeding.
- • To prepare a solution of a specific strength, write the desired solution strength as a fraction and multiply it by the amount of desired solution. This will give you the amount of solute needed.
- • The amount of desired solution – solute = amount of liquid needed to dissolve the substance (solvent).
- • Think and calculate with accuracy to avoid making errors in determining the dilution for a required solution strength.

CLINICAL REASONING

- 1. **Scenario:** Order: Ceftazidime 250 mg IM q8h.
- The nurse had the package insert below and a 1-g vial.

- Preparation of Solutions of Ceftazidime for Injection

Size	Amount of Diluent to be Added (mL)	Approximate Available Volume (mL)	Approximate Ceftazidime Concentration (mg/mL)
Intramuscular			
1-gram vial	3	3.6	280
Intravenous			
1-gram vial	10	10.8*	100
2-gram vial	10	11.5**	170

- The nurse reconstituted the medication (Ceftazidime) with 10.8 mL of diluent and administered 2.5 mL to the client.
  - a. What error occurred here?_____
  - b. What concentration should have been made?_____
  - c. What concentration did the nurse make and for which route?_____
  - d. What is the potential outcome of the error?_____
  - e. What measures could have been taken to prevent the error?

Answers on 423

CHAPTER REVIEW

Use the labels where provided to obtain the necessary information. Shade the dosage on syringes where provided. Round the answers to the nearest tenth where indicated.

- 1. Order: methylprednisolone sodium succinate 170 mg for 5 days.
- Available:

- a. How many milliliters will you administer?_____

- b. Shade the dosage calculated on the syringe provided.

- 2. Order: Ampicillin 375 mg IM q6h
- Available:

- a. How much diluent must be added to the vial for IM administration?_____
- b. What is the final concentration of the solution prepared for IM administration?_____
- c. How many milliliters will you administer?_____
- d. Shade the dosage calculated on the syringe provided.

- 3. Order: Cefdinir 0.3 g p.o. q12h for 10 days.
- Available:

- a. How much diluent must be added to prepare the solution?_____
- b. What diluent is recommended for reconstitution?_____
- c. What is the dosage strength of the reconstituted solution?_____
- d. How many milliliters will you administer?_____
- e. How long will the medication maintain its potency?_____

- 4. Order: penicillin G potassium 275,000 units IM q6h.
- Available:

- a. Which dosage strength would be best to choose?_____
- b. How many milliliters of diluent would be needed to make the dosage strength?_____
- c. How many milliliters will you administer?_____
- d. Shade the dosage calculated on the syringe provided.

- 5. Order: Vivitrol 380 mg IM every 4 weeks for a client who is alcohol dependent.
- Available: Vivitrol and enclosed diluent to use for reconstitution of medication

- a. How much diluent must be added to the vial for gluteal IM administration?_____
- b. How many milliliters of diluent will be discarded?_____
- c. What is the final dosage strength (concentration) of the reconstituted solution?_____
- d. How many milliliters will you need to administer?_____
- e. After verifying that the dosage ordered is the recommended dosage, how will you administer the dosage? Provide a rationale._____
- f. What syringe will you use?_____

- 6. Order: Cefazolin 0.5 g IM q6h.
- Available:

- a. What is the total dosage strength of Cefazolin in this vial?_____
- b. How many milliliters of diluent must be added for IM use?_____
- c. What diluent is recommended for reconstitution?_____
- d. What is the final dosage strength of the reconstituted solution?_____
- e. What is the displacement volume?_____
- f. How many milliliters will you administer?_____
- g. Shade the dosage calculated on the syringe provided.

- 7. Order: Amoxicillin/clavulanate 0.5 g p.o. q12h (calculation based on Amoxicillin).
- Available:

- a. How many milliliters of diluent must be added?_____
- b. What is the dosage strength after reconstitution?_____
- c. How many milliliters are needed to administer the required dosage?_____

- 8. Order: Cefepime 1.5 g IV q12h.
- Available: Refer to medication label and portion of the package insert.

Preparation of Solutions of Ceftazidime for Injection

Single-Dose Vials for Intravenous (IV)/Intramuscular (IM) Administration	Amount of Diluent to be Added (mL)	Approximate Cefepime Concentration (mg/mL)	Amount of Reconstituted Volume to be Withdrawn (mL)
Cefepime vial content			
1 g (IV)	10	100	10.5
1 g (IM)	2.4	280	3.6
2 g (IV)	10	160	12.5

- a. How many milliliters will you administer?_____
- b. Shade the dosage calculated on the syringe provided.

- 9. Order: Penicillin G potassium 1.8 million units IV q6h.
- Available:

- a. Which dosage strength would be best to choose?_____
- b. How many milliliters of diluent would be needed to make the dosage strength?_____
- c. How many milliliters will you add to the IV? _____
- d. Shade the dosage calculated on the syringe provided

- 10. Order: Entyvio 300 mg IV Week 1 for a client with Crohn's disease.
- Available: Refer to label and an excerpt from the reconstitution directions.

- Directions for reconstitution: Reconstitute with 4.8 mL of sterile water for injection. Allow solution to sit for up to 20 minutes at room temperature. Once it is dissolved, withdraw 5 mL (300 mg) of reconstituted Entyvio. Discard any remaining portion of the reconstituted solution in vial.
  - a. What is the total dosage strength of this vial?_____
  - b. What are the directions for use?_____
  - c. What is the dosage strength of the prepared solution?_____
  - d. How many mL will you prepare for administration?_____
- 11. Order: Vancomycin 0.45 g IV q6h.
- Available:

- a. How many milliliters of diluent must be added to the vial?_____
- b. What diluent is recommended for reconstitution?_____
- c. What is the final concentration of the prepared solution?_____
- d. How many milliliters will you add to the IV?_____
- e. Shade the dosage calculated on the syringe provided._____

- 12. Order: Levothyroxine sodium 0.05 mg IV daily.
- Available:

- a. How many milliliters will you add to the IV?_____
- b. Shade the dosage calculated on the syringe provided.

- 13. Order: Acyclovir 0.25 g IV q8h for 5 days.
- Use the directions from the insert provided.
- Available:

- a. How many milliliters will you add to the IV?_____
- b. Shade the dosage calculated on the syringe provided.

- 14. Vantin (cefpodoxime proxetil) 200 mg by nasogastric tube q12h.
- Available:

- How many milliliters will you administer?_____
- 15. Order: Nafcillin 1 g IV q4h.
- Available: Refer to label and portion of the package insert for Nafcillin.

DIRECTIONS FOR USE

For Intramuscular Use

Reconstitute with Sterile Water for Injection, USP, 0.9% Sodium Chloride Injection, USP, or Bacteriostatic Water for Injection, USP (with benzyl alcohol or parabens); add 3.4 mL to the 1-g vial for 4 mL resulting solution and 6.6 mL to the 2-g vial for 8 mL resulting solution. All reconstituted vials have a concentration of 250 mg per mL.

For Direct Intravenous Use

The required amount of drug should be diluted in 15 to 30 mL of Sterile Water for Injection, USP or Sodium Chloride Injection, USP and injected over a 5- to 10-minute period. This may be accomplished through the tubing of an intravenous infusion if desirable.

For Administration by Intravenous Drip

Reconstitute as directed above (For Intravenous Use) prior to diluting with intravenous solutions.

- a. What is the total dosage strength of this vial?_____
- b. How many milliliters of diluent must be added to the vial?_____
- c. What diluent is recommended for reconstitution?_____
- d. What is the dosage strength after reconstitution?_____
- e. What is the displacement volume?_____
- f. How many milliliters will you add to the IV?_____
- g. Shade the dosage calculated on the syringe provided.

- 16. Order: Vfend 200 mg IV q12h.
- Available:

- a. How many milliliters of diluent must be added to the vial?_____
- b. How many milliliters will you add to the IV?_____

- 17. Order: Zosyn 3.375 g IV q6h.
- Available:

- a. How many milliliters of diluent are recommended for reconstitution?_____
- b. What is the dosage strength of the vial?_____
- c. How many milliliters will you add to the IV? (The dosage is based on the two medications together.)_____

- 18. Order: Zithromax (azithromycin) 500 mg p.o. stat for 1 dose.
- Available:

- How many milliliters will you administer?_____
- 19. Order: Unasyn 1.5 g IV q6h.
- Available:

- Refer to excerpt from package insert of Unasyn.

Unasyn Vial Size	Volume of Diluent to Be Added	Withdrawal Volume
1.5 g	3.2 mL	4 mL
3 g	6.4 mL	8 mL

- How many milliliters will you add to the IV?_____
- 20. Order: Ceftriaxone 1 g IV 30 minutes before surgery.
- Available:

- How many milliliters will you administer?_____
- 21. Order: Amphotericin B 45.5 mg IV every day.
- Available:

- Use the excerpt from the package insert to answer the questions and calculate the number of milliliters you will administer.
  - a. How many milliliters of diluent must be added for the initial concentration?_____
  - b. What is the recommended diluent?_____
  - c. What is the final concentration of the prepared solution per milliliter?_____
  - d. How many milliliters will you administer (initial dose)?_____
- 22. Order: Oxacillin 0.35 g IM q6h.
- Available:

-
  - a. How many milliliters will you administer IM?_____
  - b. Shade the dosage calculated on the syringe provided.

- 23. Order: Streptomycin 0.75 g IM daily for 1 week.
- Available:

- Directions: Dilute with 1.8 mL of sterile water for injection.
    - a. How many milliliters will you administer IM?_____
    - b. Shade the dosage calculated on the syringe provided.

- 24. Order: Visudyne 10 mg IV × 1 dose.
- Available:

Reconstitute each vial of Visudyne with 7 mL of sterile water for Injection to provide 7.5 mL containing 2 mg/mL. Reconstituted Visudyne must be protected from light and used within 4 hours. It is recommended that reconstituted Visudyne be inspected visually for particulate matter and discoloration prior to administration. Reconstituted Visudyne is an opaque dark green solution. Visudyne may precipitate in saline solutions. Do not use normal saline or other parenteral solutions, except 5% Dextrose for Injection, for dilution of the reconstituted Visudyne. Do not mix Visudyne in the same solution with other drugs.

- a. How many milliliters will you administer IV?_____
- b. Shade the dosage calculated on the syringe provided.

Prepare the following solutions from the nutritional formulas. (Express answers in mL.)

- 25. Order: ¼-strength Ensure 12 oz by nasogastric tube over 6 hr._____
- 26. Order:

-strength Isomil 6 oz p.o. q4h for 24 hr. (State answer for single feeding.)_____

- 27. A client has an order for Jevity 1,000 mL by continuous feeding through a gastrostomy tube over 16 hours, followed by 250 mL of free water. The feeding is placed on an infusion pump. Calculate the mL per hr to set the pump at. (Round answer to nearest whole number.)_____
- 28. Order:

-strength Ensure 4 oz by nasogastric tube q4h for 24h. (State answer for single feeding.)_____

Indicate how you would prepare each of the following using full-strength normal saline (0.9%) (solute) and sterile water (solvent).

- 29. Clean sacral wound with 4 oz of ½-strength normal saline q6h. You make enough solution for 24 hours._____
- 30. Irrigate foot wound with 0.24 L of ¼-strength daily._____
- 31. 18 oz of

-strength solution for wound irrigation_____

- 32. 0.5 L of ¼-strength solution for wound irrigation_____

Answers on pp. 423

ANSWERS

Chapter 18

Answers to Practice Problems

- 1. 200 mg per vial
- 2. 5 mL
- 3. 0.9% sodium chloride injection without preservatives
- 4. 38 mg per mL
- 5. 24 hours
- 6. 2.6 mL
-

- 7. 100 mg per vial
- 8. 10 mL
- 9. Sterile water for injection or Bacteriostatic water for injection preserved with benzyl alcohol
- 10. 10 mg per mL
- 11. IV or IM use
- 12. See package insert.
- 13. 1.5 mL

- 14. 40 mg per vial
- 15. Bacteriostatic water for injection with benzyl alcohol
- 16. 1 mL
- 17. 40 mg per mL
- 18. 0.9 mL

- 19. 106 mL
- 20. water
- 21. 250 mg per 5 mL (1 tsp)
- 22. Refrigerate and keep tightly closed.
- 23. 70 mL
- 24. 100 mL
- 25. 200 mg per 5 mL (1 tsp)
- 26. 10 days (refrigerated)
- 27. 2 g per vial
- 28. 4.2 mL
- 29. 19.2 mL
- 30. IV diluents specified in the accompanying package insert

- 31. 100 mg per mL
- 32. 500 mg per vial
- 33. 4.8 mL
- 34. sterile water for injection
- 35. 100 mg per mL
- 36. IV infusion only
- 37. For Intravenous Infusion Only
- 38. 500,000 units per mL
- 39. 1,000,000 units per mL; this strength is closest to what is ordered.
- 40. 2 mL
- 41. 7 days (1 week)
- 42. Intramuscular or Intravenous use
- 43. See package insert for complete information.
- 44. refrigerator
- 45. 7 days (1 week)
- 46. 250,000 units per mL
- 47. 10 mg per vial
- 48. 2.1 mL
- 49. sterile water for injection
- 50. 1 hour
- 51. 1.5 mL
- 52. 0.5 mL
- 53.

- 54.

- 55. 300 mL qid = 300 mL × 4 = 1,200 mL

- x = 800 mL of formula needed
- 1,200 mL – 800 mL = 400 mL (water)
- Therefore you will add 400 mL of water to 800 mL of Sustacal to make 1,200 mL of

-strength Sustacal.

- 56. 1 oz = 30 mL; therefore 16 oz = 480 mL

- x = 360 mL of formula needed.
- 480 mL – 360 mL = 120 mL. You would need
- 360 mL of formula and 120 mL of water to make
- 480 mL of ¾-strength Ensure.
- 57. 1 oz = 30 mL; therefore 20 oz = 600 mL

- 600 mL – 300 mL × 300 mL (10 oz of water)
- Answer: You would need 300 mL of Ensure and 300 mL of water to make 600 mL of ½-strength Ensure.
- 58. 1 oz = 30 mL; therefore 8 oz = 240 mL
- ¼ × 240 mL = *x* mL

- 60 mL normal saline (solute) + 180 mL sterile water (solvent) = 240 mL ¼-strength solution.
- 59.

× 480 mL = *x* mL

- 160 mL normal saline (solute) + 320 mL sterile water (solvent) = 480 mL

-strength solution.

- 60. ¾ × 120 mL = *x* mL

- 90 mL normal saline (solute) + 30 mL sterile water (solvent) = 120 mL ¾-strength solution.
- 61.

× 160 mL = *x* mL

- 100 mL normal saline (solute) + 60 mL sterile water (solvent) = 160 mL

-strength solution.

Answers to Clinical Reasoning Questions

- 1.

- a. The wrong dosage was administered because the nurse chose the incorrect dilution instructions. The dilution instructions used were for IV instead of IM.
- b. The concentration for IM should have been made (add 3 mL of diluents to give a concentration of 280 mg per mL).
- c. The nurse added 10.8 mL of a diluent and made the concentration for IV administration 100 mg per mL.
- d. The client received almost three times the mL of medication IM (2.5 mL instead of 0.9 mL). Interchanging dilution instructions for IV and IM administration can have serious outcomes ranging from irritation of muscles to formation of a sterile abscess.
- e. This type of error could have been prevented by the nurse by reading the label carefully for the correct amount of diluents for the route ordered. Nurses must always check the route ordered and follow the directions that correspond to that route. The dilution instructions for IV and IM should never be interchanged.

NOTE

For problems in which conversion is indicated, answers are shown with order converted to what is available. Calculations could also be performed using dimensional analysis.

Answers to Chapter Review

- 1.

- a. Answer: 1.4 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the dosage ordered.
- b.

- 2.
  - a. 1.8 mL
  - b. 250 mg per 1 mL
  - c. 250 mg : 1 mL = 375 mg : *x* mL
  - d. Answer: 1.5 mL. The dosage ordered is greater than the available strength; you will need more than 1 mL to administer the dosage.

- 3. Conversion is required 1 g = 1,000 mg; therefore 0.3 g = 300 mg
  - a. 49 mL
  - b. water
  - c. 250 mg per 5 mL

- d. Answer: 6 mL. The dosage ordered is greater than the available strength. You will need more than 5 mL to give the dosage ordered.
- e. 10 days

- 4.
  - a. 250,000 units per mL
  - b. 4 mL
  - c.
  - d. Answer: 1.1 mL. The dosage ordered is greater than what is available; therefore you will need more than 1 mL to administer the dosage.

- 5.
  - a. 3.4 mL
  - b. 0.6 mL
  - c. 95 mg per mL
  - 95 mg : 1 mL = 380 mg : *x* mL
  -

- or

- d. Answer: 4 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the dosage ordered.
- e. 4 mL exceeds the maximum amount of 3 mL allowed for administration to an adult IM in one site. If more than 3 mL is needed to deliver the ordered dose IM, then the amount to administer is divided equally between two (2) syringes and administered into separate IM sites. In this case, 2 mL would be drawn up in each syringe, and 2 mL would be administered in the right gluteal and 2 mL in the left gluteal.
- f. 3-mL syringe (You will need two syringes and will draw up 2 mL in each syringe.)

- 6.
  - a. 1 g per vial
  - b. 2.5 mL
  - c. Sterile water for injection
  - d. 330 mg per mL
  - e. 0.5 mL
  - Conversion is required. Equivalent 1 g = 1,000 mg, therefore 0.5 g = 500 mg
  - 330 mg : 1 mL = 500 mg : *x* mL

- *or*

- f. Answer: 1.5 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the dosage ordered.
- g.

- 7. Conversion is required. Equivalent: 1,000 mg = 1 g; therefore 0.5 g = 500 mg
  - a. 84 mL
  - b. 400 mg per 5 mL
  - c. 6.3 mL

Answer: 6.3 mL. The dosage ordered is greater than the available strength. You will need more than 5 mL to give the dosage.

- 8. Conversion is required. Equivalent: 1,000 mg = 1 g; therefore 1.5 g = 1,500 mg
  - a. 160 mg : 1 mL = 1,500 mg : *x* mL

- *or*

- Answer: 9.4 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the dosage ordered.

- 9.
  - a. 1,000,000 units per mL. It is closest to what the prescriber ordered. The route ordered is IV; you would not choose a weak solution. The medication when administered IV is further diluted when added to the IV solution for administration (50–100 mL). Usually the maximum concentration is used for IV. You will have medication left over; therefore the dosage strength you mixed must be indicated on the medication label.
  - b. 3 mL
  -
  - c. Answer 1.8 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the dosage ordered.
  - d.

- 10.
  - a. 300 mg per vial
  - b. For intravenous use only

- c. 300 mg per 5 mL
- d. No calculation required. The dosage ordered is contained the 5 mL of solution withdrawn from the vial after the medication is reconstituted.

- 11.
  - a. 10 mL
  - b. Sterile water for injection
  - c. 500 mg per 10 mL
  - d. Conversion is required. Equivalent: 1,000 mg = 1 g; therefore 0.45 g = 450 mg
  - 500 mg : 10 mL = 450 mg : *x* mL
  -
  - *x* = 9 mL
  - *or*
  -
  - Answer: 9 mL. The dosage ordered is less than the available strength; therefore you need less than 10 mL to administer the dosage ordered.
  - e.

- 12. Conversion is required. Equivalent: 1,000 mcg = 1 mg; therefore 0.05 mg = 50 mcg.
  - a. 40 mcg : 1 mL = 50 mcg : *x* mL
  - *or*

- Answer: 1.3 mL; 1.25 mL rounded to the nearest tenth. The dosage ordered is more than the available strength; therefore you will need more than 1 mL to administer the dosage ordered.
- b.

- 13. Conversion is required. Equivalent: 1,000 mg = 1 g; therefore 0.25 g = 250 mg.
  - a. 50 mg : 1 mL = 250 mg : *x* mL
  - *or*
  - Answer: 5 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the dosage ordered.
  - b.

- 14. 100 mg : 5 mL = 200 mg : *x* mL

- Answer: 10 mL. The dosage ordered is greater than the available strength; therefore you will need more than 5 mL to administer the dosage ordered.
- 15.
    - a. 2 g per vial
    - b. 6.6 mL
    - c. Sterile Water for Injection, 0.9% Sodium Chloride Injection, or Bacteriostatic Water for Injection (with benzyl alcohol or parabens)
    - d. 250 mg per mL
    - e. 1.4 mL
    - f. Conversion is required. Equivalent: 1 g = 1,000 mg; therefore 1 g ordered = 1,000 mg
    - 250 mg : 1 mL = 1,000 mg : *x* mL
    -
    -
    - *or*
    -
    - Answer: 4 mL. The dosage ordered is more than the available strength; therefore you will need more than 1 mL to administer the dosage ordered.
    - g.

- 16.
  - a. 19 mL
  - b. 10 mg : 1 mL = 200 mg : *x* mL
  - Answer: 20 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the dosage ordered.
- 17.
  - a. 152 mL
  - b. 40.5 g per vial
  - c. Conversion is required. 1,000 mg = 1 g; 3.375 g = 3,375 mg

The piperacillin and tazobactam are added together for calculation. When reconstituted, the result is 200 mg per mL of piperacillin and 25 mg per mL of tazobactam.

200 mg per mL + 25 mg per mL = 225 mg per mL.

Answer: 15 mL. The dosage ordered is greater than the available strength; therefore more than 1 mL is needed to administer the dosage ordered.

- 18. 200 mg : 5 mL = 500 mg : *x* mL

- Answer: 12.5 mL. The dosage ordered is greater than what is available; therefore you will need more than 5 mL to administer the dosage ordered.
- 19.

Answer: 4 mL. The dosage ordered is less than the available strength; therefore you will need less than 8 mL to administer the dosage ordered. (Ordered dosage is half of the available strength.)

- 20. Conversion is required. Equivalent: 1 g = 1,000 mg; therefore the 1 g ordered = 1,000 mg
- 100 mg : 1 mL= 1,000 mg : *x* mL

-

- *x* = 10 mL
- *or*

-
- Answer: 10 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the ordered dosage.
- 21.
    - a. 10 mL
    - b. Sterile Water for Injection without a bacteriostatic agent
    - c. 5 mg per mL
    - d.

Alternate solution

This setup would net the same answer of 9.1 mL.

Answer: 9.1 mL is the dose for the initial concentration (before further dilution). The dosage ordered is greater than the available strength; therefore you need more than 1 mL to administer the dosage ordered. This medication would have to be further diluted according to the instructions as follows: The infusion solution, providing 0.1 mg amphotericin B per mL, is then obtained by further dilution (1:50) with 5% dextrose injection. This may be accomplished by adding 49 mL dextrose and water injection to each 1 mL (5 mg) of amphotericin B solution. The concentrated amphotericin solution to dilute is the 9.1 mL. Therefore we need to add it. 9.1 × 49 mL = 445.9 = 446 mL of IV solution before administering the medication IV.

- 22. Conversion is required. Equivalent: 1,000 mg = 1 g; therefore 0.35 g = 350 mg
  - a.

Answer: 2.1 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1.5 mL to administer the dosage ordered.

  - b.

- 23. Conversion is required. Equivalent: 1 g = 1,000 mg; therefore 0.75 g = 750 mg
  - a.

Answer: 1.9 mL; 1.87 rounded to the nearest tenth. The dosage ordered is greater than the available strength. Therefore you will need more than 1 mL to administer the dosage ordered.

- b.

- 24.
  - a.

Answer: 5 mL. The dosage ordered is greater than the available strength. Therefore you will need more than 1 mL to administer the dosage ordered.

  - b.

- 25. 1 oz = 30 mL; therefore 12 oz = 360 mL

- *x* = 90 mL; you need 90 mL of Ensure.
- 360 mL – 90 mL Ensure = 270 mL of water. Answer: 90 mL Ensure + 270 mL water = 360 mL ¼-strength Ensure.
- 26. 1 oz = 30 mL; therefore 6 oz = 180 mL

- 180 mL – 120 mL = 60 mL water
- You would add 60 mL of water to 120 mL Isomil to make 180 mL of

  -strength Isomil for each feeding po q4h.
- 27.

Answer: 63 mL/hr (62.5 rounded to nearest whole number)

- 28. 1 oz = 30 mL; therefore 4oz = 120 mL

- 120 mL – 15 mL = 105 mL water
- You would add 105 mL of water to 15 mL Ensure to make 120 mL of

-strength Ensure for each feeding by nasogastric tube q4h.

- 29. q6h = 4 times in 24 hours; therefore 4 oz × 4 = 16 oz.
- 1 oz = 30 mL; therefore 16 oz = 480 mL
- 480 mL × ½ = *x* mL

- 240 mL normal saline (solute) + 240 mL sterile water (solvent) = 480 mL ½-strength solution
- 30. Conversion is required. Equivalent: 1 L = 1,000 mL; therefore 0.24 L = 240 mL
- 240 mL × ¼ = *x* mL

- 60 mL normal saline (solute) + 180 mL sterile water (solvent) = 240 mL ¼-strength solution.
- 31. 1 oz = 30 mL; therefore 18 oz = 540 mL

- 540 mL ×

  = *x* mL

- 360 mL normal saline (solute) + 180 mL sterile water (solvent) = 540 mL

  -strength solution.
- 32. Conversion is required. Equivalent: 1 L = 1,000 mL.
- Therefore 0.5 L = 500 mL
- 500 mL × ¼ = *x* mL

- 125 mL normal saline (solute) + 375 mL sterile water (solvent) = 500 mL ¼-strength solution.

unknown - Section 35 (Page 316)

Introduction

Insulin, which is used in the treatment of diabetes mellitus (DM), is a hormone secreted by the islets of Langerhans in the pancreas. It is a necessary hormone for glucose use by the body. Individuals who do not produce adequate insulin experience an increase in their blood sugar (glucose) level. These individuals may require the administration of insulin. According to the Centers for Disease Control and Prevention (CDC), it is estimated that 26 million Americans have type 2 diabetes (insufficient production of insulin, causing high blood sugar). In addition, according to the American Diabetes Association (ADA), 1.5 million Americans are diagnosed with diabetes every year. With the increase in the incidence of diabetes, one can also expect that there will be an increase in the use of insulin. Insulin is considered to be a vital and life-saving medication for persons with diabetes. Therefore accuracy in administration of insulin is **critical** because inaccurate dosage administration can lead to serious life-threatening effects or death. Any error that occurs in medication administration, regardless of the reason for it, may result in harm to a client; however, there are some medications that have been designated "high-alert medications." Insulin is considered a "high-alert medication" by the Institute for Safe Medication Practices (ISMP). Medications that are considered high-alert medications have a high risk of causing injury or death to a client and are also identified as those with which health care providers oft en make errors. ISMP defines high-alert medications as "drugs that bear a heightened risk of causing significant patient harm when they are used in error." The consequences associated with errors with these medications are usually more devastating than those that occur with other medications. High-alert medications require that safeguards be in place to ensure that when they are used, there is a focus on safely using them and preventing harm to the clients who receive them. Nurses as well as other health care providers **must** be highly attentive when calculating dosages and administering high-alert medications. Always follow the policy of the institution for administering high-alert medications to decrease the chance of error and harm to the client. This chapter will focus on basic concepts related to the safe administration of insulin.

Despite the focus of health care institutions on initiatives aimed at improving safety in the administration of insulin and preventing errors, it has been noted that the occurrence of errors with insulin persists. In addition to insulin being considered a high-alert medication, insulin has also been known to be associated with more medication errors than most other medications. The U.S. Pharmacopeia Medication Errors Reporting Program states that approximately 50% of all medication errors involve insulin. The ISMP developed *Guidelines for Optimizing Safe Subcutaneous Insulin Use in Adults* (June 5, 2017), aimed at assisting health care facilities in the prevention of insulin errors and improving patient outcomes, which also included recommendations for the safe use of subcutaneous insulin in the hospital and during transition of care. Causes for insulin errors were also identified, which included administration of the wrong insulin product, improper dosing (underdosing and overdosing), dose omissions, and wrong route (intramuscular versus subcutaneous). These guidelines can be viewed on the ISMP website: https://www.ismp.org/guidelines/subcutaneous-insulin.

Diabetes in Control (News and Information for Medical Professionals), in October 2019 in an article titled "A Review of Insulin Errors," identified errors with insulin from information provided by Novo Nordisk, an insulin manufacturer, which included clinician errors, bad drawing-up procedure, improper monitoring (not checking blood glucose 2 hours after injection), and using the wrong insulin (http://www.diabetesincontrol.com/a-reviewof-insulin-errors/). The current literature identifies a variety of errors that continue to occur with insulin therapy. The errors presented are just a sample of the causes of errors with insulin. Even currently there are still reports to ISMP on the misadministration of insulin. This has serious implications for nurses as well as other health care providers. Some practices to promote safety include reading insulin labels carefully (some brand names may sound and look alike), client monitoring, and administration of U-500 insulin with a U-500 syringe.

Types of Insulin

Insulins distributed in the United States are synthetic "human insulins" or their analogs, which are chemically altered DNA. Insulin from a human source is designated on the label as recombinant DNA (rDNA origin).

- • Humalog insulin (lispro) is a fast-acting insulin analog. Lispro acts within 5 to 15 minutes. Lispro can be administered 5 minutes before meals, whereas regular insulin can be administered 30 to 60 minutes before meals. Like regular human insulin, Lispro is clear and can be administered intravenously as well as subcutaneously. Other rapid-acting insulin analogs include aspart (NovoLog) and glulisine (Apidra). Like lispro and regular insulin, these analogs are clear and can also be administered intravenously as well as subcutaneously.
- • Lantus (insulin glargine) is an analog of human insulin, classified as long-acting, and permits once-daily dosing. It can be administered at any time during the day for 24-hour coverage without a peak; however, it must be administered at the same time every day. In addition, it is clear in appearance, intended for subcutaneous use **only**, and cannot be mixed with other insulins. The packaging is distinct; the vial is tall, narrow, and the name Lantus is printed in purple letters. Levemir (detemir), which is also long-acting, is also generally given once daily. However, it does not last as long as Lantus, so clients may require a nighttime dose. Like Lantus, Levemir cannot be mixed with other insulins.
- • Tresiba (insulin degludec injection), a long-acting insulin analog, was approved in 2015 by the US Food and Drug Administration (FDA). Tresiba is administered subcutaneously once daily at any time of day. It should not be diluted or mixed with other insulins and is available in the FlexTouch pen in two concentrations: 100 units per mL and 200 units per mL. Also available in vial U-100 (multiple-dose 10-mL vial).

Labels

It is essential that the nurse know the essential information on an insulin label and where to locate it. Information such as the origin of insulin, type, brand and generic names, the dosage strength or concentration, and storage information is indicated on the label.

Figure 19.1 shows information that can be found on an insulin label. Notice the following:

Figure 19.1 Label for U-100 insulin. (NPH)

- • The trade name is followed by a large capital letter. In Figure 19.1, Humulin N is the trade name. The larger capital letter N following the trade name identifies the type of insulin by action and time. The large capital letter N indicates NPH (intermediate-acting). These letters are important identifiers for insulin.
- • Notice the use of uppercase letters for the letter N for NPH. You will see the large capital letter R to indicate Regular insulin.
- • Concentration (dosage strength) of the insulin is also indicated; notice U-100 (which means 100 units per mL). 100 units per mL is also indicated on the label. Every type of insulin is measured in units.
- • The expiration date is also indicated on insulin labels and is important to check. Review the important information identified on the label in Figure 19.1.

U-500 Insulin

U-500 insulin is a short-acting regular insulin that is concentrated and not for ordinary use. It is indicated to improve glycemic control in clients with diabetes mellitus requiring more than 200 units of insulin per day. U-500 insulin is **five (5) times more potent** than U-100 insulin. Accidental substitution of U-500 for U-100 could result in a fatal overdose. According to The Institute for Safe Medication Practices (ISMP), as the obesity epidemic continues and insulin resistance problems worsen, larger doses of insulin are more frequently required to meet glycemic goals and this has led to an increased use of U-500 insulin. U-500 insulin means 500 units per mL. U-500 insulin should only be administered using the U-500 syringe. The U-500 syringe has a green needle shield cover (cap) and U-500 indicated on the barrel of the syringe in green. Refer to Figure 19.2 for a U-500 insulin label.

Figure 19.2 Label for U-500 insulin.

Notice the following on the U-500 insulin label:

- • Notice the U-500 is indicated in green.
- • Concentration (dosage strength) U-500 (500 units per mL). The 500 units per mL is also indicated in green. This insulin is **5 times more potent than the U-100**. The dosage strength is also indicated for the total vial (10,000 units per 20 mL). The total volume of the vial is 20 mL.
- • Warnings are indicated in red: “Highly concentrated, use only with a U-500 syringe, wrong dose can be dangerous, and follow accompanying instructions for use.”
- • The directions for use are also indicated on the label, for subcutaneous use only. U-500 insulin comes in a 20-mL multiple-dose vial containing 10,000 units of insulin and a 3-mL U-500 Kwikpen containing 1,500 units of insulin.

SAFETY ALERT!

It is critical that the nurse use extreme caution when administering U-500 insulin to prevent unintentional overdose, which can result in irreversible insulin shock and death of a client.

U-500 insulin, 500 units per mL, is five (5) times more potent than U-100 insulin, which is 100 units per mL. U-500 insulin is administered with a U-500 syringe only. Read the calibrations on the syringe carefully.

SAFETY ALERT!

Careful reading of insulin labels is essential to avoid a medication error that could be life-threatening. Always read the label carefully and compare it with the medication order to ensure selection of the right type of insulin, correct action time, and concentration (strength).

Insulin Action Times

Insulins are classified by their actions as rapid-acting, short-acting, intermediate-acting, and long-acting insulin. Rapid-acting insulin and short-acting insulin are referred to as **bolus** types of insulin. These types of insulin are administered just a few minutes before a meal.

Intermediate- and long-acting insulins are considered **basal** types of insulin. Basal type insulins last longer in the body and provide a steady level of insulin throughout the day. Intermediate- and long-acting insulin can only be administered subcutaneously. Nurses must be familiar with the action times of insulins. Figure 19.3 shows samples of labels for insulin grouped by action times. As stated, note the use of N for NPH Insulin and R for Regular, indicated in bold uppercase letters. Regular and NPH insulin are the two types that have traditionally been used most frequently, and they are often mixed.

Figure 19.3 (A) Rapid-acting (fast-acting). (B) Short-acting. (C) Intermediate-acting. (D) Long-acting.

PRACTICE PROBLEMS

Using the labels provided, identify the insulin trade name and action time (short acting, rapid acting, intermediate acting, or long acting).

- 1. Trade name _____
- Action time _____

- 2. Trade name
- Action time _____

- 3. Trade name _____
- Action time _____

- 4. Trade name _____
- Action time _____

Answers on 461

Appearance of Insulin

Regular insulin, Humalog (lispro), Lantus (insulin glargine), Apidra (insulin glulisine), aspart (Novolog), and Levemir (insulin detemir) insulin are clear. All other insulin is cloudy. They include NPH and fixed-combination insulins such as Humulin 70/30 and Humalog 75/25.

Premixed, Fixed, and Combination Insulins

Fixed-combination insulins are shown in Figure 19.4. These insulins have become popular for clients who must mix fast-acting and intermediate-acting insulins. The purpose of the fixed-combination insulins is to simulate the varying levels of insulin within the bodies of diabetic persons. The availability of the premixed-combination insulins has also decreased the need for clients to mix insulins, as well as decreased the number of required injections. Premixed combination insulins are available in vials and pens for administration and contain both mealtime and basal insulin. This combination can only be administered subcutaneously or by insulin pen. Read labels carefully on combination insulins to identify differences. Selecting the incorrect combination could result in a serious or life-threatening error. Always read an insulin label carefully and compare it to the medication order to avoid errors in administration.

Figure 19.4 Fixed-combination insulins.

SAFETY ALERT!

Carefully read all insulin labels to ensure selection of the correct type of insulin. The action of insulin varies according to the type of insulin and combination.

To understand fixed-combination insulin orders, it is important for the nurse to read the labels to understand what types of insulin are included in the combination and that they have different action times. For example, Humalog 50/50 concentration in Figure 19.4A means there is a mixture of 50% insulin lispro protamine, an intermediate-acting human insulin analog, and 50% insulin lispro, a rapid-acting human insulin analog. Humulin 70/30 concentration (Figure 19.4B) is a mixture of 70% human insulin isophane, an intermediate-acting human insulin, and 30% regular human insulin, a short-acting human insulin.

Insulin Administration

The major route of administration of insulin is by subcutaneous injection; it is never administered intramuscularly. Regular U-100 insulin, aspart, and glulisine can be administered intravenously.

Insulin Pumps

Insulin can also be administered by a pump. A CSII pump (continuous subcutaneous insulin infusion) is an insulin pump. An insulin pump is not an IV pump. Figure 19.5A, shows an insulin pump and a blood glucose monitor. Insulinpumps deliver rapid- or short-acting insulin continuously for 24 hours a day through a catheter placed under the skin. This eliminates the need for multiple daily injections of insulin. Pumps can be programmed to deliver a basal rate and/or a bolus dose. Basal insulin is delivered continuously over 24 hours to keep blood glucose levels in range between meals and overnight. The basal rate can be programmed to deliver different rates at different times. Bolus doses can be delivered at mealtime to provide control for additional food intake. The two types of pumps are implantable and external (portable). There are varied insulin pumps that have become available on the market. An example of a pump currently available is the Omnipod system. This system is a tubeless, waterproof insulin pump that can be worn under the clothing. The insulin pump has a reservoir, referred to as a pod, that supplies up to 72 hours of insulin to the body continuously. A handheld device referred to as the Personal Diabetes Manager (PDM) is used to program the Omnipod with customized insulin delivery instructions and monitor the operation of the system. More information about this system can be found at https://www.myomnipod.com/home. According to ISMP, more patients are using ambulatory insulin infusion pumps; however, many inpatient practitioners are unfamiliar with their functionality and the safest way to care for such patients in an inpatient setting. Errors that have been reported with insulin pumps have included patients self-administering insulin by pump without telling the nurse; the nurse administering the same insulin dose by a subcutaneous injection; and changes in the patient's condition that require reassessment of the use of the device. In the 2017 publication by ISMP, *Guidelines for Optimizing Safe Subcutaneous Insulin Use in Adults*, it was recommended that organizational policies are in place to guide the care of patients with personal subcutaneous insulin pumps. ISMP also developed additional guidelines on the safe use of an insulin pump in 2016, which were vetted. These recommendations can be viewed on the ISMP website: https://www.ismp.org/resources/safe-management-patients-external-subcutaneous-insulin-pump-during-hospitalization.

Figure 19-5 (A) Paradigm® 515 insulin pump and Paradigm Link™ blood glucose monitor. (B) Prefilled Kwik Pens, Humulin N and Humulin 70/30. (Copyright Eli Lilly and Company. All rights reserved. Used with permission. Humulin is a registered trademark of Eli Lilly and Company.)

Insulin Pen

Insulin can also be delivered by an insulin pen. When capped, the insulin pen looks very much like an ink pen. Use of the insulin pens affords clients an easy and accurate method for self-administration of insulin. Insulin pens come in two forms, disposable and reusable. Disposable pens contain a prefilled cartridge and are thrown out after they are emptied. Reusable pens require replacement of the insulin cartridge each time it is emptied. The needles in insulin pens are extremely short and thin. Figure 19.5B shows examples of prefilled insulin pens. The insulin pen has a dose selector knob that is used to "dial" the desired dose of units. The dose dial is turned until the correct number of units is displayed in the dose window. Some of the newer pens have a digital dose display that can be easily misinterpreted if the pen is held upside down. For example, a dose of 27 units looks like 72 units on the digital display if the pen is held incorrectly and read upside down. Client education on the use of the insulin pen (correct way to hold the pen and read the display) is a **must.** This will help in the prevention of dosing errors. Once the pen has been cleared of any air in the cartridge (primed) and the dose set, the insulin is injected by pressing on the injection button. When the injection is completed, the needle is removed and cap replaced. Insulin pens are available in many styles and colors. All insulin pens are designed for single client use and cannot be shared with other clients, even if a new needle is attached.

Although insulin pens were designed for client self-administration of insulin, in an effort to decrease errors with insulin and improve medication safety, many hospitals are also switching from the administration of insulin from vials to pens. Many hospital pharmacies are also supplying insulin pens for nurses to administer insulin.

According to the ISMP's 2017 publication *Guidelines for Optimizing Safe Subcutaneous Insulin Use in Adults,* in institutions that use insulin pens for administration of insulin, there was a need for processes to be in place to reduce the risk of an insulin pen being used on more than one patient, and avoidance of pen mix-ups between patients. Recommendations by ISMP include insulin pens being dispensed to the clinical units with a patient-specific, barcode label (that has been applied in the pharmacy, using a barcode verification process that confirms the correct pen type has been selected based on the patient's order) and steps have been taken to ensure that only the correct specific label can be scanned at the bedside. Patient-specific insulin pens are stored on clinical units in a manner that prevents their inadvertent use on more than one patient. With the use of insulin pens increasing and being used in some institutions, it is important that nurses embrace practices to ensure their safe use on clients.

Glucose Monitoring Systems

In addition, there are also glucose monitoring systems available on the market that have decreased the need for pricking of the finger to check blood glucose levels. They include the FreeStyle 14-day glucose monitoring system and the Dexcom G6 continuous glucose monitoring system, which can be worn up to 10 days. Both of these systems use a sensor that is worn under the skin and provides continual monitoring of blood glucose levels. Further information on these glucose monitoring systems can be found on their websites: https://www.freestylelibre.us and https://www.dexcom.com/g6-cgm.

Measuring Insulin in a U-100 Syringe

The insulin syringes and their calibration was introduced in Chapter 17. Recall from Chapter 17 that insulin syringes are available in three sizes (100 unit, 1 mL; 50 unit, 0.5 mL; and 30 unit, 0.3 mL). These syringes are calibrated exclusively for U-100 insulin (100 units per mL) and marked U-100. Typically, these syringes also have orange caps. U-100 insulin should be measured in U-100 syringes and **not** in syringes calibrated in milliliters, such as a 1-mL or 3-mL syringe. U-500 insulin was previously administered using a tuberculin (1-mL) syringe. In 2016 the US Food and Drug Administration approved a dedicated syringe for the administration of Humulin R U-500 insulin. The U-500 insulin syringe is **only** used for the administration of U-500 insulin.

Measuring U-100 insulin with the insulin syringe makes it easy to obtain a correct dosage without mathematical calculation. To prepare the U-100 insulin when only one dosage is required, the U-100 insulin syringe is used to draw up the ordered U-100 insulin to the unit calibration that corresponds to the ordered dose. The nurse **must** carefully select the correct insulin and withdraw the correct amount. It is not necessary to use dosage calculation formulas or ratio and proportion to calculate the volume for administering U-100 insulin. The insulin syringe is designed to measure insulin in units, and insulin is ordered in units. After drawing up insulin, the nurse should provide the order, vial, and syringe to another nurse to verify the insulin dosage before administering to client to avoid errors. In other words, the dosage should always be double-checked by another nurse.

Let's look at the U-100 insulin syringes. An essential skill is correctly reading the syringe calibrations on U-100 syringes.

- 1. **Lo-Dose syringe**—It has a capacity of 50 units (0.5 mL). Each calibration on the syringe measures 1 unit. There is also a 30-unit (0.3 mL) syringe, which is used to accurately measure very small amounts of insulin. It is marked in units up to 30 units. Each calibration is 1 unit.
- 2. **1-mL (100-unit) capacity syringe**—The 100-unit syringe comes with even and odd numbers on it. There are two types of 1-mL syringes in current use.
- - a. The single-scale syringe is calibrated in 2-unit increments. Any dosage measured in an odd number of units is measured between the even calibrations. This would not be the desired syringe for clients with vision problems.
  - b. The double-scale syringe (dual syringe) has odd-numbered units on the left in 2-unit increments (1, 3, etc.) and even-numbered units on the right in 2-unit increments (2, 4, etc.). To avoid confusion, the scale on the left should be used for odd numbers of units (e.g., 13 units) and the scale on the right for even numbers of units (e.g., 26 units). When even numbers of units are measured, each calibration is then measured as 2 units.
- 3. **U-500 insulin syringe**—This has a capacity of 250 units. The U-500 insulin syringes have a green cap, and U-500 is marked on the barrel of the syringe. Each calibration on the syringe measures 5 units (0.01 mL) of U-500 insulin. You can administer 5 to 250 units in one injection. If more than 250 units is required, the client will need more than one injection. This syringe is used for the administration of U-500 insulin **only**.

SAFETY ALERT!

Administer insulin in an insulin syringe used only for the administration of U-100 insulin. Do not use an insulin syringe to measure other medications that are measured in units. Syringes of 30 and 50 units measure a smaller volume of insulin but are intended for the measurement of U-100 insulin only. Use the smallest capacity insulin syringe available to ensure the accuracy of dosage preparation.

To review what the four types of U-100 insulin syringes look like and the U-500 syringe, see Figure 19.6.

Figure 19.6 Types of insulin syringes. (A) Single-scale (100 units). (B) Lo-Dose insulin syringe (50 units). (C) Lo-Dose insulin syringe (30 units). (D) Double-scale syringe (100 units). (E) U-500 insulin syringe (250 units).

Lo-Dose Syringe

Let's look at some insulin dosages measured in the syringes to help you visualize the amounts in a syringe. Syringe *A* shows 30 units and syringe *B* shows 37 units in a Lo-Dose syringe.

PRACTICE PROBLEMS

Using the syringes below, indicate the dosages shown by the arrows.

- 5. _____

- 6. _____
- Using the syringes below, shade in the dosages indicated.
- 7. 17 units

- 8. 47 units

Answers on 461

Single-Scale 1-mL Syringe

Now let's look at what dosages would look like on a single-scale 1-mL syringe. The syringes below show 32 units in syringe *A* and 56 units in syringe *B*.

Double-Scale 1-mL Syringe

Now let's look at the dosage indicated on a double-scale (100-unit) 1-mL syringe. Syringe *C* shows 37 units; notice that the scale on the left is used. Syringe *D* shows 54 units; notice that the scale on the right is used.

SAFETY ALERT!

Look carefully at the increments when using a dual syringe.

PRACTICE PROBLEMS

Indicate the following dosages shaded on the 100-unit (1-mL) syringes.

- 9. _____
- 10. _____
- 11. _____
- 12. _____

- Shade the specified dosages on each of the U-100 syringes below.
- 13. 88 units

- 14. 44 units

- 15. 30 units

Answers on 461

U-500 Syringe

Let's look at insulin dosages measured in the U-500 syringe. Syringe *A* shows 55 units, and syringe *B* shows 125 units in a U-500 syringe.

PRACTICE PROBLEMS

Using the syringes below, indicate the dosages shown by the arrows.

- 16.

- 17.

  Using the syringes below, shade in the dosages indicated.

- 18. 15 units

- 19. 155 units

- **Answers on p.** 461

Insulin Orders

Like any written medication order, an insulin order must be written clearly and contain certain information to prevent errors in administration. An error in administration can cause harmful effects to a client. Insulin orders should contain the following information:

- a. The name of the insulin. Example: Humulin R (indicating human origin, with the R indicating regular). Some orders may be written simply as Humulin Regular.
- b. The number of units to be administered. Example: Humulin Regular 20 units.
- c. **The route of administration (subcut)**. Insulin is usually administered subcutaneously; however, regular insulin, aspart, and glulisine can be administered intravenously, as well.
- d. **The frequency or time of administration**. Example: q AM ½ hour before breakfast.
- e. The **insulin concentration** is written following the name of the insulin with regular insulin U-500. According to ISMP, the insulin concentration (example: Humulin R U-100) does not follow the name of the insulin on the medication administration record (MAR) or other medication lists on which insulin doses are recorded, with the exception of regular insulin U-500. ISMP reported having errors in which the concentration (strength) of the insulin had been mistaken for the dose when written following the name of the insulin. In addition, the most common concentration available and used is U-100.

Example of Insulin Orders: Humulin R 20 units subcut q am ½ hour before breakfast. Humulin R U-500 215 units subcut daily ½ hour before breakfast.

- • When the prescriber orders premixed (combination insulins), the name of the insulin identifying the fixed combination, the number of units to administer, the route of administration, and the frequency of administration should be specified in the order. **Example:** Humalog Mix 50/50 20 units subcut q am 30 minutes before breakfast.

There are times when the prescriber will order two insulins, such as a rapid-acting or short-acting insulin combined with an intermediate-acting insulin. These insulins are administered in the same syringe. The prescriber specifies the name of each insulin, the number of units to be administered, the route of administration, and the frequency of administration. **Example:** Humulin R 18 units and Humulin N 40 units subcut daily at 7:30 am.

To ensure the safe administration of insulin, the nurse must correctly interpret the insulin order and recognize any use of error-prone abbreviations (which include use of "u" for units and "sc" for subcutaneous) that might cause an error in administration of insulin because of misinterpretation.

SAFETY ALERT!

To avoid misinterpretation, the abbreviation "U," which stands for units, should not be used when insulin orders are written. The word *units* should be written out. Errors have occurred as a result of the "U" being mistaken for a "0" in a handwritten order. Example: 6 subcut stat of Humulin Regular. The U is almost completely closed and could be misread as 60 units. The recommendation to write out the word *units* has also been issued by the Institute for Safe Medication Practices (ISMP) and should be included on each accredited organization's "do not use" list approved by The Joint Commission (TJC).

Insulin Coverage Practices

Sometimes, in addition to standing insulin orders, clients may require additional insulin "to cover" their increased blood glucose (sugar) level.

The terms Correction Insulin and Sliding Scale Practices are different approaches used for the same purpose, which is to correct high blood glucose. According to the literature, there are differences between the two practices. Correction insulin is an extra dose of insulin given based on the preprandial (preceding a meal) glucose value, and it is often given in addition to the usual dose that a client takes to cover their meal. A dose of quick-acting insulin such as Novolog, Humalog, or Apidra is administered to lower blood sugar. Correction insulin is said to resemble a sliding scale and has been referred to as a sliding scale.

Traditionally, the use of the sliding scale has been for glycemic control. Sliding scale insulin is generally defined as a set of orders that indicate a certain dosage of insulin is administered based on the client's blood glucose level (the amount of glucose in a given amount of blood, recorded in mg in a deciliter or mg/dL). Orders for the sliding scale may also indicate capillary blood glucose (CBG) to indicate the checking of blood glucose for the sliding scale. Most sliding scales use regular (short-acting) insulin or lispro (rapid-acting) insulin. The prescriber specifies the dosage of insulin, which can increase or decrease based on a specific blood glucose level range. Sliding scales are individualized to the client. When orders for sliding scale are written, the order must include the type of insulin to be administered, the amount of insulin (in units), and the specific blood glucose range. In addition, the order should include the frequency for blood glucose checks. A sample sliding scale is shown below. Using the sliding scale, if the blood glucose level for the client is 135 mg/dL, you would not administer any insulin because 135 mg/dL is less than 180 mg/dL. However, if the client's blood glucose level is 200 mg/dL, you would administer 2 units of regular insulin immediately because 200 mg/dL is between 181 and 240 mg/dL.

Sample Insulin Sliding Scale

Sample Insulin Sliding Scale	
Humulin Regular U-100 according to finger stick q8h	
0-180 mg/dL	No coverage
181-240 mg/dL	2 units subcut
241-300 mg/dL	4 units subcut
301-400 mg/dL	6 units subcut
Greater than 400 mg/dL	8 units subcut stat and notify doctor Repeat finger stick in 2 hr

TIPS FOR CLINICAL PRACTICE

When orders are written for sliding scale, the abbreviation “SS” should not be used to mean sliding scale. In the apothecary system, ss means 1/2, and ss could also be mistaken for the number 55. Write out sliding scale.

Note that the process for documenting the insulin administered varies among institutions. Know the institution’s policies and protocols regarding the use of the sliding scale.

Despite current evidence cited in the literature indicating the sliding scale as not being effective in achieving glycemic control, and discouragement regarding its use by the American Diabetes Association (ADA), the sliding scale continues to be a common practice in some health care institutions to correct hyperglycemia (high blood glucose) in hospitalized clients.

Current Recommendations Regarding Use of the Sliding Scale

ISMP’s 2017 *Guidelines for Optimizing Safe Subcutaneous Insulin use in Adults* recommends eliminating the use of sliding scale insulin doses based on blood glucose values as the only strategy for managing hyperglycemia. This concurs with the American Association of Clinical Endocrinologists (AACE), the American Diabetes Association (ADA), and the Endocrine Society. “Scheduled subcutaneous administration of insulin is the preferred method for achieving and maintaining glucose control in non-critically ill patients with diabetes or stress hyperglycemia.” It has been found that the use of a sliding scale insulin regimen alone results in undesirable hypoglycemia (low blood glucose) and hyperglycemia (high blood glucose) and high risk of hospital complications. Scheduled subcutaneous insulin administration with basal insulin, nutritional (meal), and correctional components has been shown to promote the best outcomes in non–critically ill clients and to be safe and effective in managing hyperglycemia in non-critical hospital patients.

The basal insulin component uses a long-acting insulin analog to control the fasting plasma glucose level, and the nutritional component uses rapid-acting insulin to cover nutritional intake and correct hyperglycemia. The basal plus rapid-acting insulin is referred to as *basal/bolus insulin therapy,* which closely approximates normal physiological insulin production and controls hyperglycemia. The correction dose is determined by the patient’s insulin sensitivity and current blood glucose level. Insulin sensitivity is calculated by adding up the patient’s total daily insulin requirement and dividing that amount into 1,500 (for type 2 DM) or 1,700 (for type 1 DM). The use of this management combines the basal insulin with mealtime (prandial insulin).

In summary, the basal-prandial insulin therapy is a physiological approach to insulin therapy that uses multiple daily injections to cover both basal and prandial therapy. The basal prandial insulin therapy is a regimen that has evidence to support it as being optimal to achieving glycemic control in clients with diabetes.

Preparing a Single Dosage of Insulin in an Insulin Syringe

Measuring insulin in an insulin syringe is different from the administration of most other injectable medications. There is no calculation or conversion required because the syringe measures units of insulin, rather than volume of solution. An order must be written following the previously stated guidelines. Frequent errors have occurred with insulin dosages, and insulin is considered a high-alert medication. Because of this, special attention should be used when preparing dosages of insulin. Insulin dosage errors can be avoided by following two important rules to ensure safe administration of insulin.

RULE

Avoiding Insulin Dosage Errors

- • Insulin dosages MUST be checked by two nurses. To be considered an independent verification, the check by the second nurse must occur independently, away from the first nurse, with no prior knowledge of calculations to verify the dosage.
- • In the preparation of combination dosages (two insulins), two nurses must verify each step of the process.

Example 1: Order: Humulin R 40 units subcut in am ½ hr before breakfast

Available: Humulin R labeled U-100

To measure 40 units, withdraw insulin to the 40-unit mark on the U-100 syringe. A Lo-Dose syringe can also be used to draw up this dose, as shown below.

Example 2: Order: Humulin N 70 units subcut daily at 7:30 am

Available: Humulin N labeled U-100

There is no calculation or conversion required here. Draw up the required amount using a U-100 (1-mL) syringe.

Example 3: Order: Humulin R 5 units subcut stat

Available: Humulin R labeled U-100

Measuring Two Types of Insulin in the Same Syringe

Sometimes individuals may require two different types of insulin for control of their blood sugar levels: for example, NPH and regular. To decrease the number of injections, it is common to mix two insulins in a single syringe. To mix insulin in one syringe, remember:

RULE

Safety When Combining Two Insulins in the Same Syringe

Draw up clear insulin first, and then draw up cloudy insulin. Rapid- and short-acting insulins are clear (regular, aspart, lispro). Intermediate-acting (NPH) insulin is cloudy.

THINK: First rapid-acting or short-acting insulin, then intermediate-acting insulin.

THINK: The insulin that acts first is drawn up first.

Drawing regular insulin up first prevents contamination of the regular insulin with other insulin. This sequence is extremely important.

To prepare insulin in one syringe (mixing insulin), complete the following steps (Figures 19.7 and 19.8):

Figure 19.7 Mixing insulins. Order: Humulin N 30 units subcut, Humulin R, 12 units subcut. Step 1, Inject 30 units of air into Humulin N first; do not allow needle to touch insulin. Step 2, Inject 12 units of air into Humulin R. Step 3, Withdraw 12 units; withdraw needle. Step 4, Insert needle into vial of Humulin N and withdraw 30 units. Total 30 units Humulin N (NPH) + 12 units Humulin R (Regular) = 42 units. (Modified from Harkreader H, Hogan MA: *Fundamentals of nursing: caring and clinical judgment,* ed 3, St. Louis, 2007, Saunders.)

Figure 19.8 Total of two insulins combined. Total = 42 units (30 units Humulin N + 12 units Humulin R).

- 1. Cleanse tops of both vials with an alcohol wipe.
- 2. Inject air equal to the amount being withdrawn into the vial of cloudy insulin first. When the air is injected, the tip of the needle should not touch the solution.
- 3. Remove the needle from the vial of cloudy insulin.
- 4. Using the same syringe, inject an amount of air into the regular insulin (clear) equal to the amount to be withdrawn, invert or turn the bottle up in the air, and draw up the desired amount.
- 5. Remove the syringe from the regular insulin, and check for air bubbles. If air bubbles are present, gently tap the syringe to remove them.
- 6. Next, withdraw the desired dosage from the vial of cloudy insulin.
- 7. The total number of units in the syringe will be the sum of the two insulin orders.

Note: Provide the order, vial of insulin, and syringe to another nurse for independent verification each time you draw up an insulin dose.

SAFETY ALERT!

DO NOT combine long-acting insulin types or dilute them with any other insulin preparation. The effects can be life threatening.

TIPS FOR CLINICAL PRACTICE

- • Cloudy insulin should be rolled gently between the palms of the hands to mix it before it is drawn up. *Do not* shake insulin. Shaking creates bubbles in addition to breaking down the particles and causing clumping.
- • Insulins mix instantly; they do not remain separated. Therefore insulin that has been overdrawn cannot be returned to the vial. You must discard the entire medication and start over.

Example 1: The order is to administer 18 units of Humulin R subcut and 22 units subcut of Humulin N.

The total amount of insulin is 40 units (18 units [Humulin R] + 22 units Humulin N = 40 units).

To administer this dosage, a Lo-Dose syringe or a U-100 (1-mL) syringe can be used. However, because the dosage is 40 units, the Lo-Dose would be more desirable. (See the syringes that follow, illustrating this dosage.)

TIPS FOR CLINICAL PRACTICE

When mixing insulins, follow the steps outlined. Committing one of the following phrases to memory may help you remember the steps: (1) last injected is first drawn up; (2) run fast first (regular), then slow down (NPH); (3) clear to cloudy; or (4) it is alphabetical: clear, cloudy. Also remember, when mixing insulins, only the same type should be mixed together – for example, Humulin and Humulin.

Non-Insulin Medications

There are medications being used for the treatment of diabetes mellitus that are not insulin but deserve a brief mention in this chapter. These medications may be used in patients having trouble getting to their goal with insulin therapy. These medications may also be used to lower the A1C. A1C stands for glycated hemoglobin. According to the literature, "A1C measures the amount of glucose that attaches to hemoglobin, part of the red blood cells. The more glucose that attaches the higher the A1C." A1C test is used to diagnose diabetes as well as assess how well a person is managing their diet, food, activity, and blood glucose levels. The A1C can help in determining potential complications from diabetes (such as kidney, cardiovascular, and other problems). There are some medications that decrease the risks of major adverse cardiovascular (CV) events as well as decrease the risk of major CV events in clients with diabetes who have established CV disease. These medications are not insulin, and some may be given as adjunct therapy to diet and exercise to improve glycemic control while improving the A1C or with insulin therapy. Examples of these medications include oral forms that must be taken daily, such as Jardiance (empagliflozin), and Farxiga (dapagliflozin) (Figure 19.9). Injectable forms include Victoza (liraglutide), which is injected once a day subcutaneously, and Trulicity (dulaglutide) (Figure 19.10), which is administered once weekly subcutaneously. Note that only a few examples of these medications are provided here.

Figure 19.9 Farxiga 5-mg tablets.

Figure 19.10 Trulicity single-dose pen, 1.5 mg per 0.5 mL.

As nurses, we need to remember the importance of taking steps to prevent errors that can occur in dosage administration. Extra care must be taken to prevent errors with high-alert medications. The results can be fatal to a client. Reading insulin labels carefully, obtaining independent verification of dosages by another nurse before administering insulin, recognizing the use of dangerous abbreviations associated with insulin and the errors they can cause, and performing practices that support safety and prevent harm to a client are part of the QSEN competency of safety. Safety competencies have been incorporated in this chapter to ensure that you consider safety in each aspect of insulin administration.

POINTS TO REMEMBER

- • U-100 means 100 units per mL.
- • Carefully read the prescriber's orders.

- • To ensure accuracy, U-100 insulin should be given only with an insulin syringe. Insulin syringes should not be used to measure other medications measured in units.
- • U-100 insulin is designed to be given with syringes marked U-100.
- • Insulin dosages must be exact. Read the calibration on the insulin syringes carefully.
- • Lo-Dose syringes are desirable for small dosages up to 50 units. The Lo-Dose 30-unit syringe may be used for dosages up to 30 units. Although Lo-Dose insulin syringes (30 units and 50 units) can hold a smaller volume, they are intended for U-100 insulin only.
- • A U-100 (1-mL capacity) syringe is desirable when the dosage exceeds 50 units.
- • Drawing up insulin correctly is critical to safe administration of insulin to clients.
- • When insulins are mixed, regular insulin (clear) is always drawn up first, then cloudy.
- • Do not shake insulin. Roll the insulin gently between the palms of the hands to mix.
- • When insulins are mixed, the total volume is the sum of the two insulin amounts in units.
- • Regular insulin, aspart, and glulisine are approved for IV administration.
- • Read insulin labels to ensure that you have the correct type of insulin, to avoid medication errors. Only mix the same types of insulin (e.g., Humulin R and Humulin N).
- • Use the smallest-capacity syringe possible to ensure accuracy.
- • Insulin orders should be written with units spelled out, not abbreviated U.
- • Do not mix long-acting insulin with any other insulin or dilute with any other insulin preparation.
- • Avoid insulin dosage errors; always obtain an independent verification by a second nurse.
- • U-500 insulin means 500 units per mL. U-500 is 5x more potent than U-100.
- • Use U-500 syringe to measure and administer U-500 insulin.
- • Current evidence supports basal-prandial insulin therapy, which improves client outcomes and is an optimal strategy for achieving glycemic control in diabetic clients.

CLINICAL REASONING

- 1. **Scenario:** The prescriber wrote the following insulin order:
- Humulin 10

subcut

breakfast.

- The nurse assumed the order was for regular insulin 100 units and administered the insulin to the client.
- Later, it was discovered the insulin dose desired was NPH 10 units.
- - a. What error occurred here? _____
  - b. What client medication rights were violated? _____

- c. What is the potential outcome of the error? _____
- d. What measures could have been taken to prevent the error that occurred? _____

- 2. **Scenario:** A client is to receive Humulin R 10 units subcut and Humulin N 14 units subcut before breakfast. In drawing up the insulins in the same syringe, the nurse used the following technique:
- a. Injected 10 units of air into the regular vial.
- b. Injected 14 units of air into the NPH vial.
- c. Withdrew 14 units of NPH insulin, then the 10 units of regular insulin.
  - (a) What is the error in the technique of drawing up the two insulins? _____
  - (b) What is the potential outcome from the technique used? _____

Answers on pp. 461-462

CHAPTER REVIEW

Using the syringes below and the labels where provided, indicate the dosage you would prepare and shade the dosage on the syringe provided. All insulin available is U-100 unless specified otherwise.

- 1. Order: Humulin N 56 units subcut daily every am ½ hour before breakfast.
- Available:

- 2. Order: Humulin R 18 units subcut and Humulin N 40 units subcut daily at 7:30 am. (Indicate the total insulin dosage.)
- Available:

- 3. Order: Novolin R 9 units subcut daily.
- Available:

- Indicate the number of units measured in the following syringes.

- 4. Units measured
- 5. Units measured
- 6. Units measured
- 7. Units measured
- 8. Units measured
- 9. Units measured

- 10. Units measured

- Calculate the dosage of insulin where necessary, and shade the dosage on the syringe provided. Labels have been provided for some problems.
- 11. Order: Humulin R 10 units subcut at 7:30 am.

- 12. Order: Humulin R 16 units subcut and Humulin N 24 units subcut a.c. 7:30 am. (Indicate the total insulin dosage.)

- 13. Order: Humulin R 10 units subcut and Humulin N 15 units subcut a.c. 7:30 am. (Indicate the total insulin dosage.)

- 14. Order: Humulin R 5 units subcut and Humulin N 25 units subcut a.c. 7:30 am. (Indicate the total insulin dosage.)

- 15. Order: Novolin R 40 units subcut and Novolin N 10 units subcut at 7:30 am. (Indicate the total insulin dosage.)

- 16. Order: Humulin N 48 units subcut and Humulin R 30 units subcut a.c. 7:30 am. (Indicate the total insulin dosage.)

- 17. Order: Novolin R 16 units subcut and Novolin N 12 units subcut 7:30 am. (Indicate the total insulin dosage.)

- 18. Order: Novolin R 17 units subcut 5 pm.

- 19. Order: Humalog 15 units subcut daily at 7:30 am.

- 20. Order: Humulin R 26 units subcut and Humulin N 48 units subcut daily. (Indicate the total insulin dosage.)

- 21. Order: Humulin 70/30 27 units subcut at 5 pm.

- 22. Order: Novolin R 21 units subcut and Novolin N 35 units subcut daily at 7:30 am. (Indicate the total insulin dosage.)

- 23. Order: Novolin R 5 units subcut and Novolin N 35 units subcut 7:30 am. (Indicate the total insulin dosage.)

- 24. Order: NovoLog 36 units subcut 7:30 am before breakfast.

- 25. A client has a sliding scale for insulin dosages. The order is for Humulin Regular insulin q6h as follows:

Finger stick	0-180 mg/dL	no coverage
Blood sugar (mg/dL)	181-240 mg/dL	2 units subcut
	241-300 mg/dL	4 units subcut
	301-400 mg/dL	6 units subcut
	Greater than 400 mg/dL	8 units subcut and repeat finger stick in 2 hr

- At 11:30 am, the client's finger stick is 364 mg/dL. Shade the syringe to indicate the dosage that should be given.

- 26. Order: Humulin R 32 units subcut every morning at 7:30 am.

- 27. Order: Humulin R 9 units subcut 5 pm.

- 28. Order: Humulin N 11 units subcut at bedtime.

- 29. Order: Humulin 70/30 20 units subcut ½ hr before breakfast.

- 30. Order: Humulin R 10 units subcut and Humulin N 42 units subcut at 4:30 pm. (Indicate the total insulin dosage.)

- 31. Order: Novolin R 8 units subcut and Novolin N 15 units subcut at 7:30 am. (Indicate the total insulin dosage.)

- 32. Order: Humulin R 30 units subcut and Humulin N 40 units subcut every day at 8:00 am. (Indicate the total insulin dosage.)

- 33. A client has a sliding scale for insulin dosages. The order is for Humulin R q6h as follows:

Finger stick	201-250 mg/dL	4 units subcut
Blood sugar (mg/dL)	251-300 mg/dL	6 units subcut
	301-350 mg/dL	8 units subcut
	351-400 mg/dL	10 units subcut call MD
	Greater than 400 mg/dL	

- At 6:00 pm, the client's blood sugar is 354 mg/dL. Shade the syringe to indicate the dosage that should be administered.

- For problems 34 through 38, shade the dosage in on the syringe; available is:

- 34. Order: Humulin R U-500 200 units subcut stat.

- 35. Order: Humulin R U-500 225 units subcut stat.

- 36. Order: Humulin R U-500 235 units subcut stat.

- 37. Order: Humulin R U-500 175 units subcut qAM before breakfast.

- 38. Order: Humulin R U-500 165 units subcut stat.

Answers on pp. 462-463

For additional practice problems, refer to the the Dosages Measured in Units section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

ANSWERS

Chapter 19

Answers to Practice Problems

- 1. Humalog, rapid-acting (fast-acting)
- 2. Humulin R Regular, short-acting
- 3. Lantus, long-acting
- 4. Humulin N, NPH, intermediate-acting
- 5. 22 units
- 6. 41 units
- 7.

- 8.

- 9. 40 units
- 10. 27 units
- 11. 64 units
- 12. 14 units
- 13.

- 14.

- 15.
- 16. 95 units
- 17. 140 units
- 18.
- 19.

Answers to Clinical Reasoning Questions

- 1.
  - a. The wrong insulin was administered. Failure to clarify an insulin order when the type of insulin was not specified, and the dosage was not clear because the U for units was used. U almost closed and caused the “U” to be mistaken for “0.”
  - b. The right medication, the right dosage.
  - c. The client received 10 times the dose of an insulin (regular) that was not ordered. Regular insulin is short acting, and NPH is intermediate acting and was desired. Administering the insulin would likely cause a dangerously low glucose level (hypoglycemia). Results could be tremors, confusion, sweating, and death. This incident constitutes malpractice.
  - d. The error could have been prevented by remembering that all the essential components of an insulin order should have been in the order (name of insulin, number of units to be administered, route of administration, and frequency or time. When one element is missing, never assume. The order should have been clarified with the prescriber. Further, the dosage should have been double-checked with another nurse. In addition, units should have been written out in the order to avoid misinterpretation of “U” as a zero (0). Many insulin errors occur when the nurse fails to clarify an incomplete order or misinterprets the dosage when units is abbreviated.
- 2.
  - a. The nurse should have injected the 14 units of air into the NPH vial and then injected 10 units of air into the regular vial and drawn up the 10 units of regular insulin first. First regular, then NPH. Another nurse should have been present during the mixing and to verify the dosage drawn.

- b. Contamination of insulins. Regular (rapid acting) is drawn up first to prevent it from becoming contaminated with the intermediate-acting insulin. This can also result in reversing the doses of the two insulins being drawn up and result in incorrect insulin dosages.

Answers to Chapter Review

- 1.
- 2.
- 3.
- 4. 15 units
- 5. 26 units
- 6. 16 units
- 7. 52 units
- 8. 38 units
- 9. 65 units
- 10. 15 units
- 11.
- 12. 40 units

- 13. 25 units
- 14. 30 units
- 15. 50 units
- 16. 78 units
- 17. 28 units

- 18.
- 19.
- 20. 74 units
- 21.
- 22. 56 units
- 23. 40 units

- 24.

- 25. 6 units for blood sugar level of 364 mg/dL

- 26.

- 27.

- 28.

- 29.

- 30. 52 units

- 31. 23 units

- 32. 70 units

- 33. 10 unit blood sugar 354 mg/dL

- 34.

- 35.
- 36.
- 37.
- 38.

chapter - Section 36 (Page 333)

Unit Five

Intravenous, Heparin, and Critical Care Calculations and Pediatric and Adult Calculations Based on Weight

unknown - Section 37 (Page 336)

UNIT FIVE

Introduction to Intravenous, Heparin, and Critical Care Calculations and Pediatric and Adult Calculations Based on Weight

The ability to accurately calculate flow rates for intravenous medications is essential to both heparin administration and critical care calculations.

- **Chapter 20 Intravenous Solutions and Equipment**
- **Chapter 21 Intravenous Calculations**
- **Chapter 22 Heparin Calculations**
- **Chapter 23 Critical Care Calculations**
- **Chapter 24 Pediatric and Adult Dosage Calculations Based on Weight**

unknown - Section 38 (Page 338)

A general discussion of intravenous therapy will make it easier to understand the calculations associated with IV therapy, which will be discussed in Chapter 21. Intravenous (IV) therapy is the infusion of fluids (solutions), nutrients (i.e., *vitamins, electrolytes, carbohydrates, fatty acids*), blood or blood products, or medications through a vein. IV fluids can be ordered to infuse continuously or intermittently. The reasons for the ordering and administration of IV fluids are varied and include:

- • To maintain fluid and electrolyte balance. Fluids that are given to help sustain normal levels of fluids and electrolytes are called *maintenance fluids*.
- • To replace lost fluids—when a client has lost fluids as a result of vomiting, diarrhea, or hemorrhage, IV fluids are administered to replenish fluid volume, and referred to as *replacement fluids*.
- • To prevent depletion in clients who have the potential to become depleted, such as a client who is allowed nothing by mouth (NPO) for surgery or prior to the administration of chemotherapy.
- • Act as a medium for administering medications directly into the bloodstream. Fluids administered directly into the bloodstream have a rapid effect that is necessary during emergencies or other critical care situations when medications are needed. The advantage of administering medications by this route is the immediate availability of the medication to the body and the rapidity of action. However, IV administration of medications can be rapidly fatal to the client if the incorrect medication or dosage is administered. There are numerous medications available for IV use. Each medication has guidelines relating to its use. Health care providers are responsible to know about the medications they administer and the protocol relating to IV administration of medications.

IV medication protocols are valuable references, oft en posted in the medication room of an institution, found in a medication reference book, and online. They provide nurses with specifics about usual medication dosage, dilution for IV administration, compatibility, and specific observations of a client that need to be made during medication administration. **Always adhere to the protocol for administering IV medications.**

IV Delivery Methods

IV fluids and medications can be administered by continuous and intermittent infusion.

- • *Continuous IV infusions* replace or maintain fluids and electrolytes. As the name implies, a continuous infusion is an IV solution that flows continuously until it is changed.
- • *Intermittent IV infusions* (e.g., IV piggyback [IVPB], IV push) are used to administer medications and supplemental fluids. Intermittent peripheral infusion devices, known as saline or heparin locks, are used to maintain venous access without the need for continuous infusion.
- • Hypodermoclysis (HDC), or clysis, is the subcutaneous infusion of fluids. It is considered to be an easy hydration technique suitable for mildly to moderately dehydrated adult clients, especially the elderly; for clients who are unable to take adequate fluids orally; and for clients for whom it is difficult or impractical to insert an intravenous line. The advantages of hypodermocylsis include: it can be administered at home by family members or a nurse; it is simple to insert; and it lessens the need for hospitalization of a client for hydration.

IV Solutions

There are several types of IV fluids. The type of fluid used is individualized according to the client and the reasons for its use. IV solutions are available in glass bottles and plastic bags. IV plastic bags are more commonly used. IV solutions come prepared in plastic bags and are in various sizes, including 1,000 mL, 500 mL, 250 mL, 100 mL, 50 mL, and 25 mL. The larger-volume IV bags (500 and 1,000 mL) are usually used for continuous IV infusion in adults. The smaller-volume IV bags (usually 50 or 100 mL) are used for IV piggyback (IVPB), also referred to as a secondary IV line, and used to dilute medications for intermittent IV administration. Most IV solution bags are clearly labeled with the exact components of the IV solution, the amount of solution in the bag, storage and handling information, and the expiration date. The large-volume IV bags also have numbered markings on the side of the bag. The smaller IV bags have the same information as the large-volume IV bags, with the exception that they do not have the numbered line markings on the side of the bag. ***Note:*** The amount of IV solution, as well as the type of solution a medication is diluted in, depends on the medication being administered and is determined by the drug manufacturer. When IV solutions are written in orders and medical records (electronic or handwritten), abbreviations are used. You may encounter various abbreviations; however, the percentage and initials, regardless of how they are written, have the same meaning: “D” is for dextrose, “W” is for water, “S” is for saline, and “NS” is for normal saline. Ringer’s lactate (lactated Ringer’s), a commonly used electrolyte solution, is abbreviated “RL” or “LR” and occasionally “RLS.” Refer to Box 20.1, and learn the common abbreviations for IV solutions. Figures 20.1 to 20.6 show various IV solutions. Abbreviations are often used when health care providers discuss IV solutions. It is important for nurses to know the common IV solution components and the solution concentration strengths represented by such abbreviations. Refer to Box 20.1 and learn the common abbreviations for IV solutions. Since the name for IV solutions is usually discussed and ordered using abbreviations, it is imperative that the nurse carefully read the label on IV solutions to ensure that the correct solution is administered and that the correct solution is infusing on clients who have IV therapy in progress.

BOX 20.1 Abbreviations for Common IV Solutions

NaCl	Sodium chloride

NS	Normal saline (0.9% NaCl)
½ NS	½ Normal saline (0.45% NaCl)
D_5W or 5% D/W	Dextrose 5% in water
D_5W or D5RL	Dextrose 5% and lactated Ringer's (Ringer's lactate)
RL or RLS	Lactated Ringer's solution (electrolytes)
D_5NS	Dextrose 5% in normal saline (0.9% NaCl)
D_5 and ½ NS (0.45%)	Dextrose 5% in ½ normal saline (0.45% NaCl)

Note: IV bags are labeled as sodium chloride (NaCl) but frequently referred to as normal saline (NS).

Note: IV bags are labeled as sodium chloride (NaCl) but frequently referred to as normal saline (NS).

Figure 20.1 5% Dextrose (D_5W).

Figure 20.2 Lacated Ringer's and 5% dextrose (D_5LR).

Figure 20.3 5% Dextrose in 0.9% sodium chloride (D_5NS).

Figure 20.4 5% Dextrose in 0.45% sodium chloride (D_5 1/2 NS).

Figure 20.5 0.9% Sodium chloride.

Figure 20.6 20 mEq Potassium chloride in 5% dextrose and 0.45% sodium chloride.

SAFETY ALERT!

Administration of the right IV fluids to the right client at the right rate and monitoring the client during the therapy is a safety priority and are essential nursing responsibilities. If a client receives the incorrect IV fluid, an IV infusion too rapidly, and is not monitored closely, reactions can vary from mild to severe (death). Follow the same six rights of medication administration when administering IV therapy to clients. IV fluids are considered to be medications.

IV Solution Components

Intravenous fluids generally contain glucose (dextrose), sodium chloride (NaCl), water, and/or electrolytes. The components of IV fluids are indicated on the label of the IV fluid. IV fluids vary in terms of their components and the concentration of the components.

IV Solution Strength

The abbreviation letters indicate the components in the IV solution, and the numbers indicate the solution strength or concentration of the components in the IV fluid. The numbers may be written as subscripts; for example, D_5W (dextrose 5% in water).

Normal saline solutions are written with 0.9 and the percent sign included (e.g., 0.9% NS). NS is the abbreviation used for normal saline. Normal saline is also referred to as sodium chloride (NaCl). Saline is available in different percentages. Normal saline is the common term used for 0.9% sodium chloride.

Another common saline IV concentration is 0.45% NaCl, often written as 1/2 NS (0.45% is half of 0.9%). Other saline solution strengths include 0.33% NaCl, also abbreviated as 1/3 NS, and 0.225% NaCl, also abbreviated as 1/4 NS. Some IV orders, therefore, may be written as 1/2 NS, 1/4 NS, or 1/3 NS. IV solutions can contain saline only (see Figure 20.5) or saline mixed with dextrose, which would be indicated with percentage of dextrose (e.g., D_5 0.9% sodium chloride) (see Figures 20.3 and 20.4).

SAFETY ALERT!

Pay close attention to IV abbreviations. The letters indicate the solution components, whereas the numbers indicate the solution strength.

Let's examine some IV labels (see Figures 20.1 to 20.7). Recall from Chapter 4 that solution strength expressed as percent (%) indicates the number of grams (g) per 100 milliliters (mL).

Figure 20.7 25,000 units of Heparin in 250 mL of 5% Dextrose.

- • D_5W. This abbreviation means dextrose 5% in water, which means each 100 mL of solution contains 5 g dextrose (Figure 20.1).
- • D_5RL. This abbreviation means 5% dextrose in lactated Ringer's. Lactated Ringer's is a solution containing electrolytes, including potassium chloride and calcium chloride (Figure 20.2).
- • 5% Dextrose and 0.9% sodium chloride. This solution contains 5 g of dextrose and 0.9 g (or 900 mg) of sodium chloride per 100 mL solution (Figure 20.3).
- • 5% Dextrose and 0.45% sodium chloride. This solution contains 5 g of dextrose and 0.45 g (or 450 mg) of sodium chloride per 100 mL solution (Figure 20.4).
- • NS or 0.9% NaCl. This solution contains 0.9 g (or 900 mg) of sodium chloride per 100 mL (Figure 20.5).

IV Solution Additives

Some IV solutions are available, premixed by the manufacturer, with additives such as medications or electrolytes. Figure 20.6 shows an IV solution premixed with potassium chloride (KCl), a commonly prescribed additive to IV fluids. In many institutions, IV solutions are available premixed with potassium. Premixed additives are clearly marked on IV solutions as shown in Figure 20.6 and Figure 20.7. Potassium chloride is a *high-alert medication*. Notice the label on the IV has the "20 mEq potassium" indicated in red. Notice the solution with the additive potassium (Figure 20.6) is the same as the IV solution shown in Figure 20.4, 5% dextrose and 0.45% sodium chloride without potassium. **Do not confuse these two solutions. Always read the labels carefully.** Figure 20.7 shows an IV solution premixed with heparin (heparin 25,000 units in 250 mL of 5% dextrose). Heparin is also a *high-alert medication* that is an anticoagulant (blood thinner) that prevents the formation of blood clots. Notice the amount of heparin added to the IV solution is also indicated in red. Notice the dosage strength is indicated per total amount of the bag (25,000 units per 250 mL) and per mL (100 units per mL). Also notice it also indicates on the IV solution, *"Additives should not be made to this solution."* Heparin will be further discussed in Chapter 22. Additives can also be inserted in the IV bag through an injection port by the nurse or a pharmacist. If this is done, a label clearly indicating the name and amount of additive, date, time, and signature of the person who added the additive must be applied to the solution container.

SAFETY ALERT!

Before placing any additives in an IV solution (vitamins, medications, electrolytes), be sure the additives are compatible with the solution. Some incompatible additives may cause the solution to become cloudy or crystallize. Always verify the compatibility of the additive and solution.

IV Orders

The prescriber is responsible for writing the order. However, administering and monitoring an IV is a nursing responsibility. An IV order (Figure 20.8, shows sample IV orders) **must** specify the following:

- • Name of the IV solution
- • Name of medication to be added, if any
- • Amount (volume) to be administered
- • Time period during which the IV is to infuse

Figure 20.8 Sample IV orders.

SAFETY ALERT!

Remember the following when adding potassium to an IV:

- • It should be compatible with the solution and well diluted.
- • Monitor client during infusion; rapid infusion of potassium can cause death due to cardiac depression, arrhythmias, and arrest.
- • Check IV site frequently; medication is extremely irritating.
- • Administer IV using an infusion control device.
- • Never administer potassium concentrate IV push.
- • DO NOT add potassium to an IV bag that is already infusing. Injecting potassium into an upright infusing IV solution causes the medication to concentrate in the lower portion of the IV bag, resulting in the client receiving a concentrated medication solution, which can be harmful.

Charting of IV Solution

IV fluids are charted on the intake and output (I&O) sheet; in some institutions, they are also charted on the medication administration record (MAR). Figure 20.9 is a sample I&O charting record. In institutions where there is computer charting, this information is entered into the electronic record.

Figure 20.9 Sample of charting IV fluids on an I&O record.

Calculating Percentage of Solute in IV Fluids

The amount of each ingredient in an IV fluid can be calculated; however, it is not necessary because the label on the IV solution indicates the amount of each ingredient. Calculation of the percentage of solutions was presented in Chapter 4, which deals with percentages.

As you may recall, it is possible to determine the percentage of substances such as dextrose in IV solutions. It is important to remember that **solution strength expressed as a percentage means grams of solute per 100 mL of fluid.** Therefore 5% dextrose solution will have 5 g of dextrose in each 100 mL. In addition to the amount of dextrose in the solution, amounts of other components, such as sodium chloride, can be determined. To calculate the amount of a specific component in an IV solution, a ratio and proportion or dimensional analysis can be used.

Example 1: Calculate the amount of dextrose in 500 mL D_5W. Remember % = g per 100 mL; therefore 5% dextrose = 5 g dextrose per 100 mL.

Solution Using Ratio and Proportion

Linear Format: 5 g:100 mL = *x* g:500 mL *or* Fraction Format: 5g100mL=xg500mL

100x100=2,500100

x = 25 g

500 mL D_5W contains 25 g of dextrose

Remember that ratios and proportions can be stated in linear or fraction format.

Solution Using Dimensional Analysis

5% dextrose = 5 g dextrose per 100 mL. Enter it as the starting fraction, and determine the number of grams in the solution.

Example 2: Calculate the amount of sodium chloride (NaCl) in 1,000 mL NS.

0.9% = 0.9 g NaCl per 100 mL

0.9% = 0.9 g NaCl per 100 mL

Solution Using Ratio and Proportion

Linear Format: 0.9 g : 100 mL = *x* g : 1,000 mL *or* Fraction Format: 0.9g100mL=xg1,000mL

100x100=900100x=9gNaCl

1,000 mL of NS contains 9 g of sodium chloride

Solution Using Dimensional Analysis

0.9% = 0.9 g NaCl per 100 mL. Use the grams of solute per 100 mL of fluid as the starting fraction.

Example 3: Calculate the amount of dextrose and sodium chloride in 1,000 mL of 5% dextrose and 0.45% normal saline (D5 and ½ NS or D_5 1/2 NS).

Solution Using Ratio and Proportion

D_5 = dextrose 5% = 5 g dextrose per 100 mL

0.45% NS = 0.45 g NaCl per 100 mL

Linear Format: Dextrose: 5 g:100 mL = *x* g:1,000 mL *or* Fraction Format: 5g100mL=xg1,000mL

100x100=5,000100x=50gdextrose

Linear Format: NaCl: 0.45 g : 100 mL = *x* g : 1,000 mL *or* Fraction Format: 0.45g100mL=xg1,000mL

100x100=450100x=4.5gNaCl

1,000 mL D_5 0.45% NS contains 50 g of dextrose and 4.5 g of NaCl

Solution Using Dimensional Analysis

5% dextrose = 5 g dextrose per 100 mL

0.45% NS = 0.45 g NaCl per 100 mL

1,000 mL D_5 0.45% NS contains 50 g of dextrose and 4.5 g of NaCl

Vascular Access Devices

IV fluids may be infused through a peripheral vein or central vein using a vascular access device (VAD), also known as a venous access device.

Peripheral line—Generally used for short-term therapy. The infusion site of a peripheral line is a vein in the arm, hand, or scalp in an infant; or if other sites are not accessible, and on rare occasions, a vein in the leg.

Central line—Provides direct access to large major veins. Used for long-term therapy. For a central line, a special catheter is used to access a large vein near the heart, such as the subclavian or jugular vein. A central line is used for infusion of large amounts of fluids and for infusion of highly concentrated electrolyte replacements, chemotherapy (infusion of medications for cancer), and total parenteral nutrition (TPN). TPN is an IV solution that provides nutrients. Parenteral nutrition solutions consist of glucose, amino acids, minerals, vitamins, and/or fat emulsions. Examples of central catheters include single-lumen, triple-lumen, Hickman, Broviac, and Groshong catheters.

- • **Peripherally inserted central catheter (PICC line)—**When a peripheral vein is used to access a central vein. A PICC line is inserted into the antecubital vein in the arm and is advanced into the superior vena cava.
- • **Port-A-Cath—**Used to deliver medication to a central vein. The device is surgically placed under the skin, usually on the upper chest. When the device is in place, there is no part of the central venous catheter that is outside the body. The device is accessed using a special needle (to administer medications or draw blood) that goes through the skin and into the port.

Saline lock—Intermittent venous access device (Figure 20.10) used for the purpose of administering IV medication intermittently or for access to a vein in an emergency situation and can be used to administer medications IV push (IV bolus). A saline lock is a short IV line that is attached to an IV catheter that is capped off on the end and can be accessed by a needle or needleless system to administer medications intermittently. Various institutions use a needleless system for administration of medications through the access devices such as the saline lock as well as the primary line. Intermittent venous access devices are referred to as *med locks, saline locks, heparin locks, IV lock,* and *intermittent peripheral infusion devices* (IPIDs). Venous access devices are referred to as saline locks because they are periodically flushed with sterile normal saline solution for injection, or with heparin (heparin lock) to keep the line patent. Due to bolusing of clients when heparin is used, heparin (a potent anticoagulant despite its use in

dilute form) is now used at most institutions on the initial insertion of the catheter. For subsequent flushing of the port, normal saline solution is used (1 to 3 mL, depending on institution policy).

Figure 20.10 Intermittent lock covered with a rubber diaphragm. (From Potter PA, Perry AG, Stockert P, Hall A: *Fundamentals of nursing*, ed 9, St. Louis, 2017, Elsevier.)

SAFETY ALERT!

Remember heparin is a high-alert medication that comes in many dosage strengths (concentrations). The concentration for a heparin lock flush is 10 units per mL or 100 units per mL. The average heparin flush is 10 units and never exceeds 100 units. Always check the concentration of heparin carefully.

When medications are administered through an intermittent access device, the device must be flushed before and after medication is given. **Always refer to the policy at your institution or health care agency regarding the frequency, volume, and concentration of saline or heparin to be used to maintain the IV lock.**

Medications can be administered through a port used for direct injection of medication by syringe or directly into the vein by venipuncture. This is referred to as IV **push** or **bolus**. IV push indicates that a syringe is attached to the lock and pushed in over a certain period of time. IV bolus indicates that a large volume of IV fluid or medication is infused over a specific time through an IV administration set attached to the lock. There are guidelines, however, relating to the acceptable rate for IV push administration. **Check appropriate references for the rate for IV push medication administration**. Also check the institution's policy and a pharmacology reference regarding administration by IV push or bolus.

Monitoring IVs

The nurse is responsible for monitoring the client during an IV infusion. IV site and the infusion should be checked according to hospital policy for the volume of remaining fluid, the correct infusion rate, and for signs of complications. It is the nurse's responsibility to maintain and regulate IV infusions.

Administration of IV Fluids

IV fluids are administered by an IV infusion set, which includes the sealed IV bag containing the fluids (Figure 20.11A). The **IV infusion set (IV tubing)** (Figure 20.11B) allows the IV fluid to flow from the IV bag to the IV catheter placed in the client's vein. The IV tubing is attached to the bottom of the IV bag. A **spike** at the top of the IV tubing is used to insert the tubing into the fluid container. At the top of the tubing is a **drip chamber** that allows the nurse to observe the drops of fluid and count the drops per minute (gtt/min) for manually regulated IVs. **The roller clamp** squeezes the tubing, to allow for the IV flow rate to be increased or decreased, and is used to regulate the gtt/min that fall into the drip chamber. Some IV tubing has a **sliding clamp** attached as well, which can be used to temporarily stop the IV infusion. **Injection ports** are located on the IV tubing and on most IV solution bags. Injection ports allow for injection of medications directly into the bag of solution or line. The injection ports also allow for the attachment of secondary IV lines that contain fluids or medications to the primary line. The tubing used for the primary line is long tubing, whereas the secondary tubing used for intravenous piggyback (IVPB) is short IV tubing with a drip chamber, and a clamp.

Figure 20.11 (A) D_5W IV solution. (B) IV tubing.

IV fluids infuse by gravity flow. This means that for the IV solution to infuse, it must be hung above the level of the client's heart, which will allow for adequate pressure to be exerted for the IV to infuse. The height of the IV bag therefore has a relationship to the rate of flow. The higher the IV bag is hung, the greater the pressure; therefore the IV will infuse at a more rapid rate. The lower the IV bag is hung, the less the pressure, and the IV will infuse at a slower rate.

Primary and Secondary Lines

Primary lines—As previously stated, the primary line is usually the IV solution, which is continually infusing. The primary line is usually a large volume of fluid. Frequently used primary IV bags are 500 or 1,000 mL (see Figure 20.11A). Examples of medications added include multivitamins (MVI) and electrolytes, such as potassium chloride. These medications are usually diluted in a large volume of fluid (1,000 mL), particularly potassium chloride, because of the side effects and untoward reactions that can occur. In many institutions, IV solutions containing potassium chloride are stocked by the pharmacy and obtained on request by the unit, eliminating the need for potassium chloride to be added to an IV bag. The IV tubing used for the primary line is long tubing. Injection ports on the tubing allow for the attachment of a secondary line or for the administration of medications with the use of a syringe, or needleless entry.

Secondary lines—These attach to the primary line at an injection port. They are also known as IV piggyback (IVPB). The main purpose of secondary lines is to infuse medications on an intermittent basis (e.g., antibiotics every 6 hr). Secondary IVs usually contain a smaller volume of IV fluid (50–250 mL) than the primary. Amounts of 50 to 100 mL are seen most often. The amount of solution used for the IVPB is determined by the medication being added. The IVPB is hung higher than the primary line so that it is given a greater pressure than the primary, thereby allowing it to infuse first. To do this, an extender is attached to the primary bag to lower it below the secondary (Figure 20.12). Secondary lines can also be used to infuse other IV fluids, as long as they are compatible with the fluid on the primary line. The tubing used for secondary IVs is shorter than for primary IVs.

Figure 20.12 (A) Piggyback. (B) Tandem. (From Harkreader H, Hogan MA: *Fundamentals of nursing: Caring and clinical judgment*, ed 3, St. Louis, 2007, Saunders.)

Premixed IVPBs—Many IVPBs come premixed by the manufacturer or the pharmacist depending on the institution, or the nurse may have to prepare them.

Whether an IVPB is premixed or prepared by the nurse, the IV bag must be labeled with appropriate information which includes the name of the medication, the dosage strength of the medication, and the solution the medication is diluted in. Premixed IVPBs often come labeled with this information. The rate for an IVPB to infuse should be checked using appropriate resources. The manufacture's insert provides recommended times for infusion if not stated in the prescriber's order. This information can also be found online.

Blood Administration Tubing

The administration of blood and blood products is commonly done with a special tubing called Y-tubing. The "Y" refers to two spikes above the drip chamber of the IV tubing. One spike is attached to the blood container, and the other is attached to a container of normal saline (NaCl) solution. Normal saline is used to flush the IV tubing before and after the transfusion. Tubing for blood administration has an in-line filter (to remove small clots [microemboli] and particles from the blood before it's infused into the client). Blood may be administered by gravity or electronic pump (Figure 20.13).

Blood transfusions and blood products are regulated in the same manner as any other intravenous infusion and also involve calculation of flow rates and infusion times.

Figure 20.13 Setup for blood administration.

Systems for Administering Medications by Intravenous Piggyback

Other types of secondary medication setups used in some institutions include:

- • **ADD-Vantage system.** This system requires a special type of IV bag that has a port for inserting the medication (usually in powder form and mixed with the IV solution as a diluent). The contents of the vial are therefore mixed into the total solution and then infused (Figure 20.14).

Figure 20.14 The ADD-Vantage drug delivery system. (Courtesy Bruce Clayton.)

- The Baxter Mini-Bag Plus is also used to administer piggyback medication. The mini-bag, which is dispensed by the pharmacy, has a vial of unreconstituted medication attached to a special port. You break an internal seal and mix the medication and diluent just before administration. The medication vial remains attached to the mini-bag (Figure 20.15).

Figure 20.15 Mini-Bag Plus. (From Baxter Healthcare Corporation, Deerfield, IL.)

- • **Volume-control devices** are referred to by their trade names (Buretrol, Burette, or Volutrol), depending on the institution. These volume-control devices usually have a maximum capacity of 150 mL and attach below the primary infusion bag. Volume-control devices have a safety factor in that the volume of fluid administered can be limited, therefore decreasing the chance of infusing a large volume of fluid accidentally to a client. The volume-control fluid chamber is filled with small volumes of fluid for administration. They can also be used intermittently for medication purposes.
- There is a port on the fluid chamber that allows medication to be injected and a certain amount of IV fluid to be added (Figure 20.16). They are used often in the pediatric and critical care settings. These devices allow for precise control of the infusion and medication.

Figure 20.16 (A) Volume-controlled device. (B) Parts of a volume-control set. (A, From Potter PA, Perry AG, Stockert P, Hall A: *Fundamentals of nursing,* ed 9, St. Louis, 2017, Elsevier.)

The rate for an IVPB to infuse should **always** be verified if not stated in the prescriber's orders. The nurse has the responsibility for calculating the **right** infusion rate for the IVPB.

SAFETY ALERT!

When an infusion rate is not stated for IVPB, check appropriate resources, which include: the manufacturer's insert, a pharmacology book, online resources, or the hospital pharmacy. The nurse is responsible for any error that occurs in reference to IV administration including incorrect rate of infusion.

Methods Used for the Administration of Intravenous Fluids

There are two methods used for the infusion of IV fluids and IVPBs to clients. IV fluids can be administered by gravity or by the use of electronic devices such as infusion pumps.

- • IV **infusion by gravity—**Requires the nurse to calculate the IV flow rate in drops per minute (gtt/min).
- • IV **infusion by pump—**With infusion pumps the nurse sets the IV flow rate in milliliters per hour (mL/hr).

The calculation of the IV flow rate in gtt/min and mL/hr will be discussed in Chapter 21.

Electronic Infusion Devices

There are several electronic infusion devices on the market used to administer and regulate intravenous fluid and/or medication infusions (e.g., IV Infusion Pumps), which are used for a variety of purposes. Electronic infusion pumps are used to deliver fluids and medications into a client's body at a controlled rate. There are many types of IV pumps, which include volumetric pumps, patient-controlled analgesia (PCA) pumps, and syringe pumps. Smart infusion pumps are available on the market, which are equipped with safety features designed to reduce infusion-related medication errors. Smart pumps (Figure 20.17) have software that includes a reference library of IV medications and dosing guidelines and alerts the nurse when a pump setting is programmed outside of the pre-configured limits. According to ISMP (2020), smart infusion pumps are now used in more than 80% of US hospitals.

Figure 20.17 Smart pump.

- • **Electronic volumetric pumps—**Electronic infusion devices that infuse fluids into the vein under pressure and against resistance and do not depend on gravity. The manufacturer provides specialized tubing that must be used with this device. The rate on a volumetric pump is set in mL/hr (Figure 20.18). There is a wide range of electronic pumps. Because the pump delivers in mL/hr, milliliter calculation that results in a decimal fraction must be rounded to a whole milliliter, unless the pump has decimal capabilities. There are some IV pumps available that are capable of delivering IV fluids in tenths of a mL. These pumps may be seen in some intensive care units.

Figure 20.18 Infusion pump.

- • **Syringe pumps—**Hold a prefilled syringe and apply pressure to the plunger to deliver small volumes of fluid or medication at a set rate (Figure 20.19). These pumps are often used for neonatal and pediatric clients for delivery of small volumes at low rates. These pumps are also useful in other areas, which include intensive care units, labor and delivery, and hospice. The rate on syringe pumps is set at mL/hr.

Figure 20.19 Syringe pump.

- • **Patient-controlled analgesia (PCA) pumps—**A form of pain management that allows the client to self-administer IV pain medications with the push of control button (Figure 20.20). The PCA pump is programmed to allow dosages of narcotics only within specific limits to be delivered to prevent overdosage. The dosage and frequency of administration are programmed into the pump. The pump also stores information that includes the frequency and dosage of medication delivered to the client.

Figure 20.20 CADD Solis PCA Ambulatory Infusion Pump (from Smiths Medical, Dublin OH.)

Infusion Devices for the Home Care Setting

Infusion devices used in the outpatient and home care setting include insulin pumps and elastomeric balloon pumps. With the elastomeric balloon device, fluid is held in a stretchable balloon reservoir, and pressure from the walls of the balloon causes fluid delivery. No infusion rates are set on these devices. An example of the elastomeric pump is the ON-Q Pump. The ON-Q pump is a non-narcotic elastomeric portable pump that is being used to provide postoperative pain relief. The device automatically and continuously delivers a slow rate of local anesthetic to a patient's surgical site or in close proximity to nerves providing targeted pain relief for up to 5 days depending on the size of the pump. A small catheter is placed under the skin and attached to the pump. The pump is completely portable and can be clipped to the clothing or placed in a small carrying case. Clients using infusion devices at home **must** be educated about the device to ensure safe use, and both device and client **must** be monitored to ascertain proper functioning.

While infusion pumps were designed to improve client safety, infusion pumps are not without problems and have been associated with medication errors. Despite improvements in design and the use of smart pumps, performance problems still occur that have resulted in both over- and underinfusion. Pump efficacy is a primary and continual concern of the US Food and Drug Administration (FDA) and the Institute for Safe Medication Practices (ISMP). Problems include programming errors, calculation errors resulting from unit of measure inconsistency between the drug library and the EHR (i.e., a bolus dose ordered in mg, but the smart pump requires mg/kg), and selection errors when choosing among multiple listed concentrations in the drug library for the same medication are some of the errors identified by ISMP (2020) with the smart pump. In response to the numerous and varied errors associated with the smart pump, the ISMP revised and expanded the *Guidelines for Optimizing Safe Implementation and Use of Smart Infusion Pumps* in February 2020. The complete guidelines can be viewed on the ISMP at https://www.ismp.org/node/972.

As stated both the FDA and ISMP have published recommendations for best practices relating to infusion pumps, which include verifying that the infusion pump is programmed for the right dosage, at the right rate and volume to be infused, obtaining an independent double-check of infusion pump settings by a second clinician when infusing high-risk medications, and client monitoring as well as the infusion. Infusion Pump recommendations related to safety when using infusion pumps can be found at https://www.fda.gov/medical-devices/infusion-pumps/infusion-pump-risk-reduction-strategies-clinicians.

Other strategies that have been identified to increase safety during the use of infusion pumps include, when using multiple-channel pumps, labeling each infusion line, and prominently displaying IV fluid and medication labels on the infusion pump and the tubing at the port of entry. Hospital or clinical in-service education is required for the use of all infusion devices.

As nurses we must use best practices for client safety with the use of infusion pumps. Nurses need to apply the six “rights” of safe medication administration when using infusion pumps. The **right client** should always receive the **right fluid** and/or medication by the appropriate IV pump programmed to deliver the **right dosage and volume** with the **right documentation** and continual monitoring. **Do not** rely solely on the pump.

SAFETY ALERT!

An institution may use many different infusion pumps. The nurse must know how to use them correctly to prevent client harm and a fatal outcome.

POINTS TO REMEMBER

- • IV orders are written by the doctor or other prescriber certified to do so (e.g., nurse practitioner, physician’s assistant).
- • IV orders must specify the name of the solution, medications (if any are to be added), the amount to be administered, and the infusion time.
- • Several electronic devices are on the market for infusing IV solutions. Always familiarize yourself with the equipment before use.
- • Follow the institution’s protocol for IV administration.
- • Nurses have the primary responsibility for monitoring the client during IV therapy.
- • Nurses are responsible for any errors that occur in administration of IV fluids (e.g., inadequate dilution, too rapid infusion).
- • Pay close attention to IV abbreviations. The letters indicate the solution components, and the numbers indicate the solution strength.
- • Solution strength expressed as a percentage (%) indicates grams of solute per 100 mL of fluid.
- • Principles relating to flow rate and infusion times are also applicable to parenteral nutrition solutions and blood and blood products.
- • Apply the six rights of medication administration to IV infusion pumps. The nurse is responsible to ensure client safety when a client is receiving fluids and/or medications by an infusion pump.

PRACTICE PROBLEMS

Answer the following questions as briefly as possible.

- 1. What does PCA stand for? _____
- 2. An IV initiated in a client's lower arm is called what type of line? _____
- 3. IVPB is an abbreviation for _____.
- 4. A client has an IV of 1,000 mL 0.9% NS. The initials identify what type of solution? _____
- 5. A secondary line is hung _____ than the primary line.
- 6. Volumetric pumps infuse fluids into the vein by _____.
- Identify the components and percentage strength of the following IV solutions:
- 7. $D_{20}W$
- 8. D_5W 10 mEq KCl
- 9. How many grams of dextrose does 500 mL $D_{10}W$ contain?
- Calculate the amount of dextrose and/or sodium chloride in the following IV solutions:
- 10. 750 mL D_5 NS
- dextrose _____
- NaCl _____
- 11. 250 mL $D_{10}W$
- dextrose _____
- 12. 1,000 mL D_5 0.33% NS
- dextrose _____
- NaCl _____
- 13. 500 mL D_5 ½ NS
- dextrose _____
- NaCl _____

Answers on 487

CLINICAL **REASONING**

Scenario: A client returned to the unit after surgery connected to a patient-controlled analgesia (PCA) pump. An order was written to attach a solution of 100 mL 0.9% normal saline (NS) with morphine 100 mg to the pump and infuse at a rate of 1 mg per 6 min. The ordered solution was inserted into the device and the rate set. The client had been instructed on the use of the PCA pump. The client continued to complain of severe pain on each shift despite the pump indicating that medication was being received at the set rate. The client received intermittent boluses of morphine to relieve pain.

Twenty-four hours later, a nurse opened the PCA pump, found the full bag of IV solution in place, and noticed that the tubing had not been primed.

What should have been done in this situation?

_____

_____

_____

Answer on 487

CHAPTER **REVIEW**

For questions 1 through 4, specify the letter of the solution (*A* through *D*) corresponding to the fluid abbreviation.

- 1. D_5 ½ NS _____
- 2. D_5W _____
- 3. RL _____
- 4. D_5 NS _____

- 5. A client has a PCA in use following surgery. What is this device used to control? _____
- 6. When an IV medication is injected directly into the vein through a port, it is called an IV _____ or _____.
- 7. The two major intravenous access sites are _____ and _____.
- 8. A client is to receive an antibiotic IVPB. In order for the antibiotic to infuse first, how must it be hung in relation to the existing IV solution bag? _____

Calculate the amount of dextrose and/or sodium chloride in each of the following IV solutions:

- 9. 0.5 L D_5 1/4 NS
- dextrose g _____
- NaCl g _____
- 10. 750 mL D_5 1/2 NS
- dextrose g _____
- NaCl g _____

Answers on 488

For additional practice problems, refer to the Intravenous Flow Rates section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

ANSWERS

Chapter 20

Answers to Practice Problems

- 1. patient-controlled analgesia
- 2. peripheral
- 3. intravenous piggyback
- 4. 0.9% normal saline, 0.9% sodium chloride (NaCl)
- 5. higher
- 6. pressure
- 7. 20% dextrose in water
- 8. 5% dextrose in water with 10 mEq potassium chloride (KCl)
- 9. 50 g
- 10. Dextrose: 5 g : 100 mL = *x* g : 750 mL
- 100x100=450100x=37.5gdextrose
- *or*

  5g100mL=xg750mL

- NaCl: 0.9 g : 100 mL 5 *x* g : 750 mL

  100x100=675100x=6.75gNaCl

- *or*

0.9g100mL=xg750mL

- 750 mL D_5NS contains 37.5 g of dextrose and 6.75 g NaCl (saline).
- 11. 10 g : 100 mL = *x* g : 250 mL

  100x100=2,500100x=25gdextrose

- *or*

  10g100mL=xg250mL

- 250 mL $D_{10}W$ contains 25 g dextrose.
- 12. Dextrose: 5 g : 100 mL 5 *x* g : 1,000 mL

  100x100=5,000100x=50gdextrose

- *or*

  5g100mL=xg1,000mL

- NaCl: 0.33 g : 100 mL = *x* g : 1,000 mL

  $$100x100=330100x=3.3gNaCl$$

- *or*

  $$0.33g100mL=xg1,000mL$$

- 1,000 mL D_5 0.33% NS contains 50 g dextrose and 3.3 g NaCl (saline).
- 13. Dextrose: 5 g : 100 mL = *x* g : 500 mL

  $$100x100=2,500100x=25gdextrose$$

- *or*

  $$5g100mL=xg500mL$$

- NaCl: 0.45 g : 100 mL = *x* g : 500 mL

  $$100x100=225100x=25gNaCl$$

- *or*

  $$0.45g100mL=xg500mL$$

- 500 mL D_5 1/2 NS contains 25 g dextrose and 2.25 g of NaCl (saline).

Answer to Clinical Reasoning Question

Troubleshooting should have been done by the nurses caring for the client. If the client's pain was not being relieved, the device should have been checked for possible malfunctioning and to determine whether the machine had been set up properly. It is mandatory that all programming be double-checked by nurses and the pump be monitored frequently to ensure that it is functioning. The client's continual complaint of severe pain with no relief should have been a key to the nurses caring for the client.

Answers to Chapter Review

- 1. B
- 2. C
- 3. A
- 4. D
- 5. pain
- 6. push *or* bolus
- 7. peripheral and central
- 8. higher
- 9. 25 g dextrose; 1.125 g NaCl
- Equivalent: 1 L = 1,000 mL
- Therefore 0.5 L = 500 mL
- Dextrose:
- 5 g : 100 mL 5 *x* g : 500 mL

  $$100x100=2,500100x=25gdextrose$$

- *or*

  $$5g100mL=xg500mL$$

- NaCl:
- 0.225 g : 100 mL = *x* g : 500 mL

  100x100=112.5100x=1.125gNaCl

- *or*

  0.225g100mL=xg500mL

- 500 mL D_5 1/4 NS contains 25 g dextrose and 1.125 g NaCl (saline).
- 10. 37.5 g dextrose; 3.375 g NaCl
- Dextrose:
- 5 g : 100 mL = *x* g : 750 mL

  100x100=3,750100x=37.5gof dextrose

- *or*

  5g100mL=xg750mL

- NaCl:
- 0.45 g : 100 mL = *x* g : 750 mL

$$100x100=337.5100x=3.375gNaCl$$

- *or*

$$0.45g100mL=xg750mL$$

- 750 mL D_5 1/2 NS contains 37.5 g dextrose and 3.375 g NaCl (saline).

unknown - Section 39 (Page 352)

This chapter will present the calculations performed with intravenous therapy. As stated previously, nurses have the responsibility to make sure that clients are receiving the correct rate. Several methods to calculate IV rates are presented in the chapter: ratio and proportion, dimensional analysis, and the formula. Let's now begin our calculations with determining IV rates in milliliters per hour (mL/hr).

IV Flow Rate Calculation

As previously discussed, the prescriber's order for an IV includes the following:

- • The name of the IV solution
- • The volume to infuse
- • Medications to be added, if any
- • Time for the IV to infuse

Continuous IV, which is oft en referred to as the primary IV, usually contains a large volume of fluid (500 mL or 1,000 mL). IV fluids are usually ordered to be administered at rates expressed in mL/hr. The time for the IV to infuse may be indicated as the total number of hours (i.e., D_5W 3,000 mL in 24 hr), or mL/hr (i.e. D_5 ½. NS 1,000 mL at 125 mL/hr). Small volumes of fluid (usually 50 mL or 100 mL) are oft en used when the IV fluid contains medications such as antibiotics. Rates for IV fluids are usually expressed in drops per minute (gtt/min) when an infusion device is not used. When an infusion device such as a pump is used, the flow rate must be expressed in mL/hr.

Calculating Flow Rates for Infusion Pumps in mL/hr

When a client is using an electronic infuser, such as a volumetric pump, the prescriber orders the volume and can include mL/hr or the total number of hours for the IV to infuse. If the order states the number of mL/hr for the infusion, such as previously stated D_5 ½ NS at 125 mL/hr, there is no calculation required by the nurse. The nurse programs the pump to deliver the ordered rate. However, if the order states the total number of hours for the IV to infuse (D_5W 3,000 mL in 24 hr), the nurse will need to calculate the mL/hr to program the pump.

For most electronic devices that regulate the flow of IV solutions, the rate is expressed in milliliters per hour (mL/hr). For the purpose of this text, the equipment being used is programmable in whole mL/hr; therefore mL/hr should be rounded to a whole number unless indicated that the infusion pump has decimal capability. To determine mL/hr the following information is needed:

- • The volume (amount) of solution in milliliters
- • The time for the IV to infuse in hours

The simplest way to determine the mL/hr is by using the formula, although ratio-and-proportion and dimensional analysis can be used:

Formula to Determine mL/hr

$$x\text{mL/hr} = \frac{\text{Volume (amount) of solution (mL)}}{\text{Time in hours}}$$

Round mL/hr to the nearest **whole number**. If the answer does not result in a whole number, carry division to tenths place and round to the nearest whole number. If pump has decimal capability, round answer to the **nearest tenth.**

SAFETY ALERT!

There are some IV pumps in use that are capable of delivering IV fluids in tenths of a milliliter. Always be familiar with the IV equipment being used at the institution before rounding milliliters per hour (mL/hr) to the nearest whole mL/hr.

Let's begin with the calculation of IV flow rates in mL/hr.

Example 1: Client with an infusion pump has an order for 3,000 mL D_5W over 24 hours.

Solution:

- 1. Think: Pump is regulated in mL/hr.
- 2. No conversion required; the volume is in milliliters, and the time is in hours.
- 3. To use the formula method to determine mL/hr: *x* mL/hr = volume in mL.

xmL/hr=VolumeuinumLTimeu(hr)

- 4. To determine mL/hr using ratio and proportion, the volume ordered and hours to infuse is the known ratio; 3,000 mL : 24 hr (stated first), and the unknown is *x* mL : 1 hr. (stated as the second ratio) or:

3,000mL24hr=xmL1hr

- 5. To determine mL/hr using dimensional analysis, identify what you are looking for, and write it to the left of the equation in a fraction format. Label factor:

xmLhr

Place problem as starting fraction (if no conversion required). If conversion is required, the starting fraction is the conversion factor, and the problem is inserted as the second fraction in the equation. Refer to the setups of Example 1 using the various methods.

Formula Method

xmL/hr=3,000mL24hrx=3,00024x=125ml/hr

Ratio and Proportion (Linear Format)

3,000mL:24hr=xmL:1hr24x24=3,00024x=3,00024x=12mL/hr

Ratio and Proportion (Fraction Format)

3,000mL24hr=xmL1hrx=3,0002424x24=3,00024x=3,00024x=125mL/hr

Dimensional Analysis

xmLhr=3,000mL24hrx=3,0002424x24=3,00024x=125mL/hr

In this problem no conversion was required, the ordered amount is in mL/hr, which is the same as the desired; therefore the problem is solved by division, and no cancellation of units is required.

To infuse 3,000 mL of D_5W in 24 hr, the pump would be set to deliver 125 mL/hr.

Sometimes a conversion may be necessary before calculating mL/hr. Let's look at a problem showing the calculation of mL/hr when a conversion is required.

Example 2: Client with an infusion pump is to receive 0.5 L 0.9% NS over 8 hours.

Solution:

- 1. Convert 0.5 L to 500 mL using any of the methods presented in earlier chapters.
- Use the conversion factor 1 L = 1,000 mL. Convert 0.5 L to mL by moving the decimal three places to the right (metric to metric). Decimal movement can be used. Review methods of converting if necessary.
- 2. Set up the problem and solve using one of the calculation methods.

Formula Method

x ml/hr=500mL8hrx=5008=62.5x=63ml/hr

mL/hr is rounded to the nearest whole number of mL.

Ratio and Proportion (Linear Format)

500ml:8hr=xmL:1hr8x8=5008x=5008=62.5x=63mL/hr

mL/hr is rounded to the nearest whole number of mL.

Ratio and Proportion (Fraction Format)

500mL8hr=xmL1hr8x8=5008x=5008=62.5x=63mL/hr

mL/hr is rounded to the nearest whole number of mL.

Dimensional Analysis

mL/hr is rounded to the nearest whole number. Notice the conversion factor is written 1,000mL1L

to cancel L, leaving mL/hr.

To infuse 500 mL of 0.9% NS, the pump would be set to deliver 63 mL/hr. As previously stated, pumps deliver in whole mL unless indicated the pump has decimal capability.

Determining mL/hr When the Time Period Is Less Than 1 Hour

Often when medications are administered IV, such as IVPB (e.g., for antibiotics), the time period for the IV to infuse is less than 1 hour. When the period is less than 1 hour and an electronic infusion device is used, the IV rate must still be determined in mL/hr. **Remember that there are 60 minutes in 1 hour.** The rate can be determined using ratio and proportion. (The known ratio is the ordered rate, mL/min, and the second is the unknown ratio, x mL/60 min). Dimensional analysis can also be used to determine the rate in mL/hr. (The first factor in the equation is the ordered mL/min, and the second factor is 60 min/1 hr). The rate can also be determined using the formula:

xmL/hr=TotalmLtoinfuseNumberofminutoinfuse×60min/hr

Let's look at an example. The various methods for calculating the infusion rate will be shown.

Example 3: A client is to receive an antibiotic in 100 mL of 0.9% NS over 45 min by infusion pump. Determine the IV flow rate.

Solution:

- 1. Think: The infusion pump infuses in mL/hr. Use a ratio and proportion, the formula method, or dimensional analysis to determine mL/hr.
- 2. Remember: 1 hr = 60 min.

Ratio and Proportion (Linear Format)

100mL:45min=xmL:60min45x=100×6045x45=6,00045=133.3x=133mL/hr

Ratio and Proportion (Fraction Format)

100mL45min=xmL60min45x=100×6045x45=6,00045=133.3x=133mL/hr

Formula Method

Note: min is cancelled, leaving mL/hr.

Dimensional Analysis

Note: min is cancelled, leaving mL/hr.

The infusion pump would be set at 133 mL/hr to infuse 100 mL in 45 minutes. The volume of 100 mL will be infused.

SAFETY ALERT!

The usual rate in mL/hr ranges from 50 to 200 mL/hr. If the rate exceeds this amount, double-check the order and your calculation before programming the rate into an infusion pump.

POINTS TO REMEMBER

- • IV infusion pumps deliver IV flow rates in mL/hr.
- • IV orders indicate: the name of the IV solution, the volume to infuse, medications to be added, if any, and the time for the IV to infuse. The prescriber may indicate the time for an IV to infuse in mL/hr, or the total number of hours for the IV to infuse.
- • To determine flow rates for an electronic infusion device such as the infusion pump, determine mL/hr using the formula:

xmL/hr=Total␣volume␣to␣infuse␣(mL)Time␣(hours)

- • If the time for the IV to infuse is less than 1 hour and the infusion pump is used, the infusion rate still must be determined in mL/hr. Ratio and proportion, the formula method, or dimensional analysis can be used to determine the infusion rate. Remember that 60 min = 1 hr.
- • Milliliters per hour (mL/hr) are rounded to the nearest whole number. If math does not result in a whole number, carry math to the tenths place and round to the nearest whole number.
- • Some infusion pumps have decimal capability and can deliver IV rates in tenths of a mL. If the answer obtained is not in the tenths place, carry math to the hundredths place and round to the tenths.
- • Always be familiar with the infusion device being used by an institution before rounding mL/hr to a whole number.

PRACTICE PROBLEMS

Calculate the flow rate in mL/hr. (Equipment used is programmable in whole mL/hr.)

- 1. 1,800 mL of D_5W in 24 hr by infusion pump
- 2. 2,000 mL D_5W in 24 hr by infusion pump
- 3. 500 mL RL in 12 hr by infusion pump
- 4. 1,500 mL D_5RL in 24 hr by infusion pump
- 5. 750 mL D_5W in 16 hr by infusion pump

Answers on 538

Manually Regulated IVs

When an electronic infusion device is not used, the nurse uses a gravity-flow system and must manually regulate the infusion rate. To do this, the nurse must calculate the ordered IV flow rate in drops per minute (gtt/min). IV flow rates in gtt/min are based on the IV tubing calibration, referred to as the *drop factor*. The **drop factor** is the number of drops per milliliter (gtt/mL) that a particular IV tubing delivers and therefore will vary depending on the type of IV tubing.

The drop size is determined by the size of the tubing or the small needle inside the drop chamber releasing the drops. See Figure 21.1. Note the large opening for drops in Figure 21.1A, the drops are large (**macrodrops**). The drops delivered through the small needle in Figure 21.1B are very small drops (**microdrops**). The drop factor of the IV tubing is stated in large numbers on the IV tubing package (Figure 21.2). The drop factor of the IV tubing is needed to calculate gtt/min.

Figure 21.1 Comparison of (A) macrodrops and (B) microdrops.

Figure 21.2 IV administration sets (package). **(A)** Set with drop factor of 10 (10 gtt =1 mL). **(B)** Set with drop factor of 60 (60 gtt = 1 mL).

As stated previously, at the top of the IV tubing is a drip chamber (also referred to as a drop chamber), where the nurse observes and counts the number of drops falling into the drip chamber per minute or fraction of a minute placing a watch at the level of the drip chamber. The flow rate is regulated by a hand-operated slide clamp or a roller clamp, which is opened or closed so the drops fall at the desired rate.

SAFETY ALERT!

IV infusions that are manually regulated must be monitored regularly. The flow rate of a manually regulated IV can be affected by the height of the IV infusion, the location of the site, and changes in the client position, which can result in impediment of the IV flow rate or excessive amounts of fluid being delivered to the client.

IV Tubing

The two common types of tubing used to administer IV fluids (regulated manually) are:

- • Macodrop tubing
- • Microdrop tubing

Macrodrop Tubing

Macrodrop is the standard tubing used for general IV administration. With macrodrop tubing the size of the drop and the number of gtt/mL varies according to the manufacturer. Macrodrops are large drops, and there are fewer drops in 1 mL (see Figure 21.1A). Macrodrop tubing have the following drop factors:

- • 10 gtt/mL
- • 15 gtt/mL
- • 20 gtt/mL

Since the drop factor for macrodrop tubing differs according to the manufacturer, always read the IV tubing package and identify the drop factor of the tubing. Never assume to know the drop factor, because not all macrodrop tubing has the same factor.

SAFETY ALERT!

To accurately administer IV fluids at the correct rate to a client, the nurse **must** know the drop factor of the IV tubing. Knowing the drop factor of the IV tubing used can prevent an error in IV rate determination and the client receiving IV fluid at the incorrect rate. **Never** assume the drop factor

for macrodrop tubing.

Microdrop Tubing

Microdrop tubing delivers tiny drops through a small needle in the drip chamber and therefore has more drops in 1 mL (see Figure 21.1B). It is used to administer either small or precise amounts of fluid. For example, it is used in critical care, for the elderly, and for pediatric infusions. Microdrop tubing, because of the size of the drops (very small/ tiny) is sometimes referred to as pedidrip tubing. Microdrop tubing, regardless of the manufacturer, is only available in one drop factor (60 gtt/mL). With microdrop tubing the number of mL/hr is the same as gtt/min (i.e., if the infusion rate is 100 mL/hr, the IV rate is 100 gtt/min).

- • 60 gtt/mL

POINTS TO REMEMBER

- • Drop factor = gtt/mL of the IV tubing. This information is written on the package of the IV tubing.
- • Knowing the drop factor of the IV tubing is the **FIRST** step in accurate administration of IV fluids in gtt/min. IVs that infuse by gravity are manually regulated, and the IV flow rate is determined in gtt/min.
- • Macrodrops are large and have drop factors of 10, 15, and 20 gtt/mL.
- • Microdrops are tiny and have only one drop factor, 60 gtt/mL.

PRACTICE PROBLEMS

Refer to the drop factor provided and identify the type of tubing.

- 6. 15 gtt/ mL _____
- 7. 60 gtt/mL _____
- 8. 10 gtt/mL _____

Answers on 538

Calculating Flow Rates in Drops Per Minute Using a Formula and Dimensional Analysis

To calculate the IV flow rate in gtt/min for an IV infusing by gravity, a formula method can be used or dimensional analysis. To calculate the flow rate in gtt/min for the IV infusion regardless of the method used (formula method or dimensional analysis), the nurse needs to know the following:

- • Drop factor of the IV tubing
- • Volume (number of mL) to infuse
- • Time the IV is to infuse (minutes or hours)

The formula for calculating the IV flow rate is:

$$x\,\text{gtt/min} = \frac{\text{volume of solution (mL)} \times \text{drop factor}}{\text{time (min)}}$$

Before beginning to calculate gtt/min, let's review some basic guidelines:

Guidelines for Calculating gtt/min

- • Drops per minute are **always** expressed in whole numbers. Think: You cannot regulate an IV to half a drop or count half a drop; therefore **you can only count whole drops.**
- • Principles of rounding are applied if the calculation for gtt/min does not result in a whole number. Carry calculation to the tenths place, and round answer to the nearest whole number (i.e., 19.6 is rounded to 20 gtt/min).
- • Answers must be labeled. The label is usually drops per minute unless otherwise specified. Example: 17 gtt/min. To reinforce the differences in drop factor, the type of tubing is sometimes included as part of the label. Examples: 17 macrogtt/min, 100 microgtt/min.
- • Common conversion factors used include 1 L = 1,000 mL, and 1 hr = 60 min.

First let's look at some sample problems using the formula method and dimensional analysis.

Example 1: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 10 gtt/mL. At what rate in gtt/min should the IV infuse?

- • Notice the numbers in the problem are placed in the formula.
- • Remember the formula solves for gtt/min and the time is indicated in minutes. 60 min = 1 hr; therefore 1 hr is changed to 60 min in the formula (100 mL/60 min).
- • When mL is cancelled out, the flow rate is determined in gtt/min.
- • Reduction is done where possible.
- • The answer is labeled.
- • ***Note:*** The volume of 1,000 mL was not used in the calculation; the mL/hr was stated in the order.

Setup Using Formula Method

To deliver 100 mL/hr, the IV rate would be regulated at 17 gtt/min; 17 macrogtt/min.

Dimensional Analysis

Let's look at the previous example using dimensional analysis.

Example 1: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 10 gtt/mL. At what rate in gtt/min should the IV infuse?

- • Notice *x* gtt is written to the left of the equation, followed by the equal sign (=) (labeled *x* gtt/min because that is what you're looking for).
- • The **first** factor starts with gtt and is the drop factor, which is written, placing gtt in the numerator. 10 gtt/1 mL.
- • The next fraction is written so that the denominator matches the previous fraction (what you are looking for). The order is to infuse 100 mL in 1 hr. The 1 hr is entered as 60 min in the denominator because you are calculating gtt/min (100 mL/60 min).
- • Cancel the units and you are left with the desired gtt/min.
- • Reduction is done if possible.
- • Label the answer.

Dimensional Analysis

Note: An alternate way of setting up the problem, without changing the hourly rate to 60 min, would be to add 1 hr = 60 min conversion factor to the equation: 1hr60min

Alternate Setup Using Dimensional Analysis

Notice the hourly rate is entered in mL/hr in the equation; the fraction 1 hr/60 min is inserted into the equation. The units are cancelled, leaving gtt/min. The calculation would be the same as the previous setup.

Example 2: Order: 1.5 L 0.9% NaCl to infuse in 10 hr. Drop factor: 15 gtt/mL. At what rate in gtt/min should the IV infuse at?

- • Notice this problem contains a large volume of fluid, and the order contains the total number of hours to infuse as opposed to mL/hr as shown in Example 1.
- • A conversion is also required before the problem can be solved. L must be converted to mL. Use the conversion factor 1 L = 1,000 mL; therefore 1.5 L = 1,500 mL.
- • When using the **formula method**, the IV rate can be determined in two ways:
    - a. First convert the flow rate to mL/hr, and then calculate the gtt/min using the formula.
    - *or*
    - b. Convert the number of hours to minutes using the conversion factor 60 min = 1 hr. Multiply the number of hours by 60 min/hr and then place the calculated minutes into the formula. In this problem, 10 hr is multiplied by 60 min/hr to obtain the 600 minutes used in the formula: 10 hr × 60 min/hr.
- • For **dimensional analysis,** if the mL/hr is not expressed as mL/min, insert the conversion factor 1 hr/60 min.

Let's look at the above problem using the formula method and dimensional analysis.

Formula Method Using Two Steps

Step 1: Calculate the mL/hr:

xmL/hr1,500mL10hrx=150mL/hr

Convert mL/hr to mL/min. 1 hr = 60 min (150 mL/hr = 150 mL/60 min)

Step 2: Place into formula:

Formula Method Using hr Converted to min

Dimensional Analysis Using mL/min

Calculate mL/hr: 1,500 mL ÷ 10 hr = 150 mL/hr.

Convert mL/hr to mL/min (150 mL/hr = 150 mL/60 min).

Proceed using the steps shown in Example 1.

Dimensional Analysis Using mL/hr

Dimensional Analysis Using the Total Volume and Total Number of hr

Proceed with calculation as shown in previous examples.

Example 3:

Order: The following IVs for 24 hours. Drop factor: 15 gtt/mL

- • 1,000 mL D_5W c 10 mEq potassium chloride (KCl)
- • 500 mL D_5NS c 1 ampule of multivitamin (MVI)
- • 500 mL D_5W

What rate will you regulate the IV to deliver the ordered IV fluid?

In this problem, the order is written for different amounts and types of fluid to be given in a certain time period. Notice that medications are also ordered to be added to the solutions: potassium chloride and multivitamin. When medications such as potassium chloride and vitamins are added to the IV solutions, they are generally not considered in the total volume. (Some institutions consider the medication in the volume if it is 10 mL or more. Always check the policy of the institution.)

To calculate the IV rate, add up the IV fluid to obtain the total volume (2,000 mL). The total number of hours for the IV infusion is given (24 hours). To convert 24 hr to min, multiply: 24 hr × 60 min/hr = 1,440 min.

Formula Method Using Two Steps

Step 1: Calculate the mL/hr:

xmL/hr2,000mL24hr=83.3x=83mL/hr

Convert mL/hr to mL/min. 60 min = 1 hr (83 mL/hr = 83 mL/60 min).

Step 2: Place into formula

Formula Method Using hr Converted to min

To infuse 2,000 mL in 24 hours, the IV would be regulated at 21 gtt/min; 21 macrogtt/min.

Dimensional Analysis Using mL/min

Dimensional Analysis Using mL/hr

Dimensional Analysis Using the Total Volume and Total Number of hr

Proceed with calculation as shown in previous examples.

Example 4:

Order: 50 mL NS to infuse over 20 minutes.

Drop factor: 20 gtt/mL. What rate will you regulate the IV to infuse?

Notice, in this example, you have a small volume of fluid, and the time for the IV to infuse is in minutes. This problem can be solved using the same methods (formula method and dimensional analysis) shown in the previous examples.

Formula Method

Dimensional Analysis

To infuse 50 mL NS in 20 minutes, the IV would be regulated at 50 gtt/min; 50 macrogtt/min.

PRACTICE PROBLEMS

Calculate the flow rate in gtt/min using the formula method or dimensional analysis.

- 9. D_5RL at 75 mL/hr. The drop factor is 10 gtt/mL. _____
- 10. D_5 ½ NS at 30 mL/hr. The drop factor is a microdrop. _____
- 11. 1,000 mL D_5 0.33% NS in 6 hr. The drop factor is 15 gtt/mL. _____
- 12. An IV medication in 60 mL of 0.9% NS is to be administered in 45 min. The drop factor is a microdrop. _____
- 13. 1,000 mL of Ringer's lactate solution (RL) is to infuse in 16 hr. The drop factor is 15 gtt/mL.
- 14. 3,000 mL D_5 and ½ NS in 24 hr. The drop factor is 10 gtt/mL. _____
- 15. Infuse 2,000 mL D_5W in 12 hr. The drop factor is 15 gtt/mL. _____

Answers on pp. 538-539

Calculation of IV Flow Rates Using a Shortcut Method

This shortcut method can be used where the IV sets all have the same drop factor. Example: an institution where all the macrodrop sets deliver 10 gtt/mL. This method can also be used with microdrop sets (60 gtt/mL). It is important to note that this method can be used only if the rate of the IV infusion is expressed in mL/hr (mL/60 min).

To use this method, you must know the drop factor constant for the administration set you are using. The drop factor constant is sometimes referred to as the *division factor*. To obtain the drop factor constant (division factor) for the IV administration set being used, divide 60 by the drop factor calibration from the IV infusion set. Box 21.1 shows the constant calculated based on the drop factor for the IV tubing.

BOX 21-1 Drop Factor Constants

Drop Factor of Tubing	Drop Factor Constant
	6010=6
10 gtt/mL	
	6015=4
15 gtt/mL	

Drop Factor of Tubing	Drop Factor Constant
20 gtt/mL	6020=3
60 gtt/mL	6060=1

RULE

After the drop factor constant is determined, the gtt/min can be calculated in one step:

xgtt/min=mL/hrgtt␣factor␣constant

Let's look at examples of calculating the gtt/min using the stated rule:

Example 1:

Order: Administer D_5W at 125 mL/hr. Drop factor: 15 gtt/mL

The drop factor constant: 4.

In this example, the drop factor constant is 4. The set calibration is 15 gtt/mL (60 ÷ 15 = 4).

Solution:

xgtt/min=125mL/hr4=31.2=31

x=31gtt/min;31macrogtt/min

Solution Using Dimensional Analysis:

Remember that the shortcut method discussed (using the drop factor constant) can be used to calculate the gtt/min for any volume of fluid that can be stated in mL/hr or mL/60 min.

RULE

The shortcut method can be used if the volume of fluid is large; however, an additional step of calculating mL/hr first must be done and then calculate the gtt/min using the shortcut method.

Example 2: Order: RL 1,500 mL to infuse in 12 hr. Drop factor: 20 gtt/mL. Drop factor constant: 3.

In this example, the volume of fluid is 1,500 mL and the total hours to infuse is 10 hr. Before using the shortcut method, the mL/hr must be calculated. 1,500 mL ÷ 12 = 125 mL/hr. The set calibration is 20 gtt/mL. 60 ÷ 20 = 3.

Solution:

xgtt/min=125mL/hr341.6=42

x=42gtt/min;42macrogtt/min

Solution Using Dimensional Analysis:

Determine mL/hr expressed as mL/60 min.

The shortcut method can also be used for small volumes of fluid and when the time period is less than 1 hour. If the volume of fluid to infuse is small and the time period is less than 1 hour (60 minutes), the volume and time must each be multiplied to get mL/hr.

Example 3: Order: 20 mL D_5W in 30 minutes. Drop factor 60 gtt/mL. Drop factor constant: 1.

In this example the volume of fluid is small, and the time period is less than 60 min. The set calibration is 60 gtt/mL. 60÷ 60 = 1.

Solution: To express 20 mL in 30 minutes in mL/hr, you multiply the volume and the time by 2.

20mL/30min=(20×2)/(2×30)=40mL/hr(60min)

xgtt/min=40mL/hr140

x=40gtt/min;40␣microgtt/min

Step 1: Change 20 mL/30 min to 40 mL/hr as shown above.

Step 2: Express 40 mL/hr as 40 mL/60 min.

Note: In the above problem to administer 40 mL/hr, the IV would be set at 40 gtt/min. When the drop factor of the infusion set used is 60 gtt/mL, the number of gtt/min is equal (=) to the mL/hr.

PRACTICE PROBLEMS

Calculate the rate in gtt/min using the shortcut method.

- 16. Order: D_5W 200 mL/hr. Drop factor: 10 gtt/mL _____
- 17. Order: 0.9% NS 140 mL/hr. Drop factor: 20 gtt/mL _____
- 18. Order: 1,000 mL D_5W in 10 hr. Drop factor: 10 gtt/mL _____
- 19. Order: 40 mL D_5W in 20 min. Drop factor: 10 gtt/mL _____
- Calculate the flow rate in gtt/min.
- 20. Order: To infuse in 16 hr. Drop factor: 10 gtt/mL
  - • D_5W 500 mL c 10 potassium chloride (KCl)
  - • D_5W 1,000 mL
  - • D_5W 1,000 mL c 1 ampule of multivitamin (MVI) _____
- 21. Order: 1,000 mL D_5 0.9% NS for 3 L at 100 mL/hr. Drop factor: microdrop _____

Answers on 539

POINTS TO REMEMBER

- • To calculate the IV flow rate in gtt/min, the nurse must know the drop factor of the IV tubing, the volume to infuse, and the time for the IV to infuse.
- • Drop factor is expressed as gtt/mL and indicated on the package of the IV tubing.
- • Calculation of gtt/min can be done using the formula method or dimensional analysis.
- • Formula for calculating gtt/min is as follows:

xgtt/min=volume␣of␣solution(mL)×drop␣factortime␣in␣minutes

- • With the formula method, determine the IV rate by converting the flow rate to mL/hr (60 min), and then calculate gtt/min using the formula. **OR** Convert the number of hours to minutes using the conversion factor 60 min = 1 hr, and then place the calculated minutes into the formula.
- • For dimensional analysis, if the mL/hr is not expressed as mL/min, insert the conversion factor 1 hr/60 min into the equation.
- • Drops per minute are always expressed as whole numbers.
- • A shortcut method can be used to calculate flow rates infusing in mL/hr or mL/60 min using the drop constant.
- • To determine the drop constant factor, divide 60 by the calibration of the IV set.
- • To use the shortcut method for small volumes and time periods less than 1 hr, the volume and the time must each be multiplied to get mL/hr.

Calculating IV Flow Rates Using a Dial-Flow Controller

Dial-flow controllers are also known as IV manual flow regulators or just IV flow regulators, as well as just flow controllers. There are a wide variety of dial-flow controllers available for use and are either part of the IV tubing or added on (Figure 21.3). These devices are regulated manually and are not infusion pumps. Use of the device is based on several factors, which include severity of illness, type of therapy, and the setting. Dial-flow devices are designed to regulate the flow of IV fluid instead of using the roller clamp. The flow rate can be adjusted from 5 to 250 mL/hr. To use the device, you set or dial the desired flow rate in mL/hr, which is an estimate, and then the rate must be verified by counting drops per minute. Drops per minute would be calculated using one of the methods presented in the chapter.

Figure 21.3 Flow controller. (Courtesy and © Becton, Dickinson and Company, Franklin Lakes, NJ.)

If used, it is important to remember that use of the device does not relinquish the nurse from his or her responsibility, which is to monitor the IV to ensure there is accurate delivery of the ordered infusion rate.

Let's look at an example using this device.

Example: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 15 gtt/mL.

- 1. Turn the dial of the controller to 100 mL/hr.
- 2. Use the formula or dimensional analysis to determine gtt/min.
- 3. Verify accuracy of controller by counting the drops either for a minute or a fraction, such as 20 seconds. Divide the number of drops per minute by 3 (25 gtt ÷ 3 = 8.3 = 8 gtt). You find the number of drops is 8; the controller is delivering the correct rate for 20 seconds. If the rate is not correct for 20 seconds, the controller dial can be adjusted. The rate will have to be monitored periodically during the infusion.

Formula Method

Dimensional Analysis

Refer to examples for steps in solving.

To infuse 100 mL/hr, the IV flow rate would be set at 25 gtt/min; 25 macrogtt/min.

SAFETY ALERT!

The flow rate on the controller is in **mL/hr, not gtt/min.** Failure to verify the drop rate can result in client not receiving the correct rate, which can result in the client receiving insufficient or excessive IV fluid. To ensure client safety during IV administration, the controller as well as the client **must** be monitored.

Calculating Intermittent IV Infusions Piggyback

A medication such as an antibiotic can be administered by attaching it to a port on the primary line (referred to as Intravenous Piggyback [IVPB]) and infusing it by gravity or infused using an electronic infusion device. IVPBs may come premixed from the drug manufacturer, or medications are added to a small volume bag by the nurse, or in some institutions by the pharmacist and sent to the unit.

If the prescriber does not include the type and amount of solution for the medication to be placed in or the rate for infusion, the nurse must check a medication reference or the manufacturer's guidelines. Even if medications are premixed (with medication added to the solution by the drug manufacturer or pharmacy), the nurse is responsible for ensuring that the IVPB is infusing at the correct rate. When medications are premixed, the nurse calculates the infusion rate by using the volume of solution containing the medication. Regardless of whether the IVPB is mixed by the nurse, is premixed, or the ADD-Vantage system is used, the IVPB must be in the correct amount of solution and infused at the correct rate. The volume of IV solution used for an IVPB is usually 50 to 100 mL to infuse over 20, 30, 60 minutes, or longer depending on the type and amount of medication added.

As already stated, depending on the volume of the medication being added (for an IVPB mixed by the nurse), at some institutions the medication is considered in the volume of IV fluid when determining the IV rate. ***Note:*** For the purpose of this text, it will be indicated when to consider the medication in the IV volume and the type and amount of solution for dilution of the piggyback, and infusion rate will be indicated in the order.

Let's look at the examples shown for determining the rate for the IVPB.

Example 1: Order: Keflin 2 g IVPB in 100 mL D_5W over 30 min. Drop factor: 15 gtt/mL. Determine the IV flow rate.

Solution:

- • In this problem, there is no conversion needed; the volume of solution is in mL.

- • The amount of medication added, 2 g, is not needed to calculate the IV flow rate. The 100 mL of fluid that the Keflin is placed in is used as the volume.
- • A drop factor is stated; therefore the IV rate will be calculated in gtt/min.
- • The volume of IV fluid, which is stated in mL, the time (min), and the drop factor are the required information needed to calculate the IV flow rate, using the formula method or dimensional analysis.

Formula Method

Dimensional Analysis

To infuse 100 mL in 30 minutes the IV rate would be regulated at 50 gtt/min; 50 macrogtt/min.

Now let's look at the same problem if an electronic infusion device was used.

Example 2: Order: Keflin 2 g IVPB in 100 mL D_5W over 30 min by infusion pump.

Determine the IV flow rate.

Solution:

- • An electronic infusion device is being used; the rate will need to be determined in mL/hr.
- • As with Example 1, the amount of medication, 2 g, is not needed to calculate the IV flow rate.
- • Remember there are 60 minutes in 1 hr.
- • The rate can be determined using ratio and proportion, the formula below, or dimensional analysis.

xmL/hr=TotalmLtominutestoinfuseNumberofminutestoinfuse×60min/hr

Ratio and Proportion (Linear Format)

100mL:30min=xmL:60min30x=100×6030x30=6,00030x=200mL/hr

Ratio and Proportion (Fraction Format)

$$\frac{100\text{mL}}{30\text{min}}=\frac{x\text{mL}}{60\text{min}}\quad x=200\text{mL/hr}$$

Formula Method

Notice min is cancelled, leaving mL/hr.

Dimensional Analysis

Notice min is cancelled, leaving mL/hr.

The pump would be set at 200 mL/hr to infuse 100 mL in 30 min. ***Note:*** The actual volume of 100 mL will be infused.

PRACTICE PROBLEMS

Calculate the rate in gtt/min for the following medications being administered IVPB. Use the labels where provided. (Add the volume of medication being added to IV solutions, where indicated.)

- 22. Order: Erythromycin 200 mg in 250 mL D_5W to infuse over 1 hr. Drop factor: 10 gtt/mL _____

- 23. Order: Ampicillin 1 g in 50 mL D_5W to infuse over 45 minutes. Drop factor: 10 gtt/mL. For IV, reconstitute with 10 mL of diluent to get 1 g per 10 mL. (Consider the medication added in the volume of fluid.)
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Calculate the rate in gtt/min at which the IV should infuse. _____
- 24. Order: Clindamycin 900 mg in 75 mL D_5W over 30 minutes. Drop factor: 10 gtt/mL
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Determine the IV rate. _____
- 25. Order: Vancomycin 500 mg IVPB q24hr. The reconstituted vancomycin provides 50 mg per mL. The medication is placed in 100 mL of D_5W to infuse over 60 minutes. Drop factor: 15 gtt/mL. (Consider the medication added in the volume of fluid.)
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Calculate the rate in gtt/min at which the IV should infuse. _____
- 26. Order: Fungizone (amphotericin B) 20 mg in 300 mL D_5W over 6 hr by infusion pump. The reconstituted material contains 50 mg per 10 mL.
  - a. How many milliliters will you add to the IV solution? _____
  - b. Determine the IV rate. _____
- 27. Order: Septra (sulfamethoxazole and trimethoprim) 300 mg in 300 mL D_5W over 1 hr q6h. Drop factor: 10 gtt/mL. Calculate the dose using trimethoprim.
  - a. How many milliliters of medication will be added to the IV? (Round the answer to the nearest tenth.) _____
  - b. Consider the medication added to the volume of IV fluid. Calculate the rate in gtt/min at which the IV should infuse. _____
- 28. Order: Retrovir (zidovudine) 100 mg IV q4h over 1 hr. Available medication states each mL contains 10 mg of zidovudine.
  - a. How many milliliters of medication will be added to the IV solution? _____
  - b. The medication is placed in 100 mL of D_5W. Drop factor: 10 gtt/mL (Consider the medication added to the volume of IV fluid.) _____

Answers on pp. 539-540

Determining the Amount of Medication in a Specific Amount of Solution

Sometimes medications are added to IV solutions, and the prescriber orders a certain amount of medication to be administered in a certain time period. In order to calculate the volume of fluid needed to deliver a specific amount of medication, a ratio and proportion can be used or dimensional

analysis.

Example 1: Order: 20 mEq of potassium chloride in 1,000 mL D_5W to infuse at 2 mEq/hr. Calculate the mL/hr to deliver 2 mEq of potassium chloride/hr.

Solution:

Set up a ratio and proportion using the linear or fraction format:

- • With use of the ratio and proportion, the known ratio is the amount of medication in the total volume of solution, and the unknown ratio is what the prescriber ordered.
- • Dimensional analysis of the first factor is the total volume of solution and the amount of medication, and the second factor is what the prescriber ordered.

Ratio and Proportion (Linear Format)

20mEq:1,000mL=2mEq:xmL20x=1,000×220x20=2,00020x=2,00020=100x=100mL/hr

Ratio and Proportion (Fraction Format)

20mEq1,000mL=2mEqxmLx=100mL/hr

Dimensional Analysis

Notice cancelling mEq leaves mL/hr.

100 mL/hr will deliver 2 mEq /hr of potassium chloride.

Example 2: Order: 100 units of Humulin regular insulin in 500 mL ½ NS to infuse at 10 units/hr. Calculate the mL/hr to deliver 10 units of insulin/hr.

Ratio and Proportion (Linear Format)

100units:500mL=10units:xmL100x=500×10100x100=5,000100x=5,000100=50x=50mL/hr

Ratio and Proportion (Fraction Format)

$$\frac{100\text{units}}{500\text{mL}} = \frac{10\text{units}}{x\text{mL}} \quad x = 50\text{mL/hr}$$

Dimensional Analysis

POINTS TO REMEMBER

- • When preparing medications for intermittent infusion:
  - a. Reconstitute the medication using the label or package insert if needed.
  - b. Calculate the amount of medication to administer.
  - c. Verify the recommended infusion rate with the manufacturer's recommendations or a medication reference.
  - d. Determine the IV rate using the IV formula or dimensional analysis.
- • If the intermittent infusion is being administered by an electronic infusion device, the flow rate is determined in mL/hr using ratio and proportion, dimensional analysis, or the formula method for time periods less than 1 hour.

$$x\text{mL/hr} = \frac{\text{Total mL to infuse}}{\text{Number of min to infuse}} \times 60\text{min/hr}$$

- • To determine the volume (amount) of IV fluid to administer the prescribed amount of medication in mL/hr, use ratio and proportion or dimensional analysis.

PRACTICE PROBLEMS

Solve the following problems using the steps indicated.

- 29. Order: 15 mEq of potassium chloride in 1,000 mL of D_5 ½ NS to be administered at a rate of 2 mEq/hr.
- How many mL/hr should the IV infuse at? _____
- 30. Order: 10 units of Humulin regular insulin per hour. 50 units of insulin is placed in 250 mL NS.
- How many mL/hr should the IV infuse at? _____

Answers on pp. 540-541

Determining the Unknown for Time and Volume

You may need to calculate the following:

- a. **Time in hours**—How long it will take a certain amount of fluid to infuse or how long it may last
- b. **Volume**—The total number of milliliters a client will receive in a certain time period These unknown elements can be determined by the use of the formula method or dimensional analysis.

Formula:

xgtt/min=Volume␣of␣solution␣in␣mL×Drop␣factorTime(min)

Calculating a Problem with an Unknown Using the Formula Method and Dimensional Analysis

- 1. Take the information given in the problem and place it in the formula.
- 2. Place an *x* in the formula in the position of the unknown. If you are trying to determine time in hours, place *x* in the position for minutes; once you find the minutes, divide the number of minutes by 60 (60 minutes 5 1 hr) to get the number of hours. If you are trying to determine the volume the client would receive, place an *x* in the position for amount of solution, and label *x* mL.
- 3. Set up an algebraic equation so that you can solve for *x*.
- 4. Solve the equation.
- 5. Label the answer in hours or milliliters for volume.

Example 1: Determining hours:

An IV is regulated at 20 microgtt/min. How many hours will it take for 100 mL to infuse?

Formula Method

Note: In the position of drop factor, 60 gtt/mL was placed, IV was infusing in microgtt, and the infusion set had to be a microdrip (60 gtt/mL).

Dimensional Analysis

x hr is what you are looking for. The **first** starting fraction is 1 hr/60 min, the **second** fraction is 1 min/20 gtt to match the denominator of the starting fraction. The **third** fraction is 60 gtt/1 mL to match the denominator in the fraction before it. The **last fraction** is 100 mL/1, to match mL in the fraction before it. Cancel the units, reduce if possible, and perform mathematical process.

Note: When calculating time and the answer results in hr and min, express entire time in hr (i.e., 1 hr and 30 min = 1.5 hr, or 1½ hr; 1½ hr is the preferred way to state answer).

Example 2: Determining volume:

An IV is regulated at 17 macrogtt/min. The drop factor is 15 gtt/mL. How much fluid volume in milliliters will the client receive in 8 hr?

Formula Method

Dimensional Analysis

x mL is what you are looking for here. Enter the drop factor as the **first** starting fraction 1 mL/15 gtt. The **second** fraction is 17 gtt/1 min, so it matches the denominator of the first fraction. The **third** fraction is 480 min/1 so that it matches the denominator before it. **An alternate** to changing min to hr is to enter the conversion 60 min/1 hr, and enter 8 hr/1 to match the denominator before it. Cancel if possible, and perform the mathematical process.

Note: Some problems for calculating an unknown may be solved without using the formula method or dimensional analysis; however, the use of one or the other is recommended.

POINTS TO REMEMBER

Determining the Unknown

- • Use the IV formula and place the information given into the position of the formula.

xgtt/min=Volume␣of␣solution␣in(mL)×drop␣factorTime(min)

Use *x* for unknown values.

- 1. For determining time—place an *x* in the minutes position, and then divide the minutes by 60 to determine the time in hours.
- 2. For volume—place an *x* in the position for amount of solution and label *x* mL. Convert the hours to minutes.

- • Set up an algebraic equation and solve for *x*.
- • Answers for time are labeled in hours, with mL for volume, unless instructed otherwise.
- • Dimensional analysis can also be used to determine the unknown.

PRACTICE PROBLEMS

Solve for the unknown in the following problems as indicated.

- 31. You find that there is 150 mL of D_5W left in an IV. The IV is infusing at 60 microgtt/min. How many hours will the fluid last? _____
- 32. 0.9% NS is infusing at 35 macrogtt/min. The drop factor is 15 gtt/mL. How many milliliters of fluid will the client receive in 5 hours? _____
- 33. There is 90 mL of D_5 0.33% NS left in an IV that is infusing at 60 microgtt/min. The drop factor is 60 gtt/mL. How many hours will the fluid last? _____

Answers on 541

Recalculating an IV Flow Rate

Flow rates on IVs change when a client stands, sits, or is repositioned in bed if IVs are infusing by gravity. Therefore, nurses must frequently check the flow rates. Sometimes IVs infuse ahead of schedule, or they may be behind schedule if they are not monitored closely. When this happens, the IV flow rate must be recalculated. To recalculate the flow rate, the nurse uses the volume remaining and the time remaining. Recalculation may be done with uncomplicated infusions. IVs that require exact infusion rates should be monitored by an electronic infusion device.

SAFETY ALERT!

Never arbitrarily increase or decrease an IV to get it back on schedule without assessing a client and checking with the prescriber. Increasing or decreasing the rate without thought can result in serious harm to a client, including overhydration or underhydration. Check the policy of the institution. Avoid off-schedule IV rates by regularly monitoring the IV at least every 30 to 60 minutes.

When an IV is significantly ahead of or behind schedule, you may need to notify the prescriber, depending on the client's condition and the use of appropriate nursing judgment. **Always assess the client** before making any change in an IV rate. Changes depend on the client's condition. Check the institution's policy regarding the percentage of adjustment that can be made. Each situation must be individually evaluated, and appropriate action must be taken.

A safe rule is that the recalculated flow rate should not vary from the original rate by more than 25%. If the recalculated rate varies by more than 25% from the original rate, the prescriber should be notified. The order may require revision. If a client is stable, recalculate the IV rate, using the remaining volume and time, and then proceed to calculate gtt/min using the formula method or dimensional analysis. Refer to content in this chapter (calculating gtt/min) if necessary. Let's go over the steps to recalculate an IV rate if allowed by your institution policy, and the client is stable.

To recalculate an IV flow rate:

- • Use the remaining volume and remaining hours, and calculate the rate in mL/hr.

xmL/hr=Remaining␣volumeRemaining␣time(hr)

- • Use the mL/hr to calculate gtt/min for the recalculated rate, using the formula or the shortcut method:

Formula:xgtt/min=Volume␣of␣solution(mL)×drop␣factorTime␣in␣minutes

- • Shortcut method:

xgtt/min=mL/hrgtt␣factor␣constant

- • Determine whether the new rate calculation is greater or lesser than 25%. Use the amount of increase or decrease divided by the original rate.

Amount␣of↑or↓Original␣rate

= % of change of original rate (round to nearest whole percent)

Let's look at some examples. ***Note:*** All examples assume the institution allows a 25% IV flow variation, and the clients are stable.

Example 1: 1,000 mL of D_5 RL was to infuse in 8 hr at 31 gtt/min (31 macrogtt/min). The drop factor is 15 gtt/mL. After 4 hr, you notice 700 mL of fluid left in the IV. Recalculate the flow rate for the remaining solution. ***Note:*** The infusion is behind schedule. After 4 hr, half of the volume (or 500 mL) should have infused.

Solution:

Solution to Example 1: Using the Shortcut Method

Determine recalculated rate:

Time remaining: 8 hr – 4 hr = 4 hr

Time remaining: 8 hr – 4 hr = 4 hr

Volume remaining: 1,000 mL – 300 mL = 700 mL

Volume remaining: 1,000 mL – 300 mL = 700 mL

700 mL ÷ 4 hr = 175 mL/hr

700 mL ÷ 4 hr = 175 mL/hr

Drop factor: 15 gtt/mL; therefore the drop factor constant is 4.

Drop factor: 15 gtt/mL; therefore the drop factor constant is 4.

xgtt/min=175mL/hr4=43.7=44

x = 44 gtt/min; 44 macrogtt/min (recalculated rate)

x = 44 gtt/min; 44 macrogtt/min (recalculated rate)

Determine the percentage of the change:

44−3131=1331=0.419=42%

Dimensional Analysis

Course of Action

Assess the client.

Notify the prescriber.

Do not increase the IV rate; the increase is **greater than 25%.**

Increasing the IV could result in serious consequences for the client. Assessment of the client is always done first to determine the client's ability to tolerate an increase in fluid. In this situation the prescriber should be notified, a new order is needed, the recalculated rate is greater than 25%.

Example 2 (IV Ahead of Schedule): An IV of 1,000 mL D_5W is to infuse from 8 am to 4 pm (8 hr). The drop factor is 10 gtt/mL. The rate is set at 20 gtt/min (20 macrogtt/min). In 5 hr, you notice that 700 mL has infused. Recalculate the flow rate for the remaining solution.

Solution:

Shortcut Method

Determine recalculated rate:

Time remaining: 8 hr – 5 hr = 3 hr

Volume remaining: 1,000 mL – 700 mL = 300 mL

300 mL ÷ 3 = 100 mL/hr

Drop factor: 10 gtt/mL; therefore the drop factor constant is 6.

xgtt/min=100mL/hr6=16.6=17

x = 17 gtt/min; 17 macrogtt/min (recalculated rate)

x = 17 gtt/min; 17 macrogtt/min (recalculated rate)

Determine the percentage of change:

17−2020=−320=−0.15=−15%

Dimensional Analysis

Time remaining: 8 hr – 5 hr = 3 hr

Volume remaining: 1,000 mL – 700 mL = 300 mL

x = 17 gtt/min; 17 macrogtt/min

x = 17 gtt/min; 17 macrogtt/min

Course of Action

Assess the client.

Adjust the rate if allowed by institutional policy, and assess during the remainder of the infusion.

Notify prescriber if required.

In this situation, the flow rate must be decreased from 20 gtt/min (20 macrogtt/min) to 17 gtt/min (17 macrogtt/min), and the change is not greater than 25% of the original rate. –15% is within the acceptable 25% of change. However, the client's condition must still be assessed to determine the ability to tolerate the change, and the prescriber may still require notification.

Alternate to Determining the Percentage of Change

As already stated, you can adjust the flow rate as much as (+) or (–)25%. Think 25% = ¼. Therefore you can verify the safety of the recalculated rate by using a method that eliminates the need to use percents. To do this, do the following:

- • Divide the original rate by 4, then add, and subtract the result from the original rate. This will provide a range for the acceptable rate adjustment. Let's use the two examples we just did.

Example 1:

The original rate was 31gtt/min (macrogtt/min), and the recalculated rate is 44 gtt/min (macrogtt/min).

Original rate ± (original rate ÷ 4) = Acceptable IV rate adjustment

31 + (31 ÷ 4) = 31 + 7.75 = 38.75 = 39 gtt/min (macrogtt/min)

31 – (31 ÷ 4) = 31 – 7.75 = 23.25 = 23 gtt/min (macrogtt/min)

The safe acceptable IV rate adjustment is 23 to 39 gtt/min (macrogtt/min). 44 gtt/min is above the acceptable adjustment range, and 25%. The prescriber should be notified to provide a new order.

Example 2:

The original rate was 20 gtt/min (macrogtt/min), and the recalculated rate is 17 gtt/min (17 macrogtt/min).

Original rate ± (original rate ÷ 4) = Acceptable IV rate adjustment

20 + (20÷ 4) = 20 + 5 = 25 gtt/min (macrogtt/min).

20 – (20 ÷ 4) = 20 – 5 = 15 gtt/min (macrogtt/min).

The safe acceptable IV rate adjustment is 15 to 25 (macrogtt/min). It is safe to slow the rate to 17 gtt/min (macrogtt/min), which is less than 25%.

POINTS TO REMEMBER

- • Monitor IV therapy every 30 to 60 min to maintain the ordered IV rate.
- • Do not arbitrarily speed up or slow down an IV that is behind or ahead of schedule.
- • Know the hospital policy regarding recalculation of IV flow rate. An IV should not vary more than 25% from its original rate.
- • To recalculate an IV rate:
- • Determine mL/hr:
- xmL/hr=Remaining␣volumeRemaining␣time(hrs)

- • Use mL/hr and recalculate the rate in gtt/min, using formula or shortcut method.

  xgtt/min=Volume␣of␣solution(mL)×drop␣factorTime␣in␣minutes

  xgtt/min=mL/hrgtt␣factor␣constant

- • Determine the % of change

- Amount␣of↑or↓Original␣rate

= % of change (rounded to the nearest whole %)

- • Alternate to use of percent: Divide the original rate by 4, then add and subtract the result from the original rate to get the acceptable IV rate adjustment.
- • Contact the prescriber for a new IV order, if the recalculated rate exceeds 25%.

PRACTICE **PROBLEMS**

For each of the problems, recalculate the IV flow rates in gtt/min rates using either method presented, determine the percentage of change, and state your course of action. *Note:* The institution allows 25% variation and clients are stable.

- 34. 500 mL of 0.9% NS was ordered to infuse in 8 hr at the rate of 16 gtt/min (16 macrogtt/min). The drop factor is 15 gtt/mL. After 5 hr, you find 250 mL of fluid left.
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 35. 250 mL of D_5W was to infuse in 3 hr at the rate of 21 gtt/min (21 macrogtt/min). Drop factor: 15 gtt/mL. With 1½ hr remaining, you find 200 mL left.
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 36. 1,000 mL D_5 0.33% NS was to infuse in 12 hr at 28 gtt/min (28 macrogtt/min). After 4 hr, 250 mL has infused. Drop factor: 20 gtt/mL
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 37. 500 mL D_5 0.9% NS to infuse in 5 hr at 100 gtt/min (100 microgtt/min). After 2 hr, 250 mL has infused. Drop factor: 60 gtt/mL
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action

Answers on pp. 541-542

Calculating Infusion and Completion Time

IV fluids are ordered by the prescriber for administration indicating a specific rate in mL/hr, such as 1,000 mL D_5W to infuse at 100 mL/hr. **The nurse needs to be able to determine the amount of time (hours and minutes) that it would take for a certain volume of IV solution to infuse, which is referred to as *infusion time*.** Knowing the infusion time is important for the nurse, which includes reasons such as allowing the preparation for hanging a new solution as one infusion is being completed and preventing things such as the line clotting off as a result of not knowing when an IV was to be completed. Infusion times can be calculated using any of the following methods:

- • Ratio and proportion: The known ratio, which is written first, is the ordered rate in mL/hr, and the second ratio is the unknown, which is the total number of mL to infuse in *x* hr, total mL/*x* hr. The ratio and proportion can be written in linear or fraction format.

- • Formula method: Total␣number␣of␣mL␣to␣infuse mL/hr (infusion␣rate)

= Infusion time

- • Dimensional analysis: The unknown is *x* hr; therefore the first fraction will be the ordered rate, hr/mL, the second fraction will be total mL/1.

Let's look at some examples of calculating infusion time.

Example 1: Calculate the infusion time for an IV of 1,000 mL D_5W to infuse at a rate of 125 mL/hr.

Ratio and Proportion (Linear Format)

125 mL : 1 hr = 1,000 mL : x hr
125x = 1,000
125x/125 = 1,000/125
x = 8 hr␣(infusion␣time)

Formula Method

1,000 mL (total mL to infuse)

125 mL/hr (mL/hr to infuse)

Infusion time = 8 hr

Ratio and Proportion (Fraction Format)

125 mL / 1 hr = 1,000 mL / x hr

Solve by cross-multiplication.

Dimensional Analysis

x = 8 hr

mL is cancelled here, leaving hr.

When an infusion time result is not an even whole number but instead the infusion rate includes a decimal fraction; the decimal fraction represents a fraction of an hour and must be converted to minutes. This calculation of infusion time is done as follows:

- • Determine the infusion time using any of the methods already presented, and carry division two decimal places.
- • Calculate the minutes using, conversion factor; 60 min = 1 hr. (Multiply the fraction of an hr by 60 min/hr) or use any of the methods presented.
- • Using the rules of rounding, round the minutes to the nearest whole number of minutes.

Let's look at an example.

Example 2: 1,000 mL D_5 ½ NS to infuse at 150 mL/hr. Calculate the infusion time for the IV.

Ratio and Proportion (Linear Format)

- • Determine the infusion time
- 150 mL : 1 hr = 1,000 mL : x hr
- 150mL:1hr=1,000mL:xhr150x=1,000150x150=1,000150x=6.66hr

- • Calculate the minutes
- 1 hr : 60 min = 0.66 hr : x min
- x = 0.66 × 60 = 39.6
- x = 40 min (rounded to whole number)
- Infusion time is 6 hr and 40 min.

Formula Method

- • Determine infusion time
-

- x = 6.66 hr
- • Calculate the minutes

- Infusion time is 6 hr and 40 min.

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

- • Determine infusion time
- 150mL1hr=1,000mLxhr

- *x* = 6.66 hr
- • Calculate the minutes
- 60min1hr=xmin0.66hr=39.6=40

- *x* = 40 min

Infusion time is 6 hr and 40 min.

Dimensional Analysis

- • Determine infusion rate
-

- *x* = 6.66 hr
- • Calculate the minutes

- x = 40 min
- Infusion time is 6 hr and 40 min.

Completion Time

Once the infusion time has been calculated, the nurse can use this information to determine the completion time. Completion time is the when the infusion is completed (i.e., the client has received all of the IV fluid). This would be determined as follows: Add the calculated infusion time to the time the infusion was started. If the IV was started at 7:00 am, add the 6 hours and 40 minutes to that time (7:00 am). The IV would be completed at 1:40 pm. It is easier to calculate completion time using military time: 7:00 am = 0700; now add 6 hours and 40 minutes to arrive at the answer of 1340.

- Start time 0700
- Infusion time +0640
- **Completion time:** 1340 or 1:30 pm

Calculating Completion Time

To calculate the completion time, add the infusion time to the time the IV was (military time).

Note: Converting traditional time to military time, and a discussion of completion time, appears in Chapter 8.

Let's look at some examples.

Example 1: An IV of 1,000 mL of D_5W is started at 1000 to infuse over 8 hr. Determine the completion time.

Solution:

- Start time 1000
- Infusion time +0800

Completion time: 1800 or 6:00 pm

Example 2: An IV of 1,000 mL of 0.9% NS is started at 2130 to infuse over 12 hr. Determine the completion time.

Solution:

- Start time 2130
- Infusion time +1200
- 3330 (time here is greater than 2400)

As you recall, when the time period is greater than 2400, you must subtract 2400 from the total (the day ends at 2400). This will give you the completion time for the next day.

Using the answer from the problem, which is 3330

Subtract –2400

Subtract –2400

Completion time: 0930 or 9:30 am the next day

Completion time: 0930 or 9:30 am the next day

Example 3: An IV of D_5½ NS is started at 0430 to infuse in 6 hr and 40 min. Determine the completion time.

Solution:

- Start time 0430
- Infusion time +0640
- 1070 (the minutes here are greater than 60)

As you recall, when the minutes are greater or equal to 60, subtract 60 from the number of minutes, which in this example is 70 min, and then add the 1 hour obtained when you subtracted the 60 minutes to get the completion rate, as follows:

- 1070
- −0060 minutes (1 hr)
- 1010
- +0100 (the 1 hr obtained when you subtracted the 60 min)

Completion time: 1110 or 11:10 am

Alternate to Example 3:

- Add start time: 0430
- Infusion time +0640
- Convert 70 min to 1 hr and 10 min and add to 10 hr. 1000
- +0110
- **Completion time:** 1110 or 11:10 am

As you will notice in the examples provided, you were given the infusion time as well as the time for the infusion to start in military time. Let's look at an example in which you will need to determine the infusion time before calculating the completion time.

Example 4:

500 mL D_5W to infuse at 80 mL/hr is started at 7:30 am. Determine the completion time. State time in military and traditional time.

Solution:

- • First determine the infusion time using any of the methods already presented (ratio and proportion, formula method, or dimensional analysis)

Ratio and Proportion (Linear Format)

80 mL : 1 hr = 500 mL : x hr

80x = 500

80x80=50080=6.25

x = 6.25 hr

Calculate the minutes.

1 hr : 60 min = 0.25 hr : x min

x = 0.25 × 60 = 15

x = 15 min

Infusion time is 6 hr and 15 min.

Formula Method

Calculate the minutes.

Infusion time is 6 hr and 15 min.

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

80mL1hr=500mLxhr

x = 6.25 hr

Calculate the minutes.

60min1hr=xmin0.25hr

x = 15 min

Infusion time is 6 hr and 15 min.

Dimensional Analysis

Calculate the minutes:

Infusion time is 6 hr and 15 min.

- • Now determine the completion time (add the infusion time to the start time).
  - Start time: 0730
  - Infusion time: +06151345

= 1:45 pm

Note: The start time (7:30 am) was changed to military time: to convert am time omit colon and am, add a zero to beginning to make a 4-digit number. To convert pm time to traditional time, subtract 1200 and add pm. If necessary, review the conversion of time (traditional and military) in Chapter 8.

PRACTICE PROBLEMS

Determine infusion and completion time for the following IVs. State the time in traditional and military time.

- 38. An IV of 500 mL NS is to infuse at 60 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 10:00 pm. When would the IV infusion be completed? _____
- 39. An IV of 250 mL D_5W is to infuse at 80 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 2:00 am. When would the IV infusion be completed? _____
- 40. An IV of 1,000 mL D_5 RL is to infuse at 60 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 6:00 am. At what time would this IV infusion be completed? _____

- 41. An IV of 500 mL D_5W is to infuse at 75 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 2:00 pm. At what time would the IV infusion be completed? _____

Answers on 542

unknown - Section 39 (Page 353)

This chapter will present the calculations performed with intravenous therapy. As stated previously, nurses have the responsibility to make sure that clients are receiving the correct rate. Several methods to calculate IV rates are presented in the chapter: ratio and proportion, dimensional analysis, and the formula. Let's now begin our calculations with determining IV rates in milliliters per hour (mL/hr).

IV Flow Rate Calculation

As previously discussed, the prescriber's order for an IV includes the following:

- • The name of the IV solution
- • The volume to infuse
- • Medications to be added, if any
- • Time for the IV to infuse

Continuous IV, which is oft en referred to as the primary IV, usually contains a large volume of fluid (500 mL or 1,000 mL). IV fluids are usually ordered to be administered at rates expressed in mL/hr. The time for the IV to infuse may be indicated as the total number of hours (i.e., D_5W 3,000 mL in 24 hr), or mL/hr (i.e. D_5 ½. NS 1,000 mL at 125 mL/hr). Small volumes of fluid (usually 50 mL or 100 mL) are oft en used when the IV fluid contains medications such as antibiotics. Rates for IV fluids are usually expressed in drops per minute (gtt/min) when an infusion device is not used. When an infusion device such as a pump is used, the flow rate must be expressed in mL/hr.

Calculating Flow Rates for Infusion Pumps in mL/hr

When a client is using an electronic infuser, such as a volumetric pump, the prescriber orders the volume and can include mL/hr or the total number of hours for the IV to infuse. If the order states the number of mL/hr for the infusion, such as previously stated D_5 ½ NS at 125 mL/hr, there is no calculation required by the nurse. The nurse programs the pump to deliver the ordered rate. However, if the order states the total number of hours for the IV to infuse (D_5W 3,000 mL in 24 hr), the nurse will need to calculate the mL/hr to program the pump.

For most electronic devices that regulate the flow of IV solutions, the rate is expressed in milliliters per hour (mL/hr). For the purpose of this text, the equipment being used is programmable in whole mL/hr; therefore mL/hr should be rounded to a whole number unless indicated that the infusion pump has decimal capability. To determine mL/hr the following information is needed:

- • The volume (amount) of solution in milliliters
- • The time for the IV to infuse in hours

The simplest way to determine the mL/hr is by using the formula, although ratio-and-proportion and dimensional analysis can be used:

Formula to Determine mL/hr

Round mL/hr to the nearest **whole number**. If the answer does not result in a whole number, carry division to tenths place and round to the nearest whole number. If pump has decimal capability, round answer to the **nearest tenth.**

SAFETY ALERT!

There are some IV pumps in use that are capable of delivering IV fluids in tenths of a milliliter. Always be familiar with the IV equipment being used at the institution before rounding milliliters per hour (mL/hr) to the nearest whole mL/hr.

Let's begin with the calculation of IV flow rates in mL/hr.

Example 1: Client with an infusion pump has an order for 3,000 mL D_5W over 24 hours.

Solution:

- 1. Think: Pump is regulated in mL/hr.
- 2. No conversion required; the volume is in milliliters, and the time is in hours.
- 3. To use the formula method to determine mL/hr: *x* mL/hr = volume in mL.

- 4. To determine mL/hr using ratio and proportion, the volume ordered and hours to infuse is the known ratio; 3,000 mL : 24 hr (stated first), and the unknown is *x* mL : 1 hr. (stated as the second ratio) or:

- 5. To determine mL/hr using dimensional analysis, identify what you are looking for, and write it to the left of the equation in a fraction format. Label factor:

Place problem as starting fraction (if no conversion required). If conversion is required, the starting fraction is the conversion factor, and the problem is inserted as the second fraction in the equation. Refer to the setups of Example 1 using the various methods.

Formula Method

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

In this problem no conversion was required, the ordered amount is in mL/hr, which is the same as the desired; therefore the problem is solved by division, and no cancellation of units is required.

To infuse 3,000 mL of D_5W in 24 hr, the pump would be set to deliver 125 mL/hr.

Sometimes a conversion may be necessary before calculating mL/hr. Let's look at a problem showing the calculation of mL/hr when a conversion is required.

Example 2: Client with an infusion pump is to receive 0.5 L 0.9% NS over 8 hours.

Solution:

- 1. Convert 0.5 L to 500 mL using any of the methods presented in earlier chapters.
- Use the conversion factor 1 L = 1,000 mL. Convert 0.5 L to mL by moving the decimal three places to the right (metric to metric). Decimal movement can be used. Review methods of converting if necessary.
- 2. Set up the problem and solve using one of the calculation methods.

Formula Method

mL/hr is rounded to the nearest whole number of mL.

Ratio and Proportion (Linear Format)

mL/hr is rounded to the nearest whole number of mL.

Ratio and Proportion (Fraction Format)

mL/hr is rounded to the nearest whole number of mL.

Dimensional Analysis

mL/hr is rounded to the nearest whole number. Notice the conversion factor is written

to cancel L, leaving mL/hr.

To infuse 500 mL of 0.9% NS, the pump would be set to deliver 63 mL/hr. As previously stated, pumps deliver in whole mL unless indicated the pump has decimal capability.

Determining mL/hr When the Time Period Is Less Than 1 Hour

Often when medications are administered IV, such as IVPB (e.g., for antibiotics), the time period for the IV to infuse is less than 1 hour. When the period is less than 1 hour and an electronic infusion device is used, the IV rate must still be determined in mL/hr. **Remember that there are 60 minutes in 1 hour.** The rate can be determined using ratio and proportion. (The known ratio is the ordered rate, mL/min, and the second is the unknown ratio, x mL/60 min). Dimensional analysis can also be used to determine the rate in mL/hr. (The first factor in the equation is the ordered mL/min, and the second factor is 60 min/1 hr). The rate can also be determined using the formula:

Let’s look at an example. The various methods for calculating the infusion rate will be shown.

Example 3: A client is to receive an antibiotic in 100 mL of 0.9% NS over 45 min by infusion pump. Determine the IV flow rate.

Solution:

- 1. Think: The infusion pump infuses in mL/hr. Use a ratio and proportion, the formula method, or dimensional analysis to determine mL/hr.
- 2. Remember: 1 hr = 60 min.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Formula Method

Note: min is cancelled, leaving mL/hr.

Dimensional Analysis

Note: min is cancelled, leaving mL/hr.

The infusion pump would be set at 133 mL/hr to infuse 100 mL in 45 minutes. The volume of 100 mL will be infused.

SAFETY ALERT!

The usual rate in mL/hr ranges from 50 to 200 mL/hr. If the rate exceeds this amount, double-check the order and your calculation before programming the rate into an infusion pump.

POINTS TO REMEMBER

- • IV infusion pumps deliver IV flow rates in mL/hr.
- • IV orders indicate: the name of the IV solution, the volume to infuse, medications to be added, if any, and the time for the IV to infuse. The prescriber may indicate the time for an IV to infuse in mL/hr, or the total number of hours for the IV to infuse.
- • To determine flow rates for an electronic infusion device such as the infusion pump, determine mL/hr using the formula:

- • If the time for the IV to infuse is less than 1 hour and the infusion pump is used, the infusion rate still must be determined in mL/hr. Ratio and proportion, the formula method, or dimensional analysis can be used to determine the infusion rate. Remember that 60 min = 1 hr.
- • Milliliters per hour (mL/hr) are rounded to the nearest whole number. If math does not result in a whole number, carry math to the tenths place and round to the nearest whole number.
- • Some infusion pumps have decimal capability and can deliver IV rates in tenths of a mL. If the answer obtained is not in the tenths place, carry math to the hundredths place and round to the tenths.
- • Always be familiar with the infusion device being used by an institution before rounding mL/hr to a whole number.

PRACTICE PROBLEMS

Calculate the flow rate in mL/hr. (Equipment used is programmable in whole mL/hr.)

- 1. 1,800 mL of D_5W in 24 hr by infusion pump

- 2. 2,000 mL D_5W in 24 hr by infusion pump
- 3. 500 mL RL in 12 hr by infusion pump
- 4. 1,500 mL D_5RL in 24 hr by infusion pump
- 5. 750 mL D_5W in 16 hr by infusion pump

Answers on 538

Manually Regulated IVs

When an electronic infusion device is not used, the nurse uses a gravity-flow system and must manually regulate the infusion rate. To do this, the nurse must calculate the ordered IV flow rate in drops per minute (gtt/min). IV flow rates in gtt/min are based on the IV tubing calibration, referred to as the *drop factor*. The **drop factor** is the number of drops per milliliter (gtt/mL) that a particular IV tubing delivers and therefore will vary depending on the type of IV tubing.

The drop size is determined by the size of the tubing or the small needle inside the drop chamber releasing the drops. See Figure 21.1. Note the large opening for drops in Figure 21.1A, the drops are large (**macrodrops**). The drops delivered through the small needle in Figure 21.1B are very small drops (**microdrops**). The drop factor of the IV tubing is stated in large numbers on the IV tubing package (Figure 21.2). The drop factor of the IV tubing is needed to calculate gtt/min.

Figure 21.1 Comparison of (A) macrodrops and (B) microdrops.

Figure 21.2 IV administration sets (package). **(A)** Set with drop factor of 10 (10 gtt =1 mL). **(B)** Set with drop factor of 60 (60 gtt = 1 mL).

As stated previously, at the top of the IV tubing is a drip chamber (also referred to as a drop chamber), where the nurse observes and counts the number of drops falling into the drip chamber per minute or fraction of a minute placing a watch at the level of the drip chamber. The flow rate is regulated by a hand-operated slide clamp or a roller clamp, which is opened or closed so the drops fall at the desired rate.

SAFETY ALERT!

IV infusions that are manually regulated must be monitored regularly. The flow rate of a manually regulated IV can be affected by the height of the IV infusion, the location of the site, and changes in the client position, which can result in impediment of the IV flow rate or excessive amounts of fluid being delivered to the client.

IV Tubing

The two common types of tubing used to administer IV fluids (regulated manually) are:

- • Macodrop tubing
- • Microdrop tubing

Macrodrop Tubing

Macrodrop is the standard tubing used for general IV administration. With macrodrop tubing the size of the drop and the number of gtt/mL varies according to the manufacturer. Macrodrops are large drops, and there are fewer drops in 1 mL (see Figure 21.1A). Macrodrop tubing have the following drop factors:

- • 10 gtt/mL
- • 15 gtt/mL
- • 20 gtt/mL

Since the drop factor for macrodrop tubing differs according to the manufacturer, always read the IV tubing package and identify the drop factor of the tubing. Never assume to know the drop factor, because not all macrodrop tubing has the same factor.

SAFETY ALERT!

To accurately administer IV fluids at the correct rate to a client, the nurse **must** know the drop factor of the IV tubing. Knowing the drop factor of the IV tubing used can prevent an error in IV rate determination and the client receiving IV fluid at the incorrect rate. **Never** assume the drop factor for macrodrop tubing.

Microdrop Tubing

Microdrop tubing delivers tiny drops through a small needle in the drip chamber and therefore has more drops in 1 mL (see Figure 21.1B). It is used to administer either small or precise amounts of fluid. For example, it is used in critical care, for the elderly, and for pediatric infusions. Microdrop tubing, because of the size of the drops (very small/ tiny) is sometimes referred to as pedidrip tubing. Microdrop tubing, regardless of the manufacturer, is only available in one drop factor (60 gtt/mL). With microdrop tubing the number of mL/hr is the same as gtt/min (i.e., if the infusion rate is 100 mL/hr, the IV rate is 100 gtt/min).

- • 60 gtt/mL

POINTS TO REMEMBER

- • Drop factor = gtt/mL of the IV tubing. This information is written on the package of the IV tubing.
- • Knowing the drop factor of the IV tubing is the **FIRST** step in accurate administration of IV fluids in gtt/min. IVs that infuse by gravity are manually regulated, and the IV flow rate is determined in gtt/min.
- • Macrodrops are large and have drop factors of 10, 15, and 20 gtt/mL.
- • Microdrops are tiny and have only one drop factor, 60 gtt/mL.

PRACTICE PROBLEMS

Refer to the drop factor provided and identify the type of tubing.

- 6. 15 gtt/ mL _____
- 7. 60 gtt/mL _____
- 8. 10 gtt/mL _____

Answers on 538

Calculating Flow Rates in Drops Per Minute Using a Formula and Dimensional Analysis

To calculate the IV flow rate in gtt/min for an IV infusing by gravity, a formula method can be used or dimensional analysis. To calculate the flow rate in gtt/min for the IV infusion regardless of the method used (formula method or dimensional analysis), the nurse needs to know the following:

- • Drop factor of the IV tubing
- • Volume (number of mL) to infuse
- • Time the IV is to infuse (minutes or hours)

The formula for calculating the IV flow rate is:

Before beginning to calculate gtt/min, let's review some basic guidelines:

Guidelines for Calculating gtt/min

- • Drops per minute are **always** expressed in whole numbers. Think: You cannot regulate an IV to half a drop or count half a drop; therefore **you can only count whole drops.**
- • Principles of rounding are applied if the calculation for gtt/min does not result in a whole number. Carry calculation to the tenths place, and round answer to the nearest whole number (i.e., 19.6 is rounded to 20 gtt/min).
- • Answers must be labeled. The label is usually drops per minute unless otherwise specified. Example: 17 gtt/min. To reinforce the differences in drop factor, the type of tubing is sometimes included as part of the label. Examples: 17 macrogtt/min, 100 microgtt/min.
- • Common conversion factors used include 1 L = 1,000 mL, and 1 hr = 60 min.

First let's look at some sample problems using the formula method and dimensional analysis.

Example 1: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 10 gtt/mL. At what rate in gtt/min should the IV infuse?

- • Notice the numbers in the problem are placed in the formula.
- • Remember the formula solves for gtt/min and the time is indicated in minutes. 60 min = 1 hr; therefore 1 hr is changed to 60 min in the formula (100 mL/60 min).
- • When mL is cancelled out, the flow rate is determined in gtt/min.
- • Reduction is done where possible.
- • The answer is labeled.
- • ***Note:*** The volume of 1,000 mL was not used in the calculation; the mL/hr was stated in the order.

Setup Using Formula Method

To deliver 100 mL/hr, the IV rate would be regulated at 17 gtt/min; 17 macrogtt/min.

Dimensional Analysis

Let's look at the previous example using dimensional analysis.

Example 1: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 10 gtt/mL. At what rate in gtt/min should the IV infuse?

- • Notice *x* gtt is written to the left of the equation, followed by the equal sign (=) (labeled *x* gtt/min because that is what you're looking for).
- • The **first** factor starts with gtt and is the drop factor, which is written, placing gtt in the numerator. 10 gtt/1 mL.
- • The next fraction is written so that the denominator matches the previous fraction (what you are looking for). The order is to infuse 100 mL in 1 hr. The 1 hr is entered as 60 min in the denominator because you are calculating gtt/min (100 mL/60 min).
- • Cancel the units and you are left with the desired gtt/min.
- • Reduction is done if possible.
- • Label the answer.

Dimensional Analysis

Note: An alternate way of setting up the problem, without changing the hourly rate to 60 min, would be to add 1 hr = 60 min conversion factor to the equation:

Alternate Setup Using Dimensional Analysis

Notice the hourly rate is entered in mL/hr in the equation; the fraction 1 hr/60 min is inserted into the equation. The units are cancelled, leaving gtt/min. The calculation would be the same as the previous setup.

Example 2: Order: 1.5 L 0.9% NaCl to infuse in 10 hr. Drop factor: 15 gtt/mL. At what rate in gtt/min should the IV infuse at?

- • Notice this problem contains a large volume of fluid, and the order contains the total number of hours to infuse as opposed to mL/hr as shown in Example 1.
- • A conversion is also required before the problem can be solved. L must be converted to mL. Use the conversion factor 1 L = 1,000 mL; therefore 1.5 L = 1,500 mL.
- • When using the **formula method**, the IV rate can be determined in two ways:
  - a. First convert the flow rate to mL/hr, and then calculate the gtt/min using the formula.
  - *or*
  - b. Convert the number of hours to minutes using the conversion factor 60 min = 1 hr. Multiply the number of hours by 60 min/hr and then place the calculated minutes into the formula. In this problem, 10 hr is multiplied by 60 min/hr to obtain the 600 minutes used in the formula: 10 hr × 60 min/hr.
- • For **dimensional analysis,** if the mL/hr is not expressed as mL/min, insert the conversion factor 1 hr/60 min.

Let's look at the above problem using the formula method and dimensional analysis.

Formula Method Using Two Steps

Step 1: Calculate the mL/hr:

Convert mL/hr to mL/min. 1 hr = 60 min (150 mL/hr = 150 mL/60 min)

Step 2: Place into formula:

Formula Method Using hr Converted to min

Dimensional Analysis Using mL/min

Calculate mL/hr: 1,500 mL ÷ 10 hr = 150 mL/hr.

Convert mL/hr to mL/min (150 mL/hr = 150 mL/60 min).

Proceed using the steps shown in Example 1.

Dimensional Analysis Using mL/hr

Dimensional Analysis Using the Total Volume and Total Number of hr

Proceed with calculation as shown in previous examples.

Example 3:

Order: The following IVs for 24 hours. Drop factor: 15 gtt/mL

- • 1,000 mL D_5W c 10 mEq potassium chloride (KCl)
- • 500 mL D_5NS c 1 ampule of multivitamin (MVI)
- • 500 mL D_5W

What rate will you regulate the IV to deliver the ordered IV fluid?

In this problem, the order is written for different amounts and types of fluid to be given in a certain time period. Notice that medications are also ordered to be added to the solutions: potassium chloride and multivitamin. When medications such as potassium chloride and vitamins are added to the IV solutions, they are generally not considered in the total volume. (Some institutions consider the medication in the volume if it is 10 mL or more. Always check the policy of the institution.)

To calculate the IV rate, add up the IV fluid to obtain the total volume (2,000 mL). The total number of hours for the IV infusion is given (24 hours). To convert 24 hr to min, multiply: 24 hr × 60 min/hr = 1,440 min.

Formula Method Using Two Steps

Step 1: Calculate the mL/hr:

Convert mL/hr to mL/min. 60 min = 1 hr (83 mL/hr = 83 mL/60 min).

Step 2: Place into formula

Formula Method Using hr Converted to min

To infuse 2,000 mL in 24 hours, the IV would be regulated at 21 gtt/min; 21 macrogtt/min.

Dimensional Analysis Using mL/min

Dimensional Analysis Using mL/hr

Dimensional Analysis Using the Total Volume and Total Number of hr

Proceed with calculation as shown in previous examples.

Example 4:

Order: 50 mL NS to infuse over 20 minutes.

Drop factor: 20 gtt/mL. What rate will you regulate the IV to infuse?

Notice, in this example, you have a small volume of fluid, and the time for the IV to infuse is in minutes. This problem can be solved using the same methods (formula method and dimensional analysis) shown in the previous examples.

Formula Method

Dimensional Analysis

To infuse 50 mL NS in 20 minutes, the IV would be regulated at 50 gtt/min; 50 macrogtt/min.

PRACTICE PROBLEMS

Calculate the flow rate in gtt/min using the formula method or dimensional analysis.

- 9. D_5RL at 75 mL/hr. The drop factor is 10 gtt/mL. _____
- 10. D_5 ½ NS at 30 mL/hr. The drop factor is a microdrop. _____
- 11. 1,000 mL D_5 0.33% NS in 6 hr. The drop factor is 15 gtt/mL. _____
- 12. An IV medication in 60 mL of 0.9% NS is to be administered in 45 min. The drop factor is a microdrop. _____
- 13. 1,000 mL of Ringer's lactate solution (RL) is to infuse in 16 hr. The drop factor is 15 gtt/mL.
- 14. 3,000 mL D_5 and ½ NS in 24 hr. The drop factor is 10 gtt/mL. _____
- 15. Infuse 2,000 mL D_5W in 12 hr. The drop factor is 15 gtt/mL. _____

Answers on pp. 538-539

Calculation of IV Flow Rates Using a Shortcut Method

This shortcut method can be used where the IV sets all have the same drop factor. Example: an institution where all the macrodrop sets deliver 10 gtt/mL. This method can also be used with microdrop sets (60 gtt/mL). It is important to note that this method can be used only if the rate of the IV infusion is expressed in mL/hr (mL/60 min).

To use this method, you must know the drop factor constant for the administration set you are using. The drop factor constant is sometimes referred to as the *division factor*. To obtain the drop factor constant (division factor) for the IV administration set being used, divide 60 by the drop factor calibration from the IV infusion set. Box 21.1 shows the constant calculated based on the drop factor for the IV tubing.

BOX 21-1 Drop Factor Constants

Drop Factor of Tubing	Drop Factor Constant
10 gtt/mL	
15 gtt/mL	
20 gtt/mL	
60 gtt/mL	

RULE

After the drop factor constant is determined, the gtt/min can be calculated in one step:

Let's look at examples of calculating the gtt/min using the stated rule:

Example 1:

Order: Administer D_5W at 125 mL/hr. Drop factor: 15 gtt/mL

The drop factor constant: 4.

In this example, the drop factor constant is 4. The set calibration is 15 gtt/mL (60 ÷ 15 = 4).

Solution:

Solution Using Dimensional Analysis:

Remember that the shortcut method discussed (using the drop factor constant) can be used to calculate the gtt/min for any volume of fluid that can be stated in mL/hr or mL/60 min.

RULE

The shortcut method can be used if the volume of fluid is large; however, an additional step of calculating mL/hr first must be done and then calculate the gtt/min using the shortcut method.

Example 2: Order: RL 1,500 mL to infuse in 12 hr. Drop factor: 20 gtt/mL. Drop factor constant: 3.

In this example, the volume of fluid is 1,500 mL and the total hours to infuse is 10 hr. Before using the shortcut method, the mL/hr must be calculated. 1,500 mL ÷ 12 = 125 mL/hr. The set calibration is 20 gtt/mL. 60 ÷ 20 = 3.

Solution:

Solution Using Dimensional Analysis:

Determine mL/hr expressed as mL/60 min.

The shortcut method can also be used for small volumes of fluid and when the time period is less than 1 hour. If the volume of fluid to infuse is small and the time period is less than 1 hour (60 minutes), the volume and time must each be multiplied to get mL/hr.

Example 3: Order: 20 mL D_5W in 30 minutes. Drop factor 60 gtt/mL. Drop factor constant: 1.

In this example the volume of fluid is small, and the time period is less than 60 min. The set calibration is 60 gtt/mL. 60÷ 60 = 1.

Solution: To express 20 mL in 30 minutes in mL/hr, you multiply the volume and the time by 2.

Step 1: Change 20 mL/30 min to 40 mL/hr as shown above.

Step 2: Express 40 mL/hr as 40 mL/60 min.

Note: In the above problem to administer 40 mL/hr, the IV would be set at 40 gtt/min. When the drop factor of the infusion set used is 60 gtt/mL, the number of gtt/min is equal (=) to the mL/hr.

PRACTICE PROBLEMS

Calculate the rate in gtt/min using the shortcut method.

- 16. Order: D_5W 200 mL/hr. Drop factor: 10 gtt/mL _____
- 17. Order: 0.9% NS 140 mL/hr. Drop factor: 20 gtt/mL _____
- 18. Order: 1,000 mL D_5W in 10 hr. Drop factor: 10 gtt/mL _____
- 19. Order: 40 mL D_5W in 20 min. Drop factor: 10 gtt/mL _____
- Calculate the flow rate in gtt/min.
- 20. Order: To infuse in 16 hr. Drop factor: 10 gtt/mL
  - • D_5W 500 mL c 10 potassium chloride (KCl)
  - • D_5W 1,000 mL
  - • D_5W 1,000 mL c 1 ampule of multivitamin (MVI) _____
- 21. Order: 1,000 mL D_5 0.9% NS for 3 L at 100 mL/hr. Drop factor: microdrop _____

Answers on 539

POINTS TO REMEMBER

- • To calculate the IV flow rate in gtt/min, the nurse must know the drop factor of the IV tubing, the volume to infuse, and the time for the IV to infuse.
- • Drop factor is expressed as gtt/mL and indicated on the package of the IV tubing.
- • Calculation of gtt/min can be done using the formula method or dimensional analysis.
- • Formula for calculating gtt/min is as follows:

- • With the formula method, determine the IV rate by converting the flow rate to mL/hr (60 min), and then calculate gtt/min using the formula. **OR** Convert the number of hours to minutes using the conversion factor 60 min = 1 hr, and then place the calculated minutes into the formula.
- • For dimensional analysis, if the mL/hr is not expressed as mL/min, insert the conversion factor 1 hr/60 min into the equation.
- • Drops per minute are always expressed as whole numbers.
- • A shortcut method can be used to calculate flow rates infusing in mL/hr or mL/60 min using the drop constant.
- • To determine the drop constant factor, divide 60 by the calibration of the IV set.
- • To use the shortcut method for small volumes and time periods less than 1 hr, the volume and the time must each be multiplied to get mL/hr.

Calculating IV Flow Rates Using a Dial-Flow Controller

Dial-flow controllers are also known as IV manual flow regulators or just IV flow regulators, as well as just flow controllers. There are a wide variety of dial-flow controllers available for use and are either part of the IV tubing or added on (Figure 21.3). These devices are regulated manually and are not infusion pumps. Use of the device is based on several factors, which include severity of illness, type of therapy, and the setting. Dial-flow devices are designed to regulate the flow of IV fluid instead of using the roller clamp. The flow rate can be adjusted from 5 to 250 mL/hr. To use the device, you set or dial the desired flow rate in mL/hr, which is an estimate, and then the rate must be verified by counting drops per minute. Drops per minute would be calculated using one of the methods presented in the chapter.

Figure 21.3 Flow controller. (Courtesy and © Becton, Dickinson and Company, Franklin Lakes, NJ.)

If used, it is important to remember that use of the device does not relinquish the nurse from his or her responsibility, which is to monitor the IV to ensure there is accurate delivery of the ordered infusion rate.

Let's look at an example using this device.

Example: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 15 gtt/mL.

- 1. Turn the dial of the controller to 100 mL/hr.
- 2. Use the formula or dimensional analysis to determine gtt/min.
- 3. Verify accuracy of controller by counting the drops either for a minute or a fraction, such as 20 seconds. Divide the number of drops per minute by 3 (25 gtt ÷ 3 = 8.3 = 8 gtt). You find the number of drops is 8; the controller is delivering the correct rate for 20 seconds. If the rate is not correct for 20 seconds, the controller dial can be adjusted. The rate will have to be monitored periodically during the infusion.

Formula Method

Dimensional Analysis

Refer to examples for steps in solving.

To infuse 100 mL/hr, the IV flow rate would be set at 25 gtt/min; 25 macrogtt/min.

SAFETY ALERT!

The flow rate on the controller is in **mL/hr, not gtt/min.** Failure to verify the drop rate can result in client not receiving the correct rate, which can result in the client receiving insufficient or excessive IV fluid. To ensure client safety during IV administration, the controller as well as the client **must** be monitored.

Calculating Intermittent IV Infusions Piggyback

A medication such as an antibiotic can be administered by attaching it to a port on the primary line (referred to as Intravenous Piggyback [IVPB]) and infusing it by gravity or infused using an electronic infusion device. IVPBs may come premixed from the drug manufacturer, or medications are added to a small volume bag by the nurse, or in some institutions by the pharmacist and sent to the unit.

If the prescriber does not include the type and amount of solution for the medication to be placed in or the rate for infusion, the nurse must check a medication reference or the manufacturer's guidelines. Even if medications are premixed (with medication added to the solution by the drug manufacturer or pharmacy), the nurse is responsible for ensuring that the IVPB is infusing at the correct rate. When medications are premixed, the nurse calculates the infusion rate by using the volume of solution containing the medication. Regardless of whether the IVPB is mixed by the nurse, is premixed, or the ADD-Vantage system is used, the IVPB must be in the correct amount of solution and infused at the correct rate. The volume of IV solution used for an IVPB is usually 50 to 100 mL to infuse over 20, 30, 60 minutes, or longer depending on the type and amount of medication added.

As already stated, depending on the volume of the medication being added (for an IVPB mixed by the nurse), at some institutions the medication is considered in the volume of IV fluid when determining the IV rate. ***Note:*** For the purpose of this text, it will be indicated when to consider the medication in the IV volume and the type and amount of solution for dilution of the piggyback, and infusion rate will be indicated in the order.

Let's look at the examples shown for determining the rate for the IVPB.

Example 1: Order: Keflin 2 g IVPB in 100 mL D_5W over 30 min. Drop factor: 15 gtt/mL. Determine the IV flow rate.

Solution:

- • In this problem, there is no conversion needed; the volume of solution is in mL.
- • The amount of medication added, 2 g, is not needed to calculate the IV flow rate. The 100 mL of fluid that the Keflin is placed in is used as the volume.
- • A drop factor is stated; therefore the IV rate will be calculated in gtt/min.
- • The volume of IV fluid, which is stated in mL, the time (min), and the drop factor are the required information needed to calculate the IV flow rate, using the formula method or dimensional analysis.

Formula Method

Dimensional Analysis

To infuse 100 mL in 30 minutes the IV rate would be regulated at 50 gtt/min; 50 macrogtt/min.

Now let's look at the same problem if an electronic infusion device was used.

Example 2: Order: Keflin 2 g IVPB in 100 mL D_5W over 30 min by infusion pump.

Determine the IV flow rate.

Solution:

- • An electronic infusion device is being used; the rate will need to be determined in mL/hr.
- • As with Example 1, the amount of medication, 2 g, is not needed to calculate the IV flow rate.
- • Remember there are 60 minutes in 1 hr.
- • The rate can be determined using ratio and proportion, the formula below, or dimensional analysis.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Formula Method

Notice min is cancelled, leaving mL/hr.

Dimensional Analysis

Notice min is cancelled, leaving mL/hr.

The pump would be set at 200 mL/hr to infuse 100 mL in 30 min. ***Note:*** The actual volume of 100 mL will be infused.

PRACTICE PROBLEMS

Calculate the rate in gtt/min for the following medications being administered IVPB. Use the labels where provided. (Add the volume of medication being added to IV solutions, where indicated.)

- 22. Order: Erythromycin 200 mg in 250 mL D_5W to infuse over 1 hr. Drop factor: 10 gtt/mL _____

- 23. Order: Ampicillin 1 g in 50 mL D_5W to infuse over 45 minutes. Drop factor: 10 gtt/mL. For IV, reconstitute with 10 mL of diluent to get 1 g per 10 mL. (Consider the medication added in the volume of fluid.)
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Calculate the rate in gtt/min at which the IV should infuse. _____
- 24. Order: Clindamycin 900 mg in 75 mL D_5W over 30 minutes. Drop factor: 10 gtt/mL
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Determine the IV rate. _____
- 25. Order: Vancomycin 500 mg IVPB q24hr. The reconstituted vancomycin provides 50 mg per mL. The medication is placed in 100 mL of D_5W to infuse over 60 minutes. Drop factor: 15 gtt/mL. (Consider the medication added in the volume of fluid.)
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Calculate the rate in gtt/min at which the IV should infuse. _____
- 26. Order: Fungizone (amphotericin B) 20 mg in 300 mL D_5W over 6 hr by infusion pump. The reconstituted material contains 50 mg per 10 mL.
  - a. How many milliliters will you add to the IV solution? _____
  - b. Determine the IV rate. _____
- 27. Order: Septra (sulfamethoxazole and trimethoprim) 300 mg in 300 mL D_5W over 1 hr q6h. Drop factor: 10 gtt/mL. Calculate the dose using trimethoprim.
  - a. How many milliliters of medication will be added to the IV? (Round the answer to the nearest tenth.) _____
  - b. Consider the medication added to the volume of IV fluid. Calculate the rate in gtt/min at which the IV should infuse. _____
- 28. Order: Retrovir (zidovudine) 100 mg IV q4h over 1 hr. Available medication states each mL contains 10 mg of zidovudine.
  - a. How many milliliters of medication will be added to the IV solution? _____
  - b. The medication is placed in 100 mL of D_5W. Drop factor: 10 gtt/mL (Consider the medication added to the volume of IV fluid.) _____

Answers on pp. 539-540

Determining the Amount of Medication in a Specific Amount of Solution

Sometimes medications are added to IV solutions, and the prescriber orders a certain amount of medication to be administered in a certain time period. In order to calculate the volume of fluid needed to deliver a specific amount of medication, a ratio and proportion can be used or dimensional

analysis.

Example 1: Order: 20 mEq of potassium chloride in 1,000 mL D_5W to infuse at 2 mEq/hr. Calculate the mL/hr to deliver 2 mEq of potassium chloride/hr.

Solution:

Set up a ratio and proportion using the linear or fraction format:

- • With use of the ratio and proportion, the known ratio is the amount of medication in the total volume of solution, and the unknown ratio is what the prescriber ordered.
- • Dimensional analysis of the first factor is the total volume of solution and the amount of medication, and the second factor is what the prescriber ordered.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

Notice cancelling mEq leaves mL/hr.

100 mL/hr will deliver 2 mEq /hr of potassium chloride.

Example 2: Order: 100 units of Humulin regular insulin in 500 mL ½ NS to infuse at 10 units/hr. Calculate the mL/hr to deliver 10 units of insulin/hr.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

POINTS TO REMEMBER

- • When preparing medications for intermittent infusion:
  - a. Reconstitute the medication using the label or package insert if needed.
  - b. Calculate the amount of medication to administer.
  - c. Verify the recommended infusion rate with the manufacturer's recommendations or a medication reference.
  - d. Determine the IV rate using the IV formula or dimensional analysis.
- • If the intermittent infusion is being administered by an electronic infusion device, the flow rate is determined in mL/hr using ratio and proportion, dimensional analysis, or the formula method for time periods less than 1 hour.

- • To determine the volume (amount) of IV fluid to administer the prescribed amount of medication in mL/hr, use ratio and proportion or dimensional analysis.

PRACTICE PROBLEMS

Solve the following problems using the steps indicated.

- 29. Order: 15 mEq of potassium chloride in 1,000 mL of D_5 ½ NS to be administered at a rate of 2 mEq/hr.
- How many mL/hr should the IV infuse at? _____
- 30. Order: 10 units of Humulin regular insulin per hour. 50 units of insulin is placed in 250 mL NS.
- How many mL/hr should the IV infuse at? _____

Answers on pp. 540-541

Determining the Unknown for Time and Volume

You may need to calculate the following:

- a. **Time in hours**—How long it will take a certain amount of fluid to infuse or how long it may last
- b. **Volume**—The total number of milliliters a client will receive in a certain time period These unknown elements can be determined by the use of the formula method or dimensional analysis.

Formula:

Calculating a Problem with an Unknown Using the Formula Method and Dimensional Analysis

- 1. Take the information given in the problem and place it in the formula.
- 2. Place an *x* in the formula in the position of the unknown. If you are trying to determine time in hours, place *x* in the position for minutes; once you find the minutes, divide the number of minutes by 60 (60 minutes 5 1 hr) to get the number of hours. If you are trying to determine the volume the client would receive, place an *x* in the position for amount of solution, and label *x* mL.
- 3. Set up an algebraic equation so that you can solve for *x*.
- 4. Solve the equation.
- 5. Label the answer in hours or milliliters for volume.

Example 1: Determining hours:

An IV is regulated at 20 microgtt/min. How many hours will it take for 100 mL to infuse?

Formula Method

Note: In the position of drop factor, 60 gtt/mL was placed, IV was infusing in microgtt, and the infusion set had to be a microdrip (60 gtt/mL).

Dimensional Analysis

x hr is what you are looking for. The **first** starting fraction is 1 hr/60 min, the **second** fraction is 1 min/20 gtt to match the denominator of the starting fraction. The **third** fraction is 60 gtt/1 mL to match the denominator in the fraction before it. The **last fraction** is 100 mL/1, to match mL in the fraction before it. Cancel the units, reduce if possible, and perform mathematical process.

Note: When calculating time and the answer results in hr and min, express entire time in hr (i.e., 1 hr and 30 min = 1.5 hr, or 1½ hr; 1½ hr is the preferred way to state answer).

Example 2: Determining volume:

An IV is regulated at 17 macrogtt/min. The drop factor is 15 gtt/mL. How much fluid volume in milliliters will the client receive in 8 hr?

Formula Method

Dimensional Analysis

x mL is what you are looking for here. Enter the drop factor as the **first** starting fraction 1 mL/15 gtt. The **second** fraction is 17 gtt/1 min, so it matches the denominator of the first fraction. The **third** fraction is 480 min/1 so that it matches the denominator before it. **An alternate** to changing min to hr is to enter the conversion 60 min/1 hr, and enter 8 hr/1 to match the denominator before it. Cancel if possible, and perform the mathematical process.

Note: Some problems for calculating an unknown may be solved without using the formula method or dimensional analysis; however, the use of one or the other is recommended.

POINTS TO REMEMBER

Determining the Unknown

- • Use the IV formula and place the information given into the position of the formula.

Use *x* for unknown values.

- 1. For determining time—place an *x* in the minutes position, and then divide the minutes by 60 to determine the time in hours.
- 2. For volume—place an *x* in the position for amount of solution and label *x* mL. Convert the hours to minutes.

- • Set up an algebraic equation and solve for *x*.
- • Answers for time are labeled in hours, with mL for volume, unless instructed otherwise.
- • Dimensional analysis can also be used to determine the unknown.

PRACTICE PROBLEMS

Solve for the unknown in the following problems as indicated.

- 31. You find that there is 150 mL of D_5W left in an IV. The IV is infusing at 60 microgtt/min. How many hours will the fluid last? _____
- 32. 0.9% NS is infusing at 35 macrogtt/min. The drop factor is 15 gtt/mL. How many milliliters of fluid will the client receive in 5 hours? _____
- 33. There is 90 mL of D_5 0.33% NS left in an IV that is infusing at 60 microgtt/min. The drop factor is 60 gtt/mL. How many hours will the fluid last? _____

Answers on 541

Recalculating an IV Flow Rate

Flow rates on IVs change when a client stands, sits, or is repositioned in bed if IVs are infusing by gravity. Therefore, nurses must frequently check the flow rates. Sometimes IVs infuse ahead of schedule, or they may be behind schedule if they are not monitored closely. When this happens, the IV flow rate must be recalculated. To recalculate the flow rate, the nurse uses the volume remaining and the time remaining. Recalculation may be done with uncomplicated infusions. IVs that require exact infusion rates should be monitored by an electronic infusion device.

SAFETY ALERT!

Never arbitrarily increase or decrease an IV to get it back on schedule without assessing a client and checking with the prescriber. Increasing or decreasing the rate without thought can result in serious harm to a client, including overhydration or underhydration. Check the policy of the institution. Avoid off-schedule IV rates by regularly monitoring the IV at least every 30 to 60 minutes.

When an IV is significantly ahead of or behind schedule, you may need to notify the prescriber, depending on the client's condition and the use of appropriate nursing judgment. **Always assess the client** before making any change in an IV rate. Changes depend on the client's condition. Check the institution's policy regarding the percentage of adjustment that can be made. Each situation must be individually evaluated, and appropriate action must be taken.

A safe rule is that the recalculated flow rate should not vary from the original rate by more than 25%. If the recalculated rate varies by more than 25% from the original rate, the prescriber should be notified. The order may require revision. If a client is stable, recalculate the IV rate, using the remaining volume and time, and then proceed to calculate gtt/min using the formula method or dimensional analysis. Refer to content in this chapter (calculating gtt/min) if necessary. Let's go over the steps to recalculate an IV rate if allowed by your institution policy, and the client is stable.

To recalculate an IV flow rate:

- • Use the remaining volume and remaining hours, and calculate the rate in mL/hr.

- • Use the mL/hr to calculate gtt/min for the recalculated rate, using the formula or the shortcut method:

- • Shortcut method:

- • Determine whether the new rate calculation is greater or lesser than 25%. Use the amount of increase or decrease divided by the original rate.

= % of change of original rate (round to nearest whole percent)

Let's look at some examples. ***Note:*** All examples assume the institution allows a 25% IV flow variation, and the clients are stable.

Example 1: 1,000 mL of D_5 RL was to infuse in 8 hr at 31 gtt/min (31 macrogtt/min). The drop factor is 15 gtt/mL. After 4 hr, you notice 700 mL of fluid left in the IV. Recalculate the flow rate for the remaining solution. ***Note:*** The infusion is behind schedule. After 4 hr, half of the volume (or 500 mL) should have infused.

Solution:

Solution to Example 1: Using the Shortcut Method

Determine recalculated rate:

Time remaining: 8 hr – 4 hr = 4 hr

Time remaining: 8 hr – 4 hr = 4 hr

Volume remaining: 1,000 mL – 300 mL = 700 mL

Volume remaining: 1,000 mL – 300 mL = 700 mL

700 mL ÷ 4 hr = 175 mL/hr

700 mL ÷ 4 hr = 175 mL/hr

Drop factor: 15 gtt/mL; therefore the drop factor constant is 4.

Drop factor: 15 gtt/mL; therefore the drop factor constant is 4.

x = 44 gtt/min; 44 macrogtt/min (recalculated rate)

x = 44 gtt/min; 44 macrogtt/min (recalculated rate)

Determine the percentage of the change:

Dimensional Analysis

Course of Action

Assess the client.

Notify the prescriber.

Do not increase the IV rate; the increase is **greater than 25%.**

Increasing the IV could result in serious consequences for the client. Assessment of the client is always done first to determine the client's ability to tolerate an increase in fluid. In this situation the prescriber should be notified, a new order is needed, the recalculated rate is greater than 25%.

Example 2 (IV Ahead of Schedule): An IV of 1,000 mL D_5W is to infuse from 8 am to 4 pm (8 hr). The drop factor is 10 gtt/mL. The rate is set at 20 gtt/min (20 macrogtt/min). In 5 hr, you notice that 700 mL has infused. Recalculate the flow rate for the remaining solution.

Solution:

Shortcut Method

Determine recalculated rate:

Time remaining: 8 hr – 5 hr = 3 hr

Volume remaining: 1,000 mL – 700 mL = 300 mL

300 mL ÷ 3 = 100 mL/hr

Drop factor: 10 gtt/mL; therefore the drop factor constant is 6.

x = 17 gtt/min; 17 macrogtt/min (recalculated rate)

x = 17 gtt/min; 17 macrogtt/min (recalculated rate)

Determine the percentage of change:

Dimensional Analysis

Time remaining: 8 hr – 5 hr = 3 hr

Volume remaining: 1,000 mL – 700 mL = 300 mL

x = 17 gtt/min; 17 macrogtt/min

x = 17 gtt/min; 17 macrogtt/min

Course of Action

Assess the client.

Adjust the rate if allowed by institutional policy, and assess during the remainder of the infusion.

Notify prescriber if required.

In this situation, the flow rate must be decreased from 20 gtt/min (20 macrogtt/min) to 17 gtt/min (17 macrogtt/min), and the change is not greater than 25% of the original rate. –15% is within the acceptable 25% of change. However, the client's condition must still be assessed to determine the ability to tolerate the change, and the prescriber may still require notification.

Alternate to Determining the Percentage of Change

As already stated, you can adjust the flow rate as much as (+) or (–)25%. Think 25% = ¼. Therefore you can verify the safety of the recalculated rate by using a method that eliminates the need to use percents. To do this, do the following:

- • Divide the original rate by 4, then add, and subtract the result from the original rate. This will provide a range for the acceptable rate adjustment. Let's use the two examples we just did.

Example 1:

The original rate was 31gtt/min (macrogtt/min), and the recalculated rate is 44 gtt/min (macrogtt/min).

Original rate ± (original rate ÷ 4) = Acceptable IV rate adjustment

31 + (31 ÷ 4) = 31 + 7.75 = 38.75 = 39 gtt/min (macrogtt/min)

31 – (31 ÷ 4) = 31 – 7.75 = 23.25 = 23 gtt/min (macrogtt/min)

The safe acceptable IV rate adjustment is 23 to 39 gtt/min (macrogtt/min). 44 gtt/min is above the acceptable adjustment range, and 25%. The prescriber should be notified to provide a new order.

Example 2:

The original rate was 20 gtt/min (macrogtt/min), and the recalculated rate is 17 gtt/min (17 macrogtt/min).

Original rate ± (original rate ÷ 4) = Acceptable IV rate adjustment

20 + (20÷ 4) = 20 + 5 = 25 gtt/min (macrogtt/min).

20 – (20 ÷ 4) = 20 – 5 = 15 gtt/min (macrogtt/min).

The safe acceptable IV rate adjustment is 15 to 25 (macrogtt/min). It is safe to slow the rate to 17 gtt/min (macrogtt/min), which is less than 25%.

POINTS TO REMEMBER

- • Monitor IV therapy every 30 to 60 min to maintain the ordered IV rate.
- • Do not arbitrarily speed up or slow down an IV that is behind or ahead of schedule.
- • Know the hospital policy regarding recalculation of IV flow rate. An IV should not vary more than 25% from its original rate.
- • To recalculate an IV rate:
- • Determine mL/hr:
-

- • Use mL/hr and recalculate the rate in gtt/min, using formula or shortcut method.

- • Determine the % of change
-
  = % of change (rounded to the nearest whole %)
- • Alternate to use of percent: Divide the original rate by 4, then add and subtract the result from the original rate to get the acceptable IV rate adjustment.
- • Contact the prescriber for a new IV order, if the recalculated rate exceeds 25%.

PRACTICE **PROBLEMS**

For each of the problems, recalculate the IV flow rates in gtt/min rates using either method presented, determine the percentage of change, and state your course of action. *Note:* The institution allows 25% variation and clients are stable.

- 34. 500 mL of 0.9% NS was ordered to infuse in 8 hr at the rate of 16 gtt/min (16 macrogtt/min). The drop factor is 15 gtt/mL. After 5 hr, you find 250 mL of fluid left.
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 35. 250 mL of D_5W was to infuse in 3 hr at the rate of 21 gtt/min (21 macrogtt/min). Drop factor: 15 gtt/mL. With 1½ hr remaining, you find 200 mL left.
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 36. 1,000 mL D_5 0.33% NS was to infuse in 12 hr at 28 gtt/min (28 macrogtt/min). After 4 hr, 250 mL has infused. Drop factor: 20 gtt/mL
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 37. 500 mL D_5 0.9% NS to infuse in 5 hr at 100 gtt/min (100 microgtt/min). After 2 hr, 250 mL has infused. Drop factor: 60 gtt/mL

- a. _____ gtt/min
- b. _____ % variation
- c. _____ Course of action

Answers on pp. 541-542

Calculating Infusion and Completion Time

IV fluids are ordered by the prescriber for administration indicating a specific rate in mL/hr, such as 1,000 mL D_5W to infuse at 100 mL/hr. **The nurse needs to be able to determine the amount of time (hours and minutes) that it would take for a certain volume of IV solution to infuse, which is referred to as *infusion time*.** Knowing the infusion time is important for the nurse, which includes reasons such as allowing the preparation for hanging a new solution as one infusion is being completed and preventing things such as the line clotting off as a result of not knowing when an IV was to be completed. Infusion times can be calculated using any of the following methods:

- • Ratio and proportion: The known ratio, which is written first, is the ordered rate in mL/hr, and the second ratio is the unknown, which is the total number of mL to infuse in *x* hr, total mL/*x* hr. The ratio and proportion can be written in linear or fraction format.
- • Formula method:

  = Infusion time
- • Dimensional analysis: The unknown is *x* hr; therefore the first fraction will be the ordered rate, hr/mL, the second fraction will be total mL/1.

Let's look at some examples of calculating infusion time.

Example 1: Calculate the infusion time for an IV of 1,000 mL D_5W to infuse at a rate of 125 mL/hr.

Ratio and Proportion (Linear Format)

Formula Method

1,000 mL (total mL to infuse)

125 mL/hr (mL/hr to infuse)

Infusion time = 8 hr

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

Dimensional Analysis

x = 8 hr

mL is cancelled here, leaving hr.

When an infusion time result is not an even whole number but instead the infusion rate includes a decimal fraction; the decimal fraction represents a fraction of an hour and must be converted to minutes. This calculation of infusion time is done as follows:

- • Determine the infusion time using any of the methods already presented, and carry division two decimal places.
- • Calculate the minutes using, conversion factor; 60 min = 1 hr. (Multiply the fraction of an hr by 60 min/hr) or use any of the methods presented.
- • Using the rules of rounding, round the minutes to the nearest whole number of minutes.

Let's look at an example.

Example 2: 1,000 mL D_5 ½ NS to infuse at 150 mL/hr. Calculate the infusion time for the IV.

Ratio and Proportion (Linear Format)

- • Determine the infusion time
- 150 mL : 1 hr = 1,000 mL : x hr
-
- • Calculate the minutes
- 1 hr : 60 min = 0.66 hr : x min
- x = 0.66 × 60 = 39.6
- x = 40 min (rounded to whole number)
- Infusion time is 6 hr and 40 min.

Formula Method

- • Determine infusion time

-

- x = 6.66 hr
- • Calculate the minutes

- Infusion time is 6 hr and 40 min.

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

- • Determine infusion time

-

- x = 6.66 hr
- • Calculate the minutes

-

- x = 40 min

Infusion time is 6 hr and 40 min.

Dimensional Analysis

- • Determine infusion rate

-

- x = 6.66 hr
- • Calculate the minutes

- x = 40 min
- Infusion time is 6 hr and 40 min.

Completion Time

Once the infusion time has been calculated, the nurse can use this information to determine the completion time. Completion time is the when the infusion is completed (i.e., the client has received all of the IV fluid). This would be determined as follows: Add the calculated infusion time to the time the infusion was started. If the IV was started at 7:00 am, add the 6 hours and 40 minutes to that time (7:00 am). The IV would be completed at 1:40 pm. It is easier to calculate completion time using military time: 7:00 am = 0700; now add 6 hours and 40 minutes to arrive at the answer of 1340.

- Start time 0700
- Infusion time +0640
- **Completion time:** 1340 or 1:30 pm

Calculating Completion Time

To calculate the completion time, add the infusion time to the time the IV was (military time).

Note: Converting traditional time to military time, and a discussion of completion time, appears in Chapter 8.

Let's look at some examples.

Example 1: An IV of 1,000 mL of D_5W is started at 1000 to infuse over 8 hr. Determine the completion time.

Solution:

- Start time 1000
- Infusion time +0800

Completion time: 1800 or 6:00 pm

Example 2: An IV of 1,000 mL of 0.9% NS is started at 2130 to infuse over 12 hr. Determine the completion time.

Solution:

- Start time 2130
- Infusion time +1200
- 3330 (time here is greater than 2400)

As you recall, when the time period is greater than 2400, you must subtract 2400 from the total (the day ends at 2400). This will give you the completion time for the next day.

Using the answer from the problem, which is 3330

Subtract –2400

Subtract −2400

Completion time: 0930 or 9:30 am the next day

Completion time: 0930 or 9:30 am the next day

Example 3: An IV of D_5½ NS is started at 0430 to infuse in 6 hr and 40 min. Determine the completion time.

Solution:

- Start time 0430
- Infusion time +0640
- 1070 (the minutes here are greater than 60)

As you recall, when the minutes are greater or equal to 60, subtract 60 from the number of minutes, which in this example is 70 min, and then add the 1 hour obtained when you subtracted the 60 minutes to get the completion rate, as follows:

- 1070
- −0060 minutes (1 hr)
- 1010
- +0100 (the 1 hr obtained when you subtracted the 60 min)

Completion time: 1110 or 11:10 am

Alternate to Example 3:

- Add start time: 0430
- Infusion time +0640
- Convert 70 min to 1 hr and 10 min and add to 10 hr. 1000
- +0110
- **Completion time:** 1110 or 11:10 am

As you will notice in the examples provided, you were given the infusion time as well as the time for the infusion to start in military time. Let's look at an example in which you will need to determine the infusion time before calculating the completion time.

Example 4:

500 mL D_5W to infuse at 80 mL/hr is started at 7:30 am. Determine the completion time. State time in military and traditional time.

Solution:

- • First determine the infusion time using any of the methods already presented (ratio and proportion, formula method, or dimensional analysis)

Ratio and Proportion (Linear Format)

80 mL : 1 hr = 500 mL : x hr

$80x = 500$

$x = 6.25$ hr

Calculate the minutes.

1 hr : 60 min = 0.25 hr : x min

$x = 0.25 \times 60 = 15$

$x = 15$ min

Infusion time is 6 hr and 15 min.

Formula Method

Calculate the minutes.

Infusion time is 6 hr and 15 min.

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

$x = 6.25$ hr

Calculate the minutes.

$x = 15$ min

Infusion time is 6 hr and 15 min.

Dimensional Analysis

Calculate the minutes:

Infusion time is 6 hr and 15 min.

- • Now determine the completion time (add the infusion time to the start time).
  - Start time: 0730
  - Infusion time:

= 1:45 pm

Note: The start time (7:30 am) was changed to military time: to convert am time omit colon and am, add a zero to beginning to make a 4-digit number. To convert pm time to traditional time, subtract 1200 and add pm. If necessary, review the conversion of time (traditional and military) in Chapter 8.

PRACTICE PROBLEMS

Determine infusion and completion time for the following IVs. State the time in traditional and military time.

- 38. An IV of 500 mL NS is to infuse at 60 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 10:00 pm. When would the IV infusion be completed? _____
- 39. An IV of 250 mL D_5W is to infuse at 80 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 2:00 am. When would the IV infusion be completed? _____
- 40. An IV of 1,000 mL D_5 RL is to infuse at 60 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 6:00 am. At what time would this IV infusion be completed? _____

- 41. An IV of 500 mL D_5W is to infuse at 75 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 2:00 pm. At what time would the IV infusion be completed? _____

Answers on 542

unknown - Section 39 (Page 357)

This chapter will present the calculations performed with intravenous therapy. As stated previously, nurses have the responsibility to make sure that clients are receiving the correct rate. Several methods to calculate IV rates are presented in the chapter: ratio and proportion, dimensional analysis, and the formula. Let's now begin our calculations with determining IV rates in milliliters per hour (mL/hr).

IV Flow Rate Calculation

As previously discussed, the prescriber's order for an IV includes the following:

- • The name of the IV solution
- • The volume to infuse
- • Medications to be added, if any
- • Time for the IV to infuse

Continuous IV, which is oft en referred to as the primary IV, usually contains a large volume of fluid (500 mL or 1,000 mL). IV fluids are usually ordered to be administered at rates expressed in mL/hr. The time for the IV to infuse may be indicated as the total number of hours (i.e., D_5W 3,000 mL in 24 hr), or mL/hr (i.e. D_5 ½. NS 1,000 mL at 125 mL/hr). Small volumes of fluid (usually 50 mL or 100 mL) are oft en used when the IV fluid contains medications such as antibiotics. Rates for IV fluids are usually expressed in drops per minute (gtt/min) when an infusion device is not used. When an infusion device such as a pump is used, the flow rate must be expressed in mL/hr.

Calculating Flow Rates for Infusion Pumps in mL/hr

When a client is using an electronic infuser, such as a volumetric pump, the prescriber orders the volume and can include mL/hr or the total number of hours for the IV to infuse. If the order states the number of mL/hr for the infusion, such as previously stated D_5 ½ NS at 125 mL/hr, there is no calculation required by the nurse. The nurse programs the pump to deliver the ordered rate. However, if the order states the total number of hours for the IV to infuse (D_5W 3,000 mL in 24 hr), the nurse will need to calculate the mL/hr to program the pump.

For most electronic devices that regulate the flow of IV solutions, the rate is expressed in milliliters per hour (mL/hr). For the purpose of this text, the equipment being used is programmable in whole mL/hr; therefore mL/hr should be rounded to a whole number unless indicated that the infusion pump has decimal capability. To determine mL/hr the following information is needed:

- • The volume (amount) of solution in milliliters
- • The time for the IV to infuse in hours

The simplest way to determine the mL/hr is by using the formula, although ratio-and-proportion and dimensional analysis can be used:

Formula to Determine mL/hr

Round mL/hr to the nearest **whole number**. If the answer does not result in a whole number, carry division to tenths place and round to the nearest whole number. If pump has decimal capability, round answer to the **nearest tenth.**

SAFETY ALERT!

There are some IV pumps in use that are capable of delivering IV fluids in tenths of a milliliter. Always be familiar with the IV equipment being used at the institution before rounding milliliters per hour (mL/hr) to the nearest whole mL/hr.

Let's begin with the calculation of IV flow rates in mL/hr.

Example 1: Client with an infusion pump has an order for 3,000 mL D_5W over 24 hours.

Solution:

- 1. Think: Pump is regulated in mL/hr.
- 2. No conversion required; the volume is in milliliters, and the time is in hours.
- 3. To use the formula method to determine mL/hr: *x* mL/hr = volume in mL.

- 4. To determine mL/hr using ratio and proportion, the volume ordered and hours to infuse is the known ratio; 3,000 mL : 24 hr (stated first), and the unknown is *x* mL : 1 hr. (stated as the second ratio) or:

- 5. To determine mL/hr using dimensional analysis, identify what you are looking for, and write it to the left of the equation in a fraction format. Label factor:

Place problem as starting fraction (if no conversion required). If conversion is required, the starting fraction is the conversion factor, and the problem is inserted as the second fraction in the equation. Refer to the setups of Example 1 using the various methods.

Formula Method

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

In this problem no conversion was required, the ordered amount is in mL/hr, which is the same as the desired; therefore the problem is solved by division, and no cancellation of units is required.

To infuse 3,000 mL of D_5W in 24 hr, the pump would be set to deliver 125 mL/hr.

Sometimes a conversion may be necessary before calculating mL/hr. Let's look at a problem showing the calculation of mL/hr when a conversion is required.

Example 2: Client with an infusion pump is to receive 0.5 L 0.9% NS over 8 hours.

Solution:

- 1. Convert 0.5 L to 500 mL using any of the methods presented in earlier chapters.
- Use the conversion factor 1 L = 1,000 mL. Convert 0.5 L to mL by moving the decimal three places to the right (metric to metric). Decimal movement can be used. Review methods of converting if necessary.
- 2. Set up the problem and solve using one of the calculation methods.

Formula Method

mL/hr is rounded to the nearest whole number of mL.

Ratio and Proportion (Linear Format)

mL/hr is rounded to the nearest whole number of mL.

Ratio and Proportion (Fraction Format)

mL/hr is rounded to the nearest whole number of mL.

Dimensional Analysis

mL/hr is rounded to the nearest whole number. Notice the conversion factor is written

to cancel L, leaving mL/hr.

To infuse 500 mL of 0.9% NS, the pump would be set to deliver 63 mL/hr. As previously stated, pumps deliver in whole mL unless indicated the pump has decimal capability.

Determining mL/hr When the Time Period Is Less Than 1 Hour

Often when medications are administered IV, such as IVPB (e.g., for antibiotics), the time period for the IV to infuse is less than 1 hour. When the period is less than 1 hour and an electronic infusion device is used, the IV rate must still be determined in mL/hr. **Remember that there are 60 minutes in 1 hour.** The rate can be determined using ratio and proportion. (The known ratio is the ordered rate, mL/min, and the second is the unknown ratio, x mL/60 min). Dimensional analysis can also be used to determine the rate in mL/hr. (The first factor in the equation is the ordered mL/min, and the second factor is 60 min/1 hr). The rate can also be determined using the formula:

Let’s look at an example. The various methods for calculating the infusion rate will be shown.

Example 3: A client is to receive an antibiotic in 100 mL of 0.9% NS over 45 min by infusion pump. Determine the IV flow rate.

Solution:

- 1. Think: The infusion pump infuses in mL/hr. Use a ratio and proportion, the formula method, or dimensional analysis to determine mL/hr.
- 2. Remember: 1 hr = 60 min.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Formula Method

Note: min is cancelled, leaving mL/hr.

Dimensional Analysis

Note: min is cancelled, leaving mL/hr.

The infusion pump would be set at 133 mL/hr to infuse 100 mL in 45 minutes. The volume of 100 mL will be infused.

SAFETY ALERT!

The usual rate in mL/hr ranges from 50 to 200 mL/hr. If the rate exceeds this amount, double-check the order and your calculation before programming the rate into an infusion pump.

POINTS TO REMEMBER

- • IV infusion pumps deliver IV flow rates in mL/hr.
- • IV orders indicate: the name of the IV solution, the volume to infuse, medications to be added, if any, and the time for the IV to infuse. The prescriber may indicate the time for an IV to infuse in mL/hr, or the total number of hours for the IV to infuse.
- • To determine flow rates for an electronic infusion device such as the infusion pump, determine mL/hr using the formula:

- • If the time for the IV to infuse is less than 1 hour and the infusion pump is used, the infusion rate still must be determined in mL/hr. Ratio and proportion, the formula method, or dimensional analysis can be used to determine the infusion rate. Remember that 60 min = 1 hr.
- • Milliliters per hour (mL/hr) are rounded to the nearest whole number. If math does not result in a whole number, carry math to the tenths place and round to the nearest whole number.
- • Some infusion pumps have decimal capability and can deliver IV rates in tenths of a mL. If the answer obtained is not in the tenths place, carry math to the hundredths place and round to the tenths.
- • Always be familiar with the infusion device being used by an institution before rounding mL/hr to a whole number.

PRACTICE PROBLEMS

Calculate the flow rate in mL/hr. (Equipment used is programmable in whole mL/hr.)

- 1. 1,800 mL of D_5W in 24 hr by infusion pump

- 2. 2,000 mL D_5W in 24 hr by infusion pump
- 3. 500 mL RL in 12 hr by infusion pump
- 4. 1,500 mL D_5RL in 24 hr by infusion pump
- 5. 750 mL D_5W in 16 hr by infusion pump

Answers on 538

Manually Regulated IVs

When an electronic infusion device is not used, the nurse uses a gravity-flow system and must manually regulate the infusion rate. To do this, the nurse must calculate the ordered IV flow rate in drops per minute (gtt/min). IV flow rates in gtt/min are based on the IV tubing calibration, referred to as the *drop factor*. The **drop factor** is the number of drops per milliliter (gtt/mL) that a particular IV tubing delivers and therefore will vary depending on the type of IV tubing.

The drop size is determined by the size of the tubing or the small needle inside the drop chamber releasing the drops. See Figure 21.1. Note the large opening for drops in Figure 21.1A, the drops are large (**macrodrops**). The drops delivered through the small needle in Figure 21.1B are very small drops (**microdrops**). The drop factor of the IV tubing is stated in large numbers on the IV tubing package (Figure 21.2). The drop factor of the IV tubing is needed to calculate gtt/min.

Figure 21.1 Comparison of (A) macrodrops and (B) microdrops.

Figure 21.2 IV administration sets (package). **(A)** Set with drop factor of 10 (10 gtt =1 mL). **(B)** Set with drop factor of 60 (60 gtt = 1 mL).

As stated previously, at the top of the IV tubing is a drip chamber (also referred to as a drop chamber), where the nurse observes and counts the number of drops falling into the drip chamber per minute or fraction of a minute placing a watch at the level of the drip chamber. The flow rate is regulated by a hand-operated slide clamp or a roller clamp, which is opened or closed so the drops fall at the desired rate.

SAFETY ALERT!

IV infusions that are manually regulated must be monitored regularly. The flow rate of a manually regulated IV can be affected by the height of the IV infusion, the location of the site, and changes in the client position, which can result in impediment of the IV flow rate or excessive amounts of fluid being delivered to the client.

IV Tubing

The two common types of tubing used to administer IV fluids (regulated manually) are:

- • Macodrop tubing
- • Microdrop tubing

Macrodrop Tubing

Macrodrop is the standard tubing used for general IV administration. With macrodrop tubing the size of the drop and the number of gtt/mL varies according to the manufacturer. Macrodrops are large drops, and there are fewer drops in 1 mL (see Figure 21.1A). Macrodrop tubing have the following drop factors:

- • 10 gtt/mL
- • 15 gtt/mL
- • 20 gtt/mL

Since the drop factor for macrodrop tubing differs according to the manufacturer, always read the IV tubing package and identify the drop factor of the tubing. Never assume to know the drop factor, because not all macrodrop tubing has the same factor.

SAFETY ALERT!

To accurately administer IV fluids at the correct rate to a client, the nurse **must** know the drop factor of the IV tubing. Knowing the drop factor of the IV tubing used can prevent an error in IV rate determination and the client receiving IV fluid at the incorrect rate. **Never** assume the drop factor for macrodrop tubing.

Microdrop Tubing

Microdrop tubing delivers tiny drops through a small needle in the drip chamber and therefore has more drops in 1 mL (see Figure 21.1B). It is used to administer either small or precise amounts of fluid. For example, it is used in critical care, for the elderly, and for pediatric infusions. Microdrop tubing, because of the size of the drops (very small/ tiny) is sometimes referred to as pedidrip tubing. Microdrop tubing, regardless of the manufacturer, is only available in one drop factor (60 gtt/mL). With microdrop tubing the number of mL/hr is the same as gtt/min (i.e., if the infusion rate is 100 mL/hr, the IV rate is 100 gtt/min).

- • 60 gtt/mL

POINTS TO REMEMBER

- • Drop factor = gtt/mL of the IV tubing. This information is written on the package of the IV tubing.
- • Knowing the drop factor of the IV tubing is the **FIRST** step in accurate administration of IV fluids in gtt/min. IVs that infuse by gravity are manually regulated, and the IV flow rate is determined in gtt/min.
- • Macrodrops are large and have drop factors of 10, 15, and 20 gtt/mL.
- • Microdrops are tiny and have only one drop factor, 60 gtt/mL.

PRACTICE PROBLEMS

Refer to the drop factor provided and identify the type of tubing.

- 6. 15 gtt/ mL _____
- 7. 60 gtt/mL _____
- 8. 10 gtt/mL _____

Answers on 538

Calculating Flow Rates in Drops Per Minute Using a Formula and Dimensional Analysis

To calculate the IV flow rate in gtt/min for an IV infusing by gravity, a formula method can be used or dimensional analysis. To calculate the flow rate in gtt/min for the IV infusion regardless of the method used (formula method or dimensional analysis), the nurse needs to know the following:

- • Drop factor of the IV tubing
- • Volume (number of mL) to infuse
- • Time the IV is to infuse (minutes or hours)

The formula for calculating the IV flow rate is:

Before beginning to calculate gtt/min, let's review some basic guidelines:

Guidelines for Calculating gtt/min

- • Drops per minute are **always** expressed in whole numbers. Think: You cannot regulate an IV to half a drop or count half a drop; therefore **you can only count whole drops.**
- • Principles of rounding are applied if the calculation for gtt/min does not result in a whole number. Carry calculation to the tenths place, and round answer to the nearest whole number (i.e., 19.6 is rounded to 20 gtt/min).
- • Answers must be labeled. The label is usually drops per minute unless otherwise specified. Example: 17 gtt/min. To reinforce the differences in drop factor, the type of tubing is sometimes included as part of the label. Examples: 17 macrogtt/min, 100 microgtt/min.
- • Common conversion factors used include 1 L = 1,000 mL, and 1 hr = 60 min.

First let's look at some sample problems using the formula method and dimensional analysis.

Example 1: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 10 gtt/mL. At what rate in gtt/min should the IV infuse?

- • Notice the numbers in the problem are placed in the formula.
- • Remember the formula solves for gtt/min and the time is indicated in minutes. 60 min = 1 hr; therefore 1 hr is changed to 60 min in the formula (100 mL/60 min).
- • When mL is cancelled out, the flow rate is determined in gtt/min.
- • Reduction is done where possible.
- • The answer is labeled.
- • ***Note:*** The volume of 1,000 mL was not used in the calculation; the mL/hr was stated in the order.

Setup Using Formula Method

To deliver 100 mL/hr, the IV rate would be regulated at 17 gtt/min; 17 macrogtt/min.

Dimensional Analysis

Let's look at the previous example using dimensional analysis.

Example 1: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 10 gtt/mL. At what rate in gtt/min should the IV infuse?

- • Notice *x* gtt is written to the left of the equation, followed by the equal sign (=) (labeled *x* gtt/min because that is what you're looking for).
- • The **first** factor starts with gtt and is the drop factor, which is written, placing gtt in the numerator. 10 gtt/1 mL.
- • The next fraction is written so that the denominator matches the previous fraction (what you are looking for). The order is to infuse 100 mL in 1 hr. The 1 hr is entered as 60 min in the denominator because you are calculating gtt/min (100 mL/60 min).
- • Cancel the units and you are left with the desired gtt/min.
- • Reduction is done if possible.
- • Label the answer.

Dimensional Analysis

Note: An alternate way of setting up the problem, without changing the hourly rate to 60 min, would be to add 1 hr = 60 min conversion factor to the equation:

Alternate Setup Using Dimensional Analysis

Notice the hourly rate is entered in mL/hr in the equation; the fraction 1 hr/60 min is inserted into the equation. The units are cancelled, leaving gtt/min. The calculation would be the same as the previous setup.

Example 2: Order: 1.5 L 0.9% NaCl to infuse in 10 hr. Drop factor: 15 gtt/mL. At what rate in gtt/min should the IV infuse at?

- • Notice this problem contains a large volume of fluid, and the order contains the total number of hours to infuse as opposed to mL/hr as shown in Example 1.
- • A conversion is also required before the problem can be solved. L must be converted to mL. Use the conversion factor 1 L = 1,000 mL; therefore 1.5 L = 1,500 mL.
- • When using the **formula method**, the IV rate can be determined in two ways:
  - a. First convert the flow rate to mL/hr, and then calculate the gtt/min using the formula.
  - *or*
  - b. Convert the number of hours to minutes using the conversion factor 60 min = 1 hr. Multiply the number of hours by 60 min/hr and then place the calculated minutes into the formula. In this problem, 10 hr is multiplied by 60 min/hr to obtain the 600 minutes used in the formula: 10 hr × 60 min/hr.
- • For **dimensional analysis,** if the mL/hr is not expressed as mL/min, insert the conversion factor 1 hr/60 min.

Let's look at the above problem using the formula method and dimensional analysis.

Formula Method Using Two Steps

Step 1: Calculate the mL/hr:

Convert mL/hr to mL/min. 1 hr = 60 min (150 mL/hr = 150 mL/60 min)

Step 2: Place into formula:

Formula Method Using hr Converted to min

Dimensional Analysis Using mL/min

Calculate mL/hr: 1,500 mL ÷ 10 hr = 150 mL/hr.

Convert mL/hr to mL/min (150 mL/hr = 150 mL/60 min).

Proceed using the steps shown in Example 1.

Dimensional Analysis Using mL/hr

Dimensional Analysis Using the Total Volume and Total Number of hr

Proceed with calculation as shown in previous examples.

Example 3:

Order: The following IVs for 24 hours. Drop factor: 15 gtt/mL

- • 1,000 mL D_5W c 10 mEq potassium chloride (KCl)
- • 500 mL D_5NS c 1 ampule of multivitamin (MVI)
- • 500 mL D_5W

What rate will you regulate the IV to deliver the ordered IV fluid?

In this problem, the order is written for different amounts and types of fluid to be given in a certain time period. Notice that medications are also ordered to be added to the solutions: potassium chloride and multivitamin. When medications such as potassium chloride and vitamins are added to the IV solutions, they are generally not considered in the total volume. (Some institutions consider the medication in the volume if it is 10 mL or more. Always check the policy of the institution.)

To calculate the IV rate, add up the IV fluid to obtain the total volume (2,000 mL). The total number of hours for the IV infusion is given (24 hours). To convert 24 hr to min, multiply: 24 hr × 60 min/hr = 1,440 min.

Formula Method Using Two Steps

Step 1: Calculate the mL/hr:

Convert mL/hr to mL/min. 60 min = 1 hr (83 mL/hr = 83 mL/60 min).

Step 2: Place into formula

Formula Method Using hr Converted to min

To infuse 2,000 mL in 24 hours, the IV would be regulated at 21 gtt/min; 21 macrogtt/min.

Dimensional Analysis Using mL/min

Dimensional Analysis Using mL/hr

Dimensional Analysis Using the Total Volume and Total Number of hr

Proceed with calculation as shown in previous examples.

Example 4:

Order: 50 mL NS to infuse over 20 minutes.

Drop factor: 20 gtt/mL. What rate will you regulate the IV to infuse?

Notice, in this example, you have a small volume of fluid, and the time for the IV to infuse is in minutes. This problem can be solved using the same methods (formula method and dimensional analysis) shown in the previous examples.

Formula Method

Dimensional Analysis

To infuse 50 mL NS in 20 minutes, the IV would be regulated at 50 gtt/min; 50 macrogtt/min.

PRACTICE PROBLEMS

Calculate the flow rate in gtt/min using the formula method or dimensional analysis.

- 9. D_5RL at 75 mL/hr. The drop factor is 10 gtt/mL. _____
- 10. D_5 ½ NS at 30 mL/hr. The drop factor is a microdrop. _____
- 11. 1,000 mL D_5 0.33% NS in 6 hr. The drop factor is 15 gtt/mL. _____
- 12. An IV medication in 60 mL of 0.9% NS is to be administered in 45 min. The drop factor is a microdrop. _____
- 13. 1,000 mL of Ringer's lactate solution (RL) is to infuse in 16 hr. The drop factor is 15 gtt/mL.
- 14. 3,000 mL D_5 and ½ NS in 24 hr. The drop factor is 10 gtt/mL. _____
- 15. Infuse 2,000 mL D_5W in 12 hr. The drop factor is 15 gtt/mL. _____

Answers on pp. 538-539

Calculation of IV Flow Rates Using a Shortcut Method

This shortcut method can be used where the IV sets all have the same drop factor. Example: an institution where all the macrodrop sets deliver 10 gtt/mL. This method can also be used with microdrop sets (60 gtt/mL). It is important to note that this method can be used only if the rate of the IV infusion is expressed in mL/hr (mL/60 min).

To use this method, you must know the drop factor constant for the administration set you are using. The drop factor constant is sometimes referred to as the *division factor*. To obtain the drop factor constant (division factor) for the IV administration set being used, divide 60 by the drop factor calibration from the IV infusion set. Box 21.1 shows the constant calculated based on the drop factor for the IV tubing.

BOX 21-1 Drop Factor Constants

Drop Factor of Tubing	Drop Factor Constant
10 gtt/mL	
15 gtt/mL	
20 gtt/mL	
60 gtt/mL	

RULE

After the drop factor constant is determined, the gtt/min can be calculated in one step:

Let's look at examples of calculating the gtt/min using the stated rule:

Example 1:

Order: Administer D_5W at 125 mL/hr. Drop factor: 15 gtt/mL

The drop factor constant: 4.

In this example, the drop factor constant is 4. The set calibration is 15 gtt/mL (60 ÷ 15 = 4).

Solution:

Solution Using Dimensional Analysis:

Remember that the shortcut method discussed (using the drop factor constant) can be used to calculate the gtt/min for any volume of fluid that can be stated in mL/hr or mL/60 min.

RULE

The shortcut method can be used if the volume of fluid is large; however, an additional step of calculating mL/hr first must be done and then calculate the gtt/min using the shortcut method.

Example 2: Order: RL 1,500 mL to infuse in 12 hr. Drop factor: 20 gtt/mL. Drop factor constant: 3.

In this example, the volume of fluid is 1,500 mL and the total hours to infuse is 10 hr. Before using the shortcut method, the mL/hr must be calculated. 1,500 mL ÷ 12 = 125 mL/hr. The set calibration is 20 gtt/mL. 60 ÷ 20 = 3.

Solution:

Solution Using Dimensional Analysis:

Determine mL/hr expressed as mL/60 min.

The shortcut method can also be used for small volumes of fluid and when the time period is less than 1 hour. If the volume of fluid to infuse is small and the time period is less than 1 hour (60 minutes), the volume and time must each be multiplied to get mL/hr.

Example 3: Order: 20 mL D_5W in 30 minutes. Drop factor 60 gtt/mL. Drop factor constant: 1.

In this example the volume of fluid is small, and the time period is less than 60 min. The set calibration is 60 gtt/mL. 60÷ 60 = 1.

Solution: To express 20 mL in 30 minutes in mL/hr, you multiply the volume and the time by 2.

Step 1: Change 20 mL/30 min to 40 mL/hr as shown above.

Step 2: Express 40 mL/hr as 40 mL/60 min.

Note: In the above problem to administer 40 mL/hr, the IV would be set at 40 gtt/min. When the drop factor of the infusion set used is 60 gtt/mL, the number of gtt/min is equal (=) to the mL/hr.

PRACTICE PROBLEMS

Calculate the rate in gtt/min using the shortcut method.

- 16. Order: D_5W 200 mL/hr. Drop factor: 10 gtt/mL _____
- 17. Order: 0.9% NS 140 mL/hr. Drop factor: 20 gtt/mL _____
- 18. Order: 1,000 mL D_5W in 10 hr. Drop factor: 10 gtt/mL _____
- 19. Order: 40 mL D_5W in 20 min. Drop factor: 10 gtt/mL _____
- Calculate the flow rate in gtt/min.
- 20. Order: To infuse in 16 hr. Drop factor: 10 gtt/mL
  - • D_5W 500 mL c 10 potassium chloride (KCl)
  - • D_5W 1,000 mL
  - • D_5W 1,000 mL c 1 ampule of multivitamin (MVI) _____
- 21. Order: 1,000 mL D_5 0.9% NS for 3 L at 100 mL/hr. Drop factor: microdrop _____

Answers on 539

POINTS TO REMEMBER

- • To calculate the IV flow rate in gtt/min, the nurse must know the drop factor of the IV tubing, the volume to infuse, and the time for the IV to infuse.
- • Drop factor is expressed as gtt/mL and indicated on the package of the IV tubing.
- • Calculation of gtt/min can be done using the formula method or dimensional analysis.
- • Formula for calculating gtt/min is as follows:

- • With the formula method, determine the IV rate by converting the flow rate to mL/hr (60 min), and then calculate gtt/min using the formula. **OR** Convert the number of hours to minutes using the conversion factor 60 min = 1 hr, and then place the calculated minutes into the formula.
- • For dimensional analysis, if the mL/hr is not expressed as mL/min, insert the conversion factor 1 hr/60 min into the equation.
- • Drops per minute are always expressed as whole numbers.
- • A shortcut method can be used to calculate flow rates infusing in mL/hr or mL/60 min using the drop constant.
- • To determine the drop constant factor, divide 60 by the calibration of the IV set.
- • To use the shortcut method for small volumes and time periods less than 1 hr, the volume and the time must each be multiplied to get mL/hr.

Calculating IV Flow Rates Using a Dial-Flow Controller

Dial-flow controllers are also known as IV manual flow regulators or just IV flow regulators, as well as just flow controllers. There are a wide variety of dial-flow controllers available for use and are either part of the IV tubing or added on (Figure 21.3). These devices are regulated manually and are not infusion pumps. Use of the device is based on several factors, which include severity of illness, type of therapy, and the setting. Dial-flow devices are designed to regulate the flow of IV fluid instead of using the roller clamp. The flow rate can be adjusted from 5 to 250 mL/hr. To use the device, you set or dial the desired flow rate in mL/hr, which is an estimate, and then the rate must be verified by counting drops per minute. Drops per minute would be calculated using one of the methods presented in the chapter.

Figure 21.3 Flow controller. (Courtesy and © Becton, Dickinson and Company, Franklin Lakes, NJ.)

If used, it is important to remember that use of the device does not relinquish the nurse from his or her responsibility, which is to monitor the IV to ensure there is accurate delivery of the ordered infusion rate.

Let's look at an example using this device.

Example: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 15 gtt/mL.

- 1. Turn the dial of the controller to 100 mL/hr.
- 2. Use the formula or dimensional analysis to determine gtt/min.
- 3. Verify accuracy of controller by counting the drops either for a minute or a fraction, such as 20 seconds. Divide the number of drops per minute by 3 (25 gtt ÷ 3 = 8.3 = 8 gtt). You find the number of drops is 8; the controller is delivering the correct rate for 20 seconds. If the rate is not correct for 20 seconds, the controller dial can be adjusted. The rate will have to be monitored periodically during the infusion.

Formula Method

Dimensional Analysis

Refer to examples for steps in solving.

To infuse 100 mL/hr, the IV flow rate would be set at 25 gtt/min; 25 macrogtt/min.

SAFETY ALERT!

The flow rate on the controller is in **mL/hr, not gtt/min.** Failure to verify the drop rate can result in client not receiving the correct rate, which can result in the client receiving insufficient or excessive IV fluid. To ensure client safety during IV administration, the controller as well as the client **must** be monitored.

Calculating Intermittent IV Infusions Piggyback

A medication such as an antibiotic can be administered by attaching it to a port on the primary line (referred to as Intravenous Piggyback [IVPB]) and infusing it by gravity or infused using an electronic infusion device. IVPBs may come premixed from the drug manufacturer, or medications are added to a small volume bag by the nurse, or in some institutions by the pharmacist and sent to the unit.

If the prescriber does not include the type and amount of solution for the medication to be placed in or the rate for infusion, the nurse must check a medication reference or the manufacturer's guidelines. Even if medications are premixed (with medication added to the solution by the drug manufacturer or pharmacy), the nurse is responsible for ensuring that the IVPB is infusing at the correct rate. When medications are premixed, the nurse calculates the infusion rate by using the volume of solution containing the medication. Regardless of whether the IVPB is mixed by the nurse, is premixed, or the ADD-Vantage system is used, the IVPB must be in the correct amount of solution and infused at the correct rate. The volume of IV solution used for an IVPB is usually 50 to 100 mL to infuse over 20, 30, 60 minutes, or longer depending on the type and amount of medication added.

As already stated, depending on the volume of the medication being added (for an IVPB mixed by the nurse), at some institutions the medication is considered in the volume of IV fluid when determining the IV rate. ***Note:*** For the purpose of this text, it will be indicated when to consider the medication in the IV volume and the type and amount of solution for dilution of the piggyback, and infusion rate will be indicated in the order.

Let's look at the examples shown for determining the rate for the IVPB.

Example 1: Order: Keflin 2 g IVPB in 100 mL D_5W over 30 min. Drop factor: 15 gtt/mL. Determine the IV flow rate.

Solution:

- • In this problem, there is no conversion needed; the volume of solution is in mL.
- • The amount of medication added, 2 g, is not needed to calculate the IV flow rate. The 100 mL of fluid that the Keflin is placed in is used as the volume.
- • A drop factor is stated; therefore the IV rate will be calculated in gtt/min.
- • The volume of IV fluid, which is stated in mL, the time (min), and the drop factor are the required information needed to calculate the IV flow rate, using the formula method or dimensional analysis.

Formula Method

Dimensional Analysis

To infuse 100 mL in 30 minutes the IV rate would be regulated at 50 gtt/min; 50 macrogtt/min.

Now let's look at the same problem if an electronic infusion device was used.

Example 2: Order: Keflin 2 g IVPB in 100 mL D_5W over 30 min by infusion pump.

Determine the IV flow rate.

Solution:

- • An electronic infusion device is being used; the rate will need to be determined in mL/hr.
- • As with Example 1, the amount of medication, 2 g, is not needed to calculate the IV flow rate.
- • Remember there are 60 minutes in 1 hr.
- • The rate can be determined using ratio and proportion, the formula below, or dimensional analysis.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Formula Method

Notice min is cancelled, leaving mL/hr.

Dimensional Analysis

Notice min is cancelled, leaving mL/hr.

The pump would be set at 200 mL/hr to infuse 100 mL in 30 min. ***Note:*** The actual volume of 100 mL will be infused.

PRACTICE PROBLEMS

Calculate the rate in gtt/min for the following medications being administered IVPB. Use the labels where provided. (Add the volume of medication being added to IV solutions, where indicated.)

- 22. Order: Erythromycin 200 mg in 250 mL D_5W to infuse over 1 hr. Drop factor: 10 gtt/mL _____

- 23. Order: Ampicillin 1 g in 50 mL D_5W to infuse over 45 minutes. Drop factor: 10 gtt/mL. For IV, reconstitute with 10 mL of diluent to get 1 g per 10 mL. (Consider the medication added in the volume of fluid.)
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Calculate the rate in gtt/min at which the IV should infuse. _____
- 24. Order: Clindamycin 900 mg in 75 mL D_5W over 30 minutes. Drop factor: 10 gtt/mL
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Determine the IV rate. _____
- 25. Order: Vancomycin 500 mg IVPB q24hr. The reconstituted vancomycin provides 50 mg per mL. The medication is placed in 100 mL of D_5W to infuse over 60 minutes. Drop factor: 15 gtt/mL. (Consider the medication added in the volume of fluid.)
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Calculate the rate in gtt/min at which the IV should infuse. _____
- 26. Order: Fungizone (amphotericin B) 20 mg in 300 mL D_5W over 6 hr by infusion pump. The reconstituted material contains 50 mg per 10 mL.
  - a. How many milliliters will you add to the IV solution? _____
  - b. Determine the IV rate. _____
- 27. Order: Septra (sulfamethoxazole and trimethoprim) 300 mg in 300 mL D_5W over 1 hr q6h. Drop factor: 10 gtt/mL. Calculate the dose using trimethoprim.
  - a. How many milliliters of medication will be added to the IV? (Round the answer to the nearest tenth.) _____
  - b. Consider the medication added to the volume of IV fluid. Calculate the rate in gtt/min at which the IV should infuse. _____
- 28. Order: Retrovir (zidovudine) 100 mg IV q4h over 1 hr. Available medication states each mL contains 10 mg of zidovudine.
  - a. How many milliliters of medication will be added to the IV solution? _____
  - b. The medication is placed in 100 mL of D_5W. Drop factor: 10 gtt/mL (Consider the medication added to the volume of IV fluid.) _____

Answers on pp. 539-540

Determining the Amount of Medication in a Specific Amount of Solution

Sometimes medications are added to IV solutions, and the prescriber orders a certain amount of medication to be administered in a certain time period. In order to calculate the volume of fluid needed to deliver a specific amount of medication, a ratio and proportion can be used or dimensional

analysis.

Example 1: Order: 20 mEq of potassium chloride in 1,000 mL D_5W to infuse at 2 mEq/hr. Calculate the mL/hr to deliver 2 mEq of potassium chloride/hr.

Solution:

Set up a ratio and proportion using the linear or fraction format:

- • With use of the ratio and proportion, the known ratio is the amount of medication in the total volume of solution, and the unknown ratio is what the prescriber ordered.
- • Dimensional analysis of the first factor is the total volume of solution and the amount of medication, and the second factor is what the prescriber ordered.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

Notice cancelling mEq leaves mL/hr.

100 mL/hr will deliver 2 mEq /hr of potassium chloride.

Example 2: Order: 100 units of Humulin regular insulin in 500 mL ½ NS to infuse at 10 units/hr. Calculate the mL/hr to deliver 10 units of insulin/hr.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

POINTS TO REMEMBER

- • When preparing medications for intermittent infusion:
  - a. Reconstitute the medication using the label or package insert if needed.
  - b. Calculate the amount of medication to administer.
  - c. Verify the recommended infusion rate with the manufacturer's recommendations or a medication reference.
  - d. Determine the IV rate using the IV formula or dimensional analysis.
- • If the intermittent infusion is being administered by an electronic infusion device, the flow rate is determined in mL/hr using ratio and proportion, dimensional analysis, or the formula method for time periods less than 1 hour.

- • To determine the volume (amount) of IV fluid to administer the prescribed amount of medication in mL/hr, use ratio and proportion or dimensional analysis.

PRACTICE PROBLEMS

Solve the following problems using the steps indicated.

- 29. Order: 15 mEq of potassium chloride in 1,000 mL of D_5 ½ NS to be administered at a rate of 2 mEq/hr.
- How many mL/hr should the IV infuse at? _____
- 30. Order: 10 units of Humulin regular insulin per hour. 50 units of insulin is placed in 250 mL NS.
- How many mL/hr should the IV infuse at? _____

Answers on pp. 540-541

Determining the Unknown for Time and Volume

You may need to calculate the following:

- a. **Time in hours**—How long it will take a certain amount of fluid to infuse or how long it may last
- b. **Volume**—The total number of milliliters a client will receive in a certain time period These unknown elements can be determined by the use of the formula method or dimensional analysis.

Formula:

Calculating a Problem with an Unknown Using the Formula Method and Dimensional Analysis

- 1. Take the information given in the problem and place it in the formula.
- 2. Place an *x* in the formula in the position of the unknown. If you are trying to determine time in hours, place *x* in the position for minutes; once you find the minutes, divide the number of minutes by 60 (60 minutes 5 1 hr) to get the number of hours. If you are trying to determine the volume the client would receive, place an *x* in the position for amount of solution, and label *x* mL.
- 3. Set up an algebraic equation so that you can solve for *x*.
- 4. Solve the equation.
- 5. Label the answer in hours or milliliters for volume.

Example 1: Determining hours:

An IV is regulated at 20 microgtt/min. How many hours will it take for 100 mL to infuse?

Formula Method

Note: In the position of drop factor, 60 gtt/mL was placed, IV was infusing in microgtt, and the infusion set had to be a microdrip (60 gtt/mL).

Dimensional Analysis

x hr is what you are looking for. The **first** starting fraction is 1 hr/60 min, the **second** fraction is 1 min/20 gtt to match the denominator of the starting fraction. The **third** fraction is 60 gtt/1 mL to match the denominator in the fraction before it. The **last fraction** is 100 mL/1, to match mL in the fraction before it. Cancel the units, reduce if possible, and perform mathematical process.

Note: When calculating time and the answer results in hr and min, express entire time in hr (i.e., 1 hr and 30 min = 1.5 hr, or 1½ hr; 1½ hr is the preferred way to state answer).

Example 2: Determining volume:

An IV is regulated at 17 macrogtt/min. The drop factor is 15 gtt/mL. How much fluid volume in milliliters will the client receive in 8 hr?

Formula Method

Dimensional Analysis

x mL is what you are looking for here. Enter the drop factor as the **first** starting fraction 1 mL/15 gtt. The **second** fraction is 17 gtt/1 min, so it matches the denominator of the first fraction. The **third** fraction is 480 min/1 so that it matches the denominator before it. **An alternate** to changing min to hr is to enter the conversion 60 min/1 hr, and enter 8 hr/1 to match the denominator before it. Cancel if possible, and perform the mathematical process.

Note: Some problems for calculating an unknown may be solved without using the formula method or dimensional analysis; however, the use of one or the other is recommended.

POINTS TO REMEMBER

Determining the Unknown

- • Use the IV formula and place the information given into the position of the formula.

Use *x* for unknown values.

- 1. For determining time—place an *x* in the minutes position, and then divide the minutes by 60 to determine the time in hours.
- 2. For volume—place an *x* in the position for amount of solution and label *x* mL. Convert the hours to minutes.

- • Set up an algebraic equation and solve for *x*.
- • Answers for time are labeled in hours, with mL for volume, unless instructed otherwise.
- • Dimensional analysis can also be used to determine the unknown.

PRACTICE PROBLEMS

Solve for the unknown in the following problems as indicated.

- 31. You find that there is 150 mL of D_5W left in an IV. The IV is infusing at 60 microgtt/min. How many hours will the fluid last? _____
- 32. 0.9% NS is infusing at 35 macrogtt/min. The drop factor is 15 gtt/mL. How many milliliters of fluid will the client receive in 5 hours? _____
- 33. There is 90 mL of D_5 0.33% NS left in an IV that is infusing at 60 microgtt/min. The drop factor is 60 gtt/mL. How many hours will the fluid last? _____

Answers on 541

Recalculating an IV Flow Rate

Flow rates on IVs change when a client stands, sits, or is repositioned in bed if IVs are infusing by gravity. Therefore, nurses must frequently check the flow rates. Sometimes IVs infuse ahead of schedule, or they may be behind schedule if they are not monitored closely. When this happens, the IV flow rate must be recalculated. To recalculate the flow rate, the nurse uses the volume remaining and the time remaining. Recalculation may be done with uncomplicated infusions. IVs that require exact infusion rates should be monitored by an electronic infusion device.

SAFETY ALERT!

Never arbitrarily increase or decrease an IV to get it back on schedule without assessing a client and checking with the prescriber. Increasing or decreasing the rate without thought can result in serious harm to a client, including overhydration or underhydration. Check the policy of the institution. Avoid off-schedule IV rates by regularly monitoring the IV at least every 30 to 60 minutes.

When an IV is significantly ahead of or behind schedule, you may need to notify the prescriber, depending on the client's condition and the use of appropriate nursing judgment. **Always assess the client** before making any change in an IV rate. Changes depend on the client's condition. Check the institution's policy regarding the percentage of adjustment that can be made. Each situation must be individually evaluated, and appropriate action must be taken.

A safe rule is that the recalculated flow rate should not vary from the original rate by more than 25%. If the recalculated rate varies by more than 25% from the original rate, the prescriber should be notified. The order may require revision. If a client is stable, recalculate the IV rate, using the remaining volume and time, and then proceed to calculate gtt/min using the formula method or dimensional analysis. Refer to content in this chapter (calculating gtt/min) if necessary. Let's go over the steps to recalculate an IV rate if allowed by your institution policy, and the client is stable.

To recalculate an IV flow rate:

- • Use the remaining volume and remaining hours, and calculate the rate in mL/hr.

- • Use the mL/hr to calculate gtt/min for the recalculated rate, using the formula or the shortcut method:

- • Shortcut method:

- • Determine whether the new rate calculation is greater or lesser than 25%. Use the amount of increase or decrease divided by the original rate.

= % of change of original rate (round to nearest whole percent)

Let's look at some examples. ***Note:*** All examples assume the institution allows a 25% IV flow variation, and the clients are stable.

Example 1: 1,000 mL of D_5 RL was to infuse in 8 hr at 31 gtt/min (31 macrogtt/min). The drop factor is 15 gtt/mL. After 4 hr, you notice 700 mL of fluid left in the IV. Recalculate the flow rate for the remaining solution. ***Note:*** The infusion is behind schedule. After 4 hr, half of the volume (or 500 mL) should have infused.

Solution:

Solution to Example 1: Using the Shortcut Method

Determine recalculated rate:

Time remaining: 8 hr – 4 hr = 4 hr

Time remaining: 8 hr – 4 hr = 4 hr

Volume remaining: 1,000 mL – 300 mL = 700 mL

Volume remaining: 1,000 mL – 300 mL = 700 mL

700 mL ÷ 4 hr = 175 mL/hr

700 mL ÷ 4 hr = 175 mL/hr

Drop factor: 15 gtt/mL; therefore the drop factor constant is 4.

Drop factor: 15 gtt/mL; therefore the drop factor constant is 4.

x = 44 gtt/min; 44 macrogtt/min (recalculated rate)

x = 44 gtt/min; 44 macrogtt/min (recalculated rate)

Determine the percentage of the change:

Dimensional Analysis

Course of Action

Assess the client.

Notify the prescriber.

Do not increase the IV rate; the increase is **greater than 25%.**

Increasing the IV could result in serious consequences for the client. Assessment of the client is always done first to determine the client's ability to tolerate an increase in fluid. In this situation the prescriber should be notified, a new order is needed, the recalculated rate is greater than 25%.

Example 2 (IV Ahead of Schedule): An IV of 1,000 mL D_5W is to infuse from 8 am to 4 pm (8 hr). The drop factor is 10 gtt/mL. The rate is set at 20 gtt/min (20 macrogtt/min). In 5 hr, you notice that 700 mL has infused. Recalculate the flow rate for the remaining solution.

Solution:

Shortcut Method

Determine recalculated rate:

Time remaining: 8 hr – 5 hr = 3 hr

Volume remaining: 1,000 mL – 700 mL = 300 mL

300 mL ÷ 3 = 100 mL/hr

Drop factor: 10 gtt/mL; therefore the drop factor constant is 6.

x = 17 gtt/min; 17 macrogtt/min (recalculated rate)

x = 17 gtt/min; 17 macrogtt/min (recalculated rate)

Determine the percentage of change:

Dimensional Analysis

Time remaining: 8 hr – 5 hr = 3 hr

Volume remaining: 1,000 mL – 700 mL = 300 mL

x = 17 gtt/min; 17 macrogtt/min

x = 17 gtt/min; 17 macrogtt/min

Course of Action

Assess the client.

Adjust the rate if allowed by institutional policy, and assess during the remainder of the infusion.

Notify prescriber if required.

In this situation, the flow rate must be decreased from 20 gtt/min (20 macrogtt/min) to 17 gtt/min (17 macrogtt/min), and the change is not greater than 25% of the original rate. –15% is within the acceptable 25% of change. However, the client's condition must still be assessed to determine the ability to tolerate the change, and the prescriber may still require notification.

Alternate to Determining the Percentage of Change

As already stated, you can adjust the flow rate as much as (+) or (–)25%. Think 25% = ¼. Therefore you can verify the safety of the recalculated rate by using a method that eliminates the need to use percents. To do this, do the following:

- • Divide the original rate by 4, then add, and subtract the result from the original rate. This will provide a range for the acceptable rate adjustment. Let's use the two examples we just did.

Example 1:

The original rate was 31gtt/min (macrogtt/min), and the recalculated rate is 44 gtt/min (macrogtt/min).

Original rate ± (original rate ÷ 4) = Acceptable IV rate adjustment

31 + (31 ÷ 4) = 31 + 7.75 = 38.75 = 39 gtt/min (macrogtt/min)

31 – (31 ÷ 4) = 31 – 7.75 = 23.25 = 23 gtt/min (macrogtt/min)

The safe acceptable IV rate adjustment is 23 to 39 gtt/min (macrogtt/min). 44 gtt/min is above the acceptable adjustment range, and 25%. The prescriber should be notified to provide a new order.

Example 2:

The original rate was 20 gtt/min (macrogtt/min), and the recalculated rate is 17 gtt/min (17 macrogtt/min).

Original rate ± (original rate ÷ 4) = Acceptable IV rate adjustment

20 + (20÷ 4) = 20 + 5 = 25 gtt/min (macrogtt/min).

20 – (20 ÷ 4) = 20 – 5 = 15 gtt/min (macrogtt/min).

The safe acceptable IV rate adjustment is 15 to 25 (macrogtt/min). It is safe to slow the rate to 17 gtt/min (macrogtt/min), which is less than 25%.

POINTS TO REMEMBER

- • Monitor IV therapy every 30 to 60 min to maintain the ordered IV rate.
- • Do not arbitrarily speed up or slow down an IV that is behind or ahead of schedule.
- • Know the hospital policy regarding recalculation of IV flow rate. An IV should not vary more than 25% from its original rate.
- • To recalculate an IV rate:
- • Determine mL/hr:
-

- • Use mL/hr and recalculate the rate in gtt/min, using formula or shortcut method.

- • Determine the % of change
-
  = % of change (rounded to the nearest whole %)
- • Alternate to use of percent: Divide the original rate by 4, then add and subtract the result from the original rate to get the acceptable IV rate adjustment.
- • Contact the prescriber for a new IV order, if the recalculated rate exceeds 25%.

PRACTICE **PROBLEMS**

For each of the problems, recalculate the IV flow rates in gtt/min rates using either method presented, determine the percentage of change, and state your course of action. *Note:* The institution allows 25% variation and clients are stable.

- 34. 500 mL of 0.9% NS was ordered to infuse in 8 hr at the rate of 16 gtt/min (16 macrogtt/min). The drop factor is 15 gtt/mL. After 5 hr, you find 250 mL of fluid left.
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 35. 250 mL of D_5W was to infuse in 3 hr at the rate of 21 gtt/min (21 macrogtt/min). Drop factor: 15 gtt/mL. With 1½ hr remaining, you find 200 mL left.
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 36. 1,000 mL D_5 0.33% NS was to infuse in 12 hr at 28 gtt/min (28 macrogtt/min). After 4 hr, 250 mL has infused. Drop factor: 20 gtt/mL
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 37. 500 mL D_5 0.9% NS to infuse in 5 hr at 100 gtt/min (100 microgtt/min). After 2 hr, 250 mL has infused. Drop factor: 60 gtt/mL

- a. _____ gtt/min
- b. _____ % variation
- c. _____ Course of action

Answers on pp. 541-542

Calculating Infusion and Completion Time

IV fluids are ordered by the prescriber for administration indicating a specific rate in mL/hr, such as 1,000 mL D_5W to infuse at 100 mL/hr. **The nurse needs to be able to determine the amount of time (hours and minutes) that it would take for a certain volume of IV solution to infuse, which is referred to as *infusion time*.** Knowing the infusion time is important for the nurse, which includes reasons such as allowing the preparation for hanging a new solution as one infusion is being completed and preventing things such as the line clotting off as a result of not knowing when an IV was to be completed. Infusion times can be calculated using any of the following methods:

- • Ratio and proportion: The known ratio, which is written first, is the ordered rate in mL/hr, and the second ratio is the unknown, which is the total number of mL to infuse in *x* hr, total mL/*x* hr. The ratio and proportion can be written in linear or fraction format.
- • Formula method:

  = Infusion time
- • Dimensional analysis: The unknown is *x* hr; therefore the first fraction will be the ordered rate, hr/mL, the second fraction will be total mL/1.

Let's look at some examples of calculating infusion time.

Example 1: Calculate the infusion time for an IV of 1,000 mL D_5W to infuse at a rate of 125 mL/hr.

Ratio and Proportion (Linear Format)

Formula Method

1,000 mL (total mL to infuse)

125 mL/hr (mL/hr to infuse)

Infusion time = 8 hr

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

Dimensional Analysis

x = 8 hr

mL is cancelled here, leaving hr.

When an infusion time result is not an even whole number but instead the infusion rate includes a decimal fraction; the decimal fraction represents a fraction of an hour and must be converted to minutes. This calculation of infusion time is done as follows:

- • Determine the infusion time using any of the methods already presented, and carry division two decimal places.
- • Calculate the minutes using, conversion factor; 60 min = 1 hr. (Multiply the fraction of an hr by 60 min/hr) or use any of the methods presented.
- • Using the rules of rounding, round the minutes to the nearest whole number of minutes.

Let's look at an example.

Example 2: 1,000 mL D_5 ½ NS to infuse at 150 mL/hr. Calculate the infusion time for the IV.

Ratio and Proportion (Linear Format)

- • Determine the infusion time
- 150 mL : 1 hr = 1,000 mL : x hr
-
- • Calculate the minutes
- 1 hr : 60 min = 0.66 hr : x min
- x = 0.66 × 60 = 39.6
- x = 40 min (rounded to whole number)
- Infusion time is 6 hr and 40 min.

Formula Method

- • Determine infusion time

-

- x = 6.66 hr
- • Calculate the minutes

- Infusion time is 6 hr and 40 min.

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

- • Determine infusion time

-

- x = 6.66 hr
- • Calculate the minutes

-

- x = 40 min

Infusion time is 6 hr and 40 min.

Dimensional Analysis

- • Determine infusion rate

-

- x = 6.66 hr
- • Calculate the minutes

- x = 40 min
- Infusion time is 6 hr and 40 min.

Completion Time

Once the infusion time has been calculated, the nurse can use this information to determine the completion time. Completion time is the when the infusion is completed (i.e., the client has received all of the IV fluid). This would be determined as follows: Add the calculated infusion time to the time the infusion was started. If the IV was started at 7:00 am, add the 6 hours and 40 minutes to that time (7:00 am). The IV would be completed at 1:40 pm. It is easier to calculate completion time using military time: 7:00 am = 0700; now add 6 hours and 40 minutes to arrive at the answer of 1340.

- Start time 0700
- Infusion time +0640
- **Completion time:** 1340 or 1:30 pm

Calculating Completion Time

To calculate the completion time, add the infusion time to the time the IV was (military time).

Note: Converting traditional time to military time, and a discussion of completion time, appears in Chapter 8.

Let's look at some examples.

Example 1: An IV of 1,000 mL of D_5W is started at 1000 to infuse over 8 hr. Determine the completion time.

Solution:

- Start time 1000
- Infusion time +0800

Completion time: 1800 or 6:00 pm

Example 2: An IV of 1,000 mL of 0.9% NS is started at 2130 to infuse over 12 hr. Determine the completion time.

Solution:

- Start time 2130
- Infusion time +1200
- 3330 (time here is greater than 2400)

As you recall, when the time period is greater than 2400, you must subtract 2400 from the total (the day ends at 2400). This will give you the completion time for the next day.

Using the answer from the problem, which is 3330

Subtract –2400

Subtract −2400

Completion time: 0930 or 9:30 am the next day

Completion time: 0930 or 9:30 am the next day

Example 3: An IV of D_5½ NS is started at 0430 to infuse in 6 hr and 40 min. Determine the completion time.

Solution:

- Start time 0430
- Infusion time +0640
- 1070 (the minutes here are greater than 60)

As you recall, when the minutes are greater or equal to 60, subtract 60 from the number of minutes, which in this example is 70 min, and then add the 1 hour obtained when you subtracted the 60 minutes to get the completion rate, as follows:

- 1070
- −0060 minutes (1 hr)
- 1010
- +0100 (the 1 hr obtained when you subtracted the 60 min)

Completion time: 1110 or 11:10 am

Alternate to Example 3:

- Add start time: 0430
- Infusion time +0640
- Convert 70 min to 1 hr and 10 min and add to 10 hr. 1000
- +0110
- **Completion time:** 1110 or 11:10 am

As you will notice in the examples provided, you were given the infusion time as well as the time for the infusion to start in military time. Let's look at an example in which you will need to determine the infusion time before calculating the completion time.

Example 4:

500 mL D_5W to infuse at 80 mL/hr is started at 7:30 am. Determine the completion time. State time in military and traditional time.

Solution:

- • First determine the infusion time using any of the methods already presented (ratio and proportion, formula method, or dimensional analysis)

Ratio and Proportion (Linear Format)

80 mL : 1 hr = 500 mL : x hr

$80x = 500$

$x = 6.25$ hr

Calculate the minutes.

1 hr : 60 min = 0.25 hr : x min

$x = 0.25 \times 60 = 15$

$x = 15$ min

Infusion time is 6 hr and 15 min.

Formula Method

Calculate the minutes.

Infusion time is 6 hr and 15 min.

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

$x = 6.25$ hr

Calculate the minutes.

$x = 15$ min

Infusion time is 6 hr and 15 min.

Dimensional Analysis

Calculate the minutes:

Infusion time is 6 hr and 15 min.

- • Now determine the completion time (add the infusion time to the start time).
  - Start time: 0730
  - Infusion time:

= 1:45 pm

Note: The start time (7:30 am) was changed to military time: to convert am time omit colon and am, add a zero to beginning to make a 4-digit number. To convert pm time to traditional time, subtract 1200 and add pm. If necessary, review the conversion of time (traditional and military) in Chapter 8.

PRACTICE PROBLEMS

Determine infusion and completion time for the following IVs. State the time in traditional and military time.

- 38. An IV of 500 mL NS is to infuse at 60 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 10:00 pm. When would the IV infusion be completed? _____
- 39. An IV of 250 mL D_5W is to infuse at 80 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 2:00 am. When would the IV infusion be completed? _____
- 40. An IV of 1,000 mL D_5 RL is to infuse at 60 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 6:00 am. At what time would this IV infusion be completed? _____

- 41. An IV of 500 mL D_5W is to infuse at 75 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 2:00 pm. At what time would the IV infusion be completed? _____

Answers on 542

unknown - Section 39 (Page 358)

This chapter will present the calculations performed with intravenous therapy. As stated previously, nurses have the responsibility to make sure that clients are receiving the correct rate. Several methods to calculate IV rates are presented in the chapter: ratio and proportion, dimensional analysis, and the formula. Let's now begin our calculations with determining IV rates in milliliters per hour (mL/hr).

IV Flow Rate Calculation

As previously discussed, the prescriber's order for an IV includes the following:

- • The name of the IV solution
- • The volume to infuse
- • Medications to be added, if any
- • Time for the IV to infuse

Continuous IV, which is oft en referred to as the primary IV, usually contains a large volume of fluid (500 mL or 1,000 mL). IV fluids are usually ordered to be administered at rates expressed in mL/hr. The time for the IV to infuse may be indicated as the total number of hours (i.e., D_5W 3,000 mL in 24 hr), or mL/hr (i.e. D_5 ½. NS 1,000 mL at 125 mL/hr). Small volumes of fluid (usually 50 mL or 100 mL) are oft en used when the IV fluid contains medications such as antibiotics. Rates for IV fluids are usually expressed in drops per minute (gtt/min) when an infusion device is not used. When an infusion device such as a pump is used, the flow rate must be expressed in mL/hr.

Calculating Flow Rates for Infusion Pumps in mL/hr

When a client is using an electronic infuser, such as a volumetric pump, the prescriber orders the volume and can include mL/hr or the total number of hours for the IV to infuse. If the order states the number of mL/hr for the infusion, such as previously stated D_5 ½ NS at 125 mL/hr, there is no calculation required by the nurse. The nurse programs the pump to deliver the ordered rate. However, if the order states the total number of hours for the IV to infuse (D_5W 3,000 mL in 24 hr), the nurse will need to calculate the mL/hr to program the pump.

For most electronic devices that regulate the flow of IV solutions, the rate is expressed in milliliters per hour (mL/hr). For the purpose of this text, the equipment being used is programmable in whole mL/hr; therefore mL/hr should be rounded to a whole number unless indicated that the infusion pump has decimal capability. To determine mL/hr the following information is needed:

- • The volume (amount) of solution in milliliters
- • The time for the IV to infuse in hours

The simplest way to determine the mL/hr is by using the formula, although ratio-and-proportion and dimensional analysis can be used:

Formula to Determine mL/hr

Round mL/hr to the nearest **whole number**. If the answer does not result in a whole number, carry division to tenths place and round to the nearest whole number. If pump has decimal capability, round answer to the **nearest tenth.**

SAFETY ALERT!

There are some IV pumps in use that are capable of delivering IV fluids in tenths of a milliliter. Always be familiar with the IV equipment being used at the institution before rounding milliliters per hour (mL/hr) to the nearest whole mL/hr.

Let's begin with the calculation of IV flow rates in mL/hr.

Example 1: Client with an infusion pump has an order for 3,000 mL D_5W over 24 hours.

Solution:

- 1. Think: Pump is regulated in mL/hr.
- 2. No conversion required; the volume is in milliliters, and the time is in hours.
- 3. To use the formula method to determine mL/hr: *x* mL/hr = volume in mL.

- 4. To determine mL/hr using ratio and proportion, the volume ordered and hours to infuse is the known ratio; 3,000 mL : 24 hr (stated first), and the unknown is *x* mL : 1 hr. (stated as the second ratio) or:

- 5. To determine mL/hr using dimensional analysis, identify what you are looking for, and write it to the left of the equation in a fraction format. Label factor:

Place problem as starting fraction (if no conversion required). If conversion is required, the starting fraction is the conversion factor, and the problem is inserted as the second fraction in the equation. Refer to the setups of Example 1 using the various methods.

Formula Method

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

In this problem no conversion was required, the ordered amount is in mL/hr, which is the same as the desired; therefore the problem is solved by division, and no cancellation of units is required.

To infuse 3,000 mL of D_5W in 24 hr, the pump would be set to deliver 125 mL/hr.

Sometimes a conversion may be necessary before calculating mL/hr. Let's look at a problem showing the calculation of mL/hr when a conversion is required.

Example 2: Client with an infusion pump is to receive 0.5 L 0.9% NS over 8 hours.

Solution:

- 1. Convert 0.5 L to 500 mL using any of the methods presented in earlier chapters.
- Use the conversion factor 1 L = 1,000 mL. Convert 0.5 L to mL by moving the decimal three places to the right (metric to metric). Decimal movement can be used. Review methods of converting if necessary.
- 2. Set up the problem and solve using one of the calculation methods.

Formula Method

mL/hr is rounded to the nearest whole number of mL.

Ratio and Proportion (Linear Format)

mL/hr is rounded to the nearest whole number of mL.

Ratio and Proportion (Fraction Format)

mL/hr is rounded to the nearest whole number of mL.

Dimensional Analysis

mL/hr is rounded to the nearest whole number. Notice the conversion factor is written

to cancel L, leaving mL/hr.

To infuse 500 mL of 0.9% NS, the pump would be set to deliver 63 mL/hr. As previously stated, pumps deliver in whole mL unless indicated the pump has decimal capability.

Determining mL/hr When the Time Period Is Less Than 1 Hour

Often when medications are administered IV, such as IVPB (e.g., for antibiotics), the time period for the IV to infuse is less than 1 hour. When the period is less than 1 hour and an electronic infusion device is used, the IV rate must still be determined in mL/hr. **Remember that there are 60 minutes in 1 hour.** The rate can be determined using ratio and proportion. (The known ratio is the ordered rate, mL/min, and the second is the unknown ratio, x mL/60 min). Dimensional analysis can also be used to determine the rate in mL/hr. (The first factor in the equation is the ordered mL/min, and the second factor is 60 min/1 hr). The rate can also be determined using the formula:

Let’s look at an example. The various methods for calculating the infusion rate will be shown.

Example 3: A client is to receive an antibiotic in 100 mL of 0.9% NS over 45 min by infusion pump. Determine the IV flow rate.

Solution:

- 1. Think: The infusion pump infuses in mL/hr. Use a ratio and proportion, the formula method, or dimensional analysis to determine mL/hr.
- 2. Remember: 1 hr = 60 min.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Formula Method

Note: min is cancelled, leaving mL/hr.

Dimensional Analysis

Note: min is cancelled, leaving mL/hr.

The infusion pump would be set at 133 mL/hr to infuse 100 mL in 45 minutes. The volume of 100 mL will be infused.

SAFETY ALERT!

The usual rate in mL/hr ranges from 50 to 200 mL/hr. If the rate exceeds this amount, double-check the order and your calculation before programming the rate into an infusion pump.

POINTS TO REMEMBER

- • IV infusion pumps deliver IV flow rates in mL/hr.
- • IV orders indicate: the name of the IV solution, the volume to infuse, medications to be added, if any, and the time for the IV to infuse. The prescriber may indicate the time for an IV to infuse in mL/hr, or the total number of hours for the IV to infuse.
- • To determine flow rates for an electronic infusion device such as the infusion pump, determine mL/hr using the formula:

- • If the time for the IV to infuse is less than 1 hour and the infusion pump is used, the infusion rate still must be determined in mL/hr. Ratio and proportion, the formula method, or dimensional analysis can be used to determine the infusion rate. Remember that 60 min = 1 hr.
- • Milliliters per hour (mL/hr) are rounded to the nearest whole number. If math does not result in a whole number, carry math to the tenths place and round to the nearest whole number.
- • Some infusion pumps have decimal capability and can deliver IV rates in tenths of a mL. If the answer obtained is not in the tenths place, carry math to the hundredths place and round to the tenths.
- • Always be familiar with the infusion device being used by an institution before rounding mL/hr to a whole number.

PRACTICE PROBLEMS

Calculate the flow rate in mL/hr. (Equipment used is programmable in whole mL/hr.)

- 1. 1,800 mL of D_5W in 24 hr by infusion pump

- 2. 2,000 mL D_5W in 24 hr by infusion pump
- 3. 500 mL RL in 12 hr by infusion pump
- 4. 1,500 mL D_5RL in 24 hr by infusion pump
- 5. 750 mL D_5W in 16 hr by infusion pump

Answers on 538

Manually Regulated IVs

When an electronic infusion device is not used, the nurse uses a gravity-flow system and must manually regulate the infusion rate. To do this, the nurse must calculate the ordered IV flow rate in drops per minute (gtt/min). IV flow rates in gtt/min are based on the IV tubing calibration, referred to as the *drop factor*. The **drop factor** is the number of drops per milliliter (gtt/mL) that a particular IV tubing delivers and therefore will vary depending on the type of IV tubing.

The drop size is determined by the size of the tubing or the small needle inside the drop chamber releasing the drops. See Figure 21.1. Note the large opening for drops in Figure 21.1A, the drops are large (**macrodrops**). The drops delivered through the small needle in Figure 21.1B are very small drops (**microdrops**). The drop factor of the IV tubing is stated in large numbers on the IV tubing package (Figure 21.2). The drop factor of the IV tubing is needed to calculate gtt/min.

Figure 21.1 Comparison of (A) macrodrops and (B) microdrops.

Figure 21.2 IV administration sets (package). **(A)** Set with drop factor of 10 (10 gtt =1 mL). **(B)** Set with drop factor of 60 (60 gtt = 1 mL).

As stated previously, at the top of the IV tubing is a drip chamber (also referred to as a drop chamber), where the nurse observes and counts the number of drops falling into the drip chamber per minute or fraction of a minute placing a watch at the level of the drip chamber. The flow rate is regulated by a hand-operated slide clamp or a roller clamp, which is opened or closed so the drops fall at the desired rate.

SAFETY ALERT!

IV infusions that are manually regulated must be monitored regularly. The flow rate of a manually regulated IV can be affected by the height of the IV infusion, the location of the site, and changes in the client position, which can result in impediment of the IV flow rate or excessive amounts of fluid being delivered to the client.

IV Tubing

The two common types of tubing used to administer IV fluids (regulated manually) are:

- • Macodrop tubing
- • Microdrop tubing

Macrodrop Tubing

Macrodrop is the standard tubing used for general IV administration. With macrodrop tubing the size of the drop and the number of gtt/mL varies according to the manufacturer. Macrodrops are large drops, and there are fewer drops in 1 mL (see Figure 21.1A). Macrodrop tubing have the following drop factors:

- • 10 gtt/mL
- • 15 gtt/mL
- • 20 gtt/mL

Since the drop factor for macrodrop tubing differs according to the manufacturer, always read the IV tubing package and identify the drop factor of the tubing. Never assume to know the drop factor, because not all macrodrop tubing has the same factor.

SAFETY ALERT!

To accurately administer IV fluids at the correct rate to a client, the nurse **must** know the drop factor of the IV tubing. Knowing the drop factor of the IV tubing used can prevent an error in IV rate determination and the client receiving IV fluid at the incorrect rate. **Never** assume the drop factor for macrodrop tubing.

Microdrop Tubing

Microdrop tubing delivers tiny drops through a small needle in the drip chamber and therefore has more drops in 1 mL (see Figure 21.1B). It is used to administer either small or precise amounts of fluid. For example, it is used in critical care, for the elderly, and for pediatric infusions. Microdrop tubing, because of the size of the drops (very small/ tiny) is sometimes referred to as pedidrip tubing. Microdrop tubing, regardless of the manufacturer, is only available in one drop factor (60 gtt/mL). With microdrop tubing the number of mL/hr is the same as gtt/min (i.e., if the infusion rate is 100 mL/hr, the IV rate is 100 gtt/min).

- • 60 gtt/mL

POINTS TO REMEMBER

- • Drop factor = gtt/mL of the IV tubing. This information is written on the package of the IV tubing.
- • Knowing the drop factor of the IV tubing is the **FIRST** step in accurate administration of IV fluids in gtt/min. IVs that infuse by gravity are manually regulated, and the IV flow rate is determined in gtt/min.
- • Macrodrops are large and have drop factors of 10, 15, and 20 gtt/mL.
- • Microdrops are tiny and have only one drop factor, 60 gtt/mL.

PRACTICE PROBLEMS

Refer to the drop factor provided and identify the type of tubing.

- 6. 15 gtt/ mL _____
- 7. 60 gtt/mL _____
- 8. 10 gtt/mL _____

Answers on 538

Calculating Flow Rates in Drops Per Minute Using a Formula and Dimensional Analysis

To calculate the IV flow rate in gtt/min for an IV infusing by gravity, a formula method can be used or dimensional analysis. To calculate the flow rate in gtt/min for the IV infusion regardless of the method used (formula method or dimensional analysis), the nurse needs to know the following:

- • Drop factor of the IV tubing
- • Volume (number of mL) to infuse
- • Time the IV is to infuse (minutes or hours)

The formula for calculating the IV flow rate is:

Before beginning to calculate gtt/min, let's review some basic guidelines:

Guidelines for Calculating gtt/min

- • Drops per minute are **always** expressed in whole numbers. Think: You cannot regulate an IV to half a drop or count half a drop; therefore **you can only count whole drops.**
- • Principles of rounding are applied if the calculation for gtt/min does not result in a whole number. Carry calculation to the tenths place, and round answer to the nearest whole number (i.e., 19.6 is rounded to 20 gtt/min).
- • Answers must be labeled. The label is usually drops per minute unless otherwise specified. Example: 17 gtt/min. To reinforce the differences in drop factor, the type of tubing is sometimes included as part of the label. Examples: 17 macrogtt/min, 100 microgtt/min.
- • Common conversion factors used include 1 L = 1,000 mL, and 1 hr = 60 min.

First let's look at some sample problems using the formula method and dimensional analysis.

Example 1: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 10 gtt/mL. At what rate in gtt/min should the IV infuse?

- • Notice the numbers in the problem are placed in the formula.
- • Remember the formula solves for gtt/min and the time is indicated in minutes. 60 min = 1 hr; therefore 1 hr is changed to 60 min in the formula (100 mL/60 min).
- • When mL is cancelled out, the flow rate is determined in gtt/min.
- • Reduction is done where possible.
- • The answer is labeled.
- • ***Note:*** The volume of 1,000 mL was not used in the calculation; the mL/hr was stated in the order.

Setup Using Formula Method

To deliver 100 mL/hr, the IV rate would be regulated at 17 gtt/min; 17 macrogtt/min.

Dimensional Analysis

Let's look at the previous example using dimensional analysis.

Example 1: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 10 gtt/mL. At what rate in gtt/min should the IV infuse?

- • Notice *x* gtt is written to the left of the equation, followed by the equal sign (=) (labeled *x* gtt/min because that is what you're looking for).
- • The **first** factor starts with gtt and is the drop factor, which is written, placing gtt in the numerator. 10 gtt/1 mL.
- • The next fraction is written so that the denominator matches the previous fraction (what you are looking for). The order is to infuse 100 mL in 1 hr. The 1 hr is entered as 60 min in the denominator because you are calculating gtt/min (100 mL/60 min).
- • Cancel the units and you are left with the desired gtt/min.
- • Reduction is done if possible.
- • Label the answer.

Dimensional Analysis

Note: An alternate way of setting up the problem, without changing the hourly rate to 60 min, would be to add 1 hr = 60 min conversion factor to the equation:

Alternate Setup Using Dimensional Analysis

Notice the hourly rate is entered in mL/hr in the equation; the fraction 1 hr/60 min is inserted into the equation. The units are cancelled, leaving gtt/min. The calculation would be the same as the previous setup.

Example 2: Order: 1.5 L 0.9% NaCl to infuse in 10 hr. Drop factor: 15 gtt/mL. At what rate in gtt/min should the IV infuse at?

- • Notice this problem contains a large volume of fluid, and the order contains the total number of hours to infuse as opposed to mL/hr as shown in Example 1.
- • A conversion is also required before the problem can be solved. L must be converted to mL. Use the conversion factor 1 L = 1,000 mL; therefore 1.5 L = 1,500 mL.
- • When using the **formula method**, the IV rate can be determined in two ways:
  - a. First convert the flow rate to mL/hr, and then calculate the gtt/min using the formula.
  - *or*
  - b. Convert the number of hours to minutes using the conversion factor 60 min = 1 hr. Multiply the number of hours by 60 min/hr and then place the calculated minutes into the formula. In this problem, 10 hr is multiplied by 60 min/hr to obtain the 600 minutes used in the formula: 10 hr × 60 min/hr.
- • For **dimensional analysis,** if the mL/hr is not expressed as mL/min, insert the conversion factor 1 hr/60 min.

Let's look at the above problem using the formula method and dimensional analysis.

Formula Method Using Two Steps

Step 1: Calculate the mL/hr:

Convert mL/hr to mL/min. 1 hr = 60 min (150 mL/hr = 150 mL/60 min)

Step 2: Place into formula:

Formula Method Using hr Converted to min

Dimensional Analysis Using mL/min

Calculate mL/hr: 1,500 mL ÷ 10 hr = 150 mL/hr.

Convert mL/hr to mL/min (150 mL/hr = 150 mL/60 min).

Proceed using the steps shown in Example 1.

Dimensional Analysis Using mL/hr

Dimensional Analysis Using the Total Volume and Total Number of hr

Proceed with calculation as shown in previous examples.

Example 3:

Order: The following IVs for 24 hours. Drop factor: 15 gtt/mL

- • 1,000 mL D_5W c 10 mEq potassium chloride (KCl)
- • 500 mL D_5NS c 1 ampule of multivitamin (MVI)
- • 500 mL D_5W

What rate will you regulate the IV to deliver the ordered IV fluid?

In this problem, the order is written for different amounts and types of fluid to be given in a certain time period. Notice that medications are also ordered to be added to the solutions: potassium chloride and multivitamin. When medications such as potassium chloride and vitamins are added to the IV solutions, they are generally not considered in the total volume. (Some institutions consider the medication in the volume if it is 10 mL or more. Always check the policy of the institution.)

To calculate the IV rate, add up the IV fluid to obtain the total volume (2,000 mL). The total number of hours for the IV infusion is given (24 hours). To convert 24 hr to min, multiply: 24 hr × 60 min/hr = 1,440 min.

Formula Method Using Two Steps

Step 1: Calculate the mL/hr:

Convert mL/hr to mL/min. 60 min = 1 hr (83 mL/hr = 83 mL/60 min).

Step 2: Place into formula

Formula Method Using hr Converted to min

To infuse 2,000 mL in 24 hours, the IV would be regulated at 21 gtt/min; 21 macrogtt/min.

Dimensional Analysis Using mL/min

Dimensional Analysis Using mL/hr

Dimensional Analysis Using the Total Volume and Total Number of hr

Proceed with calculation as shown in previous examples.

Example 4:

Order: 50 mL NS to infuse over 20 minutes.

Drop factor: 20 gtt/mL. What rate will you regulate the IV to infuse?

Notice, in this example, you have a small volume of fluid, and the time for the IV to infuse is in minutes. This problem can be solved using the same methods (formula method and dimensional analysis) shown in the previous examples.

Formula Method

Dimensional Analysis

To infuse 50 mL NS in 20 minutes, the IV would be regulated at 50 gtt/min; 50 macrogtt/min.

PRACTICE PROBLEMS

Calculate the flow rate in gtt/min using the formula method or dimensional analysis.

- 9. D_5RL at 75 mL/hr. The drop factor is 10 gtt/mL. _____
- 10. D_5 ½ NS at 30 mL/hr. The drop factor is a microdrop. _____
- 11. 1,000 mL D_5 0.33% NS in 6 hr. The drop factor is 15 gtt/mL. _____
- 12. An IV medication in 60 mL of 0.9% NS is to be administered in 45 min. The drop factor is a microdrop. _____
- 13. 1,000 mL of Ringer's lactate solution (RL) is to infuse in 16 hr. The drop factor is 15 gtt/mL.
- 14. 3,000 mL D_5 and ½ NS in 24 hr. The drop factor is 10 gtt/mL. _____
- 15. Infuse 2,000 mL D_5W in 12 hr. The drop factor is 15 gtt/mL. _____

Answers on pp. 538-539

Calculation of IV Flow Rates Using a Shortcut Method

This shortcut method can be used where the IV sets all have the same drop factor. Example: an institution where all the macrodrop sets deliver 10 gtt/mL. This method can also be used with microdrop sets (60 gtt/mL). It is important to note that this method can be used only if the rate of the IV infusion is expressed in mL/hr (mL/60 min).

To use this method, you must know the drop factor constant for the administration set you are using. The drop factor constant is sometimes referred to as the *division factor*. To obtain the drop factor constant (division factor) for the IV administration set being used, divide 60 by the drop factor calibration from the IV infusion set. Box 21.1 shows the constant calculated based on the drop factor for the IV tubing.

BOX 21-1 Drop Factor Constants

Drop Factor of Tubing	Drop Factor Constant
10 gtt/mL	
15 gtt/mL	
20 gtt/mL	
60 gtt/mL	

RULE

After the drop factor constant is determined, the gtt/min can be calculated in one step:

Let's look at examples of calculating the gtt/min using the stated rule:

Example 1:

Order: Administer D_5W at 125 mL/hr. Drop factor: 15 gtt/mL

The drop factor constant: 4.

In this example, the drop factor constant is 4. The set calibration is 15 gtt/mL (60 ÷ 15 = 4).

Solution:

Solution Using Dimensional Analysis:

Remember that the shortcut method discussed (using the drop factor constant) can be used to calculate the gtt/min for any volume of fluid that can be stated in mL/hr or mL/60 min.

RULE

The shortcut method can be used if the volume of fluid is large; however, an additional step of calculating mL/hr first must be done and then calculate the gtt/min using the shortcut method.

Example 2: Order: RL 1,500 mL to infuse in 12 hr. Drop factor: 20 gtt/mL. Drop factor constant: 3.

In this example, the volume of fluid is 1,500 mL and the total hours to infuse is 10 hr. Before using the shortcut method, the mL/hr must be calculated. 1,500 mL ÷ 12 = 125 mL/hr. The set calibration is 20 gtt/mL. 60 ÷ 20 = 3.

Solution:

Solution Using Dimensional Analysis:

Determine mL/hr expressed as mL/60 min.

The shortcut method can also be used for small volumes of fluid and when the time period is less than 1 hour. If the volume of fluid to infuse is small and the time period is less than 1 hour (60 minutes), the volume and time must each be multiplied to get mL/hr.

Example 3: Order: 20 mL D_5W in 30 minutes. Drop factor 60 gtt/mL. Drop factor constant: 1.

In this example the volume of fluid is small, and the time period is less than 60 min. The set calibration is 60 gtt/mL. 60÷ 60 = 1.

Solution: To express 20 mL in 30 minutes in mL/hr, you multiply the volume and the time by 2.

Step 1: Change 20 mL/30 min to 40 mL/hr as shown above.

Step 2: Express 40 mL/hr as 40 mL/60 min.

Note: In the above problem to administer 40 mL/hr, the IV would be set at 40 gtt/min. When the drop factor of the infusion set used is 60 gtt/mL, the number of gtt/min is equal (=) to the mL/hr.

PRACTICE PROBLEMS

Calculate the rate in gtt/min using the shortcut method.

- 16. Order: D_5W 200 mL/hr. Drop factor: 10 gtt/mL _____
- 17. Order: 0.9% NS 140 mL/hr. Drop factor: 20 gtt/mL _____
- 18. Order: 1,000 mL D_5W in 10 hr. Drop factor: 10 gtt/mL _____
- 19. Order: 40 mL D_5W in 20 min. Drop factor: 10 gtt/mL _____
- Calculate the flow rate in gtt/min.
- 20. Order: To infuse in 16 hr. Drop factor: 10 gtt/mL
  - • D_5W 500 mL c 10 potassium chloride (KCl)
  - • D_5W 1,000 mL
  - • D_5W 1,000 mL c 1 ampule of multivitamin (MVI) _____
- 21. Order: 1,000 mL D_5 0.9% NS for 3 L at 100 mL/hr. Drop factor: microdrop _____

Answers on 539

POINTS TO REMEMBER

- • To calculate the IV flow rate in gtt/min, the nurse must know the drop factor of the IV tubing, the volume to infuse, and the time for the IV to infuse.
- • Drop factor is expressed as gtt/mL and indicated on the package of the IV tubing.
- • Calculation of gtt/min can be done using the formula method or dimensional analysis.
- • Formula for calculating gtt/min is as follows:

- • With the formula method, determine the IV rate by converting the flow rate to mL/hr (60 min), and then calculate gtt/min using the formula. **OR** Convert the number of hours to minutes using the conversion factor 60 min = 1 hr, and then place the calculated minutes into the formula.
- • For dimensional analysis, if the mL/hr is not expressed as mL/min, insert the conversion factor 1 hr/60 min into the equation.
- • Drops per minute are always expressed as whole numbers.
- • A shortcut method can be used to calculate flow rates infusing in mL/hr or mL/60 min using the drop constant.
- • To determine the drop constant factor, divide 60 by the calibration of the IV set.
- • To use the shortcut method for small volumes and time periods less than 1 hr, the volume and the time must each be multiplied to get mL/hr.

Calculating IV Flow Rates Using a Dial-Flow Controller

Dial-flow controllers are also known as IV manual flow regulators or just IV flow regulators, as well as just flow controllers. There are a wide variety of dial-flow controllers available for use and are either part of the IV tubing or added on (Figure 21.3). These devices are regulated manually and are not infusion pumps. Use of the device is based on several factors, which include severity of illness, type of therapy, and the setting. Dial-flow devices are designed to regulate the flow of IV fluid instead of using the roller clamp. The flow rate can be adjusted from 5 to 250 mL/hr. To use the device, you set or dial the desired flow rate in mL/hr, which is an estimate, and then the rate must be verified by counting drops per minute. Drops per minute would be calculated using one of the methods presented in the chapter.

Figure 21.3 Flow controller. (Courtesy and © Becton, Dickinson and Company, Franklin Lakes, NJ.)

If used, it is important to remember that use of the device does not relinquish the nurse from his or her responsibility, which is to monitor the IV to ensure there is accurate delivery of the ordered infusion rate.

Let's look at an example using this device.

Example: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 15 gtt/mL.

- 1. Turn the dial of the controller to 100 mL/hr.
- 2. Use the formula or dimensional analysis to determine gtt/min.
- 3. Verify accuracy of controller by counting the drops either for a minute or a fraction, such as 20 seconds. Divide the number of drops per minute by 3 (25 gtt ÷ 3 = 8.3 = 8 gtt). You find the number of drops is 8; the controller is delivering the correct rate for 20 seconds. If the rate is not correct for 20 seconds, the controller dial can be adjusted. The rate will have to be monitored periodically during the infusion.

Formula Method

Dimensional Analysis

Refer to examples for steps in solving.

To infuse 100 mL/hr, the IV flow rate would be set at 25 gtt/min; 25 macrogtt/min.

SAFETY ALERT!

The flow rate on the controller is in **mL/hr, not gtt/min.** Failure to verify the drop rate can result in client not receiving the correct rate, which can result in the client receiving insufficient or excessive IV fluid. To ensure client safety during IV administration, the controller as well as the client **must** be monitored.

Calculating Intermittent IV Infusions Piggyback

A medication such as an antibiotic can be administered by attaching it to a port on the primary line (referred to as Intravenous Piggyback [IVPB]) and infusing it by gravity or infused using an electronic infusion device. IVPBs may come premixed from the drug manufacturer, or medications are added to a small volume bag by the nurse, or in some institutions by the pharmacist and sent to the unit.

If the prescriber does not include the type and amount of solution for the medication to be placed in or the rate for infusion, the nurse must check a medication reference or the manufacturer's guidelines. Even if medications are premixed (with medication added to the solution by the drug manufacturer or pharmacy), the nurse is responsible for ensuring that the IVPB is infusing at the correct rate. When medications are premixed, the nurse calculates the infusion rate by using the volume of solution containing the medication. Regardless of whether the IVPB is mixed by the nurse, is premixed, or the ADD-Vantage system is used, the IVPB must be in the correct amount of solution and infused at the correct rate. The volume of IV solution used for an IVPB is usually 50 to 100 mL to infuse over 20, 30, 60 minutes, or longer depending on the type and amount of medication added.

As already stated, depending on the volume of the medication being added (for an IVPB mixed by the nurse), at some institutions the medication is considered in the volume of IV fluid when determining the IV rate. ***Note:*** For the purpose of this text, it will be indicated when to consider the medication in the IV volume and the type and amount of solution for dilution of the piggyback, and infusion rate will be indicated in the order.

Let's look at the examples shown for determining the rate for the IVPB.

Example 1: Order: Keflin 2 g IVPB in 100 mL D_5W over 30 min. Drop factor: 15 gtt/mL. Determine the IV flow rate.

Solution:

- • In this problem, there is no conversion needed; the volume of solution is in mL.
- • The amount of medication added, 2 g, is not needed to calculate the IV flow rate. The 100 mL of fluid that the Keflin is placed in is used as the volume.
- • A drop factor is stated; therefore the IV rate will be calculated in gtt/min.
- • The volume of IV fluid, which is stated in mL, the time (min), and the drop factor are the required information needed to calculate the IV flow rate, using the formula method or dimensional analysis.

Formula Method

Dimensional Analysis

To infuse 100 mL in 30 minutes the IV rate would be regulated at 50 gtt/min; 50 macrogtt/min.

Now let's look at the same problem if an electronic infusion device was used.

Example 2: Order: Keflin 2 g IVPB in 100 mL D_5W over 30 min by infusion pump.

Determine the IV flow rate.

Solution:

- • An electronic infusion device is being used; the rate will need to be determined in mL/hr.
- • As with Example 1, the amount of medication, 2 g, is not needed to calculate the IV flow rate.
- • Remember there are 60 minutes in 1 hr.
- • The rate can be determined using ratio and proportion, the formula below, or dimensional analysis.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Formula Method

Notice min is cancelled, leaving mL/hr.

Dimensional Analysis

Notice min is cancelled, leaving mL/hr.

The pump would be set at 200 mL/hr to infuse 100 mL in 30 min. ***Note:*** The actual volume of 100 mL will be infused.

PRACTICE PROBLEMS

Calculate the rate in gtt/min for the following medications being administered IVPB. Use the labels where provided. (Add the volume of medication being added to IV solutions, where indicated.)

- 22. Order: Erythromycin 200 mg in 250 mL D_5W to infuse over 1 hr. Drop factor: 10 gtt/mL _____

- 23. Order: Ampicillin 1 g in 50 mL D_5W to infuse over 45 minutes. Drop factor: 10 gtt/mL. For IV, reconstitute with 10 mL of diluent to get 1 g per 10 mL. (Consider the medication added in the volume of fluid.)
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Calculate the rate in gtt/min at which the IV should infuse. _____
- 24. Order: Clindamycin 900 mg in 75 mL D_5W over 30 minutes. Drop factor: 10 gtt/mL
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Determine the IV rate. _____
- 25. Order: Vancomycin 500 mg IVPB q24hr. The reconstituted vancomycin provides 50 mg per mL. The medication is placed in 100 mL of D_5W to infuse over 60 minutes. Drop factor: 15 gtt/mL. (Consider the medication added in the volume of fluid.)
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Calculate the rate in gtt/min at which the IV should infuse. _____
- 26. Order: Fungizone (amphotericin B) 20 mg in 300 mL D_5W over 6 hr by infusion pump. The reconstituted material contains 50 mg per 10 mL.
  - a. How many milliliters will you add to the IV solution? _____
  - b. Determine the IV rate. _____
- 27. Order: Septra (sulfamethoxazole and trimethoprim) 300 mg in 300 mL D_5W over 1 hr q6h. Drop factor: 10 gtt/mL. Calculate the dose using trimethoprim.
  - a. How many milliliters of medication will be added to the IV? (Round the answer to the nearest tenth.) _____
  - b. Consider the medication added to the volume of IV fluid. Calculate the rate in gtt/min at which the IV should infuse. _____
- 28. Order: Retrovir (zidovudine) 100 mg IV q4h over 1 hr. Available medication states each mL contains 10 mg of zidovudine.
  - a. How many milliliters of medication will be added to the IV solution? _____
  - b. The medication is placed in 100 mL of D_5W. Drop factor: 10 gtt/mL (Consider the medication added to the volume of IV fluid.) _____

Answers on pp. 539-540

Determining the Amount of Medication in a Specific Amount of Solution

Sometimes medications are added to IV solutions, and the prescriber orders a certain amount of medication to be administered in a certain time period. In order to calculate the volume of fluid needed to deliver a specific amount of medication, a ratio and proportion can be used or dimensional

analysis.

Example 1: Order: 20 mEq of potassium chloride in 1,000 mL D_5W to infuse at 2 mEq/hr. Calculate the mL/hr to deliver 2 mEq of potassium chloride/hr.

Solution:

Set up a ratio and proportion using the linear or fraction format:

- • With use of the ratio and proportion, the known ratio is the amount of medication in the total volume of solution, and the unknown ratio is what the prescriber ordered.
- • Dimensional analysis of the first factor is the total volume of solution and the amount of medication, and the second factor is what the prescriber ordered.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

Notice cancelling mEq leaves mL/hr.

100 mL/hr will deliver 2 mEq /hr of potassium chloride.

Example 2: Order: 100 units of Humulin regular insulin in 500 mL ½ NS to infuse at 10 units/hr. Calculate the mL/hr to deliver 10 units of insulin/hr.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

POINTS TO REMEMBER

- • When preparing medications for intermittent infusion:
  - a. Reconstitute the medication using the label or package insert if needed.
  - b. Calculate the amount of medication to administer.
  - c. Verify the recommended infusion rate with the manufacturer's recommendations or a medication reference.
  - d. Determine the IV rate using the IV formula or dimensional analysis.
- • If the intermittent infusion is being administered by an electronic infusion device, the flow rate is determined in mL/hr using ratio and proportion, dimensional analysis, or the formula method for time periods less than 1 hour.

- • To determine the volume (amount) of IV fluid to administer the prescribed amount of medication in mL/hr, use ratio and proportion or dimensional analysis.

PRACTICE PROBLEMS

Solve the following problems using the steps indicated.

- 29. Order: 15 mEq of potassium chloride in 1,000 mL of D_5 ½ NS to be administered at a rate of 2 mEq/hr.
- How many mL/hr should the IV infuse at? _____
- 30. Order: 10 units of Humulin regular insulin per hour. 50 units of insulin is placed in 250 mL NS.
- How many mL/hr should the IV infuse at? _____

Answers on pp. 540-541

Determining the Unknown for Time and Volume

You may need to calculate the following:

- a. **Time in hours**—How long it will take a certain amount of fluid to infuse or how long it may last
- b. **Volume**—The total number of milliliters a client will receive in a certain time period These unknown elements can be determined by the use of the formula method or dimensional analysis.

Formula:

Calculating a Problem with an Unknown Using the Formula Method and Dimensional Analysis

- 1. Take the information given in the problem and place it in the formula.
- 2. Place an *x* in the formula in the position of the unknown. If you are trying to determine time in hours, place *x* in the position for minutes; once you find the minutes, divide the number of minutes by 60 (60 minutes 5 1 hr) to get the number of hours. If you are trying to determine the volume the client would receive, place an *x* in the position for amount of solution, and label *x* mL.
- 3. Set up an algebraic equation so that you can solve for *x*.
- 4. Solve the equation.
- 5. Label the answer in hours or milliliters for volume.

Example 1: Determining hours:

An IV is regulated at 20 microgtt/min. How many hours will it take for 100 mL to infuse?

Formula Method

Note: In the position of drop factor, 60 gtt/mL was placed, IV was infusing in microgtt, and the infusion set had to be a microdrip (60 gtt/mL).

Dimensional Analysis

x hr is what you are looking for. The **first** starting fraction is 1 hr/60 min, the **second** fraction is 1 min/20 gtt to match the denominator of the starting fraction. The **third** fraction is 60 gtt/1 mL to match the denominator in the fraction before it. The **last fraction** is 100 mL/1, to match mL in the fraction before it. Cancel the units, reduce if possible, and perform mathematical process.

Note: When calculating time and the answer results in hr and min, express entire time in hr (i.e., 1 hr and 30 min = 1.5 hr, or 1½ hr; 1½ hr is the preferred way to state answer).

Example 2: Determining volume:

An IV is regulated at 17 macrogtt/min. The drop factor is 15 gtt/mL. How much fluid volume in milliliters will the client receive in 8 hr?

Formula Method

Dimensional Analysis

x mL is what you are looking for here. Enter the drop factor as the **first** starting fraction 1 mL/15 gtt. The **second** fraction is 17 gtt/1 min, so it matches the denominator of the first fraction. The **third** fraction is 480 min/1 so that it matches the denominator before it. **An alternate** to changing min to hr is to enter the conversion 60 min/1 hr, and enter 8 hr/1 to match the denominator before it. Cancel if possible, and perform the mathematical process.

Note: Some problems for calculating an unknown may be solved without using the formula method or dimensional analysis; however, the use of one or the other is recommended.

POINTS TO REMEMBER

Determining the Unknown

- • Use the IV formula and place the information given into the position of the formula.

Use *x* for unknown values.

- 1. For determining time—place an *x* in the minutes position, and then divide the minutes by 60 to determine the time in hours.
- 2. For volume—place an *x* in the position for amount of solution and label *x* mL. Convert the hours to minutes.

- • Set up an algebraic equation and solve for *x*.
- • Answers for time are labeled in hours, with mL for volume, unless instructed otherwise.
- • Dimensional analysis can also be used to determine the unknown.

PRACTICE PROBLEMS

Solve for the unknown in the following problems as indicated.

- 31. You find that there is 150 mL of D_5W left in an IV. The IV is infusing at 60 microgtt/min. How many hours will the fluid last? _____
- 32. 0.9% NS is infusing at 35 macrogtt/min. The drop factor is 15 gtt/mL. How many milliliters of fluid will the client receive in 5 hours? _____
- 33. There is 90 mL of D_5 0.33% NS left in an IV that is infusing at 60 microgtt/min. The drop factor is 60 gtt/mL. How many hours will the fluid last? _____

Answers on 541

Recalculating an IV Flow Rate

Flow rates on IVs change when a client stands, sits, or is repositioned in bed if IVs are infusing by gravity. Therefore, nurses must frequently check the flow rates. Sometimes IVs infuse ahead of schedule, or they may be behind schedule if they are not monitored closely. When this happens, the IV flow rate must be recalculated. To recalculate the flow rate, the nurse uses the volume remaining and the time remaining. Recalculation may be done with uncomplicated infusions. IVs that require exact infusion rates should be monitored by an electronic infusion device.

SAFETY ALERT!

Never arbitrarily increase or decrease an IV to get it back on schedule without assessing a client and checking with the prescriber. Increasing or decreasing the rate without thought can result in serious harm to a client, including overhydration or underhydration. Check the policy of the institution. Avoid off-schedule IV rates by regularly monitoring the IV at least every 30 to 60 minutes.

When an IV is significantly ahead of or behind schedule, you may need to notify the prescriber, depending on the client's condition and the use of appropriate nursing judgment. **Always assess the client** before making any change in an IV rate. Changes depend on the client's condition. Check the institution's policy regarding the percentage of adjustment that can be made. Each situation must be individually evaluated, and appropriate action must be taken.

A safe rule is that the recalculated flow rate should not vary from the original rate by more than 25%. If the recalculated rate varies by more than 25% from the original rate, the prescriber should be notified. The order may require revision. If a client is stable, recalculate the IV rate, using the remaining volume and time, and then proceed to calculate gtt/min using the formula method or dimensional analysis. Refer to content in this chapter (calculating gtt/min) if necessary. Let's go over the steps to recalculate an IV rate if allowed by your institution policy, and the client is stable.

To recalculate an IV flow rate:

- • Use the remaining volume and remaining hours, and calculate the rate in mL/hr.

- • Use the mL/hr to calculate gtt/min for the recalculated rate, using the formula or the shortcut method:

- • Shortcut method:

- • Determine whether the new rate calculation is greater or lesser than 25%. Use the amount of increase or decrease divided by the original rate.

= % of change of original rate (round to nearest whole percent)

Let's look at some examples. ***Note:*** All examples assume the institution allows a 25% IV flow variation, and the clients are stable.

Example 1: 1,000 mL of D_5 RL was to infuse in 8 hr at 31 gtt/min (31 macrogtt/min). The drop factor is 15 gtt/mL. After 4 hr, you notice 700 mL of fluid left in the IV. Recalculate the flow rate for the remaining solution. ***Note:*** The infusion is behind schedule. After 4 hr, half of the volume (or 500 mL) should have infused.

Solution:

Solution to Example 1: Using the Shortcut Method

Determine recalculated rate:

Time remaining: 8 hr – 4 hr = 4 hr

Time remaining: 8 hr – 4 hr = 4 hr

Volume remaining: 1,000 mL – 300 mL = 700 mL

Volume remaining: 1,000 mL – 300 mL = 700 mL

700 mL ÷ 4 hr = 175 mL/hr

700 mL ÷ 4 hr = 175 mL/hr

Drop factor: 15 gtt/mL; therefore the drop factor constant is 4.

Drop factor: 15 gtt/mL; therefore the drop factor constant is 4.

x = 44 gtt/min; 44 macrogtt/min (recalculated rate)

x = 44 gtt/min; 44 macrogtt/min (recalculated rate)

Determine the percentage of the change:

Dimensional Analysis

Course of Action

Assess the client.

Notify the prescriber.

Do not increase the IV rate; the increase is **greater than 25%.**

Increasing the IV could result in serious consequences for the client. Assessment of the client is always done first to determine the client's ability to tolerate an increase in fluid. In this situation the prescriber should be notified, a new order is needed, the recalculated rate is greater than 25%.

Example 2 (IV Ahead of Schedule): An IV of 1,000 mL D_5W is to infuse from 8 am to 4 pm (8 hr). The drop factor is 10 gtt/mL. The rate is set at 20 gtt/min (20 macrogtt/min). In 5 hr, you notice that 700 mL has infused. Recalculate the flow rate for the remaining solution.

Solution:

Shortcut Method

Determine recalculated rate:

Time remaining: 8 hr – 5 hr = 3 hr

Volume remaining: 1,000 mL – 700 mL = 300 mL

300 mL ÷ 3 = 100 mL/hr

Drop factor: 10 gtt/mL; therefore the drop factor constant is 6.

x = 17 gtt/min; 17 macrogtt/min (recalculated rate)

x = 17 gtt/min; 17 macrogtt/min (recalculated rate)

Determine the percentage of change:

Dimensional Analysis

Time remaining: 8 hr – 5 hr = 3 hr

Volume remaining: 1,000 mL – 700 mL = 300 mL

x = 17 gtt/min; 17 macrogtt/min

x = 17 gtt/min; 17 macrogtt/min

Course of Action

Assess the client.

Adjust the rate if allowed by institutional policy, and assess during the remainder of the infusion.

Notify prescriber if required.

In this situation, the flow rate must be decreased from 20 gtt/min (20 macrogtt/min) to 17 gtt/min (17 macrogtt/min), and the change is not greater than 25% of the original rate. –15% is within the acceptable 25% of change. However, the client's condition must still be assessed to determine the ability to tolerate the change, and the prescriber may still require notification.

Alternate to Determining the Percentage of Change

As already stated, you can adjust the flow rate as much as (+) or (–)25%. Think 25% = ¼. Therefore you can verify the safety of the recalculated rate by using a method that eliminates the need to use percents. To do this, do the following:

- • Divide the original rate by 4, then add, and subtract the result from the original rate. This will provide a range for the acceptable rate adjustment. Let's use the two examples we just did.

Example 1:

The original rate was 31gtt/min (macrogtt/min), and the recalculated rate is 44 gtt/min (macrogtt/min).

Original rate ± (original rate ÷ 4) = Acceptable IV rate adjustment

31 + (31 ÷ 4) = 31 + 7.75 = 38.75 = 39 gtt/min (macrogtt/min)

31 – (31 ÷ 4) = 31 – 7.75 = 23.25 = 23 gtt/min (macrogtt/min)

The safe acceptable IV rate adjustment is 23 to 39 gtt/min (macrogtt/min). 44 gtt/min is above the acceptable adjustment range, and 25%. The prescriber should be notified to provide a new order.

Example 2:

The original rate was 20 gtt/min (macrogtt/min), and the recalculated rate is 17 gtt/min (17 macrogtt/min).

Original rate ± (original rate ÷ 4) = Acceptable IV rate adjustment

20 + (20÷ 4) = 20 + 5 = 25 gtt/min (macrogtt/min).

20 – (20 ÷ 4) = 20 – 5 = 15 gtt/min (macrogtt/min).

The safe acceptable IV rate adjustment is 15 to 25 (macrogtt/min). It is safe to slow the rate to 17 gtt/min (macrogtt/min), which is less than 25%.

POINTS TO REMEMBER

- • Monitor IV therapy every 30 to 60 min to maintain the ordered IV rate.
- • Do not arbitrarily speed up or slow down an IV that is behind or ahead of schedule.
- • Know the hospital policy regarding recalculation of IV flow rate. An IV should not vary more than 25% from its original rate.
- • To recalculate an IV rate:
- • Determine mL/hr:
-

- • Use mL/hr and recalculate the rate in gtt/min, using formula or shortcut method.

- • Determine the % of change
-
  = % of change (rounded to the nearest whole %)
- • Alternate to use of percent: Divide the original rate by 4, then add and subtract the result from the original rate to get the acceptable IV rate adjustment.
- • Contact the prescriber for a new IV order, if the recalculated rate exceeds 25%.

PRACTICE **PROBLEMS**

For each of the problems, recalculate the IV flow rates in gtt/min rates using either method presented, determine the percentage of change, and state your course of action. *Note:* The institution allows 25% variation and clients are stable.

- 34. 500 mL of 0.9% NS was ordered to infuse in 8 hr at the rate of 16 gtt/min (16 macrogtt/min). The drop factor is 15 gtt/mL. After 5 hr, you find 250 mL of fluid left.
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 35. 250 mL of D_5W was to infuse in 3 hr at the rate of 21 gtt/min (21 macrogtt/min). Drop factor: 15 gtt/mL. With 1½ hr remaining, you find 200 mL left.
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 36. 1,000 mL D_5 0.33% NS was to infuse in 12 hr at 28 gtt/min (28 macrogtt/min). After 4 hr, 250 mL has infused. Drop factor: 20 gtt/mL
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 37. 500 mL D_5 0.9% NS to infuse in 5 hr at 100 gtt/min (100 microgtt/min). After 2 hr, 250 mL has infused. Drop factor: 60 gtt/mL

- a. _____ gtt/min
- b. _____ % variation
- c. _____ Course of action

Answers on pp. 541-542

Calculating Infusion and Completion Time

IV fluids are ordered by the prescriber for administration indicating a specific rate in mL/hr, such as 1,000 mL D_5W to infuse at 100 mL/hr. **The nurse needs to be able to determine the amount of time (hours and minutes) that it would take for a certain volume of IV solution to infuse, which is referred to as *infusion time*.** Knowing the infusion time is important for the nurse, which includes reasons such as allowing the preparation for hanging a new solution as one infusion is being completed and preventing things such as the line clotting off as a result of not knowing when an IV was to be completed. Infusion times can be calculated using any of the following methods:

- • Ratio and proportion: The known ratio, which is written first, is the ordered rate in mL/hr, and the second ratio is the unknown, which is the total number of mL to infuse in *x* hr, total mL/*x* hr. The ratio and proportion can be written in linear or fraction format.
- • Formula method:

  = Infusion time
- • Dimensional analysis: The unknown is *x* hr; therefore the first fraction will be the ordered rate, hr/mL, the second fraction will be total mL/1.

Let's look at some examples of calculating infusion time.

Example 1: Calculate the infusion time for an IV of 1,000 mL D_5W to infuse at a rate of 125 mL/hr.

Ratio and Proportion (Linear Format)

Formula Method

1,000 mL (total mL to infuse)

125 mL/hr (mL/hr to infuse)

Infusion time = 8 hr

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

Dimensional Analysis

x = 8 hr

mL is cancelled here, leaving hr.

When an infusion time result is not an even whole number but instead the infusion rate includes a decimal fraction; the decimal fraction represents a fraction of an hour and must be converted to minutes. This calculation of infusion time is done as follows:

- • Determine the infusion time using any of the methods already presented, and carry division two decimal places.
- • Calculate the minutes using, conversion factor; 60 min = 1 hr. (Multiply the fraction of an hr by 60 min/hr) or use any of the methods presented.
- • Using the rules of rounding, round the minutes to the nearest whole number of minutes.

Let's look at an example.

Example 2: 1,000 mL D_5 ½ NS to infuse at 150 mL/hr. Calculate the infusion time for the IV.

Ratio and Proportion (Linear Format)

- • Determine the infusion time
- 150 mL : 1 hr = 1,000 mL : x hr
-
- • Calculate the minutes
- 1 hr : 60 min = 0.66 hr : x min
- x = 0.66 × 60 = 39.6
- x = 40 min (rounded to whole number)
- Infusion time is 6 hr and 40 min.

Formula Method

- • Determine infusion time

-

- x = 6.66 hr
- • Calculate the minutes

- Infusion time is 6 hr and 40 min.

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

- • Determine infusion time

-

- x = 6.66 hr
- • Calculate the minutes

-

- x = 40 min

Infusion time is 6 hr and 40 min.

Dimensional Analysis

- • Determine infusion rate

-

- x = 6.66 hr
- • Calculate the minutes

- x = 40 min
- Infusion time is 6 hr and 40 min.

Completion Time

Once the infusion time has been calculated, the nurse can use this information to determine the completion time. Completion time is the when the infusion is completed (i.e., the client has received all of the IV fluid). This would be determined as follows: Add the calculated infusion time to the time the infusion was started. If the IV was started at 7:00 am, add the 6 hours and 40 minutes to that time (7:00 am). The IV would be completed at 1:40 pm. It is easier to calculate completion time using military time: 7:00 am = 0700; now add 6 hours and 40 minutes to arrive at the answer of 1340.

- Start time 0700
- Infusion time +0640
- **Completion time:** 1340 or 1:30 pm

Calculating Completion Time

To calculate the completion time, add the infusion time to the time the IV was (military time).

Note: Converting traditional time to military time, and a discussion of completion time, appears in Chapter 8.

Let's look at some examples.

Example 1: An IV of 1,000 mL of D_5W is started at 1000 to infuse over 8 hr. Determine the completion time.

Solution:

- Start time 1000
- Infusion time +0800

Completion time: 1800 or 6:00 pm

Example 2: An IV of 1,000 mL of 0.9% NS is started at 2130 to infuse over 12 hr. Determine the completion time.

Solution:

- Start time 2130
- Infusion time +1200
- 3330 (time here is greater than 2400)

As you recall, when the time period is greater than 2400, you must subtract 2400 from the total (the day ends at 2400). This will give you the completion time for the next day.

Using the answer from the problem, which is 3330

Subtract –2400

Subtract −2400

Completion time: 0930 or 9:30 am the next day

Completion time: 0930 or 9:30 am the next day

Example 3: An IV of D_5½ NS is started at 0430 to infuse in 6 hr and 40 min. Determine the completion time.

Solution:

- Start time 0430
- Infusion time +0640
- 1070 (the minutes here are greater than 60)

As you recall, when the minutes are greater or equal to 60, subtract 60 from the number of minutes, which in this example is 70 min, and then add the 1 hour obtained when you subtracted the 60 minutes to get the completion rate, as follows:

- 1070
- −0060 minutes (1 hr)
- 1010
- +0100 (the 1 hr obtained when you subtracted the 60 min)

Completion time: 1110 or 11:10 am

Alternate to Example 3:

- Add start time: 0430
- Infusion time +0640
- Convert 70 min to 1 hr and 10 min and add to 10 hr. 1000
- +0110
- **Completion time:** 1110 or 11:10 am

As you will notice in the examples provided, you were given the infusion time as well as the time for the infusion to start in military time. Let's look at an example in which you will need to determine the infusion time before calculating the completion time.

Example 4:

500 mL D_5W to infuse at 80 mL/hr is started at 7:30 am. Determine the completion time. State time in military and traditional time.

Solution:

- • First determine the infusion time using any of the methods already presented (ratio and proportion, formula method, or dimensional analysis)

Ratio and Proportion (Linear Format)

80 mL : 1 hr = 500 mL : x hr

$80x = 500$

$x = 6.25$ hr

Calculate the minutes.

1 hr : 60 min = 0.25 hr : x min

$x = 0.25 \times 60 = 15$

$x = 15$ min

Infusion time is 6 hr and 15 min.

Formula Method

Calculate the minutes.

Infusion time is 6 hr and 15 min.

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

$x = 6.25$ hr

Calculate the minutes.

$x = 15$ min

Infusion time is 6 hr and 15 min.

Dimensional Analysis

Calculate the minutes:

Infusion time is 6 hr and 15 min.

- • Now determine the completion time (add the infusion time to the start time).
  - Start time: 0730
  - Infusion time:

= 1:45 pm

Note: The start time (7:30 am) was changed to military time: to convert am time omit colon and am, add a zero to beginning to make a 4-digit number. To convert pm time to traditional time, subtract 1200 and add pm. If necessary, review the conversion of time (traditional and military) in Chapter 8.

PRACTICE PROBLEMS

Determine infusion and completion time for the following IVs. State the time in traditional and military time.

- 38. An IV of 500 mL NS is to infuse at 60 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 10:00 pm. When would the IV infusion be completed? _____
- 39. An IV of 250 mL D_5W is to infuse at 80 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 2:00 am. When would the IV infusion be completed? _____
- 40. An IV of 1,000 mL D_5 RL is to infuse at 60 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 6:00 am. At what time would this IV infusion be completed? _____

- 41. An IV of 500 mL D_5W is to infuse at 75 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 2:00 pm. At what time would the IV infusion be completed? _____

Answers on 542

unknown - Section 39 (Page 359)

This chapter will present the calculations performed with intravenous therapy. As stated previously, nurses have the responsibility to make sure that clients are receiving the correct rate. Several methods to calculate IV rates are presented in the chapter: ratio and proportion, dimensional analysis, and the formula. Let's now begin our calculations with determining IV rates in milliliters per hour (mL/hr).

IV Flow Rate Calculation

As previously discussed, the prescriber's order for an IV includes the following:

- • The name of the IV solution
- • The volume to infuse
- • Medications to be added, if any
- • Time for the IV to infuse

Continuous IV, which is oft en referred to as the primary IV, usually contains a large volume of fluid (500 mL or 1,000 mL). IV fluids are usually ordered to be administered at rates expressed in mL/hr. The time for the IV to infuse may be indicated as the total number of hours (i.e., D_5W 3,000 mL in 24 hr), or mL/hr (i.e. D_5 ½. NS 1,000 mL at 125 mL/hr). Small volumes of fluid (usually 50 mL or 100 mL) are oft en used when the IV fluid contains medications such as antibiotics. Rates for IV fluids are usually expressed in drops per minute (gtt/min) when an infusion device is not used. When an infusion device such as a pump is used, the flow rate must be expressed in mL/hr.

Calculating Flow Rates for Infusion Pumps in mL/hr

When a client is using an electronic infuser, such as a volumetric pump, the prescriber orders the volume and can include mL/hr or the total number of hours for the IV to infuse. If the order states the number of mL/hr for the infusion, such as previously stated D_5 ½ NS at 125 mL/hr, there is no calculation required by the nurse. The nurse programs the pump to deliver the ordered rate. However, if the order states the total number of hours for the IV to infuse (D_5W 3,000 mL in 24 hr), the nurse will need to calculate the mL/hr to program the pump.

For most electronic devices that regulate the flow of IV solutions, the rate is expressed in milliliters per hour (mL/hr). For the purpose of this text, the equipment being used is programmable in whole mL/hr; therefore mL/hr should be rounded to a whole number unless indicated that the infusion pump has decimal capability. To determine mL/hr the following information is needed:

- • The volume (amount) of solution in milliliters
- • The time for the IV to infuse in hours

The simplest way to determine the mL/hr is by using the formula, although ratio-and-proportion and dimensional analysis can be used:

Formula to Determine mL/hr

Round mL/hr to the nearest **whole number**. If the answer does not result in a whole number, carry division to tenths place and round to the nearest whole number. If pump has decimal capability, round answer to the **nearest tenth.**

SAFETY ALERT!

There are some IV pumps in use that are capable of delivering IV fluids in tenths of a milliliter. Always be familiar with the IV equipment being used at the institution before rounding milliliters per hour (mL/hr) to the nearest whole mL/hr.

Let's begin with the calculation of IV flow rates in mL/hr.

Example 1: Client with an infusion pump has an order for 3,000 mL D_5W over 24 hours.

Solution:

- 1. Think: Pump is regulated in mL/hr.
- 2. No conversion required; the volume is in milliliters, and the time is in hours.
- 3. To use the formula method to determine mL/hr: *x* mL/hr = volume in mL.

- 4. To determine mL/hr using ratio and proportion, the volume ordered and hours to infuse is the known ratio; 3,000 mL : 24 hr (stated first), and the unknown is *x* mL : 1 hr. (stated as the second ratio) or:

- 5. To determine mL/hr using dimensional analysis, identify what you are looking for, and write it to the left of the equation in a fraction format. Label factor:

Place problem as starting fraction (if no conversion required). If conversion is required, the starting fraction is the conversion factor, and the problem is inserted as the second fraction in the equation. Refer to the setups of Example 1 using the various methods.

Formula Method

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

In this problem no conversion was required, the ordered amount is in mL/hr, which is the same as the desired; therefore the problem is solved by division, and no cancellation of units is required.

To infuse 3,000 mL of D_5W in 24 hr, the pump would be set to deliver 125 mL/hr.

Sometimes a conversion may be necessary before calculating mL/hr. Let's look at a problem showing the calculation of mL/hr when a conversion is required.

Example 2: Client with an infusion pump is to receive 0.5 L 0.9% NS over 8 hours.

Solution:

- 1. Convert 0.5 L to 500 mL using any of the methods presented in earlier chapters.
- Use the conversion factor 1 L = 1,000 mL. Convert 0.5 L to mL by moving the decimal three places to the right (metric to metric). Decimal movement can be used. Review methods of converting if necessary.
- 2. Set up the problem and solve using one of the calculation methods.

Formula Method

mL/hr is rounded to the nearest whole number of mL.

Ratio and Proportion (Linear Format)

mL/hr is rounded to the nearest whole number of mL.

Ratio and Proportion (Fraction Format)

mL/hr is rounded to the nearest whole number of mL.

Dimensional Analysis

mL/hr is rounded to the nearest whole number. Notice the conversion factor is written

to cancel L, leaving mL/hr.

To infuse 500 mL of 0.9% NS, the pump would be set to deliver 63 mL/hr. As previously stated, pumps deliver in whole mL unless indicated the pump has decimal capability.

Determining mL/hr When the Time Period Is Less Than 1 Hour

Often when medications are administered IV, such as IVPB (e.g., for antibiotics), the time period for the IV to infuse is less than 1 hour. When the period is less than 1 hour and an electronic infusion device is used, the IV rate must still be determined in mL/hr. **Remember that there are 60 minutes in 1 hour.** The rate can be determined using ratio and proportion. (The known ratio is the ordered rate, mL/min, and the second is the unknown ratio, x mL/60 min). Dimensional analysis can also be used to determine the rate in mL/hr. (The first factor in the equation is the ordered mL/min, and the second factor is 60 min/1 hr). The rate can also be determined using the formula:

Let’s look at an example. The various methods for calculating the infusion rate will be shown.

Example 3: A client is to receive an antibiotic in 100 mL of 0.9% NS over 45 min by infusion pump. Determine the IV flow rate.

Solution:

- 1. Think: The infusion pump infuses in mL/hr. Use a ratio and proportion, the formula method, or dimensional analysis to determine mL/hr.
- 2. Remember: 1 hr = 60 min.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Formula Method

Note: min is cancelled, leaving mL/hr.

Dimensional Analysis

Note: min is cancelled, leaving mL/hr.

The infusion pump would be set at 133 mL/hr to infuse 100 mL in 45 minutes. The volume of 100 mL will be infused.

SAFETY ALERT!

The usual rate in mL/hr ranges from 50 to 200 mL/hr. If the rate exceeds this amount, double-check the order and your calculation before programming the rate into an infusion pump.

POINTS TO REMEMBER

- • IV infusion pumps deliver IV flow rates in mL/hr.
- • IV orders indicate: the name of the IV solution, the volume to infuse, medications to be added, if any, and the time for the IV to infuse. The prescriber may indicate the time for an IV to infuse in mL/hr, or the total number of hours for the IV to infuse.
- • To determine flow rates for an electronic infusion device such as the infusion pump, determine mL/hr using the formula:

- • If the time for the IV to infuse is less than 1 hour and the infusion pump is used, the infusion rate still must be determined in mL/hr. Ratio and proportion, the formula method, or dimensional analysis can be used to determine the infusion rate. Remember that 60 min = 1 hr.
- • Milliliters per hour (mL/hr) are rounded to the nearest whole number. If math does not result in a whole number, carry math to the tenths place and round to the nearest whole number.
- • Some infusion pumps have decimal capability and can deliver IV rates in tenths of a mL. If the answer obtained is not in the tenths place, carry math to the hundredths place and round to the tenths.
- • Always be familiar with the infusion device being used by an institution before rounding mL/hr to a whole number.

PRACTICE PROBLEMS

Calculate the flow rate in mL/hr. (Equipment used is programmable in whole mL/hr.)

- 1. 1,800 mL of D_5W in 24 hr by infusion pump

- 2. 2,000 mL D_5W in 24 hr by infusion pump
- 3. 500 mL RL in 12 hr by infusion pump
- 4. 1,500 mL D_5RL in 24 hr by infusion pump
- 5. 750 mL D_5W in 16 hr by infusion pump

Answers on 538

Manually Regulated IVs

When an electronic infusion device is not used, the nurse uses a gravity-flow system and must manually regulate the infusion rate. To do this, the nurse must calculate the ordered IV flow rate in drops per minute (gtt/min). IV flow rates in gtt/min are based on the IV tubing calibration, referred to as the *drop factor*. The **drop factor** is the number of drops per milliliter (gtt/mL) that a particular IV tubing delivers and therefore will vary depending on the type of IV tubing.

The drop size is determined by the size of the tubing or the small needle inside the drop chamber releasing the drops. See Figure 21.1. Note the large opening for drops in Figure 21.1A, the drops are large (**macrodrops**). The drops delivered through the small needle in Figure 21.1B are very small drops (**microdrops**). The drop factor of the IV tubing is stated in large numbers on the IV tubing package (Figure 21.2). The drop factor of the IV tubing is needed to calculate gtt/min.

Figure 21.1 Comparison of (A) macrodrops and (B) microdrops.

Figure 21.2 IV administration sets (package). **(A)** Set with drop factor of 10 (10 gtt =1 mL). **(B)** Set with drop factor of 60 (60 gtt = 1 mL).

As stated previously, at the top of the IV tubing is a drip chamber (also referred to as a drop chamber), where the nurse observes and counts the number of drops falling into the drip chamber per minute or fraction of a minute placing a watch at the level of the drip chamber. The flow rate is regulated by a hand-operated slide clamp or a roller clamp, which is opened or closed so the drops fall at the desired rate.

SAFETY ALERT!

IV infusions that are manually regulated must be monitored regularly. The flow rate of a manually regulated IV can be affected by the height of the IV infusion, the location of the site, and changes in the client position, which can result in impediment of the IV flow rate or excessive amounts of fluid being delivered to the client.

IV Tubing

The two common types of tubing used to administer IV fluids (regulated manually) are:

- • Macodrop tubing
- • Microdrop tubing

Macrodrop Tubing

Macrodrop is the standard tubing used for general IV administration. With macrodrop tubing the size of the drop and the number of gtt/mL varies according to the manufacturer. Macrodrops are large drops, and there are fewer drops in 1 mL (see Figure 21.1A). Macrodrop tubing have the following drop factors:

- • 10 gtt/mL
- • 15 gtt/mL
- • 20 gtt/mL

Since the drop factor for macrodrop tubing differs according to the manufacturer, always read the IV tubing package and identify the drop factor of the tubing. Never assume to know the drop factor, because not all macrodrop tubing has the same factor.

SAFETY ALERT!

To accurately administer IV fluids at the correct rate to a client, the nurse **must** know the drop factor of the IV tubing. Knowing the drop factor of the IV tubing used can prevent an error in IV rate determination and the client receiving IV fluid at the incorrect rate. **Never** assume the drop factor for macrodrop tubing.

Microdrop Tubing

Microdrop tubing delivers tiny drops through a small needle in the drip chamber and therefore has more drops in 1 mL (see Figure 21.1B). It is used to administer either small or precise amounts of fluid. For example, it is used in critical care, for the elderly, and for pediatric infusions. Microdrop tubing, because of the size of the drops (very small/ tiny) is sometimes referred to as pedidrip tubing. Microdrop tubing, regardless of the manufacturer, is only available in one drop factor (60 gtt/mL). With microdrop tubing the number of mL/hr is the same as gtt/min (i.e., if the infusion rate is 100 mL/hr, the IV rate is 100 gtt/min).

- • 60 gtt/mL

POINTS TO REMEMBER

- • Drop factor = gtt/mL of the IV tubing. This information is written on the package of the IV tubing.
- • Knowing the drop factor of the IV tubing is the **FIRST** step in accurate administration of IV fluids in gtt/min. IVs that infuse by gravity are manually regulated, and the IV flow rate is determined in gtt/min.
- • Macrodrops are large and have drop factors of 10, 15, and 20 gtt/mL.
- • Microdrops are tiny and have only one drop factor, 60 gtt/mL.

PRACTICE PROBLEMS

Refer to the drop factor provided and identify the type of tubing.

- 6. 15 gtt/ mL _____
- 7. 60 gtt/mL _____
- 8. 10 gtt/mL _____

Answers on 538

Calculating Flow Rates in Drops Per Minute Using a Formula and Dimensional Analysis

To calculate the IV flow rate in gtt/min for an IV infusing by gravity, a formula method can be used or dimensional analysis. To calculate the flow rate in gtt/min for the IV infusion regardless of the method used (formula method or dimensional analysis), the nurse needs to know the following:

- • Drop factor of the IV tubing
- • Volume (number of mL) to infuse
- • Time the IV is to infuse (minutes or hours)

The formula for calculating the IV flow rate is:

Before beginning to calculate gtt/min, let's review some basic guidelines:

Guidelines for Calculating gtt/min

- • Drops per minute are **always** expressed in whole numbers. Think: You cannot regulate an IV to half a drop or count half a drop; therefore **you can only count whole drops.**
- • Principles of rounding are applied if the calculation for gtt/min does not result in a whole number. Carry calculation to the tenths place, and round answer to the nearest whole number (i.e., 19.6 is rounded to 20 gtt/min).
- • Answers must be labeled. The label is usually drops per minute unless otherwise specified. Example: 17 gtt/min. To reinforce the differences in drop factor, the type of tubing is sometimes included as part of the label. Examples: 17 macrogtt/min, 100 microgtt/min.
- • Common conversion factors used include 1 L = 1,000 mL, and 1 hr = 60 min.

First let's look at some sample problems using the formula method and dimensional analysis.

Example 1: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 10 gtt/mL. At what rate in gtt/min should the IV infuse?

- • Notice the numbers in the problem are placed in the formula.
- • Remember the formula solves for gtt/min and the time is indicated in minutes. 60 min = 1 hr; therefore 1 hr is changed to 60 min in the formula (100 mL/60 min).
- • When mL is cancelled out, the flow rate is determined in gtt/min.
- • Reduction is done where possible.
- • The answer is labeled.
- • ***Note:*** The volume of 1,000 mL was not used in the calculation; the mL/hr was stated in the order.

Setup Using Formula Method

To deliver 100 mL/hr, the IV rate would be regulated at 17 gtt/min; 17 macrogtt/min.

Dimensional Analysis

Let's look at the previous example using dimensional analysis.

Example 1: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 10 gtt/mL. At what rate in gtt/min should the IV infuse?

- • Notice *x* gtt is written to the left of the equation, followed by the equal sign (=) (labeled *x* gtt/min because that is what you're looking for).
- • The **first** factor starts with gtt and is the drop factor, which is written, placing gtt in the numerator. 10 gtt/1 mL.
- • The next fraction is written so that the denominator matches the previous fraction (what you are looking for). The order is to infuse 100 mL in 1 hr. The 1 hr is entered as 60 min in the denominator because you are calculating gtt/min (100 mL/60 min).
- • Cancel the units and you are left with the desired gtt/min.
- • Reduction is done if possible.
- • Label the answer.

Dimensional Analysis

Note: An alternate way of setting up the problem, without changing the hourly rate to 60 min, would be to add 1 hr = 60 min conversion factor to the equation:

Alternate Setup Using Dimensional Analysis

Notice the hourly rate is entered in mL/hr in the equation; the fraction 1 hr/60 min is inserted into the equation. The units are cancelled, leaving gtt/min. The calculation would be the same as the previous setup.

Example 2: Order: 1.5 L 0.9% NaCl to infuse in 10 hr. Drop factor: 15 gtt/mL. At what rate in gtt/min should the IV infuse at?

- • Notice this problem contains a large volume of fluid, and the order contains the total number of hours to infuse as opposed to mL/hr as shown in Example 1.
- • A conversion is also required before the problem can be solved. L must be converted to mL. Use the conversion factor 1 L = 1,000 mL; therefore 1.5 L = 1,500 mL.
- • When using the **formula method**, the IV rate can be determined in two ways:
  - a. First convert the flow rate to mL/hr, and then calculate the gtt/min using the formula.
  - *or*
  - b. Convert the number of hours to minutes using the conversion factor 60 min = 1 hr. Multiply the number of hours by 60 min/hr and then place the calculated minutes into the formula. In this problem, 10 hr is multiplied by 60 min/hr to obtain the 600 minutes used in the formula: 10 hr × 60 min/hr.
- • For **dimensional analysis,** if the mL/hr is not expressed as mL/min, insert the conversion factor 1 hr/60 min.

Let's look at the above problem using the formula method and dimensional analysis.

Formula Method Using Two Steps

Step 1: Calculate the mL/hr:

Convert mL/hr to mL/min. 1 hr = 60 min (150 mL/hr = 150 mL/60 min)

Step 2: Place into formula:

Formula Method Using hr Converted to min

Dimensional Analysis Using mL/min

Calculate mL/hr: 1,500 mL ÷ 10 hr = 150 mL/hr.

Convert mL/hr to mL/min (150 mL/hr = 150 mL/60 min).

Proceed using the steps shown in Example 1.

Dimensional Analysis Using mL/hr

Dimensional Analysis Using the Total Volume and Total Number of hr

Proceed with calculation as shown in previous examples.

Example 3:

Order: The following IVs for 24 hours. Drop factor: 15 gtt/mL

- • 1,000 mL D_5W c 10 mEq potassium chloride (KCl)
- • 500 mL D_5NS c 1 ampule of multivitamin (MVI)
- • 500 mL D_5W

What rate will you regulate the IV to deliver the ordered IV fluid?

In this problem, the order is written for different amounts and types of fluid to be given in a certain time period. Notice that medications are also ordered to be added to the solutions: potassium chloride and multivitamin. When medications such as potassium chloride and vitamins are added to the IV solutions, they are generally not considered in the total volume. (Some institutions consider the medication in the volume if it is 10 mL or more. Always check the policy of the institution.)

To calculate the IV rate, add up the IV fluid to obtain the total volume (2,000 mL). The total number of hours for the IV infusion is given (24 hours). To convert 24 hr to min, multiply: 24 hr × 60 min/hr = 1,440 min.

Formula Method Using Two Steps

Step 1: Calculate the mL/hr:

Convert mL/hr to mL/min. 60 min = 1 hr (83 mL/hr = 83 mL/60 min).

Step 2: Place into formula

Formula Method Using hr Converted to min

To infuse 2,000 mL in 24 hours, the IV would be regulated at 21 gtt/min; 21 macrogtt/min.

Dimensional Analysis Using mL/min

Dimensional Analysis Using mL/hr

Dimensional Analysis Using the Total Volume and Total Number of hr

Proceed with calculation as shown in previous examples.

Example 4:

Order: 50 mL NS to infuse over 20 minutes.

Drop factor: 20 gtt/mL. What rate will you regulate the IV to infuse?

Notice, in this example, you have a small volume of fluid, and the time for the IV to infuse is in minutes. This problem can be solved using the same methods (formula method and dimensional analysis) shown in the previous examples.

Formula Method

Dimensional Analysis

To infuse 50 mL NS in 20 minutes, the IV would be regulated at 50 gtt/min; 50 macrogtt/min.

PRACTICE PROBLEMS

Calculate the flow rate in gtt/min using the formula method or dimensional analysis.

- 9. D_5RL at 75 mL/hr. The drop factor is 10 gtt/mL. _____
- 10. D_5 ½ NS at 30 mL/hr. The drop factor is a microdrop. _____
- 11. 1,000 mL D_5 0.33% NS in 6 hr. The drop factor is 15 gtt/mL. _____
- 12. An IV medication in 60 mL of 0.9% NS is to be administered in 45 min. The drop factor is a microdrop. _____
- 13. 1,000 mL of Ringer's lactate solution (RL) is to infuse in 16 hr. The drop factor is 15 gtt/mL.
- 14. 3,000 mL D_5 and ½ NS in 24 hr. The drop factor is 10 gtt/mL. _____
- 15. Infuse 2,000 mL D_5W in 12 hr. The drop factor is 15 gtt/mL. _____

Answers on pp. 538-539

Calculation of IV Flow Rates Using a Shortcut Method

This shortcut method can be used where the IV sets all have the same drop factor. Example: an institution where all the macrodrop sets deliver 10 gtt/mL. This method can also be used with microdrop sets (60 gtt/mL). It is important to note that this method can be used only if the rate of the IV infusion is expressed in mL/hr (mL/60 min).

To use this method, you must know the drop factor constant for the administration set you are using. The drop factor constant is sometimes referred to as the *division factor*. To obtain the drop factor constant (division factor) for the IV administration set being used, divide 60 by the drop factor calibration from the IV infusion set. Box 21.1 shows the constant calculated based on the drop factor for the IV tubing.

BOX 21-1 Drop Factor Constants

Drop Factor of Tubing	Drop Factor Constant
10 gtt/mL	
15 gtt/mL	
20 gtt/mL	
60 gtt/mL	

RULE

After the drop factor constant is determined, the gtt/min can be calculated in one step:

Let's look at examples of calculating the gtt/min using the stated rule:

Example 1:

Order: Administer D_5W at 125 mL/hr. Drop factor: 15 gtt/mL

The drop factor constant: 4.

In this example, the drop factor constant is 4. The set calibration is 15 gtt/mL (60 ÷ 15 = 4).

Solution:

Solution Using Dimensional Analysis:

Remember that the shortcut method discussed (using the drop factor constant) can be used to calculate the gtt/min for any volume of fluid that can be stated in mL/hr or mL/60 min.

RULE

The shortcut method can be used if the volume of fluid is large; however, an additional step of calculating mL/hr first must be done and then calculate the gtt/min using the shortcut method.

Example 2: Order: RL 1,500 mL to infuse in 12 hr. Drop factor: 20 gtt/mL. Drop factor constant: 3.

In this example, the volume of fluid is 1,500 mL and the total hours to infuse is 10 hr. Before using the shortcut method, the mL/hr must be calculated. 1,500 mL ÷ 12 = 125 mL/hr. The set calibration is 20 gtt/mL. 60 ÷ 20 = 3.

Solution:

Solution Using Dimensional Analysis:

Determine mL/hr expressed as mL/60 min.

The shortcut method can also be used for small volumes of fluid and when the time period is less than 1 hour. If the volume of fluid to infuse is small and the time period is less than 1 hour (60 minutes), the volume and time must each be multiplied to get mL/hr.

Example 3: Order: 20 mL D_5W in 30 minutes. Drop factor 60 gtt/mL. Drop factor constant: 1.

In this example the volume of fluid is small, and the time period is less than 60 min. The set calibration is 60 gtt/mL. 60÷ 60 = 1.

Solution: To express 20 mL in 30 minutes in mL/hr, you multiply the volume and the time by 2.

Step 1: Change 20 mL/30 min to 40 mL/hr as shown above.

Step 2: Express 40 mL/hr as 40 mL/60 min.

Note: In the above problem to administer 40 mL/hr, the IV would be set at 40 gtt/min. When the drop factor of the infusion set used is 60 gtt/mL, the number of gtt/min is equal (=) to the mL/hr.

PRACTICE PROBLEMS

Calculate the rate in gtt/min using the shortcut method.

- 16. Order: D_5W 200 mL/hr. Drop factor: 10 gtt/mL _____
- 17. Order: 0.9% NS 140 mL/hr. Drop factor: 20 gtt/mL _____
- 18. Order: 1,000 mL D_5W in 10 hr. Drop factor: 10 gtt/mL _____
- 19. Order: 40 mL D_5W in 20 min. Drop factor: 10 gtt/mL _____
- Calculate the flow rate in gtt/min.
- 20. Order: To infuse in 16 hr. Drop factor: 10 gtt/mL
  - • D_5W 500 mL c 10 potassium chloride (KCl)
  - • D_5W 1,000 mL
  - • D_5W 1,000 mL c 1 ampule of multivitamin (MVI) _____
- 21. Order: 1,000 mL D_5 0.9% NS for 3 L at 100 mL/hr. Drop factor: microdrop _____

Answers on 539

POINTS TO REMEMBER

- • To calculate the IV flow rate in gtt/min, the nurse must know the drop factor of the IV tubing, the volume to infuse, and the time for the IV to infuse.
- • Drop factor is expressed as gtt/mL and indicated on the package of the IV tubing.
- • Calculation of gtt/min can be done using the formula method or dimensional analysis.
- • Formula for calculating gtt/min is as follows:

- • With the formula method, determine the IV rate by converting the flow rate to mL/hr (60 min), and then calculate gtt/min using the formula. **OR** Convert the number of hours to minutes using the conversion factor 60 min = 1 hr, and then place the calculated minutes into the formula.
- • For dimensional analysis, if the mL/hr is not expressed as mL/min, insert the conversion factor 1 hr/60 min into the equation.
- • Drops per minute are always expressed as whole numbers.
- • A shortcut method can be used to calculate flow rates infusing in mL/hr or mL/60 min using the drop constant.
- • To determine the drop constant factor, divide 60 by the calibration of the IV set.
- • To use the shortcut method for small volumes and time periods less than 1 hr, the volume and the time must each be multiplied to get mL/hr.

Calculating IV Flow Rates Using a Dial-Flow Controller

Dial-flow controllers are also known as IV manual flow regulators or just IV flow regulators, as well as just flow controllers. There are a wide variety of dial-flow controllers available for use and are either part of the IV tubing or added on (Figure 21.3). These devices are regulated manually and are not infusion pumps. Use of the device is based on several factors, which include severity of illness, type of therapy, and the setting. Dial-flow devices are designed to regulate the flow of IV fluid instead of using the roller clamp. The flow rate can be adjusted from 5 to 250 mL/hr. To use the device, you set or dial the desired flow rate in mL/hr, which is an estimate, and then the rate must be verified by counting drops per minute. Drops per minute would be calculated using one of the methods presented in the chapter.

Figure 21.3 Flow controller. (Courtesy and © Becton, Dickinson and Company, Franklin Lakes, NJ.)

If used, it is important to remember that use of the device does not relinquish the nurse from his or her responsibility, which is to monitor the IV to ensure there is accurate delivery of the ordered infusion rate.

Let's look at an example using this device.

Example: Order: D_5W 1,000 mL to infuse at 100 mL/hr. Drop factor: 15 gtt/mL.

- 1. Turn the dial of the controller to 100 mL/hr.
- 2. Use the formula or dimensional analysis to determine gtt/min.
- 3. Verify accuracy of controller by counting the drops either for a minute or a fraction, such as 20 seconds. Divide the number of drops per minute by 3 (25 gtt ÷ 3 = 8.3 = 8 gtt). You find the number of drops is 8; the controller is delivering the correct rate for 20 seconds. If the rate is not correct for 20 seconds, the controller dial can be adjusted. The rate will have to be monitored periodically during the infusion.

Formula Method

Dimensional Analysis

Refer to examples for steps in solving.

To infuse 100 mL/hr, the IV flow rate would be set at 25 gtt/min; 25 macrogtt/min.

SAFETY ALERT!

The flow rate on the controller is in **mL/hr, not gtt/min.** Failure to verify the drop rate can result in client not receiving the correct rate, which can result in the client receiving insufficient or excessive IV fluid. To ensure client safety during IV administration, the controller as well as the client **must** be monitored.

Calculating Intermittent IV Infusions Piggyback

A medication such as an antibiotic can be administered by attaching it to a port on the primary line (referred to as Intravenous Piggyback [IVPB]) and infusing it by gravity or infused using an electronic infusion device. IVPBs may come premixed from the drug manufacturer, or medications are added to a small volume bag by the nurse, or in some institutions by the pharmacist and sent to the unit.

If the prescriber does not include the type and amount of solution for the medication to be placed in or the rate for infusion, the nurse must check a medication reference or the manufacturer's guidelines. Even if medications are premixed (with medication added to the solution by the drug manufacturer or pharmacy), the nurse is responsible for ensuring that the IVPB is infusing at the correct rate. When medications are premixed, the nurse calculates the infusion rate by using the volume of solution containing the medication. Regardless of whether the IVPB is mixed by the nurse, is premixed, or the ADD-Vantage system is used, the IVPB must be in the correct amount of solution and infused at the correct rate. The volume of IV solution used for an IVPB is usually 50 to 100 mL to infuse over 20, 30, 60 minutes, or longer depending on the type and amount of medication added.

As already stated, depending on the volume of the medication being added (for an IVPB mixed by the nurse), at some institutions the medication is considered in the volume of IV fluid when determining the IV rate. ***Note:*** For the purpose of this text, it will be indicated when to consider the medication in the IV volume and the type and amount of solution for dilution of the piggyback, and infusion rate will be indicated in the order.

Let's look at the examples shown for determining the rate for the IVPB.

Example 1: Order: Keflin 2 g IVPB in 100 mL D_5W over 30 min. Drop factor: 15 gtt/mL. Determine the IV flow rate.

Solution:

- • In this problem, there is no conversion needed; the volume of solution is in mL.
- • The amount of medication added, 2 g, is not needed to calculate the IV flow rate. The 100 mL of fluid that the Keflin is placed in is used as the volume.
- • A drop factor is stated; therefore the IV rate will be calculated in gtt/min.
- • The volume of IV fluid, which is stated in mL, the time (min), and the drop factor are the required information needed to calculate the IV flow rate, using the formula method or dimensional analysis.

Formula Method

Dimensional Analysis

To infuse 100 mL in 30 minutes the IV rate would be regulated at 50 gtt/min; 50 macrogtt/min.

Now let's look at the same problem if an electronic infusion device was used.

Example 2: Order: Keflin 2 g IVPB in 100 mL D_5W over 30 min by infusion pump.

Determine the IV flow rate.

Solution:

- • An electronic infusion device is being used; the rate will need to be determined in mL/hr.
- • As with Example 1, the amount of medication, 2 g, is not needed to calculate the IV flow rate.
- • Remember there are 60 minutes in 1 hr.
- • The rate can be determined using ratio and proportion, the formula below, or dimensional analysis.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Formula Method

Notice min is cancelled, leaving mL/hr.

Dimensional Analysis

Notice min is cancelled, leaving mL/hr.

The pump would be set at 200 mL/hr to infuse 100 mL in 30 min. ***Note:*** The actual volume of 100 mL will be infused.

PRACTICE PROBLEMS

Calculate the rate in gtt/min for the following medications being administered IVPB. Use the labels where provided. (Add the volume of medication being added to IV solutions, where indicated.)

- 22. Order: Erythromycin 200 mg in 250 mL D_5W to infuse over 1 hr. Drop factor: 10 gtt/mL _____

- 23. Order: Ampicillin 1 g in 50 mL D_5W to infuse over 45 minutes. Drop factor: 10 gtt/mL. For IV, reconstitute with 10 mL of diluent to get 1 g per 10 mL. (Consider the medication added in the volume of fluid.)
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Calculate the rate in gtt/min at which the IV should infuse. _____
- 24. Order: Clindamycin 900 mg in 75 mL D_5W over 30 minutes. Drop factor: 10 gtt/mL
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Determine the IV rate. _____
- 25. Order: Vancomycin 500 mg IVPB q24hr. The reconstituted vancomycin provides 50 mg per mL. The medication is placed in 100 mL of D_5W to infuse over 60 minutes. Drop factor: 15 gtt/mL. (Consider the medication added in the volume of fluid.)
  - a. How many milliliters of medication must be added to the solution? _____
  - b. Calculate the rate in gtt/min at which the IV should infuse. _____
- 26. Order: Fungizone (amphotericin B) 20 mg in 300 mL D_5W over 6 hr by infusion pump. The reconstituted material contains 50 mg per 10 mL.
  - a. How many milliliters will you add to the IV solution? _____
  - b. Determine the IV rate. _____
- 27. Order: Septra (sulfamethoxazole and trimethoprim) 300 mg in 300 mL D_5W over 1 hr q6h. Drop factor: 10 gtt/mL. Calculate the dose using trimethoprim.
  - a. How many milliliters of medication will be added to the IV? (Round the answer to the nearest tenth.) _____
  - b. Consider the medication added to the volume of IV fluid. Calculate the rate in gtt/min at which the IV should infuse. _____
- 28. Order: Retrovir (zidovudine) 100 mg IV q4h over 1 hr. Available medication states each mL contains 10 mg of zidovudine.
  - a. How many milliliters of medication will be added to the IV solution? _____
  - b. The medication is placed in 100 mL of D_5W. Drop factor: 10 gtt/mL (Consider the medication added to the volume of IV fluid.) _____

Answers on pp. 539-540

Determining the Amount of Medication in a Specific Amount of Solution

Sometimes medications are added to IV solutions, and the prescriber orders a certain amount of medication to be administered in a certain time period. In order to calculate the volume of fluid needed to deliver a specific amount of medication, a ratio and proportion can be used or dimensional

analysis.

Example 1: Order: 20 mEq of potassium chloride in 1,000 mL D_5W to infuse at 2 mEq/hr. Calculate the mL/hr to deliver 2 mEq of potassium chloride/hr.

Solution:

Set up a ratio and proportion using the linear or fraction format:

- • With use of the ratio and proportion, the known ratio is the amount of medication in the total volume of solution, and the unknown ratio is what the prescriber ordered.
- • Dimensional analysis of the first factor is the total volume of solution and the amount of medication, and the second factor is what the prescriber ordered.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

Notice cancelling mEq leaves mL/hr.

100 mL/hr will deliver 2 mEq /hr of potassium chloride.

Example 2: Order: 100 units of Humulin regular insulin in 500 mL ½ NS to infuse at 10 units/hr. Calculate the mL/hr to deliver 10 units of insulin/hr.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

POINTS TO REMEMBER

- • When preparing medications for intermittent infusion:
  - a. Reconstitute the medication using the label or package insert if needed.
  - b. Calculate the amount of medication to administer.
  - c. Verify the recommended infusion rate with the manufacturer's recommendations or a medication reference.
  - d. Determine the IV rate using the IV formula or dimensional analysis.
- • If the intermittent infusion is being administered by an electronic infusion device, the flow rate is determined in mL/hr using ratio and proportion, dimensional analysis, or the formula method for time periods less than 1 hour.

- • To determine the volume (amount) of IV fluid to administer the prescribed amount of medication in mL/hr, use ratio and proportion or dimensional analysis.

PRACTICE PROBLEMS

Solve the following problems using the steps indicated.

- 29. Order: 15 mEq of potassium chloride in 1,000 mL of D_5 ½ NS to be administered at a rate of 2 mEq/hr.
- How many mL/hr should the IV infuse at? _____
- 30. Order: 10 units of Humulin regular insulin per hour. 50 units of insulin is placed in 250 mL NS.
- How many mL/hr should the IV infuse at? _____

Answers on pp. 540-541

Determining the Unknown for Time and Volume

You may need to calculate the following:

- a. **Time in hours**—How long it will take a certain amount of fluid to infuse or how long it may last
- b. **Volume**—The total number of milliliters a client will receive in a certain time period These unknown elements can be determined by the use of the formula method or dimensional analysis.

Formula:

Calculating a Problem with an Unknown Using the Formula Method and Dimensional Analysis

- 1. Take the information given in the problem and place it in the formula.
- 2. Place an *x* in the formula in the position of the unknown. If you are trying to determine time in hours, place *x* in the position for minutes; once you find the minutes, divide the number of minutes by 60 (60 minutes 5 1 hr) to get the number of hours. If you are trying to determine the volume the client would receive, place an *x* in the position for amount of solution, and label *x* mL.
- 3. Set up an algebraic equation so that you can solve for *x*.
- 4. Solve the equation.
- 5. Label the answer in hours or milliliters for volume.

Example 1: Determining hours:

An IV is regulated at 20 microgtt/min. How many hours will it take for 100 mL to infuse?

Formula Method

Note: In the position of drop factor, 60 gtt/mL was placed, IV was infusing in microgtt, and the infusion set had to be a microdrip (60 gtt/mL).

Dimensional Analysis

x hr is what you are looking for. The **first** starting fraction is 1 hr/60 min, the **second** fraction is 1 min/20 gtt to match the denominator of the starting fraction. The **third** fraction is 60 gtt/1 mL to match the denominator in the fraction before it. The **last fraction** is 100 mL/1, to match mL in the fraction before it. Cancel the units, reduce if possible, and perform mathematical process.

Note: When calculating time and the answer results in hr and min, express entire time in hr (i.e., 1 hr and 30 min = 1.5 hr, or 1½ hr; 1½ hr is the preferred way to state answer).

Example 2: Determining volume:

An IV is regulated at 17 macrogtt/min. The drop factor is 15 gtt/mL. How much fluid volume in milliliters will the client receive in 8 hr?

Formula Method

Dimensional Analysis

x mL is what you are looking for here. Enter the drop factor as the **first** starting fraction 1 mL/15 gtt. The **second** fraction is 17 gtt/1 min, so it matches the denominator of the first fraction. The **third** fraction is 480 min/1 so that it matches the denominator before it. **An alternate** to changing min to hr is to enter the conversion 60 min/1 hr, and enter 8 hr/1 to match the denominator before it. Cancel if possible, and perform the mathematical process.

Note: Some problems for calculating an unknown may be solved without using the formula method or dimensional analysis; however, the use of one or the other is recommended.

POINTS TO REMEMBER

Determining the Unknown

- • Use the IV formula and place the information given into the position of the formula.

Use *x* for unknown values.

- 1. For determining time—place an *x* in the minutes position, and then divide the minutes by 60 to determine the time in hours.
- 2. For volume—place an *x* in the position for amount of solution and label *x* mL. Convert the hours to minutes.

- • Set up an algebraic equation and solve for *x*.
- • Answers for time are labeled in hours, with mL for volume, unless instructed otherwise.
- • Dimensional analysis can also be used to determine the unknown.

PRACTICE PROBLEMS

Solve for the unknown in the following problems as indicated.

- 31. You find that there is 150 mL of D_5W left in an IV. The IV is infusing at 60 microgtt/min. How many hours will the fluid last? _____
- 32. 0.9% NS is infusing at 35 macrogtt/min. The drop factor is 15 gtt/mL. How many milliliters of fluid will the client receive in 5 hours? _____
- 33. There is 90 mL of D_5 0.33% NS left in an IV that is infusing at 60 microgtt/min. The drop factor is 60 gtt/mL. How many hours will the fluid last? _____

Answers on 541

Recalculating an IV Flow Rate

Flow rates on IVs change when a client stands, sits, or is repositioned in bed if IVs are infusing by gravity. Therefore, nurses must frequently check the flow rates. Sometimes IVs infuse ahead of schedule, or they may be behind schedule if they are not monitored closely. When this happens, the IV flow rate must be recalculated. To recalculate the flow rate, the nurse uses the volume remaining and the time remaining. Recalculation may be done with uncomplicated infusions. IVs that require exact infusion rates should be monitored by an electronic infusion device.

SAFETY ALERT!

Never arbitrarily increase or decrease an IV to get it back on schedule without assessing a client and checking with the prescriber. Increasing or decreasing the rate without thought can result in serious harm to a client, including overhydration or underhydration. Check the policy of the institution. Avoid off-schedule IV rates by regularly monitoring the IV at least every 30 to 60 minutes.

When an IV is significantly ahead of or behind schedule, you may need to notify the prescriber, depending on the client's condition and the use of appropriate nursing judgment. **Always assess the client** before making any change in an IV rate. Changes depend on the client's condition. Check the institution's policy regarding the percentage of adjustment that can be made. Each situation must be individually evaluated, and appropriate action must be taken.

A safe rule is that the recalculated flow rate should not vary from the original rate by more than 25%. If the recalculated rate varies by more than 25% from the original rate, the prescriber should be notified. The order may require revision. If a client is stable, recalculate the IV rate, using the remaining volume and time, and then proceed to calculate gtt/min using the formula method or dimensional analysis. Refer to content in this chapter (calculating gtt/min) if necessary. Let's go over the steps to recalculate an IV rate if allowed by your institution policy, and the client is stable.

To recalculate an IV flow rate:

- • Use the remaining volume and remaining hours, and calculate the rate in mL/hr.

- • Use the mL/hr to calculate gtt/min for the recalculated rate, using the formula or the shortcut method:

- • Shortcut method:

- • Determine whether the new rate calculation is greater or lesser than 25%. Use the amount of increase or decrease divided by the original rate.

= % of change of original rate (round to nearest whole percent)

Let's look at some examples. ***Note:*** All examples assume the institution allows a 25% IV flow variation, and the clients are stable.

Example 1: 1,000 mL of D_5 RL was to infuse in 8 hr at 31 gtt/min (31 macrogtt/min). The drop factor is 15 gtt/mL. After 4 hr, you notice 700 mL of fluid left in the IV. Recalculate the flow rate for the remaining solution. ***Note:*** The infusion is behind schedule. After 4 hr, half of the volume (or 500 mL) should have infused.

Solution:

Solution to Example 1: Using the Shortcut Method

Determine recalculated rate:

Time remaining: 8 hr – 4 hr = 4 hr

Time remaining: 8 hr – 4 hr = 4 hr

Volume remaining: 1,000 mL – 300 mL = 700 mL

Volume remaining: 1,000 mL – 300 mL = 700 mL

700 mL ÷ 4 hr = 175 mL/hr

700 mL ÷ 4 hr = 175 mL/hr

Drop factor: 15 gtt/mL; therefore the drop factor constant is 4.

Drop factor: 15 gtt/mL; therefore the drop factor constant is 4.

x = 44 gtt/min; 44 macrogtt/min (recalculated rate)

x = 44 gtt/min; 44 macrogtt/min (recalculated rate)

Determine the percentage of the change:

Dimensional Analysis

Course of Action

Assess the client.

Notify the prescriber.

Do not increase the IV rate; the increase is **greater than 25%.**

Increasing the IV could result in serious consequences for the client. Assessment of the client is always done first to determine the client's ability to tolerate an increase in fluid. In this situation the prescriber should be notified, a new order is needed, the recalculated rate is greater than 25%.

Example 2 (IV Ahead of Schedule): An IV of 1,000 mL D_5W is to infuse from 8 am to 4 pm (8 hr). The drop factor is 10 gtt/mL. The rate is set at 20 gtt/min (20 macrogtt/min). In 5 hr, you notice that 700 mL has infused. Recalculate the flow rate for the remaining solution.

Solution:

Shortcut Method

Determine recalculated rate:

Time remaining: 8 hr – 5 hr = 3 hr

Volume remaining: 1,000 mL – 700 mL = 300 mL

300 mL ÷ 3 = 100 mL/hr

Drop factor: 10 gtt/mL; therefore the drop factor constant is 6.

x = 17 gtt/min; 17 macrogtt/min (recalculated rate)

x = 17 gtt/min; 17 macrogtt/min (recalculated rate)

Determine the percentage of change:

Dimensional Analysis

Time remaining: 8 hr – 5 hr = 3 hr

Volume remaining: 1,000 mL – 700 mL = 300 mL

x = 17 gtt/min; 17 macrogtt/min

x = 17 gtt/min; 17 macrogtt/min

Course of Action

Assess the client.

Adjust the rate if allowed by institutional policy, and assess during the remainder of the infusion.

Notify prescriber if required.

In this situation, the flow rate must be decreased from 20 gtt/min (20 macrogtt/min) to 17 gtt/min (17 macrogtt/min), and the change is not greater than 25% of the original rate. –15% is within the acceptable 25% of change. However, the client's condition must still be assessed to determine the ability to tolerate the change, and the prescriber may still require notification.

Alternate to Determining the Percentage of Change

As already stated, you can adjust the flow rate as much as (+) or (–)25%. Think 25% = ¼. Therefore you can verify the safety of the recalculated rate by using a method that eliminates the need to use percents. To do this, do the following:

- • Divide the original rate by 4, then add, and subtract the result from the original rate. This will provide a range for the acceptable rate adjustment. Let's use the two examples we just did.

Example 1:

The original rate was 31gtt/min (macrogtt/min), and the recalculated rate is 44 gtt/min (macrogtt/min).

Original rate ± (original rate ÷ 4) = Acceptable IV rate adjustment

31 + (31 ÷ 4) = 31 + 7.75 = 38.75 = 39 gtt/min (macrogtt/min)

31 – (31 ÷ 4) = 31 – 7.75 = 23.25 = 23 gtt/min (macrogtt/min)

The safe acceptable IV rate adjustment is 23 to 39 gtt/min (macrogtt/min). 44 gtt/min is above the acceptable adjustment range, and 25%. The prescriber should be notified to provide a new order.

Example 2:

The original rate was 20 gtt/min (macrogtt/min), and the recalculated rate is 17 gtt/min (17 macrogtt/min).

Original rate ± (original rate ÷ 4) = Acceptable IV rate adjustment

20 + (20÷ 4) = 20 + 5 = 25 gtt/min (macrogtt/min).

20 – (20 ÷ 4) = 20 – 5 = 15 gtt/min (macrogtt/min).

The safe acceptable IV rate adjustment is 15 to 25 (macrogtt/min). It is safe to slow the rate to 17 gtt/min (macrogtt/min), which is less than 25%.

POINTS TO REMEMBER

- • Monitor IV therapy every 30 to 60 min to maintain the ordered IV rate.
- • Do not arbitrarily speed up or slow down an IV that is behind or ahead of schedule.
- • Know the hospital policy regarding recalculation of IV flow rate. An IV should not vary more than 25% from its original rate.
- • To recalculate an IV rate:
- • Determine mL/hr:
-

- • Use mL/hr and recalculate the rate in gtt/min, using formula or shortcut method.

- • Determine the % of change
-
  = % of change (rounded to the nearest whole %)
- • Alternate to use of percent: Divide the original rate by 4, then add and subtract the result from the original rate to get the acceptable IV rate adjustment.
- • Contact the prescriber for a new IV order, if the recalculated rate exceeds 25%.

PRACTICE **PROBLEMS**

For each of the problems, recalculate the IV flow rates in gtt/min rates using either method presented, determine the percentage of change, and state your course of action. *Note:* The institution allows 25% variation and clients are stable.

- 34. 500 mL of 0.9% NS was ordered to infuse in 8 hr at the rate of 16 gtt/min (16 macrogtt/min). The drop factor is 15 gtt/mL. After 5 hr, you find 250 mL of fluid left.
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 35. 250 mL of D_5W was to infuse in 3 hr at the rate of 21 gtt/min (21 macrogtt/min). Drop factor: 15 gtt/mL. With 1½ hr remaining, you find 200 mL left.
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 36. 1,000 mL D_5 0.33% NS was to infuse in 12 hr at 28 gtt/min (28 macrogtt/min). After 4 hr, 250 mL has infused. Drop factor: 20 gtt/mL
  - a. _____ gtt/min
  - b. _____ % variation
  - c. _____ Course of action
- 37. 500 mL D_5 0.9% NS to infuse in 5 hr at 100 gtt/min (100 microgtt/min). After 2 hr, 250 mL has infused. Drop factor: 60 gtt/mL

- a. _____ gtt/min
- b. _____ % variation
- c. _____ Course of action

Answers on pp. 541-542

Calculating Infusion and Completion Time

IV fluids are ordered by the prescriber for administration indicating a specific rate in mL/hr, such as 1,000 mL D_5W to infuse at 100 mL/hr. **The nurse needs to be able to determine the amount of time (hours and minutes) that it would take for a certain volume of IV solution to infuse, which is referred to as *infusion time*.** Knowing the infusion time is important for the nurse, which includes reasons such as allowing the preparation for hanging a new solution as one infusion is being completed and preventing things such as the line clotting off as a result of not knowing when an IV was to be completed. Infusion times can be calculated using any of the following methods:

- • Ratio and proportion: The known ratio, which is written first, is the ordered rate in mL/hr, and the second ratio is the unknown, which is the total number of mL to infuse in *x* hr, total mL/*x* hr. The ratio and proportion can be written in linear or fraction format.
- • Formula method:

  = Infusion time
- • Dimensional analysis: The unknown is *x* hr; therefore the first fraction will be the ordered rate, hr/mL, the second fraction will be total mL/1.

Let's look at some examples of calculating infusion time.

Example 1: Calculate the infusion time for an IV of 1,000 mL D_5W to infuse at a rate of 125 mL/hr.

Ratio and Proportion (Linear Format)

Formula Method

1,000 mL (total mL to infuse)

125 mL/hr (mL/hr to infuse)

Infusion time = 8 hr

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

Dimensional Analysis

x = 8 hr

mL is cancelled here, leaving hr.

When an infusion time result is not an even whole number but instead the infusion rate includes a decimal fraction; the decimal fraction represents a fraction of an hour and must be converted to minutes. This calculation of infusion time is done as follows:

- • Determine the infusion time using any of the methods already presented, and carry division two decimal places.
- • Calculate the minutes using, conversion factor; 60 min = 1 hr. (Multiply the fraction of an hr by 60 min/hr) or use any of the methods presented.
- • Using the rules of rounding, round the minutes to the nearest whole number of minutes.

Let's look at an example.

Example 2: 1,000 mL D_5 ½ NS to infuse at 150 mL/hr. Calculate the infusion time for the IV.

Ratio and Proportion (Linear Format)

- • Determine the infusion time
- 150 mL : 1 hr = 1,000 mL : x hr
-
- • Calculate the minutes
- 1 hr : 60 min = 0.66 hr : x min
- x = 0.66 × 60 = 39.6
- x = 40 min (rounded to whole number)
- Infusion time is 6 hr and 40 min.

Formula Method

- • Determine infusion time

-

- x = 6.66 hr
- • Calculate the minutes

- Infusion time is 6 hr and 40 min.

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

- • Determine infusion time

-

- x = 6.66 hr
- • Calculate the minutes

-

- x = 40 min

Infusion time is 6 hr and 40 min.

Dimensional Analysis

- • Determine infusion rate

-

- x = 6.66 hr
- • Calculate the minutes

- x = 40 min
- Infusion time is 6 hr and 40 min.

Completion Time

Once the infusion time has been calculated, the nurse can use this information to determine the completion time. Completion time is the when the infusion is completed (i.e., the client has received all of the IV fluid). This would be determined as follows: Add the calculated infusion time to the time the infusion was started. If the IV was started at 7:00 am, add the 6 hours and 40 minutes to that time (7:00 am). The IV would be completed at 1:40 pm. It is easier to calculate completion time using military time: 7:00 am = 0700; now add 6 hours and 40 minutes to arrive at the answer of 1340.

- Start time 0700
- Infusion time +0640
- **Completion time:** 1340 or 1:30 pm

Calculating Completion Time

To calculate the completion time, add the infusion time to the time the IV was (military time).

Note: Converting traditional time to military time, and a discussion of completion time, appears in Chapter 8.

Let's look at some examples.

Example 1: An IV of 1,000 mL of D_5W is started at 1000 to infuse over 8 hr. Determine the completion time.

Solution:

- Start time 1000
- Infusion time +0800

Completion time: 1800 or 6:00 pm

Example 2: An IV of 1,000 mL of 0.9% NS is started at 2130 to infuse over 12 hr. Determine the completion time.

Solution:

- Start time 2130
- Infusion time +1200
- 3330 (time here is greater than 2400)

As you recall, when the time period is greater than 2400, you must subtract 2400 from the total (the day ends at 2400). This will give you the completion time for the next day.

Using the answer from the problem, which is 3330

Subtract –2400

Subtract −2400

Completion time: 0930 or 9:30 am the next day

Completion time: 0930 or 9:30 am the next day

Example 3: An IV of D_5½ NS is started at 0430 to infuse in 6 hr and 40 min. Determine the completion time.

Solution:

- Start time 0430
- Infusion time +0640
- 1070 (the minutes here are greater than 60)

As you recall, when the minutes are greater or equal to 60, subtract 60 from the number of minutes, which in this example is 70 min, and then add the 1 hour obtained when you subtracted the 60 minutes to get the completion rate, as follows:

- 1070
- −0060 minutes (1 hr)
- 1010
- +0100 (the 1 hr obtained when you subtracted the 60 min)

Completion time: 1110 or 11:10 am

Alternate to Example 3:

- Add start time: 0430
- Infusion time +0640
- Convert 70 min to 1 hr and 10 min and add to 10 hr. 1000
- +0110
- **Completion time:** 1110 or 11:10 am

As you will notice in the examples provided, you were given the infusion time as well as the time for the infusion to start in military time. Let's look at an example in which you will need to determine the infusion time before calculating the completion time.

Example 4:

500 mL D_5W to infuse at 80 mL/hr is started at 7:30 am. Determine the completion time. State time in military and traditional time.

Solution:

- • First determine the infusion time using any of the methods already presented (ratio and proportion, formula method, or dimensional analysis)

Ratio and Proportion (Linear Format)

80 mL : 1 hr = 500 mL : x hr

$80x = 500$

$x = 6.25$ hr

Calculate the minutes.

1 hr : 60 min = 0.25 hr : x min

$x = 0.25 \times 60 = 15$

$x = 15$ min

Infusion time is 6 hr and 15 min.

Formula Method

Calculate the minutes.

Infusion time is 6 hr and 15 min.

Ratio and Proportion (Fraction Format)

Solve by cross-multiplication.

$x = 6.25$ hr

Calculate the minutes.

$x = 15$ min

Infusion time is 6 hr and 15 min.

Dimensional Analysis

Calculate the minutes:

Infusion time is 6 hr and 15 min.

- • Now determine the completion time (add the infusion time to the start time).
  - Start time: 0730
  - Infusion time:

= 1:45 pm

Note: The start time (7:30 am) was changed to military time: to convert am time omit colon and am, add a zero to beginning to make a 4-digit number. To convert pm time to traditional time, subtract 1200 and add pm. If necessary, review the conversion of time (traditional and military) in Chapter 8.

PRACTICE PROBLEMS

Determine infusion and completion time for the following IVs. State the time in traditional and military time.

- 38. An IV of 500 mL NS is to infuse at 60 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 10:00 pm. When would the IV infusion be completed? _____
- 39. An IV of 250 mL D_5W is to infuse at 80 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 2:00 am. When would the IV infusion be completed? _____
- 40. An IV of 1,000 mL D_5 RL is to infuse at 60 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 6:00 am. At what time would this IV infusion be completed? _____

- 41. An IV of 500 mL D_5W is to infuse at 75 mL/hr.
  - a. Determine the infusion time. _____
  - b. The IV was started at 2:00 pm. At what time would the IV infusion be completed? _____

Answers on 542

unknown - Section 40 (Page 378)

Calculating Infusion Time When Rate in mL/hr Is Not Indicated for Large Volumes of Fluid

There are situations in which the prescriber may order the IV solution and not indicate the rate in mL/hr. The only information may be the total number of milliliters to infuse, the flow rate (gtt/min) of the IV, and the number of gtt/mL that the tubing delivers. In this situation, before the infusion time is calculated, the following must be done:

- • Convert gtt/min to mL/min.
- • Convert mL/min to mL/hr.
- • Use the formula or other methods shown to determine the infusion time.

Example: A client is receiving 1,000 mL of RL. The IV is infusing at 21 macrogtt/min (21 gtt/min). The administration set delivers 10 gtt/mL. Calculate the infusion time.

Step 1: Change gtt/min to mL/min.

Ratio and Proportion (Linear Format)

10 gtt : 1 mL = 21 gtt : *x* mL

10x10=2110

x = 2.1 mL/min

Note: Ratio and proportion could also be set up in fraction format.

Step 2: Convert mL/min to mL/hr.

Step 3: Calculate the infusion time.

Convert hr to min.

Infusion time is 7 hr and 56 min.

Solution Using Dimensional Analysis

x hr is being calculated. The **first fraction** is 1 hr/60 min; the **second fraction** is written so that min is in the numerator: 1 min/21 gtt. The **third fraction** is written so that it matches the denominator of the second fraction; the drop factor is written 10 gtt/mL. **The final fraction** is written so that the denominator matches the proceeding fraction. The mL is provided by the volume to infuse (1,000 mL), the fraction is written 1,000 mL/1.

Calculate the infusion time.

Convert hr to minutes.

Infusion time is 7 hr and 56 min.

PRACTICE PROBLEMS

Determine the infusion time for the following IVs.

- 42. A client is receiving 250 mL of NS at 17 macrogtt/min. Drop factor: 15 gtt/mL _____
- 43. A client is receiving 1,000 mL D_5W at 20 macrogtt/min. Drop factor: 10 gtt/mL _____
- 44. A client is receiving 100 mL D_5W at 10 macrogtt/min. Drop factor: 15 gtt/mL _____

Answers on pp. 542-543

Calculating Infusion Time for Small Volumes of Fluid

There may be times when it is necessary for the nurse to determine the infusion time for small volumes of fluid that will infuse in less than an hour. To do this the nurse must first do the following:

- • Calculate the mL/min.
- • Divide the total volume by the mL/min to obtain the infusion time. The infusion time will be in minutes.

Example: An IV antibiotic of 30 mL is infusing at 20 macrogtt/min. Drop factor is 10 gtt/mL. Determine the infusion time.

Step 1: Calculate the mL/min.

10 gtt :1 mL = 20 gtt : *x* mL

10x10=2010

x = 2 mL/min

Step 2: Divide the total volume by mL/min to determine the infusion time.

Infusion time is 15 min.

Solution Using Dimensional Analysis

Since a small volume is being infused in less than 1 hr and there is a drop factor the time will be in minutes. The conversion factor 60 min = 1 hr is not needed.

Infusion time is 15 min.

PRACTICE **PROBLEM**

Determine the infusion time for the following:

- 45. An IV medication of 20 mL is infusing at 35 microgtt/min. Drop factor: 60 gtt/mL _____

Answers on 543

Monitoring the Infusion of IV Solutions

Whether a client is receiving fluids by gravity or with the use of an infusion device, the nurse has the responsibility to monitor the client to ensure the right fluid is infusing at the right rate. When the client is receiving IV fluids by infusion pump, the rate is set in mL/hr and the pump delivers the amount each hour that it is programmed to deliver. When IVs infuse by gravity, the nurse often monitors the IV therapy visually. The IV bag is marked in increments of 50 to 100 mL and provides a visual for the nurse that includes the amount of fluid that has infused and the amount remaining in the bag. Some health care institutions use a commercially prepared label on IVs, referred to as flow meter, and time tape, which is a strip of paper applied to the IV bag. The flow meter and time tape include information such as starting time for the IV and the ending time. These strips applied to the side of the IV bag allow the nurse to visually identify the hourly fluid level.

Charting IV Therapy

The documentation of IV therapy varies from institution to institution. Some institutions chart IV therapy on a special record or flow sheet for IV therapy. Medications that are administered intermittently by IVPB may be charted on medication administration records according to the order (i.e., standing medication, prn). At institutions where a computerized system is used, IV therapy is charted directly into the computer (this includes IV solutions with or without medications). Assessments relating to IV therapy that include the status of the site and complications are also charted on either a form for IV therapy or in the computer. Regardless of what method is used for documentation, it is a nursing responsibility to accurately document all IV therapy that is administered to a client.

POINTS TO REMEMBER

- • The infusion rate can be calculated using ratio and proportion, dimensional analysis, or the formula method:
- Total␣number␣of␣mL␣to␣infusemL/hr(infusion␣rate)=Infusion␣time

- • Express fractional hours for infusion rate in minutes using 60 min = 1 hr. Multiply the fractional hour by 60 min/hr, and round to the nearest whole number.
- • To calculate the completion time, add the start time and infusion time. Time can be stated as military or traditional time.
- • Calculation of completion times provides the nurse with the opportunity to plan ahead, (i.e., having the next IV solution ready to hang once solution is completed).
- • Monitoring of IV fluids is a nursing responsibility. Tape and flow meters allow for a visual of the status of IV infusions.

IV Push Medications

When medications are administered by IV push (IVP), the medication is injected directly into a vein, the medication is rapidly absorbed in the bloodstream, and the client experiences a rapid result from the medication. Several terms are used for IVP, including IV bolus and direct IV injection. IVP administration is used to deliver diluted and undiluted medication over a brief period (seconds or minutes). Drug references provide the acceptable rate for IV push medication administration. Because of the rapidity of action, an error in calculation can result in a serious outcome for the client. Most IV push medications should be administered over a period of 1 to 5 minutes (or longer), depending on the medication. The volume of the prescribed medication should be calculated in increments of 15 to 30 seconds. This allows for the use of a watch to provide accurate administration.

The prescriber orders the medication, dosage, route, frequency, and time to administer a medication for IVP. To ensure client safety, the nurse should always consult a drug reference for the following:

- • The recommended rate for administering the medication
- • The directions for dilution of the medication including, the amount and type of solution

SAFETY ALERT!

Never infuse IV push medications more rapidly than recommended. Carefully read the drug reference for proper dilution, and the time for administration of medications IV push. IV medications are potent and rapid acting.

Administration of Medications by IV Push

Injection ports on IV tubing can be used for direct injection of the medication with a syringe which is called IV push. When using the primary line, administer the medication through the port closest to the client. An IV push medication can also be administered using a saline or heparin lock, which can be attached to the IV catheter. A saline lock indicates that saline is used to flush or maintain IV catheter patency, whereas a heparin lock indicates that heparin is used to maintain the IV catheter patency. Know the policy of the institution regarding the use of saline or heparin. Medications can be administered IV push by attaching the syringe to the lock and pushing in the medication. The lock is usually flushed after administration of the medication. Medications can be administered by IV push by registered nurses who have been specially trained in this practice at some institutions. The actual administration of IV push medications is beyond the scope of this text. For a detailed description on the technique, consult a clinical skills textbook or view the skill online. This text provides a brief discussion of medications by IV push and some examples.

SAFETY ALERT!

Remember heparin is a **high-alert medication.** Heparin lock flush solution is usually in dosage strengths of 10 or 100 units per mL. **Always read** the label carefully. Know the agency policy for the use of heparin to maintain an IV lock.

When administering medications by direct IV infusion, remember the following:

- • **The compatibility of the IV solution and the medication must be verified.**
- • The tubing will require a flush after direct administration to ensure that all the medication has been given and none remains in the tubing.
- • The amount of time needed to administer a medication by direct IV infusion can be determined by using ratio and proportion or dimensional analysis. Let's look at some examples.

Example 1: Order: 200 mg of a medication IV push stat.

Available: The medication available is 300 mg per 2 mL.

The literature recommends diluting the medication to a total of 20 mL. Compatible solution recommended is sodium chloride (0.9%) injection. Inject over a period of not less than 2 minutes. An injection time of 5 minutes is ordered.

- a. How many mL of the medication will you administer?
- b. How many mL of sodium chloride must you add to obtain the desired volume?
- c. To administer the infusion in 5 minutes, how many mL should you infuse every minute?
- d. How much should you infuse every 15 seconds?
    - a. First determine the number of mL to administer the dosage.

Ratio and Proportion (Linear Format)

300 mg : 2 mL = 200 mg : x mL

$300x = 200 \times 2$

300x300=400300=1.33

$x = 1.3$ mL

Formula Method

200mg300mg ×2mL=xmL

Dimensional Analysis

Ratio and Proportion (Fraction Format)

300mg2mL =200mgxml

1.3 mL would be equal to 200 mg of the medication

b. According to the literature, the total volume of the diluent and medication is 20 mL. If the literature stated to dilute in 20 mL, then the total volume would be the medication and the diluent.

20 mL (desired diluent)

–1.3 mL (medication dosage)

18.7 mL (amount of diluent to add)

18.7 mL of sodium chloride is needed to obtain the desired volume.

c. Determine the number of mL to administer the infusion in 1 minute.

Ratio and Proportion (Linear Format)

20 mL : 5 min = *x* mL : 1 min

5*x* = 20

5x5=205=4

x = 4 mL per min

Ratio and Proportion (Fraction Format)

20mL5min=xmL1min

Dimensional Analysis

Place the desired unit mL to the left of the equal sign. Place the mL ordered as the first fraction (20 mL in 5 min); place mL in the numerator, place 1 min in the numerator of the next unit.

4 mL per min to administer the infusion in 5 min.

d. Determine the volume to infuse every 15 sec.

Ratio and Proportion (Linear Format)

4 mL : 60 sec = *x* mL : 15 sec

60*x* = 4 × 15

60x60=6060=1

x = 1 mL every 15 sec

Ratio and Proportion (Fraction Format)

4mL60sec=xmL15sec

Dimensional Analysis

Note: In this question you are asked to determine sec. (Express 4 mL per min as 4 mL per 60 sec. 60 sec = 1 min. The starting fraction would be 4 mL/60 sec.)

Alternate format: To use 4 mL/min; however, you would need to add 1 min/60 sec to the equation and the setup would be as follows:

Example 2: Order: Ativan 3 mg IV push stat

Available: Ativan 4 mg per mL

The literature states: not to exceed 2 mg/min.

- a. How many mL of Ativan will you prepare? (Express answer in hundredths.)
- b. How many min would it take to administer the medication as ordered?
    - • a. First calculate the dosage to be administered using ratio and proportion, dimensional analysis, or formula method.

Ratio and Proportion (Linear Format)

4 mg : 1 mL = 3 mg : x mL

4x = 3

4x4=34=0.75mL

x = 0. 75 mL

Formula Method

3mg4mg×1mL=xmL

Dimensional Analysis

Ratio and Proportion (Fraction Format)

4mg1mL=3mgxmL

b. Determine the time needed to administer the medication as ordered.

Ratio and Proportion (Linear Format)

2 mg : 1 min = 3 mg : x min

2x = 3

2x2=32=1.5(1½)

x = 1½ min

Ratio and Proportion (Fraction Format)

2mg1min=3mgxmin

1½ min would deliver the medication.

Dimensional Analysis

Note: Use the steps outlined in Example 1.

POINTS TO REMEMBER

IV Push Medications

- • Always verify the compatibility of the medication and the IV solution when administering medications by IV push.
- • Never administer a medication by IV push at a rate faster than recommended. Always read package inserts and reputable medication resources for minimum time for IV administration and dilution.
- • Use ratio and proportion or dimensional analysis to determine the IV push time as recommended by a reputable reference.

PRACTICE PROBLEMS

Calculate the IV push rate as indicated for problems 46-47.

- 46. Order: Valium 20 mg IV push stat at 5 mg/min for a client with seizures.
- Available: Valium 5 mg per mL
    - a. How many milliliters will be needed to administer the dosage? _____
    - b. Determine the time it would take to infuse the dosage. _____
    - c. How many milligrams would you administer every 15 seconds? _____
- 47. Order: Dilantin 150 mg IV push stat.
- Available: Dilantin 250 mg per 5 mL. Literature states IV infusion not to exceed 50 mg/min.
    - a. How much should you prepare to administer? _____
    - b. How much time is needed to administer the required dosage? _____

Answers on 543

CLINICAL **REASONING**

Scenario: An elderly client has an order for 1,000 mL D_5W at 100 mL/hr. The nurse assigned to the client attached IV tubing to the IV with a drop factor of 10 gtt/mL without checking the package of IV tubing. As a habit from a previous institution where she worked, the IV flow rate was calculated based on the drop factor of 20 gtt/mL. At the beginning of the next shift, the nurse making rounds noticed that the client was having difficulty breathing and seemed restless. When the nurse checked the IV rate, she discovered the rate was 33 macrogtt/min instead of 17 macrogtt/min.

- a. What factors contributed to the error? _____
- b. How did the IV rate contribute to the problem and why? _____
- c. What should have been the action of the nurse who attached the IV tubing in relation to IV administration? _____

Answers on 543

CHAPTER **REVIEW**

Calculate the IV flow rate in gtt/min for the following IV administrations, unless another unit of measure is stated.

- 1. 2,500 mL D_5NS to infuse in 24 hr. Drop factor: 10 gtt/mL _____
- 2. 500 mL D_5W to infuse in 4 hr. Drop factor: 15 gtt/mL _____
- 3. 300 mL NS to infuse in 6 hr. Drop factor: 60 gtt/mL _____
- 4. 500 mL D_5 ½ NS over 12 hr. Drop factor: 20 gtt/mL _____

- 5. A unit of whole blood (500 mL) to infuse in 4 hr. Drop factor: 10 gtt/mL _____
- 6. Infuse 2 L RL in 24 hr. Drop factor: 15 gtt/mL _____
- 7. 1,000 mL D_5 0.45% NS in 6 hr. Drop factor: 20 gtt/mL _____
- 8. 250 mL D_5W in 8 hr. Drop factor: 60 gtt/mL _____
- 9. 2 L D_5RL at 150 mL/hr. Drop factor: 15 gtt/mL _____
- 10. 1,500 mL D_5W in 24 hr. Drop factor: 15 gtt/mL _____
- 11. 250 mL D_5W in 10 hr. Drop factor: 60 gtt/mL _____
- 12. Infuse 300 mL of D_5W at 75 mL/hr. Drop factor: 60 gtt/mL _____
- 13. Infuse an IV medication with a volume of 50 mL in 45 minutes. Drop factor: 60 gtt/mL _____
- 14. Infuse 90 mL/hr of NS. Drop factor: 15 gtt/mL _____
- 15. Infuse an IV medication in 100 mL D_5W in 30 minutes. Drop factor: 20 gtt/mL _____
- 16. Infuse 250 mL 0.45% NS in 5 hr. Drop factor: 20 gtt/mL _____
- 17. Infuse Kefzol 0.5 g in 50 mL D_5W in 30 minutes. Drop factor: 60 gtt/mL _____
- 18. Infuse Plasmanate 500 mL over 3 hr. Drop factor: 10 gtt/mL _____
- 19. The prescriber orders the following IVs for 24 hr. Drop factor: 10 gtt/mL
  - • 1,000 mL D_5W c 1 ampule multivitamin (MVI)
  - • 500 mL D_5W
  - • 250 mL D_5W _____
- 20. If 500 mL of D_5W is to infuse in 8 hr, how many milliliters are to be administered per hour? _____
- 21. Infuse 500 mL Intralipids IV in 6 hr. Drop factor: 10 gtt/mL _____
- 22. An IV of 500 mL D_5W with 200 mg of minocycline is to infuse in 6 hr.
- Drop factor: 15 gtt/mL _____
- 23. An IV of D_5W 500 mL was ordered to infuse over 10 hr at a rate of 13 gtt/min (13 macrogtt/min). Drop factor: 15 gtt/mL
- After 3 hr, you notice that 300 mL of IV solution is left. Recalculate the rate in gtt/min for the remaining solution _____ gtt/min
- Determine the percentage of change in IV rate, and state your course of action. _____ %
- 24. An IV of D_5W 1,000 mL was ordered to infuse over 8 hr at a rate of 42 gtt/min (42 macrogtt/min).
- Drop factor: 20 gtt/mL
- After 4 hr, you notice that only 400 mL has infused. Recalculate the rate in gtt/min for the remaining solution. _____ gtt/min
- Determine the percentage of change, and state your course of action. _____ %
- 25. An IV of 1,000 mL D_5 1/2 NS has been ordered to infuse at 125 mL/hr.
- Drop factor: 15 gtt/mL
- The IV was hung at 7 am. At 11 am, you check the IV, and there is 400 mL left. Recalculate the rate in gtt/min for the remaining solution. _____ gtt/min
- Determine the percentage of change, and state your course of action. _____ %
- 26. 900 mL of RL is infusing at a rate of 80 gtt/min (80 macrodrops/min).
- Drop factor: 15 gtt/mL
- How long will it take for the IV to infuse? (Express time in hours and minutes.) _____
- 27. 1,000 mL of D_5W is infusing at 20 gtt/min (20 macrogtt/min).
- Drop factor: 10 gtt/mL
- How long will it take for the IV to infuse? (Express time in hours and minutes.) _____
- 28. 450 mL of NS is infusing at 25 gtt/min (25 macrogtt/min).
- Drop factor: 20 gtt/mL
- How many hours will it take for the IV to infuse? _____
- 29. An IV is regulated at 25 gtt/min (25 macrogtt/min).
- Drop factor: 15 gtt/mL
- How many milliliters of fluid will the client receive in 8 hr? _____
- 30. An IV is regulated at 30 gtt/min (30 macrogtt/min).
- Drop factor: 15 gtt/mL
- How many milliliters of fluid will the client receive in 5 hr? _____
- 31. 10 mEq of potassium chloride is placed in 500 mL of D_5W to be administered at the rate of 2 mEq/hr. At what rate in mL/hr should the IV infuse? _____
- 32. Order: Humulin regular 7 units/hr. The IV solution contains 50 units of Humulin regular insulin in 250 mL of 0.9% NS. At what rate in mL/hr should the IV infuse? _____
- 33. Order: Humulin regular U-100 11 units/hr. The IV solution contains 100 units of Humulin regular insulin in 100 mL of 0.9% NS. At what rate in mL/hr should the IV infuse? _____
- 34. Infuse gentamicin 65 mg in 150 mL 0.9% NS IVPB over 1 hr.

- Drop factor: 10 gtt/mL
- At what rate in gtt/min should the IV infuse? _____
- 35. Infuse ampicillin 1 g that has been diluted in 40 mL 0.9% NS to infuse in 40 minutes.
- Drop factor: 60 gtt/mL
- At what rate in gtt/min should the IV infuse? _____
- 36. 50 mL of 0.9% NS with 1 g ampicillin is infusing at 50 microgtt/min (50 gtt/min).
- Drop factor: 60 gtt/mL
- Determine the infusion time. _____
- 37. 500 mL RL is to infuse at a rate of 80 mL/hr. If the IV was started at 7 pm,
- what time will the IV be completed? _____
- State time in military and traditional time. _____
- 38. A volume of 150 mL of NS is to infuse at 25 mL/hr.
    - a. Calculate the infusion time. _____
    - b. The IV was started at 3:10 am.
    - What time will the IV be completed? State time in traditional and military time. _____
- 39. The doctor orders 2.5 L of D_5W to infuse at 150 mL/hr. Determine the infusion time. _____
- 40. Order: Lasix 120 mg IV stat.
- Available: 10 mg per mL. The literature states IV not to exceed 40 mg/min.
    - a. How many milliliters will you prepare? _____
    - b. Calculate the time required to administer the medication as ordered. _____
- 41. 500 mL D_5W with 30,000 units of heparin to infuse at 1,500 units per hour.
- Determine rate in mL/hr. _____
- 42. Order: Humulin regular 20 units per hr. The IV solution contains 100 units of Humulin Regular in 500 mL of 0.9% NS.
- At what rate in mL/hr should the IV infuse? _____
- 43. Order: Infuse Cefazolin 1 g in 100 mL 0.9% NS over 40 min by infusion pump. _____
- 44. Order: Infuse Vancomycin 1 g in 200 mL D_5W over 90 min by infusion pump. _____
- 45. An IV of 1,000 mL of D_5W is started 1045 to infuse over 8. hr. What is the completion time of the IV? (State time in military and traditional time.) _____
- 46. 1,000 mL 0.9% NS was started at 2100 to infuse at 80 mL/hr. Determine the infusion and completion time. (State in military and traditional time.) _____

Answers on pp. 543-547

For additional practice problems, refer to the Intravenous Flow Rates section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

ANSWERS

Chapter 21

Answers to Practice Problems

- 1. x mL/hr = 1,800mL24hr

; x = 75 mL/hr

- 2. x mL/hr = 2,000mL24hr

= 83.3; x = 83 mL/hr

- 3. x mL/hr = 500mL12hr

= 41.6; x = 42 mL/hr

- 4. x mL/hr = 1,500mL24hr

= 62.5; x = 63 mL/hr

- 5. x mL/hr = 750mL16hr

= 46.8; x = 47 mL/hr

- 6. macrodrop
- 7. microdrop
- 8. macrodrop

NOTE

Some problems related to calculating gtt/min can be calculated using the formula method, dimensional analysis, or the formula method, with hours converted to minutes where indicated.

- 9. $\frac{x \text{ gtt/min}}{75 \text{ mL}} \times \frac{10 \text{ gtt/mL}}{60 \text{ min}} = \frac{}{75} \times \frac{10}{60} = \frac{}{16} = 756$
- $x = 756 = 12.5$
- x = 13 gtt/min; 13 macrogtt/min
- 10. $\frac{x \text{ gtt/min}}{30 \text{ mL}} \times \frac{60 \text{ gtt/mL}}{60 \text{ min}} = \frac{}{30} \times \frac{60}{60} = \frac{}{30} \times \frac{1}{1} = 301$
- $x = 301; x = 30$
- x = 30 gtt/min; 30 microgtt/min
- 11. Step 1: Calculate mL/ hr.
- x mL/hr = $\frac{1{,}000 \text{ mL}}{6 \text{ hr}}$

= 166.6

- x = 167
- Step 2: Calculate gtt/min.

- xgtt/min=167mL×15gtt/mL60min=167×1560=167×14=1674

- x=1674=41.7

- *x* = 42 gtt/min; 42 macrogtt/min
- 12. xgtt/min=60mL×60gtt/mL45min=60×6045=60×43=2403

- x=2403;x=80

- *x* = 80 gtt/min; 80 microgtt/min
- 13. Step 1: Calculate mL/ hr.
- *x* mL/hr = 1,000mL16hr

  = 62.5; *x* = 63 mL/hr
- Step 2: Calculate gtt/min.

- xgtt/min=63mL×15gtt/mL60min=63×1560=63×14=634

- x=634=15.7=16

- *x* = 16 gtt/min; 16 macrogtt/min
- 14. Step 1: Calculate mL/ hr.
- *x* mL/hr = 3,000mL24hr;x=125mL/hr

- Step 2: Calculate gtt/min.
- xgtt/min=125mL×10gtt/mL60min=125×1060=125×16=1256

- x=1256=20.8=21

- *x* = 21 gtt/min; 21 macrogtt/min
- 15. Step 1: Calculate mL/ hr.

- xmL/hr=2,000mL12hr=166.6=167

- *x* = 167 mL/ hr
- Step 2: Calculate gtt/min.
- xgtt/min=167mL×15gtt/mL60min=167×1560=167×14=1674

- x=1674=41.7=42

- *x* = 42 gtt/min; 42 macrogtt/min
- 16. Step 1: Determine the drop factor constant.
- 60 ÷ 10 = 6
- Step 2: Calculate gtt/min.
- xgtt/min=200mL/hr6=33.3=33

- *x* = 33 gtt/min; 33 macrogtt/min
- 17. Step 1: Determine the drop factor constant.
- 60 ÷ 10 = 6
- Step 2: Calculate gtt/min.

- xgtt/min=140mL/hr3=46.6=47

- *x* = 47 gtt/min; 47 macrogtt/min
- 18. Step 1: Determine mL/ hr.
- xgtt/min=1,000mL10hr;x=100mL/hr

- Step 2: Determine the drop factor constant.
- 60 ÷ 10 = 6
- Step 3: Calculate gtt/min.
- xgtt/min=100mL/hr6=16.6=17

- *x* = 17 gtt/min; 17 macrogtt/min
- 19. Remember that small volumes are multiplied and expressed in mL/ hr.
- Step 1: Determine mL/hr.
- 40 mL/20 min = 40 × 3 (3 × 20 min)
- = 120 mL/hr
- Step 2: Determine the drop factor constant.
- 60 ÷ 10 5 6
- Step 3: Calculate gtt/min.
- xgtt/min=120mL/hr6=20

- *x* = 20 gtt/min; 20 macrogtt/min
- 20. Step 1: Determine mL/ hr.

- xmL/hr=2,500mL16hr=156.2=156

- Step 2: Calculate gtt/min.
- xgtt/min=156mL×10gtt.mL60min=156×1060=156×16=1566

- x=1566=26

- *x* = 26 gtt/min; 26 macrogtt/min
- 21. xgtt/min=100mL×60gtt/mL60min=100×6060=100×11=1001

- x=1101=100

- *x* = 100 gtt/min; 100 microgtt/min

- 22. xgtt/min=250mL×10gtt/mL60min=250×10060=250×16=2506

- x=2506=41.6=42

- *x* = 42 gtt/min; 42 macrogtt/min
- 23.
    - a. 1 g : 10 mL = 1 g : *x* mL
    - *or*
    - 1g1g×10mL=xmL

    - *x* = 10 mL
    - Answer: 10 mL. The dosage ordered is contained in a volume of 10 mL. 10 mL of medication is added to the 50 mL of IV solution to give a total of 60 mL.
    - b. xgtt/min=60mL×10gtt/mL45min=60×1045=60×29=1209

    - x=1209=13.3=13

    - *x* = 13 gtt/min; 13 macrogtt/min

- 24.
  - a. 150 mg : 1 mL = 900 mg : *x* mL
  - *or*
  - 900mg150mg×1mL=xmL

  - *x* = 6 mL
  - Answer: 6 mL. The dosage ordered is more than the available strength; therefore more than 1 mL is needed to administer the dosage ordered.
  - Alternate solution:
  - 300 mg : 2 mL = 900 mg : *x* mL
  - *or*

    900mg300mg×2mL=xmL

  - This setup would net the same answer.
  - b. *x* gtt/min =

    75mL×10gtt/mL30min=75×1030=75×13=753

    x=753=25

  - *x* = 25 gtt/min; 25 macrogtt/min
- 25.
  - a. 50 mg : 1 mL = 500 mg : *x* mL
  - *or*

    500mg50mg×1mL=xmL

$$x = 10\text{mL}$$

- Answer: 10 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the ordered dosage. The volume of medication is added to the 100 mL of IV solution to get a total of 110 mL.
- b. *x* gtt/min = $110\text{mL} \times \frac{15\text{gtt}}{\text{mL}} \frac{60\text{min}}{} =$

$$\frac{110 \times 15}{60} = \frac{110 \times 1}{4} = \frac{110}{4}$$

$$x = \frac{110}{4} = 27.5 = 28$$

- *x* = 28 gtt/min; 28 macrogtt/min

- 26.
  - a. 50 mg : 10 mL = 20 mg : *x* mL
  - *or*

$$\frac{20\text{mg}}{50\text{mg}} \times 10\text{mL} = x\text{mL}$$

- Answer: 4 mL. The dosage ordered is less than the available strength; therefore you will need less than 10 mL to administer the ordered dosage.
- b. Calculate mL/ hr.

  $$\frac{x \text{ mL}}{\text{hr}} = \frac{300 \text{ mL}}{6 \text{ hr}}; x = 50 \text{ mL/hr}$$

- 27.
  - a. 16 mg : 1 mL = 300 mg : *x* mL
  - *or*

    $$\frac{300 \text{ mg}}{16 \text{ mg}} \times 1 \text{ mL} = x \text{ mL}$$

  - Answer: 18.8 mL (18.75 mL rounded to the nearest tenth). The dosage ordered is more than the available strength; therefore you will need more than 1 mL to administer the ordered dosage.
  - b. *x* gtt/min =

    $$\frac{318.8 \text{ mL} \times 10 \text{ gtt/mL}}{60 \text{ min}} = 318.8 \times \frac{10}{60} = 318.8 \times \frac{1}{6} = 318.86$$

    $$x = 318.86 = 53.1 = 53$$

  - *x* = 53 gtt/min; 53 macrogtt/min

- Alternate solution:
- 160 mg : 10 mL = 300 mg : *x* mL
- *or*

$$\frac{300\text{mg}}{160\text{mg}} \times 10\text{mL} = x\text{mL}$$

- 28.
  - a. 10 mg : 1 mL = 100 mg : *x* mL
  - *or*

$$\frac{100\text{mg}}{10\text{mg}} \times 1\text{mL} = x\text{mL}$$

  - *x* = 10 mL
  - The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the ordered dose. 100 mL of IV fluid and medication volume gives a total of 110 mL.
  - b. *x* gtt/min =

$$\frac{110\text{mL} \times 10\text{gtt/mL}}{60\text{min}} = \frac{110 \times 10}{60} = \frac{110}{6} = 18.3 = 18$$

  - *x* = 18 gtt/min; 18 macrogtt/min
- 29. 15 mEq : 1,000 mL = 2 mEq : *x* mL

$$\frac{15x}{15} = \frac{2{,}000}{15} = 133.3x = 133\text{mL/hr}$$

- *or*

  15mEq1,000mL=2mEqxmL

- Answer: 133 mL/hr to deliver 2 mEq of potassium chloride per hour.
- 30. 50 units : 250 mL = 10 units : *x* mL

  50x50=2,50050x=50mL/hror50units250mL=10unitsxmL

- Answer: 50 mL/hr must be administered for the client to receive 10 units/hr.
- 31.

  60microgtt/min=150mL×60gtt/mLxmin60=150×60x60=9,000x60x60=9,00060x=150minutes

  60 min = 1 hr; 150 min ÷ 60 = 2.5 hr

- Answer: 2½ hr
- 32.

- 33.

60microgtt/min=90mL×60gtt/mLxmin60=90×60x60=5,400x60x60=5,40060x=90minutes

60 min = 1 hr; 90 min ÷ 60 = 1.5 hr = 1½ hr

- 34. Step 1: Determine mL/ hr for the remaining solution.

  xmL/hr=250mL3hr;x=83.3=83mL/hr

- Step 2: Calculate gtt/min.

  xgtt/min=83mL×15gtt/mL60min=

  83×1560=83×14=834=20.7=21

  - a. *x* = 21 gtt/min; 21 macrogtt/min
  - b. Determine the percentage of change.

    21-1616=510=0.312=31%

  - c. Percentage of change is greater than 25%. Assess

- client. Consult prescriber; order may need to be
- revised.
- Determine the acceptable range for variation.
- 16 + (16 ÷ 4) = 16 + 4 = 20 gtt/min (macrogtt/min)
- 16 – (16 ÷ 4) = 16 – 4 = 12 gtt/min (macrogtt/min)
- The safe range is 12–20 gtt/min (macrodrop/min). The recalculated rate is 21, although only out of range by 1 gtt. It is greater than 25%.

- 35. Step 1: Determine mL/hr for the remaining solution.

  $$x\text{mL/hr} = \frac{200\text{mL}}{1.5\text{hr}} = 133.3 = 133\text{mL/hr}$$

- Step 2: Calculate gtt/min.
- *x* gtt/min =

  $$\frac{133\text{mL} \times 15\text{gtt/mL}}{60\text{min}} = \frac{133 \times 15}{60} = 133 \times 14 = 1334$$

  $$x = 1334 = 33.2 = 33$$

- a. *x* = 33 gtt/min; 33 macrogtt/min
- b. Determine the percentage of change.

  $$\frac{33 - 21}{21} = \frac{12}{21} = 0.571 = 57\%$$

- c. Percentage of change is greater than 25%. Assess client. Consult prescriber; order may need to be revised.

Determine the acceptable range for variation.

21 + (21 ÷ 4) = 21 + 5.25 = 26.25 = 26 gtt/min (macrogtt/min)

21 – (21 ÷ 4) = 21 – 5.25 = 15.75 = 16 gtt/min (macrogtt/min)

The safe range is 16–20 gtt/min (macrogtt/min). The recalculated rate is 33 gtt/min (macrogtt). No, increasing the IV rate is greater than 25%.

- 36. Step 1: Determine mL/hr for the remaining solution.

xmL/hr=750mL8hr=93.7=94x=94mL/hr

- Step 2: Calculate gtt/min.
- *x* gtt/min =

94mL×20gtt/mL60min=94×2060=94×13=943

x=943=31.3=31

  - a. *x* = 31 gtt/min; 31 macrogtt/min
  - b. Determine the percentage of change.

31-2828=328=0.107=11%

  - c. The percentage of change is 11%. This is an acceptable increase. Assess if client can tolerate adjustment in rate. Check if allowed by institution policy.

Determine the acceptable range of variation.

28 + (28 ÷ 4) = 28 + 7 = 35 gtt/min (macrogtt/min)

28 – (28 ÷ 4) = 28 – 7 = 21 gtt/min (macrogtt/min)

The safe range is 21–35 gtt/min (macrogtt/min). The recalculated rate is 31. It is safe to increase the IV rate, which falls within the safe ±25% range.

- 37. Step 1: Determine mL/hr for remaining solution.

  xmL/hr=250mL3hr=83.3=83x=83mL/hr

- Step 2: Calculate gtt/min.

  xgtt/min=83mL×60gtt/mL60min=

  83×6060=83×11=831

  - a. x = 83 gtt/min; 83 microgtt/min
  - b. Determine the percentage of change.

    83-100100=-17100=-0.17=-17%

  - c. The percentage of change is 217%. This is an acceptable decrease. Assess client to see if able to tolerate adjustment in rate. Check if allowed by institution policy.

  Determine the acceptable range for variation.

  100 + (100 ÷ 4) = 100 + 25 = 125 gtt/min (microdrop)

  100 – (100 ÷ 4) = 100 – 25 = 75 gtt/min (microdrop)

  The safe range is 75–125 gtt/min (microdrop). The recalculated rate is 83 gtt/min (microdrop). It is safe to decrease the rate to slow the rate to 83 gtt/min (microgtt), which is within the safe ±25% range.

- 38.
    - a. Answer: 8 hr 1 20 min 5 infusion time
    - b. Answer: 6:20 am (10:00 pm 1 8 hr 1 20 min) *or* military time 0620 (2200 + 0820 = 3020 3020 – 2400 = 0620)
- 39.
- 40.
- 41.
- 42.
- 43.

- 44.
- 45.
- 46.
    - a. 5 mg : 1 mL 5 20 mg : *x* mL

      5x5=205x=4mL

    - Answer: 4 mL. The dosage ordered is greater than the available strength; therefore more than 1 mL is needed to administer the dosage ordered.

    - b. 5 mg : 1 min 5 20 mg : *x* min

      5x5=205x=4min

- c. 5 mg : 60 sec 5 *x* mg : 15 sec

  60x60=1560x=1.25mgper15sec

- 47.
  - a. 250 mg : 5 mL = 150 mg : *x* mL

    250x250=750250x=3mL

  - *or*

    150mg250mg×5mL=xmL

  - Answer: 3 mL. The dosage ordered is less than the available strength; therefore you would need less than 5 mL to administer the dosage ordered.
  - b. 50 mg : 1 min = 150 mg : *x* min

    50x50=15050x=3min

Answers to Clinical Reasoning Questions

- a. The nurse was accustomed to using 20 gtt/mL and calculated the IV rate using 20 gtt/mL. The tubing used at the institution delivered 10 gtt/mL, and the nurse did not check the drop factor on the IV set package. Failure to check the drop factor of the IV tubing resulted in an incorrect IV rate.
- b. Because of the excessive IV rate, the client developed signs of fluid overload and could have developed congestive heart failure.
- c. The nurse should never assume what the drop factor for IV tubing is for macrodrop administration sets because they can vary. The nurse should have checked the IV tubing package for the drop factor, which is printed on the package.

Answers to Chapter Review

NOTE

Many of the IV problems involving gtt/min could also be done by using the shortcut method or dimensional analysis.

NOTE

Some answers in the Chapter Review reflect the number of drops rounded to the nearest whole number and the rate in mL/hr.

- 1.
  - a. Determine mL/hr.

    $$\frac{x \text{ mL/hr}}{2{,}500 \text{ mL}} = \frac{24 \text{ hr}}{x}; x = 104 \text{ mL/hr}$$

  - b. Calculate gtt/min.

    $$x \text{ gtt/min} = \frac{104 \text{ mL} \times 10 \text{ gtt/ml}}{60 \text{ min}}$$

  - x = 17 gtt/min; 17 macrogtt/min
- 2.

- a. Determine mL/hr.

  $$x\text{mL/hr} = \frac{500\text{mL}}{4\text{hr}}; x = 125\text{mL/hr}$$

- b. Calculate gtt/min.

  $$x\text{gtt/min} = \frac{125\text{mL} \times 15\text{gtt/mL}}{60\text{min}}$$

- x = 31 gtt/min; 31 macrogtt/min

- 3.
  - a. Determine mL/hr.

    $$x\text{mL/hr} = \frac{300\text{mL}}{6\text{hr}}; x = 50\text{mL/hr}$$

  - b. Calculate gtt/min.

    $$x\text{gtt/min} = \frac{50\text{mL} \times 60\text{gtt/mL}}{60\text{min}}$$

  - x = 50 gtt/min; 50 microgtt/min

- 4.
  - a. Determine mL/hr.

    $$x\text{mL/hr} = \frac{500\text{mL}}{12\text{hr}} = x = 42\text{mL/hr}$$

- b. Calculate gtt/min.

  $$x\text{gtt/min} = \frac{42\text{mL} \times 20\text{gtt/mL}}{60\text{min}}$$

- x = 14 gtt/min; 14 macrogtt/min

- 5.
  - a. Determine mL/hr.

    $$x\text{mL/hr} = \frac{500\text{mL}}{4\text{hr}}; x = 125\text{mL/hr}$$

  - b. Calculate gtt/min.

    $$x\text{gtt/min} = \frac{125\text{mL} \times 10\text{gtt/mL}}{60\text{min}}$$

  - x = 21 gtt/min; 21 macrogtt/min
- 6. 1 L = 1,000 mL
- 2 L = 2,000 mL
  - a. Determine mL/hr.

    $$x\text{mL/hr} = \frac{2{,}000\text{mL}}{24\text{hr}}; x = 83\text{mL/hr}$$

- b. Calculate gtt/min.

  $$x\text{gtt/min} = 83\text{mL} \times \frac{15\text{gtt/mL}}{60\text{min}}$$

- x = 21 gtt/min; 21 macrogtt/min

- 7.
  - a. Determine mL/hr.

    $$x\text{mL/hr} = \frac{1{,}000\text{mL}}{6\text{hr}}; x = 167\text{mL/hr}$$

  - b. Calculate gtt/min.

    $$x\text{gtt/min} = 167\text{mL} \times \frac{20\text{gtt/mL}}{60\text{min}}$$

  - x = 56 gtt/min; 56 macrogtt/min

- 8.
  - a. Determine mL/hr.

    $$x\text{mL/hr} = \frac{250\text{mL}}{8\text{hr}}; x = 31\text{mL/hr}$$

  - b. Calculate gtt/min.

    $$x\text{gtt/min} = 31\text{mL} \times \frac{60\text{gtt/mL}}{60\text{min}}$$

- x = 31 gtt/min; 31 microgtt/min

- 9.

  $$\frac{x\text{ gtt/min}}{150\text{ mL}} = \frac{15\text{ gtt/mL}}{60\text{ min}}$$

  x = 38 gtt/min; 38 macrogtt/min

- 10.
  - a. Determine mL/hr.

    $$\frac{x\text{ mL/hr}}{1{,}500\text{ mL}} = \frac{24\text{ hr}}{x}; x = 63\text{ mL/hr}$$

  - b. Calculate gtt/min.

    $$\frac{x\text{ gtt/min}}{63\text{ mL}} = \frac{15\text{ gtt/mL}}{60\text{ min}}$$

  - x = 16 gtt/min; 16 macrogtt/min

- 11.
  - a. Determine mL/hr.

    $$\frac{x\text{ mL/hr}}{250\text{ mL}} = \frac{10\text{ hr}}{x}; x = 25\text{ mL/hr}$$

- b. Calculate gtt/min.

  $$x\text{gtt/min} = 25\text{mL} \times \frac{60\text{gtt/mL}}{60\text{min}}$$

  - x = 25 gtt/min; 25 microgtt/min

- 12.

  $$x\text{gtt/min} = 75\text{mL} \times \frac{60\text{gtt/mL}}{60\text{min}}$$

  x = 75 gtt/min; 75 microgtt/min

- 13.

  $$x\text{gtt/min} = 50\text{mL} \times \frac{60\text{gtt/mL}}{45\text{min}}$$

  x = 67 gtt/min; 67 microgtt/min

- 14.

  $$x\text{gtt/min} = 90\text{mL} \times \frac{15\text{gtt/mL}}{60\text{min}}$$

  x = 23 gtt/min; 23 macrogtt/min

- 15.

  $$x\text{gtt/min} = 100\text{mL} \times \frac{20\text{gtt/mL}}{30\text{min}}$$

x = 67 gtt/min; 67 macrogtt/min

- 16.
  - a. Determine mL/ hr.

    xmL/hr=250mL5hr;x=50mL/hr

  - b. Calculate gtt/min.

    xgtt/min=50mL×20gtt/mL60min

  - *x* = 17 gtt/min; 17 macrogtt/min
- 17.

  xgtt/min=50mL×60gtt/mL30min

  x = 100 gtt/min; 100 microgtt/min
- 18.
  - a. Determine mL/hr.

    xmL/hr=500mL3hr;x=167mL/hr

- b. Calculate gtt/min.

  xgtt/min=167mL×10gtt/mL60min

- *x* = 28 gtt/min; 28 macrogtt/min

- 19.
  - a. Determine mL/hr.

    xmL/hr=1,750mL24hr;x=73mL/hr

  - b. Calculate gtt/min.

    xgtt/min=73mL×10gtt/mL60min

  - *x* = 12 gtt/min; 12 macrogtt/min

- 20.

  xmL/hr=500mL8hr;x=63mL/hr

- 21.

- a. Determine mL/hr.

  $$\frac{x \text{ mL/hr}}{500 \text{ mL}} = \frac{6 \text{ hr}}{x}; x = 83 \text{ mL/hr}$$

- b. Calculate gtt/min.

  $$\frac{x \text{ gtt/min}}{83 \text{ mL}} \times \frac{10 \text{ gtt/mL}}{60 \text{ min}}$$

- x = 14 gtt/min; 14 macrogtt/min

- 22.
  - a. Determine mL/hr.

    $$\frac{x \text{ mL/hr}}{500 \text{ mL}} = \frac{6 \text{ hr}}{x}; x = 83 \text{ mL/hr}$$

  - b. Calculate gtt/min.

    $$\frac{x \text{ gtt/min}}{83 \text{ mL}} \times \frac{15 \text{ gtt/mL}}{60 \text{ min}}$$

  - x = 21 gtt/min; 21 macrogtt/min
- 23. Time remaining = 7 hr
- Volume remaining = 300 mL
  - a. Determine mL/hr for remaining solution.

    $$\frac{x \text{ mL/hr}}{300 \text{ mL}} = \frac{7 \text{ hr}}{x}; x = 43 \text{ mL/hr}$$

- b. Determine gtt/min (recalculated rate).

  $$x\text{gtt/min} = \frac{43\text{mL} \times 15\text{gtt/mL}}{60\text{min}}$$

- x = 11 gtt/min
- Answer: 11 macrogtt/min; 11 gtt/min
- c. Determine the percentage change.

  $$\frac{11-13}{13} = \frac{-2}{13} = -0.153 = -15\%$$

- The –15% is within the acceptable 25% variation. Assess if client can tolerate adjustment in rate.
- Negative percentage of variation (215%) indicates the adjusted rate will be decreased. Assess client, check institution policy, and continue to assess client during rate change.

Determine accepted range of variation.

13 + (13 ÷ 4) = 13 + 3.25 = 16.25 = 16 gtt/min (macrogtt/min)

13 – (13 ÷ 4) = 13 – 3.25 = 9.75 = 10 gtt/min (macrogtt/min)

The acceptable range is 10–16 gtt/min (macrogtt/min).

The recalculated rate is 11 gtt/min (macrogtt/min). It is safe to slow the IV rate to 11 gtt/min (macrogtt/min), which is in the safe range. It is below 25%.

- 24. Time remaining = 4 hr
- Volume remaining = 600 mL
  - a. Determine mL/hr for remaining solution.

    $$x\text{mL/hr} = \frac{600\text{mL}}{4\text{hr}}; x = 150\text{mL/hr}$$

- b. Determine gtt/min (recalculated rate).

  $$x\text{gtt/min} = \frac{150\text{mL} \times 20\text{gtt/mL}}{60\text{min}}$$

- x = 50 gtt/min
- Answer: 50 gtt/min; 50 macrogtt/min
- c. Determine the percentage change.

  $$\frac{50 - 42}{42} = \frac{8}{42} = 0.190 = 19\%$$

- The percentage of change is 19%. This is an acceptable increase. Assess if client can tolerate the adjustment in rate (42 gtt/min to 50 gtt/min). Check if allowed by institution policy. Assess client during rate change.
- Determine accepted range of variation.
- 42 + (42 ÷ 4) = 42 + 10.5 = 52.5 = 53 gtt/min (macrodrop)
- 42 – (42 ÷ 4) = 42 – 10.5 = 31.5 = 32 gtt/min (macrodrop)
- The acceptable range is 32–53 gtt/min (macrodrop). The recalculated rate is 50 gtt/min (macrodrop). The IV increase to 50 gtt/min (macrogtt) is within the safe range of 25%.

- 25. Time remaining = 4 hr
- Volume remaining = 400 mL
  - a. Determine mL/hr for remaining solution.

    $$x\text{mL/hr} = \frac{400\text{mL}}{4\text{hr}}; \quad x = 100\text{mL/hr}$$

  - After determining mL/hr, gtt/min is recalculated.
  - b. Determine gtt/min (recalculated rate).

    $$x\text{gtt/min} = \frac{100\text{mL} \times 15\text{gtt/mL}}{60\text{min}}$$

- x = 25 gtt/min
- Answer: 25 gtt/min; 25 macrogtt/min
- c. Determine the percentage change. The IV was ahead. The original IV order was
- 125 mL/hr = 31 gtt/min (31 macrogtt/min). The IV would have to be decreased from 31 gtt/min (31 macrogtt/min) to 25 gtt/min (25 macrogtt/min).

$$25-3131=-631=-0.193=-19\%$$

- The –19% is within acceptable 25% variation. Assess if client can tolerate the adjustment in rate. Negative percentage of variation (–19%) indicates the adjusted rate will be decreased. Check institution policy. Assess client during rate change.
- Determine accepted range of variation.
- 31 + (31 ÷ 4) = 31 + 7.75 = 38.75 = 39 gtt/min (macrogtt/min)
- 31 – (31 ÷ 4) = 31 – 7.75 = 23.25 = 23 gtt/min (macrogtt/min)
- The accepted range is 23–39 gtt/min (macrogtt). The recalculated rate is 25 gtt/min (macrogtt/min). It is safe to slow the rate to 25 gtt/min (macrogtt/min) which is within the safe range of 25%.

- 26. 80 macrogtt/min (80 gtt/min) =

$$900mL\times15gtt/mLxmin$$

$$80=900\times15x80x80=13,50080x=168.75minutes$$

- 60 min = 1 hr; 168.75 ÷ 60 = 2.81 hr

- Answer: 2 hr and 49 min
- 27. 20 macrogtt/min (20 gtt/min) =

$$1,000mL\times10gtt/mLxmin$$

20=1,000×10x20x20=10,00020x=500min

- 60 min = 1 hr; 500 ÷ 60 = 8.33 hr
- Time: 8.33 hr

- Answer: 8 hr and 20 min
- 28. 25 macrogtt/min (25 gtt/min) =

450mL×20gtt/mLxmin

25=450×20x25x25=9,00025x=360min

- 60 min 5 = hr; 360 ÷ 60 = 6 hr

NOTE

For problems 29-30: Formula, time expressed in minutes (60 min = 1 hr).

- 29. 25 macrogtt/min (25 gtt/min) =

  xmL×15gtt/mL480min

  25=x×1548025=15x48015x15=25×4801515x15=12,00015x=800mL

- 30. 30 macrogtt/min 130 gtt/min2

  =xmL×15gtt/mL300min

  30=x×1530030=15x30015x15=30×3001515x15=9,00015x=600mL

NOTE

For problems 31-33, a ratio and proportion could be set up in a format other than the one shown in the problems.

- 31. 10 mEq : 500 mL = 2 mEq : *x* mL

  10x=500×210x10=1,00010

- *x* = 100 mL/ hr would be needed to infuse
- 2 mEq/hr of potassium chloride
- 32. 50 units: 250 mL = 7 units: *x* mL
- 50x50=1,75050;

  x = 35 mL/hr would be needed to infuse 7 units/hr of Humulin Regular insulin
- 33. 100 units; 100 mL = 11 units; *x* mL
- 100x100=1,100100;

  x = 11 mL/hr of fluid would be needed to infuse 11 units/hr of Humulin Regular insulin
- 34. *x* gtt/min = 150mL×10gtt/mL60min

- *x* = 25 gtt/min; 25 macrogtt/min
- 35. *x* gtt/min = 40mL×60gtt/mL40min

- *x* = 60 gtt/min; 60 microgtt/min
- 36.

- 37.

- 38.
    - a. 6 hr 5 infusion time
    - b. (3:10 am + 6 hr = 9:10 am). IV will be completed at 9:10 am; military time: 0910.
- 39.

- 40.
    - a. 10 mg : 1 mL = 120 mg : *x* mL

      10x10=12010;x=12mL

- *or*

$$\frac{120\text{mg}}{10\text{mg}} \times 1\text{mL} = x\text{mL}$$

- Answer: 12 mL. The dosage ordered is more than the available strength; therefore more than 1 mL would be required to administer the dosage ordered.
- b. 40 mg; 1 min = 120 mg : *x* min

$$40x40 = 120 40; x = 3\text{min}$$

- Answer: 3 min

- 41. 30,000 units: 500 mL = 1,500 units: *x* mL

$$\frac{30,000}{30,000} x \frac{30,000}{750,000} = \frac{30,000}{}$$

$$x = \frac{750,000}{30,000} = 25$$

- *x* = 25 mL/hr of fluid would be needed to infuse 1,500 units/hr of heparin
- 42. 100 units: 500 mL = 20 units: *x* mL

100x100=10,000100=100

- x = 100 mL/hr of fluid would be needed to infuse 20 units/hr of Humulin Regular insulin
- 43. 100 mL : 40 min = x mL : 60 min

- 44. x mL hr = 200mL1.5hr=133.3=133

- x = 133 mL/hr
- 45. 1045 start time

r

- Answer: 1915; 7:15 pm
- Alternate solution:

- Convert 75 min to 1 hr and 15 min and add to 1800.

- 46. Step 1: Determine infusion time

- Step 2: Determine completion time.

- Answer: Infusion time 12½ hr (12.5 hr); completion time 0930; 9:30 am

unknown - Section 40 (Page 379)

Calculating Infusion Time When Rate in mL/hr Is Not Indicated for Large Volumes of Fluid

There are situations in which the prescriber may order the IV solution and not indicate the rate in mL/hr. The only information may be the total number of milliliters to infuse, the flow rate (gtt/min) of the IV, and the number of gtt/mL that the tubing delivers. In this situation, before the infusion time is calculated, the following must be done:

- • Convert gtt/min to mL/min.
- • Convert mL/min to mL/hr.
- • Use the formula or other methods shown to determine the infusion time.

Example: A client is receiving 1,000 mL of RL. The IV is infusing at 21 macrogtt/min (21 gtt/min). The administration set delivers 10 gtt/mL. Calculate the infusion time.

Step 1: Change gtt/min to mL/min.

Ratio and Proportion (Linear Format)

10 gtt : 1 mL = 21 gtt : *x* mL

x = 2.1 mL/min

Note: Ratio and proportion could also be set up in fraction format.

Step 2: Convert mL/min to mL/hr.

Step 3: Calculate the infusion time.

Convert hr to min.

Infusion time is 7 hr and 56 min.

Solution Using Dimensional Analysis

x hr is being calculated. The **first fraction** is 1 hr/60 min; the **second fraction** is written so that min is in the numerator: 1 min/21 gtt. The **third fraction** is written so that it matches the denominator of the second fraction; the drop factor is written 10 gtt/mL. **The final fraction** is written so that the denominator matches the proceeding fraction. The mL is provided by the volume to infuse (1,000 mL), the fraction is written 1,000 mL/1.

Calculate the infusion time.

Convert hr to minutes.

Infusion time is 7 hr and 56 min.

PRACTICE PROBLEMS

Determine the infusion time for the following IVs.

- 42. A client is receiving 250 mL of NS at 17 macrogtt/min. Drop factor: 15 gtt/mL _____
- 43. A client is receiving 1,000 mL D_5W at 20 macrogtt/min. Drop factor: 10 gtt/mL _____
- 44. A client is receiving 100 mL D_5W at 10 macrogtt/min. Drop factor: 15 gtt/mL _____

Answers on pp. 542-543

Calculating Infusion Time for Small Volumes of Fluid

There may be times when it is necessary for the nurse to determine the infusion time for small volumes of fluid that will infuse in less than an hour. To do this the nurse must first do the following:

- • Calculate the mL/min.
- • Divide the total volume by the mL/min to obtain the infusion time. The infusion time will be in minutes.

Example: An IV antibiotic of 30 mL is infusing at 20 macrogtt/min. Drop factor is 10 gtt/mL. Determine the infusion time.

Step 1: Calculate the mL/min.

10 gtt :1 mL = 20 gtt : *x* mL

x = 2 mL/min

Step 2: Divide the total volume by mL/min to determine the infusion time.

Infusion time is 15 min.

Solution Using Dimensional Analysis

Since a small volume is being infused in less than 1 hr and there is a drop factor the time will be in minutes. The conversion factor 60 min = 1 hr is not needed.

Infusion time is 15 min.

PRACTICE **PROBLEM**

Determine the infusion time for the following:

- 45. An IV medication of 20 mL is infusing at 35 microgtt/min. Drop factor: 60 gtt/mL _____

Answers on 543

Monitoring the Infusion of IV Solutions

Whether a client is receiving fluids by gravity or with the use of an infusion device, the nurse has the responsibility to monitor the client to ensure the right fluid is infusing at the right rate. When the client is receiving IV fluids by infusion pump, the rate is set in mL/hr and the pump delivers the amount each hour that it is programmed to deliver. When IVs infuse by gravity, the nurse often monitors the IV therapy visually. The IV bag is marked in increments of 50 to 100 mL and provides a visual for the nurse that includes the amount of fluid that has infused and the amount remaining in the bag. Some health care institutions use a commercially prepared label on IVs, referred to as flow meter, and time tape, which is a strip of paper applied to the IV bag. The flow meter and time tape include information such as starting time for the IV and the ending time. These strips applied to the side of the IV bag allow the nurse to visually identify the hourly fluid level.

Charting IV Therapy

The documentation of IV therapy varies from institution to institution. Some institutions chart IV therapy on a special record or flow sheet for IV therapy. Medications that are administered intermittently by IVPB may be charted on medication administration records according to the order (i.e., standing medication, prn). At institutions where a computerized system is used, IV therapy is charted directly into the computer (this includes IV solutions with or without medications). Assessments relating to IV therapy that include the status of the site and complications are also charted on either a form for IV therapy or in the computer. Regardless of what method is used for documentation, it is a nursing responsibility to accurately document all IV therapy that is administered to a client.

POINTS TO REMEMBER

- • The infusion rate can be calculated using ratio and proportion, dimensional analysis, or the formula method:
-
- • Express fractional hours for infusion rate in minutes using 60 min = 1 hr. Multiply the fractional hour by 60 min/hr, and round to the nearest whole number.
- • To calculate the completion time, add the start time and infusion time. Time can be stated as military or traditional time.
- • Calculation of completion times provides the nurse with the opportunity to plan ahead, (i.e., having the next IV solution ready to hang once solution is completed).
- • Monitoring of IV fluids is a nursing responsibility. Tape and flow meters allow for a visual of the status of IV infusions.

IV Push Medications

When medications are administered by IV push (IVP), the medication is injected directly into a vein, the medication is rapidly absorbed in the bloodstream, and the client experiences a rapid result from the medication. Several terms are used for IVP, including IV bolus and direct IV injection. IVP administration is used to deliver diluted and undiluted medication over a brief period (seconds or minutes). Drug references provide the acceptable rate for IV push medication administration. Because of the rapidity of action, an error in calculation can result in a serious outcome for the client. Most IV push medications should be administered over a period of 1 to 5 minutes (or longer), depending on the medication. The volume of the prescribed medication should be calculated in increments of 15 to 30 seconds. This allows for the use of a watch to provide accurate administration. The prescriber orders the medication, dosage, route, frequency, and time to administer a medication for IVP. To ensure client safety, the nurse should always consult a drug reference for the following:

- • The recommended rate for administering the medication

- • The directions for dilution of the medication including, the amount and type of solution

SAFETY ALERT!

Never infuse IV push medications more rapidly than recommended. Carefully read the drug reference for proper dilution, and the time for administration of medications IV push. IV medications are potent and rapid acting.

Administration of Medications by IV Push

Injection ports on IV tubing can be used for direct injection of the medication with a syringe which is called IV push. When using the primary line, administer the medication through the port closest to the client. An IV push medication can also be administered using a saline or heparin lock, which can be attached to the IV catheter. A saline lock indicates that saline is used to flush or maintain IV catheter patency, whereas a heparin lock indicates that heparin is used to maintain the IV catheter patency. Know the policy of the institution regarding the use of saline or heparin. Medications can be administered IV push by attaching the syringe to the lock and pushing in the medication. The lock is usually flushed after administration of the medication. Medications can be administered by IV push by registered nurses who have been specially trained in this practice at some institutions. The actual administration of IV push medications is beyond the scope of this text. For a detailed description on the technique, consult a clinical skills textbook or view the skill online. This text provides a brief discussion of medications by IV push and some examples.

SAFETY ALERT!

Remember heparin is a **high-alert medication.** Heparin lock flush solution is usually in dosage strengths of 10 or 100 units per mL. **Always read** the label carefully. Know the agency policy for the use of heparin to maintain an IV lock.

When administering medications by direct IV infusion, remember the following:

- • **The compatibility of the IV solution and the medication must be verified.**
- • The tubing will require a flush after direct administration to ensure that all the medication has been given and none remains in the tubing.
- • The amount of time needed to administer a medication by direct IV infusion can be determined by using ratio and proportion or dimensional analysis. Let's look at some examples.

Example 1: Order: 200 mg of a medication IV push stat.

Available: The medication available is 300 mg per 2 mL.

The literature recommends diluting the medication to a total of 20 mL. Compatible solution recommended is sodium chloride (0.9%) injection. Inject over a period of not less than 2 minutes. An injection time of 5 minutes is ordered.

- a. How many mL of the medication will you administer?
- b. How many mL of sodium chloride must you add to obtain the desired volume?
- c. To administer the infusion in 5 minutes, how many mL should you infuse every minute?
- d. How much should you infuse every 15 seconds?
    - a. First determine the number of mL to administer the dosage.

Ratio and Proportion (Linear Format)

300 mg : 2 mL = 200 mg : x mL

$300x = 200 \times 2$

$x = 1.3$ mL

Formula Method

Dimensional Analysis

Ratio and Proportion (Fraction Format)

1.3 mL would be equal to 200 mg of the medication

b. According to the literature, the total volume of the diluent and medication is 20 mL. If the literature stated to dilute in 20 mL, then the total volume would be the medication and the diluent.

20 mL (desired diluent)

–1.3 mL (medication dosage)

18.7 mL (amount of diluent to add)

18.7 mL of sodium chloride is needed to obtain the desired volume.

c. Determine the number of mL to administer the infusion in 1 minute.

Ratio and Proportion (Linear Format)

20 mL : 5 min = x mL : 1 min

$5x = 20$

x = 4 mL per min

Ratio and Proportion (Fraction Format)

Dimensional Analysis

Place the desired unit mL to the left of the equal sign. Place the mL ordered as the first fraction (20 mL in 5 min); place mL in the numerator, place 1 min in the numerator of the next unit.

4 mL per min to administer the infusion in 5 min.

d. Determine the volume to infuse every 15 sec.

Ratio and Proportion (Linear Format)

4 mL : 60 sec = x mL : 15 sec

$60x = 4 \times 15$

x = 1 mL every 15 sec

Ratio and Proportion (Fraction Format)

Dimensional Analysis

Note: In this question you are asked to determine sec. (Express 4 mL per min as 4 mL per 60 sec. 60 sec = 1 min. The starting fraction would be 4 mL/60 sec.)

Alternate format: To use 4 mL/min; however, you would need to add 1 min/60 sec to the equation and the setup would be as follows:

Example 2: Order: Ativan 3 mg IV push stat

Available: Ativan 4 mg per mL

The literature states: not to exceed 2 mg/min.

- a. How many mL of Ativan will you prepare? (Express answer in hundredths.)
- b. How many min would it take to administer the medication as ordered?
    - • a. First calculate the dosage to be administered using ratio and proportion, dimensional analysis, or formula method.

Ratio and Proportion (Linear Format)

4 mg : 1 mL = 3 mg : x mL

$4x = 3$

x = 0. 75 mL

Formula Method

Dimensional Analysis

Ratio and Proportion (Fraction Format)

b. Determine the time needed to administer the medication as ordered.

Ratio and Proportion (Linear Format)

2 mg : 1 min = 3 mg : x min

$2x = 3$

$x = 1\frac{1}{2}$ min

Ratio and Proportion (Fraction Format)

1½ min would deliver the medication.

Dimensional Analysis

Note: Use the steps outlined in Example 1.

POINTS TO REMEMBER

IV Push Medications

- • Always verify the compatibility of the medication and the IV solution when administering medications by IV push.
- • Never administer a medication by IV push at a rate faster than recommended. Always read package inserts and reputable medication resources for minimum time for IV administration and dilution.
- • Use ratio and proportion or dimensional analysis to determine the IV push time as recommended by a reputable reference.

PRACTICE PROBLEMS

Calculate the IV push rate as indicated for problems 46-47.

- 46. Order: Valium 20 mg IV push stat at 5 mg/min for a client with seizures.
- Available: Valium 5 mg per mL
    - a. How many milliliters will be needed to administer the dosage? _____
    - b. Determine the time it would take to infuse the dosage. _____
    - c. How many milligrams would you administer every 15 seconds? _____
- 47. Order: Dilantin 150 mg IV push stat.
- Available: Dilantin 250 mg per 5 mL. Literature states IV infusion not to exceed 50 mg/min.
    - a. How much should you prepare to administer? _____
    - b. How much time is needed to administer the required dosage? _____

Answers on 543

CLINICAL **REASONING**

Scenario: An elderly client has an order for 1,000 mL D_5W at 100 mL/hr. The nurse assigned to the client attached IV tubing to the IV with a drop factor of 10 gtt/mL without checking the package of IV tubing. As a habit from a previous institution where she worked, the IV flow rate was calculated based on the drop factor of 20 gtt/mL. At the beginning of the next shift, the nurse making rounds noticed that the client was having difficulty breathing and seemed restless. When the nurse checked the IV rate, she discovered the rate was 33 macrogtt/min instead of 17 macrogtt/min.

- a. What factors contributed to the error? _____
- b. How did the IV rate contribute to the problem and why? _____
- c. What should have been the action of the nurse who attached the IV tubing in relation to IV administration? _____

Answers on 543

CHAPTER **REVIEW**

Calculate the IV flow rate in gtt/min for the following IV administrations, unless another unit of measure is stated.

- 1. 2,500 mL D_5NS to infuse in 24 hr. Drop factor: 10 gtt/mL _____
- 2. 500 mL D_5W to infuse in 4 hr. Drop factor: 15 gtt/mL _____
- 3. 300 mL NS to infuse in 6 hr. Drop factor: 60 gtt/mL _____
- 4. 500 mL D_5 ½ NS over 12 hr. Drop factor: 20 gtt/mL _____
- 5. A unit of whole blood (500 mL) to infuse in 4 hr. Drop factor: 10 gtt/mL _____
- 6. Infuse 2 L RL in 24 hr. Drop factor: 15 gtt/mL _____
- 7. 1,000 mL D_5 0.45% NS in 6 hr. Drop factor: 20 gtt/mL _____
- 8. 250 mL D_5W in 8 hr. Drop factor: 60 gtt/mL _____
- 9. 2 L D_5RL at 150 mL/hr. Drop factor: 15 gtt/mL _____
- 10. 1,500 mL D_5W in 24 hr. Drop factor: 15 gtt/mL _____
- 11. 250 mL D_5W in 10 hr. Drop factor: 60 gtt/mL _____
- 12. Infuse 300 mL of D_5W at 75 mL/hr. Drop factor: 60 gtt/mL _____
- 13. Infuse an IV medication with a volume of 50 mL in 45 minutes. Drop factor: 60 gtt/mL _____
- 14. Infuse 90 mL/hr of NS. Drop factor: 15 gtt/mL _____
- 15. Infuse an IV medication in 100 mL D_5W in 30 minutes. Drop factor: 20 gtt/mL _____
- 16. Infuse 250 mL 0.45% NS in 5 hr. Drop factor: 20 gtt/mL _____
- 17. Infuse Kefzol 0.5 g in 50 mL D_5W in 30 minutes. Drop factor: 60 gtt/mL _____
- 18. Infuse Plasmanate 500 mL over 3 hr. Drop factor: 10 gtt/mL _____
- 19. The prescriber orders the following IVs for 24 hr. Drop factor: 10 gtt/mL
  - • 1,000 mL D_5W c 1 ampule multivitamin (MVI)
  - • 500 mL D_5W
  - • 250 mL D_5W _____
- 20. If 500 mL of D_5W is to infuse in 8 hr, how many milliliters are to be administered per hour? _____
- 21. Infuse 500 mL Intralipids IV in 6 hr. Drop factor: 10 gtt/mL _____
- 22. An IV of 500 mL D_5W with 200 mg of minocycline is to infuse in 6 hr.
- Drop factor: 15 gtt/mL _____
- 23. An IV of D_5W 500 mL was ordered to infuse over 10 hr at a rate of 13 gtt/min (13 macrogtt/min). Drop factor: 15 gtt/mL
- After 3 hr, you notice that 300 mL of IV solution is left. Recalculate the rate in gtt/min for the remaining solution _____ gtt/min
- Determine the percentage of change in IV rate, and state your course of action. _____ %
- 24. An IV of D_5W 1,000 mL was ordered to infuse over 8 hr at a rate of 42 gtt/min (42 macrogtt/min).
- Drop factor: 20 gtt/mL
- After 4 hr, you notice that only 400 mL has infused. Recalculate the rate in gtt/min for the remaining solution. _____ gtt/min
- Determine the percentage of change, and state your course of action. _____ %
- 25. An IV of 1,000 mL D_5 1/2 NS has been ordered to infuse at 125 mL/hr.
- Drop factor: 15 gtt/mL

- The IV was hung at 7 am. At 11 am, you check the IV, and there is 400 mL left. Recalculate the rate in gtt/min for the remaining solution. _____ gtt/min
- Determine the percentage of change, and state your course of action. _____ %
- 26. 900 mL of RL is infusing at a rate of 80 gtt/min (80 macrodrops/min).
- Drop factor: 15 gtt/mL
- How long will it take for the IV to infuse? (Express time in hours and minutes.) _____
- 27. 1,000 mL of D_5W is infusing at 20 gtt/min (20 macrogtt/min).
- Drop factor: 10 gtt/mL
- How long will it take for the IV to infuse? (Express time in hours and minutes.) _____
- 28. 450 mL of NS is infusing at 25 gtt/min (25 macrogtt/min).
- Drop factor: 20 gtt/mL
- How many hours will it take for the IV to infuse? _____
- 29. An IV is regulated at 25 gtt/min (25 macrogtt/min).
- Drop factor: 15 gtt/mL
- How many milliliters of fluid will the client receive in 8 hr? _____
- 30. An IV is regulated at 30 gtt/min (30 macrogtt/min).
- Drop factor: 15 gtt/mL
- How many milliliters of fluid will the client receive in 5 hr? _____
- 31. 10 mEq of potassium chloride is placed in 500 mL of D_5W to be administered at the rate of 2 mEq/hr. At what rate in mL/hr should the IV infuse? _____
- 32. Order: Humulin regular 7 units/hr. The IV solution contains 50 units of Humulin regular insulin in 250 mL of 0.9% NS. At what rate in mL/hr should the IV infuse? _____
- 33. Order: Humulin regular U-100 11 units/hr. The IV solution contains 100 units of Humulin regular insulin in 100 mL of 0.9% NS. At what rate in mL/hr should the IV infuse? _____
- 34. Infuse gentamicin 65 mg in 150 mL 0.9% NS IVPB over 1 hr.
- Drop factor: 10 gtt/mL
- At what rate in gtt/min should the IV infuse? _____
- 35. Infuse ampicillin 1 g that has been diluted in 40 mL 0.9% NS to infuse in 40 minutes.
- Drop factor: 60 gtt/mL
- At what rate in gtt/min should the IV infuse? _____
- 36. 50 mL of 0.9% NS with 1 g ampicillin is infusing at 50 microgtt/min (50 gtt/min).
- Drop factor: 60 gtt/mL
- Determine the infusion time. _____
- 37. 500 mL RL is to infuse at a rate of 80 mL/hr. If the IV was started at 7 pm,
- what time will the IV be completed? _____
- State time in military and traditional time. _____
- 38. A volume of 150 mL of NS is to infuse at 25 mL/hr.
    - a. Calculate the infusion time. _____
    - b. The IV was started at 3:10 am.
    - What time will the IV be completed? State time in traditional and military time. _____
- 39. The doctor orders 2.5 L of D_5W to infuse at 150 mL/hr. Determine the infusion time. _____
- 40. Order: Lasix 120 mg IV stat.
- Available: 10 mg per mL. The literature states IV not to exceed 40 mg/min.
    - a. How many milliliters will you prepare? _____
    - b. Calculate the time required to administer the medication as ordered. _____
- 41. 500 mL D_5W with 30,000 units of heparin to infuse at 1,500 units per hour.
- Determine rate in mL/hr. _____
- 42. Order: Humulin regular 20 units per hr. The IV solution contains 100 units of Humulin Regular in 500 mL of 0.9% NS.
- At what rate in mL/hr should the IV infuse? _____
- 43. Order: Infuse Cefazolin 1 g in 100 mL 0.9% NS over 40 min by infusion pump. _____
- 44. Order: Infuse Vancomycin 1 g in 200 mL D_5W over 90 min by infusion pump. _____
- 45. An IV of 1,000 mL of D_5W is started 1045 to infuse over 8. hr. What is the completion time of the IV? (State time in military and traditional time.) _____
- 46. 1,000 mL 0.9% NS was started at 2100 to infuse at 80 mL/hr. Determine the infusion and completion time. (State in military and traditional time.) _____

Answers on pp. 543-547

For additional practice problems, refer to the Intravenous Flow Rates section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

ANSWERS

Chapter 21

Answers to Practice Problems

- 1. x mL/hr =

  ; x = 75 mL/hr
- 2. x mL/hr =

  = 83.3; x = 83 mL/hr
- 3. x mL/hr =

  = 41.6; x = 42 mL/hr
- 4. x mL/hr =

= 62.5; x = 63 mL/hr

- 5. x mL/hr =

= 46.8; x = 47 mL/hr

- 6. macrodrop
- 7. microdrop
- 8. macrodrop

NOTE

Some problems related to calculating gtt/min can be calculated using the formula method, dimensional analysis, or the formula method, with hours converted to minutes where indicated.

- 9.

- x = 13 gtt/min; 13 macrogtt/min
- 10.

-
- *x* = 30 gtt/min; 30 microgtt/min
- 11. Step 1: Calculate mL/ hr.
- *x* mL/hr =

  = 166.6
- *x* = 167
- Step 2: Calculate gtt/min.

-
-
- *x* = 42 gtt/min; 42 macrogtt/min
- 12.

-
- *x* = 80 gtt/min; 80 microgtt/min
- 13. Step 1: Calculate mL/ hr.
- *x* mL/hr =

  = 62.5; *x* = 63 mL/hr
- Step 2: Calculate gtt/min.

-
-
- *x* = 16 gtt/min; 16 macrogtt/min
- 14. Step 1: Calculate mL/ hr.
- *x* mL/hr =

- Step 2: Calculate gtt/min.

-
-
- *x* = 21 gtt/min; 21 macrogtt/min
- 15. Step 1: Calculate mL/ hr.
-
- *x* = 167 mL/ hr
- Step 2: Calculate gtt/min.
-
-
- *x* = 42 gtt/min; 42 macrogtt/min
- 16. Step 1: Determine the drop factor constant.
- 60 ÷ 10 = 6
- Step 2: Calculate gtt/min.

-
- *x* = 33 gtt/min; 33 macrogtt/min
- 17. Step 1: Determine the drop factor constant.
- 60 ÷ 10 = 6
- Step 2: Calculate gtt/min.

-
- *x* = 47 gtt/min; 47 macrogtt/min
- 18. Step 1: Determine mL/ hr.

-
- Step 2: Determine the drop factor constant.
- 60 ÷ 10 = 6
- Step 3: Calculate gtt/min.

-
- *x* = 17 gtt/min; 17 macrogtt/min
- 19. Remember that small volumes are multiplied and expressed in mL/ hr.
- Step 1: Determine mL/hr.
- 40 mL/20 min = 40 × 3 (3 × 20 min)
- = 120 mL/hr
- Step 2: Determine the drop factor constant.
- 60 ÷ 10 5 6
- Step 3: Calculate gtt/min.

-
- x = 20 gtt/min; 20 macrogtt/min
- 20. Step 1: Determine mL/ hr.
-
- Step 2: Calculate gtt/min.
-
-
- x = 26 gtt/min; 26 macrogtt/min
- 21.
-
- x = 100 gtt/min; 100 microgtt/min

- 22.
-
- x = 42 gtt/min; 42 macrogtt/min
- 23.
  - a. 1 g : 10 mL = 1 g : x mL
  - *or*
  -
  - x = 10 mL
  - Answer: 10 mL. The dosage ordered is contained in a volume of 10 mL. 10 mL of medication is added to the 50 mL of IV solution to give a total of 60 mL.
  - b.
  -
  - x = 13 gtt/min; 13 macrogtt/min
- 24.
  - a. 150 mg : 1 mL = 900 mg : x mL
  - *or*

-
- x = 6 mL
- Answer: 6 mL. The dosage ordered is more than the available strength; therefore more than 1 mL is needed to administer the dosage ordered.
- Alternate solution:
- 300 mg : 2 mL = 900 mg : x mL
- *or*

- This setup would net the same answer.
- b. x gtt/min =

- x = 25 gtt/min; 25 macrogtt/min

- 25.
  - a. 50 mg : 1 mL = 500 mg : x mL
  - *or*

- Answer: 10 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the ordered dosage. The volume of medication is added to the 100 mL of IV solution to get a total of 110 mL.
- b. *x* gtt/min =

- *x* = 28 gtt/min; 28 macrogtt/min

- 26.
  - a. 50 mg : 10 mL = 20 mg : *x* mL
  - *or*

- Answer: 4 mL. The dosage ordered is less than the available strength; therefore you will need less than 10 mL to administer the ordered dosage.
- b. Calculate mL/ hr.

- 27.
  - a. 16 mg : 1 mL = 300 mg : *x* mL
  - *or*
  - Answer: 18.8 mL (18.75 mL rounded to the nearest tenth). The dosage ordered is more than the available strength; therefore you will need more than 1 mL to administer the ordered dosage.
  - b. *x* gtt/min =
  - *x* = 53 gtt/min; 53 macrogtt/min
  - Alternate solution:
  - 160 mg : 10 mL = 300 mg : *x* mL
  - *or*
- 28.
  - a. 10 mg : 1 mL = 100 mg : *x* mL
  - *or*

- x = 10 mL
- The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the ordered dose. 100 mL of IV fluid and medication volume gives a total of 110 mL.
- b. x gtt/min =

- x = 18 gtt/min; 18 macrogtt/min

- 29. 15 mEq : 1,000 mL = 2 mEq : x mL

- *or*

- Answer: 133 mL/hr to deliver 2 mEq of potassium chloride per hour.
- 30. 50 units : 250 mL = 10 units : x mL

- Answer: 50 mL/hr must be administered for the client to receive 10 units/hr.
- 31.

  60 min = 1 hr; 150 min ÷ 60 = 2.5 hr

- Answer: 2½ hr
- 32.

- 33.

  60 min = 1 hr; 90 min ÷ 60 = 1.5 hr = 1½ hr

- 34. Step 1: Determine mL/ hr for the remaining solution.

- Step 2: Calculate gtt/min.

    - a. x = 21 gtt/min; 21 macrogtt/min
    - b. Determine the percentage of change.

    - c. Percentage of change is greater than 25%. Assess
    - client. Consult prescriber; order may need to be
    - revised.
    - Determine the acceptable range for variation.
    - 16 + (16 ÷ 4) = 16 + 4 = 20 gtt/min (macrogtt/min)
    - 16 – (16 ÷ 4) = 16 – 4 = 12 gtt/min (macrogtt/min)
    - The safe range is 12–20 gtt/min (macrodrop/min). The recalculated rate is 21, although only out of range by 1 gtt. It is greater than 25%.
- 35. Step 1: Determine mL/hr for the remaining solution.

- Step 2: Calculate gtt/min.
- x gtt/min =

- a. x = 33 gtt/min; 33 macrogtt/min
- b. Determine the percentage of change.

- c. Percentage of change is greater than 25%. Assess client. Consult prescriber; order may need to be revised.

Determine the acceptable range for variation.

21 + (21 ÷ 4) = 21 + 5.25 = 26.25 = 26 gtt/min (macrogtt/min)

21 – (21 ÷ 4) = 21 – 5.25 = 15.75 = 16 gtt/min (macrogtt/min)

The safe range is 16–20 gtt/min (macrogtt/min). The recalculated rate is 33 gtt/min (macrogtt). No, increasing the IV rate is greater than 25%.

- 36. Step 1: Determine mL/hr for the remaining solution.

- Step 2: Calculate gtt/min.
- x gtt/min =

- a. x = 31 gtt/min; 31 macrogtt/min

- b. Determine the percentage of change.

- c. The percentage of change is 11%. This is an acceptable increase. Assess if client can tolerate adjustment in rate. Check if allowed by institution policy.

Determine the acceptable range of variation.

28 + (28 ÷ 4) = 28 + 7 = 35 gtt/min (macrogtt/min)

28 – (28 ÷ 4) = 28 – 7 = 21 gtt/min (macrogtt/min)

The safe range is 21–35 gtt/min (macrogtt/min). The recalculated rate is 31. It is safe to increase the IV rate, which falls within the safe ±25% range.

- 37. Step 1: Determine mL/hr for remaining solution.

- Step 2: Calculate gtt/min.

- a. x = 83 gtt/min; 83 microgtt/min
- b. Determine the percentage of change.

- c. The percentage of change is 217%. This is an acceptable decrease. Assess client to see if able to tolerate adjustment in rate. Check if allowed by institution policy.

Determine the acceptable range for variation.

100 + (100 ÷ 4) = 100 + 25 = 125 gtt/min (microdrop)

100 – (100 ÷ 4) = 100 – 25 = 75 gtt/min (microdrop)

The safe range is 75–125 gtt/min (microdrop). The recalculated rate is 83 gtt/min (microdrop). It is safe to decrease the rate to slow the rate to 83 gtt/min (microgtt), which is within the safe ±25% range.

- 38.
  - a. Answer: 8 hr 1 20 min 5 infusion time
  - b. Answer: 6:20 am (10:00 pm 1 8 hr 1 20 min) *or* military time 0620 (2200 + 0820 = 3020 3020 – 2400 = 0620)
- 39.
- 40.
- 41.
- 42.

- 43.
- 44.
- 45.
- 46.
    - a. 5 mg : 1 mL 5 20 mg : *x* mL
    - Answer: 4 mL. The dosage ordered is greater than the available strength; therefore more than 1 mL is needed to administer the dosage ordered.

- b. 5 mg : 1 min 5 20 mg : *x* min
- c. 5 mg : 60 sec 5 *x* mg : 15 sec

- 47.
  - a. 250 mg : 5 mL = 150 mg : *x* mL
  - *or*
  - Answer: 3 mL. The dosage ordered is less than the available strength; therefore you would need less than 5 mL to administer the dosage ordered.
  - b. 50 mg : 1 min = 150 mg : *x* min

Answers to Clinical Reasoning Questions

- a. The nurse was accustomed to using 20 gtt/mL and calculated the IV rate using 20 gtt/mL. The tubing used at the institution delivered 10 gtt/mL, and the nurse did not check the drop factor on the IV set package. Failure to check the drop factor of the IV tubing resulted in an incorrect IV rate.
- b. Because of the excessive IV rate, the client developed signs of fluid overload and could have developed congestive heart failure.
- c. The nurse should never assume what the drop factor for IV tubing is for macrodrop administration sets because they can vary. The nurse should have checked the IV tubing package for the drop factor, which is printed on the package.

Answers to Chapter Review

NOTE

Many of the IV problems involving gtt/min could also be done by using the shortcut method or dimensional analysis.

NOTE

Some answers in the Chapter Review reflect the number of drops rounded to the nearest whole number and the rate in mL/hr.

- 1.
    - a. Determine mL/hr.
    - b. Calculate gtt/min.

- x = 17 gtt/min; 17 macrogtt/min

- 2.
  - a. Determine mL/hr.
  - b. Calculate gtt/min.
  - x = 31 gtt/min; 31 macrogtt/min
- 3.
  - a. Determine mL/hr.
  - b. Calculate gtt/min.
  - x = 50 gtt/min; 50 microgtt/min
- 4.
  - a. Determine mL/hr.

    - b. Calculate gtt/min.

    - *x* = 14 gtt/min; 14 macrogtt/min
- 5.
    - a. Determine mL/hr.

    - b. Calculate gtt/min.

    - *x* = 21 gtt/min; 21 macrogtt/min
- 6. 1 L = 1,000 mL
- 2 L = 2,000 mL
    - a. Determine mL/hr.

    - b. Calculate gtt/min.

- x = 21 gtt/min; 21 macrogtt/min

- 7.
  - a. Determine mL/hr.
  - b. Calculate gtt/min.
  - x = 56 gtt/min; 56 macrogtt/min
- 8.
  - a. Determine mL/hr.
  - b. Calculate gtt/min.
  - x = 31 gtt/min; 31 microgtt/min
- 9.

x = 38 gtt/min; 38 macrogtt/min

- 10.
  - a. Determine mL/hr.
  - b. Calculate gtt/min.
  - x = 16 gtt/min; 16 macrogtt/min
- 11.
  - a. Determine mL/hr.
  - b. Calculate gtt/min.
  - x = 25 gtt/min; 25 microgtt/min
- 12.

x = 75 gtt/min; 75 microgtt/min

- 13.

x = 67 gtt/min; 67 microgtt/min

- 14.

x = 23 gtt/min; 23 macrogtt/min

- 15.

x = 67 gtt/min; 67 macrogtt/min

- 16.
  - a. Determine mL/ hr.
  - b. Calculate gtt/min.

- x = 17 gtt/min; 17 macrogtt/min

- 17.

x = 100 gtt/min; 100 microgtt/min

- 18.
  - a. Determine mL/hr.
  - b. Calculate gtt/min.
  - x = 28 gtt/min; 28 macrogtt/min
- 19.
  - a. Determine mL/hr.
  - b. Calculate gtt/min.

- x = 12 gtt/min; 12 macrogtt/min

- 20.

- 21.
  - a. Determine mL/hr.
  - b. Calculate gtt/min.
  - x = 14 gtt/min; 14 macrogtt/min
- 22.
  - a. Determine mL/hr.
  - b. Calculate gtt/min.

- x = 21 gtt/min; 21 macrogtt/min

- 23. Time remaining = 7 hr
- Volume remaining = 300 mL
  - a. Determine mL/hr for remaining solution.

  - b. Determine gtt/min (recalculated rate).

  - x = 11 gtt/min
  - Answer: 11 macrogtt/min; 11 gtt/min
  - c. Determine the percentage change.

  - The –15% is within the acceptable 25% variation. Assess if client can tolerate adjustment in rate.
  - Negative percentage of variation (215%) indicates the adjusted rate will be decreased. Assess client, check institution policy, and continue to assess client during rate change.

  Determine accepted range of variation.

  13 + (13 ÷ 4) = 13 + 3.25 = 16.25 = 16 gtt/min (macrogtt/min)

  13 – (13 ÷ 4) = 13 – 3.25 = 9.75 = 10 gtt/min (macrogtt/min)

  The acceptable range is 10–16 gtt/min (macrogtt/min).

  The recalculated rate is 11 gtt/min (macrogtt/min). It is safe to slow the IV rate to 11 gtt/min (macrogtt/min), which is in the safe range. It is below 25%.

- 24. Time remaining = 4 hr
- Volume remaining = 600 mL
  - a. Determine mL/hr for remaining solution.

- b. Determine gtt/min (recalculated rate).

- x = 50 gtt/min
- Answer: 50 gtt/min; 50 macrogtt/min
- c. Determine the percentage change.

- The percentage of change is 19%. This is an acceptable increase. Assess if client can tolerate the adjustment in rate (42 gtt/min to 50 gtt/min). Check if allowed by institution policy. Assess client during rate change.
- Determine accepted range of variation.
- 42 + (42 ÷ 4) = 42 + 10.5 = 52.5 = 53 gtt/min (macrodrop)
- 42 – (42 ÷ 4) = 42 – 10.5 = 31.5 = 32 gtt/min (macrodrop)
- The acceptable range is 32–53 gtt/min (macrodrop). The recalculated rate is 50 gtt/min (macrodrop). The IV increase to 50 gtt/min (macrogtt) is within the safe range of 25%.

- 25. Time remaining = 4 hr
- Volume remaining = 400 mL
  - a. Determine mL/hr for remaining solution.

  - After determining mL/hr, gtt/min is recalculated.
  - b. Determine gtt/min (recalculated rate).

- x = 25 gtt/min
- Answer: 25 gtt/min; 25 macrogtt/min
- c. Determine the percentage change. The IV was ahead. The original IV order was
- 125 mL/hr = 31 gtt/min (31 macrogtt/min). The IV would have to be decreased from 31 gtt/min (31 macrogtt/min) to 25 gtt/min (25 macrogtt/min).

- The –19% is within acceptable 25% variation. Assess if client can tolerate the adjustment in rate. Negative percentage of variation (–19%) indicates the adjusted rate will be decreased. Check institution policy. Assess client during rate change.
- Determine accepted range of variation.
- 31 + (31 ÷ 4) = 31 + 7.75 = 38.75 = 39 gtt/min (macrogtt/min)
- 31 – (31 ÷ 4) = 31 – 7.75 = 23.25 = 23 gtt/min (macrogtt/min)
- The accepted range is 23–39 gtt/min (macrogtt). The recalculated rate is 25 gtt/min (macrogtt/min). It is safe to slow the rate to 25 gtt/min (macrogtt/min) which is within the safe range of 25%.

- 26. 80 macrogtt/min (80 gtt/min) =

- 60 min = 1 hr; 168.75 ÷ 60 = 2.81 hr

- Answer: 2 hr and 49 min

- 27. 20 macrogtt/min (20 gtt/min) =

- 60 min = 1 hr; 500 ÷ 60 = 8.33 hr
- Time: 8.33 hr

- Answer: 8 hr and 20 min
- 28. 25 macrogtt/min (25 gtt/min) =

- 60 min 5 = hr; 360 ÷ 60 = 6 hr

NOTE

For problems 29-30: Formula, time expressed in minutes (60 min = 1 hr).

- 29. 25 macrogtt/min (25 gtt/min) =

- 30. 30 macrogtt/min 130 gtt/min2

NOTE

For problems 31-33, a ratio and proportion could be set up in a format other than the one shown in the problems.

- 31. 10 mEq : 500 mL = 2 mEq : *x* mL

- x = 100 mL/ hr would be needed to infuse
- 2 mEq/hr of potassium chloride
- 32. 50 units: 250 mL = 7 units: x mL

- x = 35 mL/hr would be needed to infuse 7 units/hr of Humulin Regular insulin
- 33. 100 units; 100 mL = 11 units; x mL

- x = 11 mL/hr of fluid would be needed to infuse 11 units/hr of Humulin Regular insulin
- 34. x gtt/min =

- x = 25 gtt/min; 25 macrogtt/min
- 35. x gtt/min =

- x = 60 gtt/min; 60 microgtt/min
- 36.

- 37.
- 38.
    - a. 6 hr 5 infusion time
    - b. (3:10 am + 6 hr = 9:10 am). IV will be completed at 9:10 am; military time: 0910.
- 39.
- 40.
    - a. 10 mg : 1 mL = 120 mg : *x* mL
    - *or*

    - Answer: 12 mL. The dosage ordered is more than the available strength; therefore more than 1 mL would be required to administer the dosage ordered.
    - b. 40 mg; 1 min = 120 mg : *x* min

    - Answer: 3 min
- 41. 30,000 units: 500 mL = 1,500 units: *x* mL

- *x* = 25 mL/hr of fluid would be needed to infuse 1,500 units/hr of heparin
- 42. 100 units: 500 mL = 20 units: *x* mL

- *x* = 100 mL/hr of fluid would be needed to infuse 20 units/hr of Humulin Regular insulin
- 43. 100 mL : 40 min = *x* mL : 60 min

- 44. *x* mL hr =

- *x* = 133 mL/hr
- 45. 1045 start time

r

- Answer: 1915; 7:15 pm
- Alternate solution:

- Convert 75 min to 1 hr and 15 min and add to 1800.

- 46. Step 1: Determine infusion time

- Step 2: Determine completion time.

- Answer: Infusion time 12½ hr (12.5 hr); completion time 0930; 9:30 am

Heparin Errors

Heparin is an anticoagulant medication used to prevent the formation of blood clots, and it is identified as a ***high-alert*** medication because it carries a significant risk of causing serious injury or death to a client if misused. Despite the identification of heparin as being a high-alert medication, errors that involve the use of heparin have been well documented in the literature. Some of the cited causes of errors include mix-ups with concentrations of heparin, inadequate client monitoring, and calculation errors.

The occurrence of errors with anticoagulant medications prompted attention from organizations such as the Institute for Safe Medication Practices (ISMP), The Joint Commission (TJC), the Food and Drug Administration (FDA), and the United States Pharmacopeia (USP). The focus of these organizations was to minimize the potential for medication errors associated with anticoagulant therapy and reduce client harm from their use. TJC developed a National Patient Safety Goal (NPSG) [03.05.01] to address a hospital's responsibilities for the administration of anticoagulant therapy to reduce the likelihood of client harm. The NPSG includes client monitoring (baseline and ongoing laboratory tests) and the use of programmable infusion pumps when heparin is administered IV and continuously. The current National Patient Safety Goals (effective January 2020) can be viewed on TJC's website at www.jointcommission.org. The updated USP label standards for heparin became effective in 2013. The labeling standards for Heparin Sodium Injection, USP, and Heparin Lock Flush Solution, USP, were updated to clearly state the total dosage strength on the label, followed by the dosage strength per milliliter enclosed in parentheses. Other label enhancements will be discussed further in this chapter with the discussion of sample heparin labels.

There have been safety protocols instituted in many health care institutions related to the administration of heparin; these include (1) independent double-checks of heparin dosages (another nurse independently double-checking calculations before administration) and (2) the use of a weight-based protocol that uses the client's weight in kilograms (kg) as the basis for determining heparin bolus doses and infusion rates, which will be discussed later in this chapter. Although in some health care settings nurses prepare and mix IV heparin, the trend is to use premixed preparations of heparin from the manufacturer or have the pharmacy mix the solution. Strategies to reduce errors and therefore reduce the risk of harm to clients incorporate the Quality and Safety Education for Nurses (QSEN) competency of safety.

Heparin requires close monitoring of the client's blood work because of the bleeding potential associated with anticoagulant medications. Some heparin protocols also use the activated partial thromboplastin time (aPTT or APTT) to monitor the client's clotting values while receiving heparin. Another laboratory test being used is the measurement of anti-factor Xa levels.

As nurses, it is important to remember that even though heparin is commonly used in clinical practice, client safety during administration is an essential priority and needs to include correct calculations, client monitoring, and adherence to safety protocols to prevent errors and harm to a client.

Heparin Administration

Heparin can be administered subcutaneously or intravenously; it is **never** administered intramuscularly because of the danger of hematomas (collections of extravasated blood trapped in tissues of skin or in an organ). Heparin therapy frequently consists of a combination of prescribed intermittent IV boluses (large doses to achieve a rapid therapeutic effect), followed by continuous IV infusion. When administered as a continuous IV infusion, the heparin dosage rate may be ordered in units/hr or mL/hr or individualized by weight as units per kilogram per hour (units/kg/hr). To maintain a constant rate, accurate dosing, and safe administration, IV heparin is always administered by an electronic infusion device. Only a syringe measured in milliliters should be used to measure a heparin dose. When calculating dosages of heparin, it is ordered in units and the medication is in units; there is no conversion of units.

Heparin Dosage Strengths

Heparin is available in single-dose and multi-dose vials as well as in commercially prepared IV solutions and prefilled syringes. Heparin is available in various concentrations such as 1,000, 2,000, 5,000, and 10,000 units per mL and higher. Heparin Lock Flush Solution, which is used for flushing (e.g., med-locks, specialized IV lines), is available in 10 and 100 units per mL. The higher concentrations of heparin are used for anticoagulant therapy. Commercially prepared IV solutions with heparin are also available from pharmaceutical companies in several strengths. The dosage of heparin is written in red on IV bags to attract attention to the fact that the IV solution contains heparin.

SAFETY ALERT!

The average heparin flush dosage strength is 10 units per mL and never exceeds 100 units per mL. Hep arin sodium for injection and heparin lock fl ush solution can never be used interchangeably.

Other Anticoagulant Medications

Low-molecular-weight heparins (LMWHs) are heparin derivatives that are used in clinical practice. They are prescribed for prevention and treatment of deep-vein thrombosis (DVT) following abdominal surgery, hip or knee replacement, unstable angina, and acute coronary syndromes. Examples are Lovenox (enoxaparin) and Fragmin (dalteparin). (See the labels for these medications in Figure 22.1.) Notice that the Lovenox label indicates the dosage strength in mg per 0.4 mL, and the Fragmin label indicates the dosage strength in international units (IU) per 0.3 mL; therefore Lovenox would be ordered in mg and Fragmin in IU.

Figure 22.1 (A) Lovenox label, 40 mg per 0.4 mL. (B) Fragmin label, 7,500 lU per 0.3 mL.

Reading Heparin Labels

As previously stated, heparin comes in various concentrations. Nurses **must always** carefully read the heparin label to verify that they have the correct concentration, which is critical to the prevention of lethal dosage errors with heparin. Refer to the labels shown in Figure 22.2 for Heparin Sodium Injection, USP, showing various heparin concentrations. Notice the following:

Figure 22.2 (A) 10,000 units per 10 mL (1,000 units per mL). (B) 50,000 units per 10 mL (5,000 units per mL). (C) 1-mL vial, 1,000 units per mL.

- • Bolder, larger font
- • Strength per total volume expressed (i.e., Label A, 10,000 units per 10 mL; Label B, 50,000 units per 10 mL), followed by dosage strength per mL in parentheses for both (Label A, 1,000 units per mL; Label B, 5,000 units per mL), Label C is a 1-mL size vial and states 1,000 units per mL.
- • The statement “Not for lock flush”

Figure 22.3 shows a label for Heparin Lock Flush Solution USP; notice the strength per total volume (100 units per 10 mL) and the dosage strength per mL (10 units per mL).

Figure 22.3 Heparin Lock Flush Solution, 100 units per 10 mL (10 units per mL).

SAFETY ALERT!

Heparin is available in different strengths; read labels carefully before administering to ensure the client's safety. Verify the dosage, vial, and amount to be given. Obtain an independent double-check from another nurse to ensure accuracy. Continuous monitoring of the client receiving heparin is essential because of the risk of hemorrhage or clots with an incorrect dose. To avoid misinterpretation of orders, whether written or done by computer entry or entered on the Medication Administration Record (MAR), the word *units* should not be abbreviated.

Now let's proceed with the calculation of heparin dosages.

Calculation of Subcutaneous Dosages

Because of its inherent dangers and the need to ensure an accurate and exact dosage, when heparin is administered subcutaneously, a tuberculin syringe (1 mL) is used. Heparin is also available for use in prepackaged syringes. Institutional policies differ regarding the administration of heparin, and the nurse is responsible for knowing and following the policies. The methods of calculating presented in previous chapters are used to calculate subcutaneous (subcut) heparin, except the dosage is never rounded and is usually administered with a tuberculin syringe.

Example: Order: Heparin 7,500 units subcut daily

Available: Heparin labeled 10,000 units per mL

What will you administer to the client?

Setup:

- • No conversion is necessary. The order is in units and it is available in units.
- • Think: What would be a logical dosage?
- • Set up in ratio and proportion, the formula method, or dimensional analysis and solve.

Ratio and Proportion (Linear Format)

10,000 units : 1 mL = 7,500 units : x mL

10,000 units : 1 mL = 7,500 units : x mL

Ratio and Proportion (Fraction Format)

Formula Method

Dimensional Analysis

The dosage of 0.75 mL is reasonable because the dosage ordered is less than what is available. Therefore less than 1 mL will be needed to administer the ordered dosage. This dosage can be measured accurately with a tuberculin syringe (calibrated in tenths and hundredths of a milliliter). This dosage would not be rounded to the nearest tenth of a milliliter. Heparin is administered in exact dosages. A tuberculin syringe illustrating the dosage to be administered is shown in Figure 22.4.

Figure 22.4 Tuberculin syringe illustrating 0.75 mL drawn up.

Calculation of IV Heparin Solutions

An infusion pump is **required** for the safe administration of IV heparin infusions. The nurse's primary responsibility is to administer the correct dosage and ensure that the dosage being administered is safe. When in doubt regarding a dosage ordered for a client or that the client is receiving, always check with the prescriber before administering it. Verify the dosage to be administered by obtaining an independent double-check (i.e., a second qualified person, such as another nurse, separately checking the calculation without knowing the result of their colleague). The ISMP does not recommend the use of an independent double-check for all high-alert medications. Independent double-checks should be based on careful assessment of processes and medications (e.g., IV heparin) that could pose the greatest risk of harm if an error occurs (June 2019; https://www.ismp.org/resources/independent-double-checks-worth-effort-if-used-judiciously-and-properly).

The dosing guidelines for continuous heparin IV infusion for an adult are 20,000 to 40,000 units every 24 hours. These guidelines are based on factors that include the client's condition, age, and test results, (i.e., aPTT).

Let's look at calculations with IV heparin

Calculating Units per Hour

This can be done using ratio and proportion or dimensional analysis.

Example: An IV solution of heparin is ordered for a client. D_5W 1,000 mL containing 20,000 units of heparin is to infuse at 30 mL/hr. Calculate the dosage of heparin the client is to receive per hour.

Solution:

- • If using ratio and proportion, the solution on hand (20,000 units in 1,000 mL) is the known ratio; for the rate of the infusion (in this problem, you want to determine the units that would be contained in 30 mL), *x* units/30 mL would be the unknown ratio.

- • For dimensional analysis, *x* units/hr is what is being calculated. The **starting fraction** is 20,000 units per 1,000 mL, which is written with units in the numerator to match the units in the numerator being calculated. The rate, 30 mL/hr, is placed in the equation as the **second fraction** with 30 mL as the numerator, which matches the denominator of the starting fraction. Cancel the units to obtain the desired unit (units/hr). Reduce if possible and perform math operations.

Ratio and Proportion (Linear Format)

20,000 units : 1,000 mL 5 *x* units : 30 mL

20,000 units : 1,000 mL 5 *x* units : 30 mL

or

Ratio and Proportion (Fraction Format)

Dimensional Analysis

The client would receive **600 units/hr** from a solution containing 20,000 units in 1,000 mL of solution if the IV infusion is infusing at 30 mL/hr.

Calculating mL/hr from Units/hr

Because heparin is ordered in units/hr and infused with an electronic infusion device, it is necessary to do calculations in mL/hr.

Example 1: Order: Infuse heparin 850 units/hr from a solution containing 25,000 units in 500 mL D_5W.

Solution:

- • For ratio and proportion, the available solution (in this problem, 25,000 units/500 mL) is the known ratio, and the desired units/*x* mL (in this problem 850 units/x mL) is the unknown ratio.
- • For dimensional analysis, mL/hr is being calculated. The **starting fraction** is 25,000 units per 500 mL, placing mL as the numerator to match the mL numerator of the units being calculated (500 mL/25,000 units). The **second fraction** is the 850 units/hr rate ordered, with units in the numerator, 850 units/1 hr. Cancel units; the desired unit mL/hr is left. Reduce if possible and perform math operations.

Ratio and Proportion (Linear Format)

25,000 units : 500 mL 5 850 units : *x* mL

25,000 units : 500 mL 5 850 units : *x* mL

Ratio and Proportion (Fraction Format)

Dimensional Analysis

To infuse 850 units/hr from a solution of 25,000 units of heparin in D_5W 500 mL, the infusion pump would be set at 17 mL/hr.

Example 2: Order: Infuse 1,200 units of heparin per hour from a solution containing 20,000 units in 250 mL D_5W.

Solution:

Refer to Example 1 for the steps for ratio and proportion and dimensional analysis.

Ratio and Proportion (Linear Format)

20,000 units : 250 mL 5 1,200 units : *x* mL

20,000 units : 250 mL 5 1,200 units : *x* mL

Ratio and Proportion (Fraction Format)

Dimensional Analysis

To infuse 1,200 units/hr of heparin from a solution containing 20,000 units in 250 mL D_5W, the infusion pump would be set at 15 mL/hr.

Calculating Heparin Dosages Based on Weight

To prevent dosage and administration errors with heparin and increase client safety, many health care institutions have established **heparin protocols** to guide the administration of IV heparin dosages. The dosages of heparin are individualized based on the client's weight. The protocols are based on the client's weight in kilograms and their activated partial thromboplastin time APTT (sometimes written as aPTT). The APTT is a blood

clotting value measured in seconds and is used as the criterion to titrate the heparin dosage, and adjustments are made accordingly. (See the sample protocol in Figure 22.5.) Heparin protocols consist of:

Figure 22.5 Sample heparin weight-based protocol. *Note:* This protocol is for calculation purposes only.

- • The bolus or loading dose, which is the initial bolus based on the client's weight in kilograms
- • The initial infusion rate based on the client's weight in kilograms
- • Directions on what additional bolus and rate alterations must be made based on APTT results

Heparin protocols consist of **three** steps in the administration process in the following sequence:

- 1. **Bolus**
- 2. **Continuous infusion**
- 3. **Rebolus** and/or adjust infusion rate (increase, decrease, or discontinue)

It is imperative that nurses be familiar with the protocol at their individual institutions. The bolus and infusion rate can vary among institutions. According to Willihnganz, Gurevitz, and Clayton (2020), the bolus dosage is 70 to 100 units/kg, and the infusion rate is 15 to 25 units/kg/hr. These values can be different depending on the health care institution. For weight-based heparin calculations, the weight of the client is rounded to the nearest tenth of a kilogram or the exact number of kilograms. IV rates in mL/hr are rounded to the nearest whole number or nearest tenth depending on the infusion pump (some of which are capable of delivering IV fluids in tenths of a milliliter). Always check the equipment available at the institution before rounding IV flow rates to whole milliliters per hour (mL/hr). **Always be familiar with the values and protocol used for heparin administration at the institution to prevent errors that could be fatal and to ensure the safe administration of heparin to a client.** Also remember the importance of independent double-checks with IV heparin.

SAFETY ALERT!

For heparin to be therapeutically effective, the dosage **must** be accurate. A larger dosage than required can cause a client to hemorrhage, and an underdosage may not have the desired effect. Any questionable dosages should be verified with the prescriber **before** administration.

In this text, for the purpose of calculating, round weight in kilograms to the nearest tenth. Milliliters per hour (mL/hr) are to be rounded to the whole number unless information is provided to do otherwise. Let's work through some examples of calculation of heparin dosages based on weight.

Example 1: A client weighs 160 lb.

Order: Administer a bolus of heparin sodium IV. The hospital protocol is 80 units/kg. Calculate the number of units to administer the bolus dosage.

Solution:

Step 1: Convert the client's weight to kilograms.

Conversion factor: 1 kg 5 2.2 lb

160 lb ÷ 2.2 = 72.72 = 72.7 kg (rounded to nearest tenth)

160 lb ÷ 2.2 = 72.72 = 72.7 kg (rounded to nearest tenth)

Step 2: Calculate the heparin bolus dosage.

The client should receive 5,816 units as a bolus dosage.

Example 2: A client weighs 165 lb.

Order: Bolus with heparin sodium 80 units/kg, then initiate IV infusion at 18 units/kg/hr.

Available: Heparin 25,000 units in 1,000 mL 0.9% NS

- • Calculate the bolus dosage.
- • Calculate the infusion rate.
- • Determine the rate in mL/hr to set the infusion device.

Solution:

Step 1: Convert the client's weight to kg.

Conversion factor: 1 kg = 2.2 lb

165 lb ÷ 2.2 = 75 kg

Step 2: Calculate the heparin bolus dosage.

The client should receive 6,000 units as a bolus dosage.

Step 3: Calculate the infusion rate.

Step 4: Determine the rate in mL/hr at which to set the infusion device.

The infusion pump would be set at 54 mL/hr to deliver 1,350 units/hr.

Note: The problem only illustrates some of the methods that can be used for solving the problem.

Now let's do a problem illustrating the steps of calculating the bolus, continuous infusion, or rebolus and/or adjusting the infusion rate for a client weighing 198 lb using the sample protocol in Figure 22.5.

Solution:

Step 1: Convert the client's weight to kilograms.

Conversion factor: 1 kg = 2.2 lb

198 lb ÷ 2.2 = 90 kg

Step 2: Calculate the heparin bolus dosage.

The client should receive 7,200 units IV heparin as a bolus.

- • To determine the volume (mL) the client would receive, remember that the concentration of heparin was indicated as 100 units per mL. This can be determined using the formula method, dimensional analysis, or ratio and proportion.

Step 3: Calculate the infusion rate (18 units/kg/hr)

- • Determine the rate in mL/hr at which to set the infusion pump to deliver 1,620 units/hr. Use the concentration of 100 units per mL.

  100 units : 1 mL = 1,620 units : x mL

  100 units : 1 mL = 1,620 units : x mL

  100 x = 1,620

  100 x = 1,620

x = 16 mL/hr

x = 16 mL/hr

- The pump would be set at 16 mL/hr to deliver 1,620 units/hr.

The client's APTT after 6 hours is reported as 43 seconds. According to the protocol, rebolus with 40 units/kg and increase the rate by 2 units/kg/hr. Let's look at how the rebolus and rate increase would be calculated.

Step 4: Calculate the dosage (units/hr) of the continuous infusion increase based on the protocol using the client's weight in kg.

- • Calculate the dosage (units) of heparin rebolus.
-

- Determine the volume (mL) to administer 3,600 units.

- x = 36 mL (administer 36 mL to administer the rebolus of 3,600 units)

Step 5: Now determine the infusion rate increase (2 units/kg/hr 3 kg).

The infusion rate should be increased by 180 units/hr.

- • Calculate the adjustment in the hourly infusion rate (mL/hr).

- x = 1.8 mL/hr (adjustment that would be needed in the rate)
- • Determine the increase rate:

Increase the rate on the pump to 18 mL/hr to increase the infusion by 180 units/hr.

POINTS TO REMEMBER

- • Heparin is a potent anticoagulant; it is often administered intravenously but can be administered subcutaneously.
- • Heparin is measured in USP units. When orders are written, the word *units* is spelled out to prevent misinterpretation.
- • Heparin dosages must be accurately calculated to prevent inherent dangers associated with the medication. Discrepancies in dosage should be verified with the prescriber before administration.
- • Independent double-checks should be done for IV heparin before administration.
- • When subcut heparin is administered, a tuberculin syringe is used (calibrated in tenths and hundredths of a milliliter). Answers are expressed in hundredths.
- • Read heparin labels carefully because heparin comes in several strengths.
- • There are several IV calculations that can be done (mL/hr, units/hr).
- • Heparin is commonly ordered in units/hr and infused with an electronic infusion device.
- • Heparin sodium for injection and heparin lock solution cannot be used interchangeably.
- • The method of calculating IV heparin dosages can also be used to calculate IV dosages for other medications. Ratio and proportion and dimensional analysis can be used as well.
- • Heparin dosages are individualized according to the weight of the client in kilograms and adjusted based on the APTT.
- • Protocols for IV heparin vary from institution to institution; always know and follow the institution's policy. Heparin protocol consists of three steps in the administration process: (1) bolus, (2) continuous infusion, (3) rebolus and/or adjust infusion rate (increase, decrease, or discontinue).
- • Monitoring a client's APTT while they are receiving heparin is a **must.**
- • New heparin labels indicate the dosage strength (amount) per the entire container (vial) and the dosage strength per mL in parentheses.

PRACTICE **PROBLEMS**

Calculate the units of measure indicated by the problem.

- 1. Order: Infuse 1,000 units/hr of heparin IV from a solution of 1,000 mL 0.45% NS with 25,000 units of heparin. Calculate the rate in mL/hr. _____
- 2. Order: Infuse D_5 0.9% NS 1,000 mL with 25,000 units of heparin IV at 35 mL/hr. Calculate the dosage in units/hr. _____
- 3. Order: Infuse 750 mL D_5W with 30,000 units of heparin IV at 25 mL/hr. Calculate the dosage in units/hr. _____
- 4. Order: Infuse D_5W 1,000 mL with 25,000 units of heparin IV at 100 mL/hr. Determine the dosage in units/hr. _____
- 5. A client weighs 176 lb. Heparin infusion 20,000 units in 1,000 mL 0.9% sodium chloride. Order: Bolus with heparin sodium at 80 units/kg, then initiate drip at 18 units/kg/hr. (Round weight to the nearest tenth as indicated.) Calculate the following:

- a. _____ bolus dosage
- b. _____ infusion rate (initial)
- c. _____ mL/hr

Use the following weight-based heparin protocol for question 6. (Round weight to the nearest tenth as indicated; IV pump is calibrated in whole mL/hr.)

Bolus with heparin at 80 units/kg.

Begin intravenous infusion of heparin at 18 units/kg/hr using 25,000 units heparin in 500 mL D_5W for 50 units per mL.

Adjust intravenous heparin daily based on APTT results.

- • APTT less than 35 seconds: Rebolus with 80 units/kg and increase rate by 4 units/kg/hr.
- • APTT 35-45 seconds: Rebolus with 40 units/kg and increase rate by 2 units/kg/hr.
- • APTT 46-70 seconds: **No change.**
- • APTT 71-90 seconds: Decrease rate by 2 units/kg/hr.
- • APTT greater than 90 sec. **Stop heparin** infusion for 1 hour and decrease rate by 3 units/kg/hr.

- 6. A client weighs 134.2 lb. Determine the bolus dose of heparin, the initial infusion rate, and then adjust the hourly infusion rate up or down based on the APTT results using the above weight-based heparin protocol. APTT is reported as 31 seconds.

Answers on pp. 569-570

CLINICAL **REASONING**

Scenario: A client has an order for heparin 3,500 units in 500 mL D_5W to infuse at a rate of 40 mL/hr. The nurse prepares the IV using the heparin labeled 100 units per mL and adds 35 mL of heparin to the IV.

- a. What error occurred in the preparation of the IV solution and why? _____
- b. What preventive measures should the nurse have taken? _____

Answers on 570

NGN Case Study

Learning Outcomes:

- 1. Calculate heparin dosages being administered intravenously (in mL/hr or units/hr).
- 2. Calculate safe heparin dosages based on weight.

Case Scenario: A client is admitted to the hospital with complaints of chest pain and shortness of breath. The client is diagnosed with a pulmonary embolism. The client weighs 192 lb. The physician writes an order for a heparin protocol (please see the heparin protocol below). Round the weight to the nearest tenth. The infusion pump can deliver medication to the tenths of an mL.

Weight-Based Heparin Protocol

- 1. Bolus with heparin at 80 units/kg
- 2. Begin intravenous infusion of heparin at 18 units/kg/hr using 25,000 units heparin in 250 mL D_5W or a concentration of 100 units per mL.
- 3. APTT 6 hours after rate change and then daily at 7am
- 4. Adjust intravenous heparin daily based on APTT results
  - • APTT less than 35 sec, Bolus with 80 units/kg and increase rate by 4 units/kg/hr.
  - • APTT 35-45 sec, Bolus with 40 units/kg and increase rate by 2 units/kg/hr.
  - • APTT 46-70 sec, **No Change.**
  - • APTT 71-90 sec, Decrease rate by 2 units/kg/hr.
  - • APTT greater than 90 sec, **Stop** heparin infusion for 1 hour, and decrease rate by 3 units/kg/hr.

Potential Action	Appropriate Action
Calculate the client's weight as 87.3 kg.	
Calculate the client's weight as 422.4 kg.	
Calculate the client's weight as 192 kg.	
Give the client a bolus of 15,360 units.	
Give the client a bolus of 33,792 units.	
Give the client a bolus of 6,984 units.	
Begin the heparin drip at 7,603 units/hr.	
Begin the heparin drip at 1,571.4 units/hr.	
Begin the heparin drip at 3,456 units/hr.	
Program the electronic infusion device at 76 mL/hr.	
Program the electronic infusion device at 34.5 mL/hr.	
Program the electronic infusion device at 15.7 mL/hr.	

Reference: Morris D: *Calculate with confidence,* ed 8, St Louis, Elsevier, copyright 2022.

Case Study answers and rationales can be found on Evolve.

CHAPTER **REVIEW**

For questions 1-7, calculate the dosage of heparin you will administer, use labels where provided, and shade the dosage on the syringe provided. For questions 8-30, calculate the units as indicated by the problem.

- 1. Order: Heparin 3,500 units subcut daily.
- Available:

- _____
- 2. Order: Heparin 16,000 units subcut stat.
- Available:

- _____
- 3. Order: Heparin 2,000 units subcut b.i.d.
- Available:

- _____
- 4. Order: Heparin flush 10 units every shift to flush a heparin lock.
- Available:

- 5. Order: Heparin 25,000 units IV in D_5W 500 mL.
- Available:

- _____
- 6. Order: Heparin 17,000 units subcut daily.
- Available:

- _____
- 7. Order: Heparin 2,500 units subcut q12h.
- Available:

- _____
- 8. Order: Heparin 2,000 units/hr IV. Available: 25,000 units of heparin in 1,000 mL of 0.9% NS.
- What rate in mL/hr will deliver 2,000 units/hr? _____
- 9. Order: Heparin 1,500 units/hr IV. Available: 25,000 units of heparin in 500 mL D_5W.
- What rate in mL/hr will deliver 1,500 units/hr? _____
- 10. Order: Heparin 1,800 units/hr IV. Available: 25,000 units heparin in 250 mL D_5W.
- What rate in mL per hr will deliver 1,800 units/hr? _____
- 11. Order: 40,000 units heparin IV in 1 L 0.9% NaCl to infuse at 25 mL/hr.
- Calculate the hourly heparin dosage (units/hr). _____
- 12. Order: Heparin 40,000 units IV in 500 mL D_5W to infuse at 30 mL/hr.
- Calculate the hourly heparin dosage (units/hr). _____
- 13. Order: 1 L of 0.9% NS with 40,000 units heparin IV over 24 hr. Calculate the following:
- a. mL/hr _____
- b. units/hr _____
- 14. Order: 1 L of D_5W with 15,000 units heparin IV over 10 hr. Calculate the following:
- a. mL/hr _____
- b. units/hr _____
- 15. Order: 500 mL of 0.9% NS with 10,000 units of heparin IV to infuse at 120 mL/hr.
- Calculate the hourly heparin dosage (units/hr). _____
- 16. Order: Heparin 40,000 units IV in 1 L 0.9% NS to infuse at 1,000 units/hr.
- Calculate the rate in mL/hr. _____
- 17. Order: Heparin 25,000 units IV in 1 L 0.9% NS to infuse at 2,000 units/hr.
- Calculate the rate in mL/hr. _____
- Calculate the hourly dosage of heparin (units/hr) for Questions 18-23.
- 18. Order: 50,000 units of heparin IV in 1,000 mL of D_5W to infuse at 60 mL/hr. _____
- 19. Order: 20,000 units of heparin IV in 500 mL D_5W to infuse at 20 mL/hr. _____
- 20. Order: 25,000 units of heparin IV in 1 L of D_5W to infuse at 56 mL/hr. _____
- 21. Order: 30,000 units of heparin IV in 500 mL of D_5W to infuse at 25 mL/hr. _____
- 22. Order: 40,000 units of heparin IV in 500 mL 0.45% NS to infuse at 25 mL/hr. _____
- 23. Order: 20,000 units of heparin IV in 1 L of D_5W to infuse at 80 mL/hr. _____
- 24. A central venous line requires flushing with heparin. Which of the two labels shown is appropriate for a heparin flush?

- For problems 25-27, round the weight to the nearest tenth as indicated. The pump delivers in whole mL/hr.
- 25. Order: Heparin drip at 18 units/kg/hr.
- Available: 25,000 units of heparin sodium in 1,000 mL of D_5W. The client weighs 80 kg. At what rate will you set the infusion pump? _____
- 26. A client weighs 210 lb. Heparin IV infusion: heparin sodium 25,000 units in 1,000 mL of 0.9% NS. Order is to give a bolus with heparin sodium 80 units/kg, then initiate drip at 14 units/kg/hr.
- Calculate the following:
- a. Heparin bolus dosage _____
- b. Infusion rate for the IV (initial) _____ units/hr
- c. At what rate will you set the infusion pump? _____
- 27. A client weighs 154 lb. Heparin IV infusion: heparin sodium 20,000 units in 1,000 mL D_5W. The hospital protocol is to give a bolus to the client with 80 units/kg and start drip at 14 units/kg/hr.
- Calculate the following:
- a. Heparin bolus dosage _____
- b. Infusion rate for the IV (initial) _____ units/hr
- c. Infusion rate in mL/hr _____
- **Heparin Protocol for Questions 28-29**

  Bolus heparin at 80 units/kg.

  Begin intravenous infusion of heparin at 18 units/kg/hr using 25,000 units heparin in 250 mL D_5W for 100 units per mL.

  Adjust intravenous heparin daily based on APTT results.

  - • APTT less than 35 sec: Rebolus with 80 units/kg and increase rate by 4 units/kg/hr.
  - • APTT 35-45 sec: Rebolus with 40 units/kg and increase rate by 2 units/kg/hr.
  - • APTT 46-70 sec: **No change.**
  - • APTT 71-90 sec: Decrease rate by 2 units/kg/hr.
  - • APTT greater than 90 sec: **Stop heparin** infusion for 1 hour and decrease rate by 3 units/kg/hr.

- 28. A client weighs 100 kg. Determine the bolus dose of heparin, the initial infusion rate, and then adjust the hourly infusion rate up or down based on APTT results using the above weight-based heparin protocol. The APTT is reported as 71 seconds. The pump delivers in whole mL/hr.
- 29. A client weighs 162.8 lb. Determine the bolus dose of heparin, the initial infusion rate, and then adjust the hourly infusion rate up or down based on APTT results using the above weight-based protocol. The APTT is reported as 38 sec. The pump delivers in tenths of a mL.
- 30. **Directions for question 30:** Calculate the heparin dose in units/hr and the heparin infusion rate in mL/hr. (The pump is capable of delivering in tenths of a mL.)
- Order: Heparin 20 units/kg/hr. IV infusion for a patient/client who weighs 89 kg.
- Available: Heparin 25,000 units in 500 mL D_5W (50 units per mL)
- a. Calculate dose in units/hr _____
- b. Determine the rate in mL/hr _____

Answers on pp. 570-574

For additional practice problems, refer to the Dosages Measured in Units section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

ANSWERS

Chapter 22

Answers to Practice Problems

- 1. 25,000 units : 1,000 mL = 1,000 units : *x* mL
-
- Answer: 40 mL/hr
- 2. 25,000 units : 1,000 mL = *x* units : 35 mL
- Answer: 875 units/hr.
- 3. 30,000 units : 750 mL = *x* units : 25 mL
- Answer: 1,000 units/hr
- 4. Calculate units/hr infusing.
- 1,000 mL : 25,000 units = 100 mL : *x* units
- Answer: 2,500 units/hr
- 5. Convert the weight to kilograms.
- Conversion factor: 2.2 lb = 1 kg
- 176 lb ÷ 2.2 = 80 kg
    - a. Calculate the heparin bolus dosage.

- Answer: 6,400 units
- b. Calculate the infusion rate for the IV drip (initial).

- c. Determine the rate in mL/hr at which to set the infusion rate.
- 1,000 mL : 20,000 units = *x* mL : 1,440 units

Answer: 72 mL/hr

- 6. **Step 1:** Convert the client's weight to kilograms.
- Conversion factor: 1 kg = 2.2 lb

134.2 lb ÷ 2.2 = 61 kg

134.2 lb ÷ 2.2 = 61 kg

- **Step 2:** Calculate the heparin bolus dosage.

- Determine the volume (mL) the client would receive. The concentration of heparin is stated as 50 units per mL.

50 units : 1 mL = 4,880 units : *x* mL

50 units : 1 mL = 4,880 units : *x* mL

x = 98 mL (bolus is 98 mL)

x = 98 mL (bolus is 98 mL)

- **Step 3:** Calculate the infusion rate (18 units/kg/hr).

- Determine the rate in mL/hr at which to set the infusion device (using the concentration of 50 units per mL).

50 units : 1 mL = 1,098 units : x mL

50 units : 1 mL = 1,098 units : x mL

- The client's APTT is 31 seconds. According to the protocol, rebolus with 80 units/kg and increase the rate by 4 units/kg/hr.
- **Step 4:** Calculate the dosage (units/hr) of the continuous infusion increase based on the protocol using the client's weight in kg.
- Calculate the dosage (units) of heparin rebolus.

- Determine the volume (mL) to administer 4,880 units.

  50 units : 1 mL = 4,880 units : *x* mL

  50 units : 1 mL = 4,880 units : *x* mL

- Now determine the infusion rate increase (4 units/kg/hr × kg).

  - The infusion rate should be increased by 244 units/hr.

Calculate the adjustment in the hourly infusion rate (mL/hr).

50 units : 1 mL = 244 units : *x* mL

50 units : 1 mL = 244 units : *x* mL

Increase rate:

Note: This problem could also be done using the dimensional analysis or formula method.

Answers to Clinical Reasoning Questions

- a. The nurse used the incorrect concentration of heparin to prepare the IV solution. Heparin concentration of 100 units per mL is used for maintaining the patency of a line and for flushing.
- b. The nurse should have read the label carefully because heparin comes in a variety of concentrations. The label indicates what the heparin flush is used for and that it is not for anticoagulant therapy. In addition, heparin is a high-alert medication and should have been double-checked with another nurse before administering. Heparin IV flushes are available in 10 units per mL and 100 units per mL. Heparin for IV flush is never used interchangeably with heparin sodium for injection.

Answers to Chapter Review

For problems 4 and 5, an alternate solution might be to use the total amount (volume) in the vial and the number of mL to calculate the dose. Problems are shown using the dosage strength per mL.

- 1. 10,000 units : 1 mL = 3,500 units : x mL
- *or*

- x = 0.35 mL. The dosage ordered is less than the available strength; therefore you will need less than 1 mL to administer the dosage.

- 2. 20,000 units : 1 mL = 16,000 units : x mL
- *or*

- Answer: 0.8 mL. The dosage ordered is less than the available strength; therefore you will need less than 1 mL to administer the dosage.

- 3. 5,000 units : 1 mL = 2,000 units : *x* mL
- *or*

- Answer: 0.4 mL. The dosage ordered is less than the available strength; therefore you will need less than 1 mL to administer the dosage.

- 4. 10 units : 1 mL = 10 units : *x* mL
- *or*

- 1 mL contains 10 units, so you will need 1 mL to flush the heparin lock.

- 5. 5,000 units : 1 mL = 25,000 units : *x* mL
- *or*

- Answer: 5 mL. The dosage ordered is more than the available strength; therefore you will need more than 1 mL to administer the dosage.

- 6. 20,000 units : 1 mL = 17,000 units : *x* mL
- *or*

- Answer: 0.85 mL. The dosage ordered is less than the available strength; therefore you will need less than 1 mL to administer the dosage.

- 7. 10,000 units : 1 mL = 2,500 units : *x* mL
- *or*

- Answer: 0.25 mL. The dosage ordered is less than the available strength; therefore you will need less than 1 mL to administer the dosage.

- 8. 25,000 units : 1,000 mL = 2,000 units : *x* mL

- *x* = 80 mL/hr. To administer 2,000 units of heparin per hour, 80 mL/hr must be given.
- 9. 25,000 units : 500 mL = 1,500 units : *x* mL

- *x* = 30 mL/hr. To administer 1,500 units of heparin per hour, 30 mL/hr must be given.
- 10. 25,000 units : 250 mL = 1,800 units : *x* mL

- *x* = 18 mL/hr. To administer 1,800 units of heparin per hour, 18 mL/hr must be given.
- 11. 1 L = 1,000 mL

- 12. 40,000 units : 500 mL = *x* units : 30 mL

- 13. 1 L = 1,000 mL
  - a. Calculate mL/hr.

  - b. Calculate units/hr.

- 14. 1 L = 1,000 mL
  - a. Calculate mL/hr.

  - b. Calculate units/hr.

- 15.

- 16. 1 L = 1,000 mL

- 17. 1 L = 1,000 mL

- 18.

- 19.

- 20. 1 L = 1,000 mL
- 21.
- 22.
- 23. 1 L = 1,000 mL
- 24. Label “B” at 10 units per mL (100 units per 10 mL) is appropriate for flush. Heparin sodium for injection cannot be interchanged with heparin lock solution.
- 25.
    - a. First determine units/kg the client should receive.
    - b.

Answer: 58 mL/hr

- 26.
  - a. Convert the weight to kilograms.
  - Conversion factor: 2.2 lb = 1 kg
  - 210 lb ÷ 2.2 = 95.45 kg = 95.5 kg
  - Calculate the heparin bolus dosage.
  -
  - Answer: 7,640 units
  - b. Calculate the infusion rate for the heparin drip.
  -
  - c. Calculate the infusion rate in mL/hr.

Answer: 53 mL/hr

- 27.
  - a. Convert the weight to kilograms.
  - Conversion factor: 2.2 lb = 1 kg
  - 154 lb ÷ 2.2 = 70 kg
  - Calculate the heparin bolus dosage.

- Answer: 5,600 units
- b. Calculate the infusion rate for the heparin drip.

- Answer: 980 units/hr
- c. Calculate the infusion rate in mL/hr.

- 28. **Step 1:** Calculate the heparin bolus dosage. (No weight conversion required; the weight is in kg.)

- Determine the volume (mL) the client would receive. The concentration is indicated as 100 units per mL.

- **Step 2:** Calculate the infusion rate (18 units/kg/hr × kg).

- Determine the rate in mL/hr at which to set the infusion device (using the concentration of 100 units per mL).
- The client's APTT is reported as being 71 sec. (According to the protocol, decrease the rate by 2 units/kg/hr; there's no rebolus.)
- **Step 3:** Determine the infusion decrease rate (2 units/kg/hr × kg).
- **Step 4:** Calculate the adjustment in the hourly infusion rate (mL/hr).
- **Decrease rate:**
- Decrease the rate on the pump to 16 mL/hr.
- ***Note:*** This problem could also be done using dimensional analysis or formula method.
- 29. **Step 1:** Calculate the heparin bolus dosage.
- Convert the weight to kg. Equivalent: 2.2 lb = 1 kg
- 162.8 lb ÷ 2.2 = 74 kg

- The client should receive 5,920 units IV heparin as a bolus.
- Determine the volume (mL) the client would receive. The concentration is indicated as 100 units per mL.

  100 units : 1 mL = 5,920 units : *x* mL

  100 units : 1 mL = 5,920 units : *x* mL

- **Step 2:** Calculate the infusion rate (18 units/kg/hr × kg)

- Determine the rate in mL/hr at which to set the infusion device (using the concentration of 100 units per mL).

  100 units : 1 mL = 1,332 units : *x* mL

  100 units : 1 mL = 1,332 units : *x* mL

- x = 13.3 mL/hr (The pump delivers in tenth of a mL)
- The client's APTT is reported as being 38 sec (according to the protocol). Rebolus with 40 units/kg and increase rate by 2 units/kg/hr.

- **Step 3:** Determine the infusion increase rate.

- **Step 4:** Calculate the adjustment in the hourly infusion rate (mL/hr).

  100 units : 1 mL = 148 units : x mL

100 units : 1 mL = 148 units : x mL

- Increase rate:

- Increase the rate on the pump to 14.8 mL/hr.
- ***Note:*** This problem could also be done using dimensional analysis or formula method.
- 30. No weight conversion required, the weight is in kg.
    - a. Calculate the dose in units/hr
    -
    - Answer: 1,780 units/hr
    - b. Determine the rate in mL/hr to deliver 1,780 units/hr

      50 units : 1 mL = 1,780 units : *x* mL

      50 units : 1 mL = 1,780 units : *x* mL
    - *x* = 35.6 mL/hr (pump capable of delivering in tenths)

  Answer: 35.6 mL/hr. The pump would be set at 35.6 mL/hr to deliver 1,780 units/hr.

The content in this chapter may be required in nursing curriculums that have a critical care component or a specific component of advanced medical-surgical nursing that addresses this content. The content in this chapter can also be used as a reference for nurses working in specialty areas. This chapter provides basic information on medicated drips and titration. In the critical care setting, clients oft en receive medications to control vital functions that are potent and require close monitoring. These may include medications to maintain the client's blood pressure within normal range and antiarrhythmic medications to regulate the client's heart rate and/or rhythm. Other medications that may be given include sedatives and narcotics. Medications in the critical care setting may be given continuously IV at a constant rate, or the rate of the IV may be titrated (adjusted) to the client response. Examples of how medication dosages may be ordered include milliliters per hour (mL/hr), milligrams per hour (mg/hr), and micrograms per kilogram per minute (mcg/kg/min).

Although there have been instances in the past in which critical care medications were administered using volume-control tubing that has a microdrop calibration (60 gtt/mL), their use should only be in dire circumstances when an infusion pump is not available. Critical care medications should be administered using an electronic infusion pump. This text will focus on critical care medications administered using an infusion pump. As discussed in Chapter 20, pumps deliver in whole milliliters, and there are some pumps that deliver in tenths of a milliliter (usually used in the critical care setting). **Always** be familiar with the pump calibration at your institution. Because of the potency of the medications used, it is essential that nurses perform accurate calculation of dosages, correctly program the infusion pump, and perform continuous monitoring of the client for their response to the medications that are being administered. Despite the use of electronic infusion pumps, calculation errors, infusion pump malfunction, or errors in programming an infusion pump can occur. **Never assume;** to ensure client safety, always use an electronic infusion pump and verify calculations and programming of the pump with a second nurse before administering medications. Like insulin and heparin, many of the medications administered are high-alert medications. Errors in programming infusion pumps or administration of medications at a faster rate than specified or recommended can result in life-threatening effects.

SAFETY ALERT!

Electronic infusion devices are routinely used to administer medications that are potent. Accurate calculations, correct programming of the pump, and client monitoring are crucial to prevent life-threatening effects, ensure the desired physiological response, and maintain client safety during administration of potent high-alert medications.

Calculating Rate in mL/hr

The same methods shown in previous chapters involving medications in solution can be applied to critical care medications. Let's look at some examples.

Example 1: A solution of Morphine Sulfate 50 mg in 100 mL D_5W at 3.5 mg/hr. Calculate the rate in mL/hr using the solution strength available.

Solution:

Ratio and Proportion (Linear Format)

50mg:100mL=3.5mg:xmL50x=100×3.550x50=35050x=7mL/hror

Ratio and Proportion (Fraction Format)

50mg100mL=3.5mgxmLx=7mL/hr

Formula Method

Dimensional Analysis

As shown in previous chapters involving medications in solution, **isolate what is being calculated.** In this example, it is mL/hr. The **starting fraction** will be the information from the problem containing mL. (mL is placed in the numerator.) Set up **each fraction after** the starting fraction matching the previous denominator.

To infuse 3.5 mg/hr of Morphine Sulfate, set the infusion pump at 7 mL/hr.

Example 2: A solution of Isuprel (isoproterenol) 2 mg in 250 mL D_5W to infuse at a rate of 5 mcg/min. (The infusion pump is capable of delivering in tenths of an mL.)

Solution:

Step 1: Calculate the dose per hour.

Step 2: Convert 300 mcg to mg to match the available strength.

1,000 mcg = 1 mg; therefore 300 mcg = 0.3 mg

Step 3: Calculate the rate in mL/hr. (Use any of the methods shown in Example 1.)

Ratio and Proportion (Linear Format *or* Fraction Format)

2mg:250mL=0.3mg:xmL2mg250mL=0.3mgxmL2x=250×0.32x2=752=37.5

x = 37.5 mL/hr (this is not rounded to the whole number; the pump delivers in tenths of an mL)

Formula Method

Dimensional Analysis

Note: In this equation, you will need two additional conversion factors, 60 min = 1 hr and 1,000 mcg = 1 mg.

To infuse 5 mcg/min of Isuprel, set the infusion pump at 37.5 mL/hr.

Calculating Critical Care Dosages per Hour or per Minute

Example: Infuse dopamine 400 mg in 500 mL D_5W at 30 mL/hr. Calculate the dosage in mcg/min and mcg/hr.

Solution:

Step 1: Determine mg/hr.

Remember, ratio and proportion can be set up in linear or fraction format.

Step 2: The next step is to convert 24 mg to mcg because the question asks for mcg/min and mcg/hr. Change mg to mcg using the equivalent 1,000 mcg = 1 mg. Change mg to mcg by multiplying by 1,000 or moving the decimal point three places to the right.

24 mg/hr = 24,000 mcg/hr

Step 3: Now that you have the mcg/hr, change the mcg/hr to mcg/min using the equivalent 60 min = 1 hr.

Divide the number of mcg/hr by 60 to get the mcg/min.

Note: This is in mcg/min; however, these medications are usually delivered in mL/hr by pump, and you will need to take the calculation further. Later in the chapter you will see examples of changing mcg/min to mL/hr.

Dimensional Analysis

Dopamine infusing at 30 mL/hr = 24,000 mcg/hr; 400 mcg/min.

Medications Ordered in Milligrams per Minute

Medications such as Lidocaine and Pronestyl are ordered in mg/min.

Example: A client is receiving Pronestyl 60 mL/hr. The solution available is Pronestyl 2 g in 500 mL D_5W. Calculate the mg/hr and the mg/min the client will receive.

Solution:

Step 1: A conversion is necessary; g must be converted to mg.

You are being asked for **(mg/min, mg/hr).** Equivalent: 1 g = 1,000 mg.

Therefore 2 g = 2,000 mg. Multiply 2 by 1,000 or move decimal point three places to the right.

Step 2: Now determine the mg/hr by setting up a proportion. (Refer to problems earlier in the chapter illustrating the various methods that can be used.)

Step 3: Convert mg/hr to mg/min. Equivalent: 60 min = 1 hr.

Dimensional Analysis

(***Note:*** The starting fraction here is the conversion factor to match the desired numerator, and the solution strength is in g, with the conversion factor written so g is written in the numerator to match the denominator of the starting fraction.)

Pronestyl infusing at 60 mL/hr is delivering 240 mg/hr; 4 mg/min.

Calculating Dosages Based on mcg/kg/min

Medications are also ordered for clients based on dosage per kilogram per minute. These medications include Nipride, dopamine, and dobutamine. In these problems, the weight will be rounded to the nearest tenth as indicated for calculation.

Example: Order: Dopamine 2 mcg/kg/min. The solution available is dopamine 400 mg in 250 mL D_5W. The client weighs 154 lb. (The pump is capable of delivering in tenths of an mL.)

Solution:

Step 1: Convert the client's weight in pounds to kilograms.

Equivalent: 2.2 lb = 1 kg

To convert the weight, divide 154 lb by 2.2.

154 lb ÷ 2.2 = 70 kg

Step 2: Now that you have the client's weight in kg, determine the dosage per minute.

Converting mcg/min to mL/hr then would be easy using this example. (Equivalent: 1,000 mcg = 1 mg.)

- a. Convert mcg/min to mcg/hr.
- b. Convert mcg/hr to mg/hr.
- 8,400 ÷ 1,000 = 8.4 mg/hr
- c. Determine IV flow rate.

Ratio and Proportion

Dimensional Analysis

The pump would be set at 5.3 mL/hr to administer the dose of dopamine at 2 mcg/kg/min.

IV Flow Rates for Titrated Medications

Critically ill clients in the critical care area can receive potent medications by IV infusion using a process referred to as **titration**. **Titrated medications** are added to a specific volume of fluid and then adjusted accordingly to infuse at a rate at which the desired effect is attained. **The medications that are titrated include potent antiarrhythmic, vasopressor, and vasodilator medications; these must be monitored closely by the nurse**. IV medications that are titrated usually start at the lowest dosage and are increased and decreased as needed. Medications that are titrated are administered according to a protocol. Nurses **must** know the institution's protocol regarding administration of titrated medications. Because of the potency of medications used, minute changes in the infusion cause an effect on the client. Titrated medications are ordered within parameters to obtain a desirable outcome. The outcome desired depends on the medication. When a solution is titrated, **the lowest dosage of the medication is set first and increased or decreased as necessary. The higher dosage should not be exceeded without an order.** When a medication is to be titrated, the prescriber determines the titration for the individual client based on the desired outcome. The order for the titration of a medication includes the medication, the dosage in a specific volume of fluid, the dosage range (minimal dose and maximum dose), the starting dose for the medication (which is usually the minimal dose), and the desired outcome.

Dosage errors with titrated medications can result in dire consequences. Therefore, the nurse must have knowledge regarding the medication, the proper dosage adjustment, and the frequency of adjustments based on the client assessment and the prescribed parameters. Electronic infusion pumps are used with titrated medications.

There are also IV pumps available in the critical care setting, referred to as *smart pumps*. Smart pumps were discussed in Chapter 20. The sophistication of the smart pump depends on the software. Some smart pumps have incorporated calculating IV rates for specific medications. The nurse is able to select the medication from the IV pump "library" and enter the desired dose and concentration of the medication and the client's weight in kilograms; the pump then displays the IV rate in mL/hr.

Regardless of the type of infusion pump used, the nurse has the responsibility of having knowledge about the equipment to ensure safe medication administration of potent high-alert medications. The increase in sophistication of pumps do not relieve the nurse from his or her responsibility to think critically (i.e., Is the dosage reasonable? Is the rate correct to deliver the ordered dosage?). Pumps that have the ability to perform the needed calculations or a calculator should be used as a tool to check calculations and not as a tool for dosage calculation. Smart pumps should be used as a drive toward safe practice and used properly to ensure client safety. Remember that all pumps require human entry.

Because of the consequences associated with titrated medications, it is common practice at many institutions to have a double- or triple-check of medication dosages and the mathematical computations associated with them, even in instances where calculators may be used.

SAFETY ALERT!

Know the equipment you are using and the institution's policy regarding the administration of titrated medications. **Never exceed** the prescribed upper dose limit. Notify the prescriber when the maximum limit is reached for a new order.

Let's look at some examples of titration of medications.

Example 1: Nipride has been ordered to titrate at 3 to 6 mcg/kg/min to maintain a client's systolic blood pressure below 140 mm Hg. The solution contains 50 mg Nipride in 250 mL D_5W. The client weighs 56 kg. Determine the rate to set the IV pump.

Step 1: Convert to **like units**.

Equivalent: 1,000 mcg = 1 mg

Therefore 50 mg = 50,000 mcg

Step 2: Calculate the concentration of solution in mcg/mL.

50,000mcg:250mL=xmcg:1mL250x250=50,000250x=200mcg/mL

The concentration of solution is 200 mcg/mL.

Step 3: Calculate the dosage range using the upper and lower dosages.

Step 4: Convert dosage range to mL/min.

(Lowerdosage)200mcg:1mL=168mcg:xmL200x200=168200x=0.84mL/min

(Upperdosage)200mcg:1mL=336mcg:xmL200x200=336200x=1.68mL/min

Step 5: Convert mL/min to mL/hr.

A dosage range of 3 to 6 mcg/kg/min is equal to a flow rate of 50 to 101 mL/hr.

The client's condition has stabilized, and the flow rate is now maintained at 60 mL/hr. What dosage will be infusing per minute?

Solution to Example 1 Using Dimensional Analysis

Step 1: Calculate the dosage range first.

Step 2: Calculate the IV rate in mL/hr for the lower dosage.

Step 3: Calculate the IV rate in mL/hr for the upper dosage.

A dosage range of 3 to 6 mcg/kg/min is equal to a flow rate of 50 to 101 mL/hr.

The client's condition has stabilized, and the IV flow rate is now maintained at 60 mL/hr. What dosage will be infusing per minute?

Developing a Titration Table

After calculating an initial IV rate for a medication being titrated, the client is monitored. If the desired response is not achieved, the dosage may have to be increased. This will require the nurse to find the corresponding IV rate in mL/hr for the new dosage. Any time the dosage is changed, recalculation of the corresponding IV rate is required. Rather than performing calculations each time a dosage is modified, the nurse can develop a titration table to provide the IV rate for any possible change in the medication dosage.

Let's look at the previous example (Example 1) and develop a titration table to increase the dosage by 1 mcg/min up to 6 mcg/min. Set up a ratio proportion to develop the titration table; use the minimum rate required to deliver 3 mcg/min to find the incremental flow rate that provides a dosage rate change of 1mcg/min.

The proportion is:

$$3\text{mcg/min} 50\text{mL/hr} = 1\text{mcg/min} x\text{mL/hr} 3x3 = 502 = 16.6x = 17\text{mL/hr}$$

So, for each change of 1 mcg/min, the incremental IV flow rate is 17 mL/hr.

Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
3 mcg/min **(minimum)**	50 mL/hr
4 mcg/min	67 mL/hr
5 mcg/min	84 mL/hr
6 mcg/min **(maximum)**	101 mL/hr

Notice in this problem mL/hr was rounded to the nearest whole number. Remember, there are pumps capable of accepting one decimal place.

Example 2: Nitroglycerin has been ordered to titrate at 10 mcg/min to 60 mcg/min, and the rate should be increased by 10 mcg/min every 3-5 minutes for chest pain. The solution contains 50 mg nitroglycerin in 250 mL D_5W.

Step 1: Calculate the dose per hour using the upper and lower dosages.

Step 2: Convert mcg to mg to match the available strength.

1,000 mcg = 1 mg

600 mcg = 0.6 mg

3,600 mcg = 3.6 mg

Step 3: Calculate the rate in mL/hr.

50mg:250mL=0.6mg:xmL50x=250×0.650x50=15050x=3mL/hr

To infuse 10 mcg/min, set the IV rate at 3 mL/hr (minimum).

50mg:250mL=3.6mg:xmL50x=250×3.650x50=90050x=18mL/hr

To infuse 60 mcg/min, set the IV rate at 18 mL/hr (maximum). A dosage range of 10 to 60 mcg/min is equal to a flow rate of 3 to 18 mL/hr.

Dimensional Analysis Setup for Example 2

Calculate the lower dosage.

Calculate upper dosage.

A dosage range of 10-60 mcg/min is equal to a flow rate of 3-18 mL/hr.

Develop a titration table using 10-mcg increments. Set up the proportion using the minimum to determine the dosage change of 10 mcg/min.

10mcg/min3mL/hr=10mcg/minxmL/hr10x10=3010x=3mL/hr

So, for each change of 10 mcg/min, the incremental IV flow rate is 3 mL/hr.

Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
10 mcg/min **(minimum)**	3 mL/hr
20 mcg/min	6 mL/hr
30 mcg/min	9 mL/hr
40 mcg/min	12 mL/hr
50 mcg/min	15 mL/hr
60 mcg/min **(maximum)**	18 mL/hr

Example 3: Levophed (norepinephrine bitartrate) has been ordered to titrate at 3 mcg/min to 10 mcg/min, and the rate should be increased at 1 mcg/min to maintain blood pressure and keep systolic blood pressure greater than 100 mm Hg. The solution contains 2 mg Levophed in 250 mL D_5W. Develop a titration table at 1-mcg increments. The pump delivers in tenths.

Step 1: Calculate the dose per hour using the upper and lower dosages.

Step 2: Convert mcg to mg to match the available strength.

1,000 mcg = 1 mg

180 mcg = 0.18 mg

600 mcg = 0.6 mg

Step 3: Calculate the rate in mL/hr

2mg:250mL=0.18mg:xmL2x=250×0.182x2=452x=22.5mL/hr

To infuse 3 mcg/min, set the IV rate at 22.5 mL/hr (minimum)

2mg:250mL=0.6mg:xmL2x=250×0.62x2=1502x=75mL/hr

To infuse 10 mcg/min, set the IV rate at 75 mL/hr. A dosage range of 3-10 mcg/min is equal to a flow rate of 22.5-75 mL/hr.

Dimensional Analysis Setup for Example 3

Calculate the lower dosage.

Calculate the upper dosage.

A dosage range of 3-10 mcg/min is equal to a flow rate of 22.5-75 mL/hr.

Find the incremental flow rate for a dosage rate change of 1 mcg/min by setting up a ratio proportion.

The proportion is:

3mcg/min22.5mL/hr=1mcg/minxmL/hr3x3=22.53x=7.5mL/hr

So, for each change of 1 mcg/min, the incremental IV flow rate is 7.5 mL/hr.

Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
3 mcg/min **(minimum)**	22.5 mL/hr
4 mcg/min	30 mL/hr
5 mcg/min	37.5 mL/hr
6 mcg/min	45 mL/hr
7 mcg/min	52.5 mL/hr
8 mcg/min	60 mL/hr
9 mcg/min	67.5 mL/hr

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
10 mcg/min **(maximum)**	75 mL/hr

POINTS TO REMEMBER

- • Potent medications in the critical care setting should be administered by an electronic infusion device.
- • Accurate calculation of dosages and client monitoring are essential when clients are receiving potent medications by IV infusion.
- • Double-checking of calculations is essential to ensure correct dosage administration.
- • Titration of medications requires careful adjustment of dosages to obtain a desirable client outcome.
- • Know the institution's policy relating to titration of medications.
- • **Do not** exceed the upper dose limit for titrated medications.
- • **Always** be familiar with the calibration of the infusion pump being used to administer IV medications.
- • The use of infusion pumps **does not** relieve the responsibility of the nurse to critically think.

PRACTICE PROBLEMS

Calculate the following as indicated. Unless stated otherwise, infusion pumps deliver in whole mL/hr.

- 1. A client weighing 50 kg is to receive a Dobutamine solution of 250 mg in 500 mL D5W ordered to titrate between 2.5 and 5 mcg/kg/min.
  - a. Determine the flow rate setting for an infusion pump. _____
  - b. If the IV flow rate is being maintained at 25 mL/hr after several titrations, what is the dosage infusing per minute? _____
- 2. Order: Epinephrine at 30 mL/hr. The solution available is 2 mg of epinephrine in 250 mL D_5W. Calculate the following:
  - a. mg/hr _____
  - b. mcg/hr _____
  - c. mcg/min _____
- 3. Aminophylline 0.25 g is added to 500 mL D_5W to infuse at 20 mL/hr. Calculate the following:
- mg/hr _____
- 4. Order: Pitocin at 25 mL/hr. The solution contains 20 units of Pitocin in 1,000 mL Ringer's Lactate.
- Calculate the number of units per hour the client is receiving. _____
- 5. Order: 3 mcg/kg/min of Nipride RTU.
- Available: 50 mg of Nipride RTU in 250 mL D_5W. Client's weight is 60 kg.
- Calculate the flow rate in mL/hr that will deliver this dosage. _____
- 6. A nitroglycerin drip is infusing at 3 mL/hr. The solution available is 50 mg of nitroglycerin in 250 mL D_5W. Calculate the following:
  - a. mcg/hr _____
  - b. mcg/min _____
- 7. Order: Procainamide to titrate at 2 mg/min to the maximum of 6 mg/min. The available solution is procainamide 2 g in 250 mL D_5W. Develop a titration table in 2-mg/min increments up to the maximum dose.

Answers on pp. 593-594

CLINICAL REASONING

Scenario: Isuprel is ordered for a client at the rate of 3 mcg/min with a solution containing Isuprel 1 mg in 250 mL D_5W. The nurse performed the following calculation to determine the rate by pump in mL/hr.

- • Calculated the dosage per hour:

- • Converted 180 mcg to milligrams to match the units in the solution strength:
- 180 mcg = 0.018 mg
- • Calculated the rate in mL/hr:
- 1 mg : 250 mL = 0.018 mg : *x* mL
- *x* = 250 × 0.018
- *x* = 4.5 = 5 mL/hr

- a. What error did the nurse make in her calculation to determine the rate in mL/hr? _____
- b. What could be the potential outcome of the error? _____
- c. What should the rate be in mL/hr? _____
- d. What preventive measures could have been taken by the nurse? _____

Answers on 594

NGN Case Study

Learning Objectives:

- 1. Calculate dosages in mcg/min, mcg/hr, and mg/min.
- 2. Calculate dosages in mg/kg/hr, mg/kg/min, and mcg/kg/min, mcg/kg/hr.

Case Scenario: The client is in the intensive care unit for respiratory failure, is placed on a mechanical ventilator, and needs to be given sedation for comfort. Propofol is ordered for sedation at 15 mcg/kg/min. The client weighs 188 pounds. The solution available is Propofol 1,000 mg in 100 mL of D_5W. The electronic infusion device can be programed to tenths. Which actions are appropriate in planning care for this client? **Select all that apply.**

- 1. Calculate the client weight as 85.5 kg.
- 2. Calculate the patient weight as 413.6 kg.
- 3. Calculate the dose of propofol as 1282.5 mcg/min.
- 4. Calculate the dose of propofol as 6204 mcg/min.
- 5. Program the electronic infusion device for 7.7 mL/hr.
- 6. Program the electronic infusion device for 38.5 mL/hr.
- 7. Program the electronic infusion device for 16.9 mL/hr.

Reference: Morris: *Calculate with confidence*, ed 8, St Louis, Elsevier, copyright 2022.

Case Study answers and rationales can be found on Evolve.

CHAPTER REVIEW

Calculate the dosages as indicated. Use the labels where provided. Unless stated otherwise, pump is capable of delivering in a whole number of mL.

- 1. Client is receiving Isuprel at 30 mL/hr. The solution available is 2 mg of Isuprel in 250 mL D_5W. Calculate the following:
  - a. mg/hr _____
  - b. mcg/hr _____
  - c. mcg/min _____
- 2. Infuse dopamine 800 mg in 500 mL D_5W at 30 mL/hr. Calculate the dosage in mcg/hr and mcg/min.
- Available:

  - a. mcg/hr _____
  - b. mcg/min _____
  - c. Calculate the number of milliliters you will add to the IV for this dosage. _____
- 3. Infuse Sodium Nitroprusside at 30 mL/hr. The solution available is 50 mg sodium nitroprusside in 250 mL 0.9% NS.
- Available:

- Calculate the following:
  - a. mcg/hr _____
  - b. mcg/min _____
  - c. Number of milliliters you will add to the IV for this dosage _____
- 4. Order: Lidocaine 2 g in 250 mL D_5W to infuse at 60 mL/hr. Calculate the following:
  - a. mg/hr _____
  - b. mg/min _____
- 5. Order: Aminophylline 0.25 g to be added to 250 mL of D_5W. The order is to infuse over 6 hr.
- Available:

- a. Calculate the dosage in mg/hr the client will receive. _____
- b. Calculate the number of milliliters you will add to the IV for this dosage. _____

- 6. A client is receiving Pronestyl at 30 mL/hr. The solution available is 2 g Pronestyl in 250 mL D_5W. Calculate the following:
  - a. mg/hr _____
  - b. mg/min _____
- 7. Order: Pitocin (oxytocin) at 40 mL/hr. The solution available is 30 units of Pitocin in 1,000 mL of D_5W. Calculate the following:
  - a. units/hr _____
  - b. units/min _____
- 8. A client is receiving bretylium at 45 mL/hr. The solution available is 2 g bretylium in 500 mL D_5W. Calculate the following:
  - a. mg/hr _____
  - b. mg/min _____
- 9. A client is receiving nitroglycerin 50 mg in 250 mL D_5W. The order is to infuse 500 mcg/min.
- What flow rate in mL/hr would be needed to deliver the ordered dosage? _____
- 10. Dopamine has been ordered to maintain a client's blood pressure; 400 mg dopamine has been placed in 500 mL D_5W to infuse at 35 mL/hr.
- How many milligrams are being administered per hour? _____
- 11. A client is receiving Isuprel 2 mg in 250 mL D_5W. The order is to infuse at 20 mL/hr. Calculate the following:
  - a. mg/hr _____
  - b. mcg/hr _____
  - c. mcg/min _____
- 12. Order: 1 g of aminophylline in 1,000 mL D_5W to infuse over 10 hr.
- Calculate the dosage in mg/hr the client will receive. _____
- 13. A client is receiving lidocaine 2 g in 250 mL D_5W. The solution is infusing at 22 mL/hr. Calculate the following:
  - a. mg/hr _____
  - b. mg/min _____
- 14. Order: Esmolol 2.5 g in 250 mL 0.9% NS at 30 mL/hr. Calculate the following:
  - a. mg/hr _____
  - b. mg/min _____
- 15. Order: Dobutamine 500 mg in 500 mL D_5W to infuse at 30 mL/hr.
- Calculate the following:
  - a. mcg/hr _____
  - b. mcg/min _____
- 16. Order: Dopamine 400 mg in 500 mL 0.9% NS to infuse at 200 mcg/min.
- Calculate the rate in mL/hr. _____
- 17. Order: Magnesium sulfate 3 g/hr.
- Available: 25 g of 50% magnesium sulfate in 300 mL D_5W.
- What rate in mL/hr would be needed to administer the required dose? _____
- 18. Order: Nipride 50 mg in 250 mL D_5W to infuse at 2 mcg/kg/min. Client's weight is 120 lb.
- Calculate the dosage per minute. _____
- 19. Order: Dobutamine 250 mg in 500 mL of D_5W at 3 mcg/kg/min. The client weighs 80 kg.
- What dosage in mcg/min should the client receive? _____
- 20. Order: Infuse 1 g of aminophylline in 1,000 mL of D_5W at 0.7 mg/kg/hr. The client weighs 110 lb.
  - a. Calculate the dosage in mg/hr. _____
  - b. Calculate the dosage in mg/min. _____
  - c. Reference states no more than 20 mg/min. Is the order safe? _____
- 21. Norepinephrine (Levophed) 2 to 6 mcg/min has been ordered to maintain a client's systolic blood pressure at 100 mm Hg. The solution concentration is 2 mg in 500 mL D_5W.
- Determine the flow rate in mL/hr. _____
- 22. Esmolol is to titrate between 50 to 75 mcg/kg/min. The client weighs 60 kg. The solution strength is 5,000 mg of esmolol in 500 mL D_5W.
  - a. Determine the flow rate for an infusion pump. _____
  - b. The titration rate is at 24 mL/hr. What is the dosage infusing per minute? _____
- 23. Order: Dobutamine 500 mg in 250 mL D_5W to infuse at 10 mcg/kg/min. The client weighs 65 kg.
- Calculate the flow rate in mL/hr. _____
- 24. A client is receiving lidocaine 1 g in 500 mL D_5W at a rate of 20 mL/hr. Calculate the following:
  - a. mg/hr _____
  - b. mg/min _____
- 25. Esmolol 1.5 g in 250 mL D_5W has been ordered at a rate of 100 mcg/kg/min for a client weighing 102.4 kg. Determine the following:
  - a. dosage in mcg/min _____

- b. rate in mL/hr _____
- 26. Order: Dopamine 400 mg in 500 mL D_5W to infuse at 20 mL/hr. Determine the following:
  - a. mg/min _____
  - b. mcg/min _____
- 27. Order: Diltiazem HCl 125 mg in 100 mL D_5W to infuse at 20 mg/hr.
- Available:

- Determine the following:
  - a. How many milliliters will you add to the IV? _____
  - b. Determine the rate in mL/hr. (Consider the medication in the volume.) _____
- 28. Order: 2 g Pronestyl in 500 mL D_5W to infuse at 2 mg/min.
- Determine the rate in mL/hr. _____
- 29. Dopamine is ordered at a rate of 3 mcg/kg/min for a client weighing 95.9 kg. The solution strength is 400 mg dopamine in 250 mL D_5W. Determine the flow rate for an IV pump. The pump is capable of delivering in tenths of an mL. _____
- 30. Infuse Dobutamine 250 mg in 500 mL D_5W at 5 mcg/kg/min. The client weighs 143 lb. Concentration of solution is 500 mcg per mL. How many mcg of dobutamine will be infused per minute? _____ per hour? _____
- 31. A medication has been ordered at 2 to 4 mcg/min to maintain a client's systolic BP greater than 100 mm Hg. The medication being titrated has 8 mg of medication in 250 mL D_5W. Determine the IV rate for 2 to 4 mcg range. Then assume that after several changes in mL/hr have been made, the BP has stabilized at a rate of 5 mL/hr. How many mcg/min is the client receiving at this rate? Determine the flow rate for an IV pump capable of delivering in tenths of an mL.
  - a. _____ Flow rate for 2-4 mcg range
  - b. _____ mcg per/min at 5 mL /hr
- 32. Order: Nitroglycerin to titrate at 40 mcg/min for chest pain to a maximum of 100 mcg/min. The solution contains 40 mg of nitroglycerin in 250 mL D_5W. Develop a titration table from minimum to maximum dose in 20-mcg/min increments. The pump is capable of delivering in tenths.
- 33. Order: Levophed 4 mcg/min to maintain BP systolic greater than 100 mm Hg to a maximum of 12 mcg/min. Available solution: Levophed 4 mg in 500 mL D_5W. Develop a titration table in 2-mcg/min increments.
- 34. A solution of lorazepam 4 mg in 100 mL 0.9% NS to infuse at 1 mg/hr. Determine the infusion rate.
- 35. A solution of Amiodarone 900 mg in 500 mL of D_5W to infuse at 0.5 mg/min. Determine the infusion rate to deliver the ordered dosage. (The pump is capable of delivering in tenths of an mL.)

Answers on pp. 594-600

For additional practice problems, refer to the Advanced Calculations section of the Critical Care Dosages section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

ANSWERS

Chapter 23

Answers to Practice Problems

- 1. a. Step 1: Conversion: Equivalent: 1,000 mcg = 1 mg.
- Therefore 250 mg = 250,000 mcg.
- Step 2: 250,000 mcg : 500 mL = *x* mcg : 1 mL

  500x500=250,000500;x=500mcg/mL

- Concentration of solution is 500 mcg/mL.
- Step 3: Calculate dosage range.
- Lower dosage:

- Upper dosage:

- Step 4: Convert dosage range to mL/min.
- Lower dosage:

  500mcg:1mL=125mcg:xmL500x500=125500x=0.25mL/min

- Upper dosage:

  500mcg:1mL=250mcg:xmL500x500=125500x=0.5mL/min

- Step 5: Convert mL/min to mL/hr.

- A dosage range of 2.5-5 mcg/kg/min is equal to a flow rate of 15-30 mL/hr.
- b. Determine dosage infusing per minute at 25 mL/hr:
- 500 mcg : 1 mL = *x* mcg : 25 mL
- *x* = 12,500 mcg/hr
- 12,500 mcg ÷ 60 min = 208.3 mcg/min
- 2. a.

  2mg:250mL=xmg:30mL250x250=60250x=0.24mg/hr

- b. Convert milligrams to micrograms
- (1,000 mcg = 1 mg).
- 0.24 mg = 240 mcg/hr
- c. Convert mcg/hr to mcg/min.

- 3. a. Change grams to milligrams. (Note that you were asked to calculate mg/hr.)
- 0.25 g = 250 mg (1 g = 1,000 mg)
- b. Calculate mg/hr.

  250mg:500mL=xmg:20mL500x500=5,000500x=10mg/hr

- 4. *Note:* Calculate units per hour only.

  20units:1,000mL=xunits:25mL1,000x1,000=5001,000;x=0.5units/hr

- The client is receiving 0.5 units/hr.
- 5. Step 1: Determine the dosage per minute.

- Step 2: Convert to dosage per hour.

- Step 3: Convert to like units (1,000 mcg = 1 mg).
- 10,800 mcg = 10.8 mg
- Calculate flow rate (mL/hr).

  50mg:250mL=10.8mg:xmL50x=250×10.850x50=2,70050x=54mL/hr

- 6.a.

  50mg:250mL=xmg:3mL250x250=150250x=0.6mg/hr

  Convert to micrograms (1,000 mcg = 1 mg).

- 0.6 mg/hr = 600 mcg/hr
- b. Convert mcg/hr to mcg/min.

- 7. Step 1: Calculate the dose per hour using the lower and upper dosages.

- Step 2: Convert mg to g to match the available strength.
- 1,000 mg = 1 g
- 120 mg = 0.12 g
- 360 mg = 0.36 g

Step 3: Calculate the rate in mL/hr

2g:250mL=0.12g:xmL2x=250×0.122x2=302x=15mL/hr

To infuse 2 mg/min, set the IV rate at 15 mL/hr (minimum).

2g:250mL=0.36g:xmL2x=250×0.362x2=902x=45mL/hr

To infuse 6 mg/min, set the IV rate at 45 mL/hr (maximum).

A dosage range of 2-6 mg/min is equal to a flow rate of 15-45 mL/hr.

Set up proportion to determine the dosage of 2 mg/min.

2mg/min15mL/hr=2mg/minxmL/hr2x2=302x=15mL/hr

So for a change of 2 mg/min, the incremental IV flow rate is 15 mL/hr.

Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
2 mg/min (minimum)	15 mL/hr
4 mg/min	30 mL/hr
6 mg/min **(maximum)**	45 mL/hr

Note: This problem could also be done using dimensional analysis.

Answers to Clinical Reasoning Questions

- a. The nurse made the error in the second step (converting 180 mcg to mg to match the units in the solution strength). This led to the error in the mL/hr rate.

  180mcg=0.18mg(1,000mcg=1mg)180÷1,000=0.18mg

- b. The error would result in an incorrect IV rate in mL/hr; the answer obtained is used to determine the rate in mL/hr. Use of 0.018 mg would net an incorrect answer.

  1mg=250mL=0.018mg:xmLx=250×0.018x=4.5=5mL/hr

- c. The rate in mL/hr should be 45 mL/hr and not 5 mL/hr.

  1mg:250mL=0.18mg:xmLx=250×0.18x=45mL/hr

- d. The nurse should have double-checked the math at each step. In addition, having another nurse check the calculation may have helped in recognizing the error in calculation.

Answers to Chapter Review

- 1. a. Calculate the dosage per hr.

  2mg:250mL=xmg:30mL250x250=60250x=60250x=0.24mg/hr

- b. Convert milligrams to micrograms
- (1,000 mcg = 1 mg).
- 1,000 × 0.24 mg/hr = 240 mcg/hr
- c. Convert mcg/hr to mcg/min.

- 2. Step 1: Determine dosage per hour.

  800mg:500mL=xmg:30mL500x500=24,000500x=24,000500x=48mg/hr

- a. Step 2: Convert milligrams to micrograms
- (1,000 mcg = 1 mg).
- 48 mg/hr × 1,000 = 48,000 mcg/hr
- b. Step 3: Convert mcg/hr to mcg/min.

- c. 400 mg : 5 mL = 800 mg : *x* mL
- *or*

  $$\frac{800\text{mg}}{400\text{mg}} \times 5\text{mL} = x\text{mL}$$

Answer: 10 mL. The dosage ordered is greater than what is available. Therefore you will need more than 5 mL to administer the dosage.

Alternate solution:

80 mg : 1 mL = 800 mg : *x* mL

or

$$\frac{800\text{mg}}{80\text{mg}} \times 1\text{mL} = x\text{mL}$$

- 3. a. Determine dosage per hour.

  $$50\text{mg}:250\text{mL} = x\text{mg}:30\text{mL}$$
  $$250x = 250$$
  $$250x = 1{,}500$$
  $$x = 6\text{mg/hr}$$

- Convert milligrams to micrograms
- (1,000 mcg = 1 mg).
- 6 mg/hr × 1,000 = 6,000 mcg/hr
- b. Convert mcg/hr to mcg/min.

- c.

  50mg:2mL=50mL:xmL50mg50mg×2mL=xmL

  Answer: 2 mL. The dosage ordered is contained in a volume of 2 mL.

- Alternate solution: 25 mg : 1 mL = 50 mg : *x* mL
- *or*

  50mg25mg×1mL=xmL

- 4. a. Convert metric weight to the same as answer requested. Convert grams to milligrams.
- 1 g = 1,000 mg; therefore 2 g = 2,000 mg

  2,000mg:250mL=xmg:60mL250x250=120,000250x=120,000250x=480mg/hr

- b. Convert mg/hr to mg/min.

- 5. a. Step 1: Convert grams to milligrams
- (1,000 mg = 1 g).

- 0.25 g = 250 mg
- Step 2: Calculate mg/hr.

  250mg:6hr=xmg:1hr6x6=2506x=2506=41.66x=41.7mg/hr

- b. 500 mg : 20 mL = 250 mg : *x* mL
- *or*

  250mg500mg×20mL=xmL

- Answer: 10 mL. The dosage ordered is less than the available strength; therefore you will need less than 20 mL to administer the dosage.
- Alternate solution: 25 mg : 1 mL = 250 mg : *x* mL
- *or*

  250mg25mg×1mL=xmL

- 6. a. Convert grams to milligrams (1,000 mg = 1 g).
- 2 g = 2,000 mg
- Calculate mg/hr.

  2,000mg:250mL=xmg:30mL250x250=60,000250x=60,000250x=240mg/hr

- b. Convert mg/hr to mg/min.

- 7. a. Step 1: Calculate units/hr.

  30units:1,000mL=xunits:40mL1,000x1,000=1,2001,000x=1.2units/hr

- b. Step 2: Calculate units/min.

- 8. a. Change metric measures to same as question.
- 2 g = 2,000 mg (1 g = 1,000 mg)
- Calculate mg/hr.

  2,000mg:500mL=xmg:45mL500x500=90,000500x=90,000500x=180mg/hr

- b. Change mg/hr to mg/min.

- 9. Determine dosage per hour.

- Convert micrograms to milligrams to match the available strength.
- 1,000 mcg = 1 mg
- 30,000 mcg/hr = 30 mg/hr
- Calculate flow rate in mL/hr.

  50mg:250mL=30mg:xmL50x50=7,50050x=150mL/hr

- Set at 150 mL/hr to deliver 500 mcg/min.
- 10.

  400mg:500mL=xmg:35mL500x500=14,000500x=28mg/hr

- 11. a. Calculate mg/hr.

  2mg:250mL=xmg:20mL250x250=40250x=40250x=0.16mg/hr

- b. Convert milligrams to micrograms
- (1,000 mcg = 1 mg).
- 0.16 mg × 1,000 = 160 mcg/hr
- c. Convert mcg/hr to mcg/min (60 min = 1 hr).

- 12. Convert metric weight to same as question.
- 1,000 mg = 1 g
- Calculate mg/hr.

  1,000mg:10hr=xmg:1hr10x10=1,00010x=100mg/hr

- 13. a. Convert grams to milligrams.

  2g=2,000mg(1,000mg=1g)2,000mg:250mL=xmg:22mL250x250=44,000250x=44,000250x=176mg/hr

- 14. Convert g to mg.
- 2.5 g = 2,500 mg (1 g = 1,000 mg)
- a.

  2,500mg:250mL=xmg:30mL250x250=75,000250x=75,000250x=300mg/hr

- b. Convert mg/hr to mg/min.

- 15. a. Calculate mg/hr.

500mg:500mL=xmg:30mL500x500=15,000500x=15,000500x=30mg/hr

- Convert milligrams to micrograms
- (1,000 mcg = 1 mg).
- 30 mg = 30,000 mcg/hr
- b. Convert mcg/hr to mcg/min.

- 16. Determine dosage per hour.

- Convert micrograms to milligrams
- (1,000 mcg = 1 mg).
- 12,000 mcg ÷ 1,000 = 12 mg/hr
- Calculate the mL/hr.

  400mg:500mL=12mg:xmL400x400=6,000400x=15mL/hr

- 17.

  25g:300mL=3g:xmL25x25=90025x=90025x=36mL/hr;wouldadminister3g

- 18. Convert weight in pounds to kilograms
- (2.2 lb = 1 kg).
- 120 lb ÷ 2.2 = 54.54 = 54.5 kg
- Calculate dosage per minute.

- 19. No conversion of weight is required.

- 20. a. Convert weight in pounds to kilograms
- (2.2 lb = 1 kg).
- 110 lb ÷ 2.2 = 50 kg
- Calculate the dosage per hour.

- b. Calculate the dosage per minute.

- c. The dosage is safe; it falls within the safe range.
- 21. Step 1: Convert to like units.
- Equivalent: 1,000 mcg = 1 mg
- Therefore 2 mg = 2,000 mcg
- Step 2: Calculate the concentration of solution in mcg per mL.

  2,000mcg:500mL=xmcg:1mL500x500=2,000500x=4mcgpermL

- Lower dosage: 4 mcg : 1 mL = 2 mcg : *x* mL

  4x4=24x=0.5mL/min

- Upper dosage: 4 mcg : 1 mL = 6 mcg : *x* mL

  4x4=64x=1.5mL/min

- Step 3: Convert mL/min to mL/hr.

- A dosage range of 2-6 mcg/min is equal to a flow rate of 30-90 mL/hr.
- 22. Step 1: Convert to like units of measurement.
- Equivalent: 1,000 mcg = 1 mg
- Therefore 5,000 mg = 5,000,000 mcg
- Step 2: Calculate the concentration of solution in mcg per mL.

  5,000,000mcg:500mL=xmcg:1mL500x500=5,000,000500x=10,000mcgpermL

- The concentration of solution is
- 10,000 mcg per mL.

- Step 3: Calculate the dosage range.

- Step 4: Convert the dosage range to mL/min.
- 10,000 mcg : 1 mL = 1,000 mcg : *x* mL
- Lower dosage: 10,000 mcg : 1 mL = 3,000 mcg : *x* mL

  10,000x10,000=3,00010,000x=0.3mL/min

- Upper dosage: 10,000 mcg : 1 mL = 4,500 mcg : *x* mL

  10,000x10,000=4,50010,000x=0.45mL/min

- Step 5: Convert mL/min to mL/hr.

- a. A dosage range of 50-75 mcg is equal to a flow rate of 18-27 mL/hr.
- b. Determine the dosage per minute infusing at 24 mL/hr.

- 23. Calculate the dosage per minute for the client.

- Determine the dosage per hour.

- Convert to like units.
- 1,000 mcg = 1 mg
- 39,000 mcg/hr = 39 mg/hr
- Calculate mL/hr flow rate.

  500mg:250mL=39mg:xmL500x500=9,750500=19.5x=20mL/hr

- Answer: To deliver a dosage of 10 mcg/kg/min, set the flow rate at 20 mL/hr (gtt/min).
- 24. a. Convert grams to milligrams.
- 1 g = 1,000 mg
- Calculate mg/hr.

  1,000mg:500mL=xmg:20mL500x500=20,000500x=20,000500x=40mL/hr

- b. Convert mg/hr to mg/min.

- Answer: At the rate of 20 mL/hr, the client is receiving a dosage of 40 mg/hr or 0.7 mg/min.

- 25. a. 10,240 mcg/min
- b. 102 mL/hr
- Calculate the dosage per minute.

- Convert mcg/min to mg/min.
- 10,240 mcg ÷ 1,000 = 10.24 = 10.2 mg/min
- Convert mg/min to mg/hr.

- Calculate flow rate.
- 1 g = 1,000 mg; 1.5 g = 1,500 mg
- 1,500 mg : 250 mL = 612 mg : *x* mL
- 1,500 *x* = 250 × 612

1,500x1,500=153,001500x=102mL/hr

- 26. a. 0.27 mg/min
- b. 270 mcg/min
- Calculate the mg/hr infusing.
- 500 mL : 400 mg = 20 mL : *x* mg

500x=400×20500x500=8,000500x=16mg/hr

- Calculate the mg/min infusing.

- Calculate the mcg/min.
- 1,000 mcg = 1 mg
- 0.27 mg/min = 270 mcg/min
- 27. a. 5 mg : 1 mL = 125 mg : *x* mL
- *or*

$$125mg5mg×1mL=xmL$$

- Answer: 25 mL. The dosage ordered is more than the available strength. Therefore you will need more than 5 mL to administer the dosage.
- Alternate solution:
- 25 mg : 1 mL = 125 mg : *x* mL
- *or*

$$125mg25mg×5mL=xmL$$

- b. 25 mL (med) + 100 mL IV solution = 125 mL (total fluid volume)
- 125 mg : 125 mL = 20 mg : *x* mL

$$125x=125×20125x125=2,500125x=20mL/hr$$

- 28. Calculate the dosage per hour.

- Convert grams to milligrams.
- 1,000 mg = 1 g; 2 g = 2,000 mg
- Calculate mL/hr.

- 29. Calculate the dosage per minute.

- Convert mcg/min to mcg/hr.

- Convert mcg/hr to mg/hr (1,000 mcg = 1 mg).
- 17,262 mcg/hr ÷ 1,000 = 17.26 = 17.3 mg/hr
- Calculate the IV flow rate.
- 400 mg : 250 mL = 17.3 mg : *x* mL

$$400x=250\times17.3400x400=4,325400x=4,325400=10.81x=10.8\text{mL/hr}$$

- To infuse 3 mcg/kg/min, set the rate at 10.8 mL/hr. The rate is not rounded to 11 mL/hr because the IV pump is capable of delivering in tenths of an mL.
- 30. Convert lb to kg (2.2 lb = 1 kg).
- 143 lb ÷ 2.2 = 65 kg

- Find concentration per minute (mcg/min).

- Find concentration per hour.

- The concentration of dobutamine infused per minute is 325 mcg/min and 19,500 mcg/hr.
- 31. a. Convert mcg/min to mcg/hr.

- Convert mcg/hr to mg/hr (1,000 mcg = 1 mg).
- 120 mcg/hr ÷ 1,000 = 0.12 mg/hr
- Calculate the lower mL/hr flow rate.
- 8 mg : 250 mL = 0.12 mg : *x* mL

  $$8x=250\times0.128x8=308x=308=3.75x=3.8mL/hr$$

- The flow rate for the lower 2 mcg/min dosage is 3.8 mL/hr.
- Calculate the upper 4 mcg/min flow rate.
- Convert mcg/min to mcg/hr.

- Convert mcg/hr to mg/hr (1,000 mcg = 1 mg).
- 240 mcg/hr ÷ 1,000 = 0.24 mg/hr
- Calculate the upper mL/hr flow rate.
- 8 mg : 250 mL = 0.24 mg : *x* mL

$$8x=250\times0.248x8=608x=608x=7.5mL/h$$

- The flow rate for the upper 4 mcg/min = 7.5 mL/hr. The flow rate range to titrate a dosage of 2-4 mcg/min is 3.8-7.5 mL/hr (mL/hr is not rounded; pump capable of delivering in tenths of an mL).
- b. Calculate the dosage infusing at 5 mL/hr.

$$250mL:8mg=5mL:xmg250x250=8\times5250x=40250x=0.16mg/hr$$

- Convert mg/hr to mcg/hr (1,000 mcg = 1 mg).
- 0.16 mg/hr × 1,000 = 160 mcg/hr
- Convert mcg/hr to mcg/min.

- At the flow rate of 5 mL/hr, the client is now receiving 2.7 mcg/min.
- 32. Step 1: Calculate the dose per hour using the lower and upper dosages.

- Step 2: Convert mcg to mg to match the available strength.
- 1,000 mcg = 1 mg
- 2,400 mcg = 2.4 mg
- 6,000 mcg = 6 mg
- Step 3: Calculate the rate in mL/hr

$$40mg:250mL=2.4md:xmL40x=250\times2.440x40=60040x=15mL/hr$$

- To infuse 40 mcg/min, set the IV rate at 15 mL/hr (minimum)

  40mg:250mL=6mg:xmL40x=250×6=40x40=1,50040x=37.5mL/hr

- To infuse 100 mcg/min, set the IV rate at 37.5 mL/hr (maximum).
- A dosage of 40 to 100 mcg/min is equal to 15 to 37.5 mL/hr.
- Set up proportion to determine the dosage change of 20 mcg/min.

  40mcg/min15mL/hr=20mcg/minxmL/hr40x40=30040x=7.5mL/hr

- So, for each change of 20 mcg/min, the incremental IV flow rate is 7.5 mL/hr.

  Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
40 mcg/min **(minimum)**	15 mL/hr
60 mcg/min	22.5 mL/hr
80 mcg/min	30 mL/hr
100 mcg/min **(maximum)**	37.5 mL/hr

- 33. Step 1: Calculate the dose per hour using the lower and upper dosages.

- Step 2: Convert mcg/hr to available strength.
- 1,000 mcg = 1 mg
- 240 mcg = 0.24 mg
- 720 mcg = 0.72 mg
- Step 3: Calculate the rate in mL/hr.

4mg:500mL=0.24mg:xmL4x=500×0.244x4=1204x=30mL/hr

- To infuse 4 mcg/min, set the IV rate at 30 mL/hr (minimum).

  4mg:500mL=0.72mg:xmL4x=500×0.724x4=3604x=90mL/hr

- To infuse 12 mcg/min, set the IV rate at 90 mL/hr (maximum).
- A dosage of 4-12 mcg/min is equal to 30-90 mL/hr. Set up a proportion to determine the dosage change of 2 mcg/min.

  4mcg/min30mL/hr=2mcg/minxmL/hr4x4=604x=15mL/hr

- For each change of 2 mcg/min, the incremental flow rate is 15 mL/hr.

  Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
4 mcg/min **(minimum)**	30 mL/hr
6 mcg/min	45 mL/hr
8 mcg/min	60 mL/hr
10 mcg/min	75 mL/hr
12 mcg/min **(maximum)**	90 mL/hr

- 34.

  4mg:100mL=1mg:xmL4x4=1004x=25mL/hr

- 35. Calculate the dosage per hr.

- Calculate the mL/hr.

  $900mg:500mL=30mg:xmL900x=500\times30900x900=1,500900=16.66$

- x = 16.7 mL/hr (mL/hr is not rounded; pump capable of delivering in tenths of a mL)

unknown - Section 42 (Page 412)

The content in this chapter may be required in nursing curriculums that have a critical care component or a specific component of advanced medical-surgical nursing that addresses this content. The content in this chapter can also be used as a reference for nurses working in specialty areas. This chapter provides basic information on medicated drips and titration. In the critical care setting, clients oft en receive medications to control vital functions that are potent and require close monitoring. These may include medications to maintain the client's blood pressure within normal range and antiarrhythmic medications to regulate the client's heart rate and/or rhythm. Other medications that may be given include sedatives and narcotics. Medications in the critical care setting may be given continuously IV at a constant rate, or the rate of the IV may be titrated (adjusted) to the client response. Examples of how medication dosages may be ordered include milliliters per hour (mL/hr), milligrams per hour (mg/hr), and micrograms per kilogram per minute (mcg/kg/min).

Although there have been instances in the past in which critical care medications were administered using volume-control tubing that has a microdrop calibration (60 gtt/mL), their use should only be in dire circumstances when an infusion pump is not available. Critical care medications should be administered using an electronic infusion pump. This text will focus on critical care medications administered using an infusion pump. As discussed in Chapter 20, pumps deliver in whole milliliters, and there are some pumps that deliver in tenths of a milliliter (usually used in the critical care setting). **Always** be familiar with the pump calibration at your institution. Because of the potency of the medications used, it is essential that nurses perform accurate calculation of dosages, correctly program the infusion pump, and perform continuous monitoring of the client for their response to the medications that are being administered. Despite the use of electronic infusion pumps, calculation errors, infusion pump malfunction, or errors in programming an infusion pump can occur. **Never assume;** to ensure client safety, always use an electronic infusion pump and verify calculations and programming of the pump with a second nurse before administering medications. Like insulin and heparin, many of the medications administered are high-alert medications. Errors in programming infusion pumps or administration of medications at a faster rate than specified or recommended can result in life-threatening effects.

SAFETY ALERT!

Electronic infusion devices are routinely used to administer medications that are potent. Accurate calculations, correct programming of the pump, and client monitoring are crucial to prevent life-threatening effects, ensure the desired physiological response, and maintain client safety during administration of potent high-alert medications.

Calculating Rate in mL/hr

The same methods shown in previous chapters involving medications in solution can be applied to critical care medications. Let's look at some examples.

Example 1: A solution of Morphine Sulfate 50 mg in 100 mL D_5W at 3.5 mg/hr. Calculate the rate in mL/hr using the solution strength available.

Solution:

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Formula Method

Dimensional Analysis

As shown in previous chapters involving medications in solution, **isolate what is being calculated.** In this example, it is mL/hr. The **starting fraction** will be the information from the problem containing mL. (mL is placed in the numerator.) Set up **each fraction after** the starting fraction matching the previous denominator.

To infuse 3.5 mg/hr of Morphine Sulfate, set the infusion pump at 7 mL/hr.

Example 2: A solution of Isuprel (isoproterenol) 2 mg in 250 mL D_5W to infuse at a rate of 5 mcg/min. (The infusion pump is capable of delivering in tenths of an mL.)

Solution:

Step 1: Calculate the dose per hour.

Step 2: Convert 300 mcg to mg to match the available strength.

1,000 mcg = 1 mg; therefore 300 mcg = 0.3 mg

Step 3: Calculate the rate in mL/hr. (Use any of the methods shown in Example 1.)

Ratio and Proportion (Linear Format *or* Fraction Format)

x = 37.5 mL/hr (this is not rounded to the whole number; the pump delivers in tenths of an mL)

Formula Method

Dimensional Analysis

Note: In this equation, you will need two additional conversion factors, 60 min = 1 hr and 1,000 mcg = 1 mg.

To infuse 5 mcg/min of Isuprel, set the infusion pump at 37.5 mL/hr.

Calculating Critical Care Dosages per Hour or per Minute

Example: Infuse dopamine 400 mg in 500 mL D_5W at 30 mL/hr. Calculate the dosage in mcg/min and mcg/hr.

Solution:

Step 1: Determine mg/hr.

Remember, ratio and proportion can be set up in linear or fraction format.

Step 2: The next step is to convert 24 mg to mcg because the question asks for mcg/min and mcg/hr. Change mg to mcg using the equivalent 1,000 mcg = 1 mg. Change mg to mcg by multiplying by 1,000 or moving the decimal point three places to the right.

24 mg/hr = 24,000 mcg/hr

Step 3: Now that you have the mcg/hr, change the mcg/hr to mcg/min using the equivalent 60 min = 1 hr.

Divide the number of mcg/hr by 60 to get the mcg/min.

Note: This is in mcg/min; however, these medications are usually delivered in mL/hr by pump, and you will need to take the calculation further. Later in the chapter you will see examples of changing mcg/min to mL/hr.

Dimensional Analysis

Dopamine infusing at 30 mL/hr = 24,000 mcg/hr; 400 mcg/min.

Medications Ordered in Milligrams per Minute

Medications such as Lidocaine and Pronestyl are ordered in mg/min.

Example: A client is receiving Pronestyl 60 mL/hr. The solution available is Pronestyl 2 g in 500 mL D_5W. Calculate the mg/hr and the mg/min the client will receive.

Solution:

Step 1: A conversion is necessary; g must be converted to mg.

You are being asked for **(mg/min, mg/hr).** Equivalent: 1 g = 1,000 mg.

Therefore 2 g = 2,000 mg. Multiply 2 by 1,000 or move decimal point three places to the right.

Step 2: Now determine the mg/hr by setting up a proportion. (Refer to problems earlier in the chapter illustrating the various methods that can be used.)

Step 3: Convert mg/hr to mg/min. Equivalent: 60 min = 1 hr.

Dimensional Analysis

(***Note:*** The starting fraction here is the conversion factor to match the desired numerator, and the solution strength is in g, with the conversion factor written so g is written in the numerator to match the denominator of the starting fraction.)

Pronestyl infusing at 60 mL/hr is delivering 240 mg/hr; 4 mg/min.

Calculating Dosages Based on mcg/kg/min

Medications are also ordered for clients based on dosage per kilogram per minute. These medications include Nipride, dopamine, and dobutamine. In these problems, the weight will be rounded to the nearest tenth as indicated for calculation.

Example: Order: Dopamine 2 mcg/kg/min. The solution available is dopamine 400 mg in 250 mL D_5W. The client weighs 154 lb. (The pump is capable of delivering in tenths of an mL.)

Solution:

Step 1: Convert the client's weight in pounds to kilograms.

Equivalent: 2.2 lb = 1 kg

To convert the weight, divide 154 lb by 2.2.

154 lb ÷ 2.2 = 70 kg

Step 2: Now that you have the client's weight in kg, determine the dosage per minute.

Converting mcg/min to mL/hr then would be easy using this example. (Equivalent: 1,000 mcg = 1 mg.)

- a. Convert mcg/min to mcg/hr.

- b. Convert mcg/hr to mg/hr.
- 8,400 ÷ 1,000 = 8.4 mg/hr
- c. Determine IV flow rate.

Ratio and Proportion

Dimensional Analysis

The pump would be set at 5.3 mL/hr to administer the dose of dopamine at 2 mcg/kg/min.

IV Flow Rates for Titrated Medications

Critically ill clients in the critical care area can receive potent medications by IV infusion using a process referred to as **titration**. **Titrated medications** are added to a specific volume of fluid and then adjusted accordingly to infuse at a rate at which the desired effect is attained. **The medications that are titrated include potent antiarrhythmic, vasopressor, and vasodilator medications; these must be monitored closely by the nurse**. IV medications that are titrated usually start at the lowest dosage and are increased and decreased as needed. Medications that are titrated are administered according to a protocol. Nurses **must** know the institution's protocol regarding administration of titrated medications. Because of the potency of medications used, minute changes in the infusion cause an effect on the client. Titrated medications are ordered within parameters to obtain a desirable outcome. The outcome desired depends on the medication. When a solution is titrated, **the lowest dosage of the medication is set first and increased or decreased as necessary. The higher dosage should not be exceeded without an order.** When a medication is to be titrated, the prescriber determines the titration for the individual client based on the desired outcome. The order for the titration of a medication includes the medication, the dosage in a specific volume of fluid, the dosage range (minimal dose and maximum dose), the starting dose for the medication (which is usually the minimal dose), and the desired outcome.

Dosage errors with titrated medications can result in dire consequences. Therefore, the nurse must have knowledge regarding the medication, the proper dosage adjustment, and the frequency of adjustments based on the client assessment and the prescribed parameters. Electronic infusion pumps are used with titrated medications.

There are also IV pumps available in the critical care setting, referred to as *smart pumps*. Smart pumps were discussed in Chapter 20. The sophistication of the smart pump depends on the software. Some smart pumps have incorporated calculating IV rates for specific medications. The nurse is able to select the medication from the IV pump "library" and enter the desired dose and concentration of the medication and the client's weight in kilograms; the pump then displays the IV rate in mL/hr.

Regardless of the type of infusion pump used, the nurse has the responsibility of having knowledge about the equipment to ensure safe medication administration of potent high-alert medications. The increase in sophistication of pumps do not relieve the nurse from his or her responsibility to think critically (i.e., Is the dosage reasonable? Is the rate correct to deliver the ordered dosage?). Pumps that have the ability to perform the needed calculations or a calculator should be used as a tool to check calculations and not as a tool for dosage calculation. Smart pumps should be used as a drive toward safe practice and used properly to ensure client safety. Remember that all pumps require human entry.

Because of the consequences associated with titrated medications, it is common practice at many institutions to have a double- or triple-check of medication dosages and the mathematical computations associated with them, even in instances where calculators may be used.

SAFETY ALERT!

Know the equipment you are using and the institution's policy regarding the administration of titrated medications. **Never exceed** the prescribed upper dose limit. Notify the prescriber when the maximum limit is reached for a new order.

Let's look at some examples of titration of medications.

Example 1: Nipride has been ordered to titrate at 3 to 6 mcg/kg/min to maintain a client's systolic blood pressure below 140 mm Hg. The solution contains 50 mg Nipride in 250 mL D_5W. The client weighs 56 kg. Determine the rate to set the IV pump.

Step 1: Convert to **like units**.

Equivalent: 1,000 mcg = 1 mg

Therefore 50 mg = 50,000 mcg

Step 2: Calculate the concentration of solution in mcg/mL.

The concentration of solution is 200 mcg/mL.

Step 3: Calculate the dosage range using the upper and lower dosages.

Step 4: Convert dosage range to mL/min.

Step 5: Convert mL/min to mL/hr.

A dosage range of 3 to 6 mcg/kg/min is equal to a flow rate of 50 to 101 mL/hr.

The client's condition has stabilized, and the flow rate is now maintained at 60 mL/hr. What dosage will be infusing per minute?

Solution to Example 1 Using Dimensional Analysis

Step 1: Calculate the dosage range first.

Step 2: Calculate the IV rate in mL/hr for the lower dosage.

Step 3: Calculate the IV rate in mL/hr for the upper dosage.

A dosage range of 3 to 6 mcg/kg/min is equal to a flow rate of 50 to 101 mL/hr.

The client's condition has stabilized, and the IV flow rate is now maintained at 60 mL/hr. What dosage will be infusing per minute?

Developing a Titration Table

After calculating an initial IV rate for a medication being titrated, the client is monitored. If the desired response is not achieved, the dosage may have to be increased. This will require the nurse to find the corresponding IV rate in mL/hr for the new dosage. Any time the dosage is changed, recalculation of the corresponding IV rate is required. Rather than performing calculations each time a dosage is modified, the nurse can develop a titration table to provide the IV rate for any possible change in the medication dosage.

Let's look at the previous example (Example 1) and develop a titration table to increase the dosage by 1 mcg/min up to 6 mcg/min. Set up a ratio proportion to develop the titration table; use the minimum rate required to deliver 3 mcg/min to find the incremental flow rate that provides a dosage rate change of 1mcg/min.

The proportion is:

So, for each change of 1 mcg/min, the incremental IV flow rate is 17 mL/hr.

Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
3 mcg/min **(minimum)**	50 mL/hr
4 mcg/min	67 mL/hr
5 mcg/min	84 mL/hr
6 mcg/min **(maximum)**	101 mL/hr

Notice in this problem mL/hr was rounded to the nearest whole number. Remember, there are pumps capable of accepting one decimal place.

Example 2: Nitroglycerin has been ordered to titrate at 10 mcg/min to 60 mcg/min, and the rate should be increased by 10 mcg/min every 3-5 minutes for chest pain. The solution contains 50 mg nitroglycerin in 250 mL D_5W.

Step 1: Calculate the dose per hour using the upper and lower dosages.

Step 2: Convert mcg to mg to match the available strength.

1,000 mcg = 1 mg

600 mcg = 0.6 mg

3,600 mcg = 3.6 mg

Step 3: Calculate the rate in mL/hr.

To infuse 10 mcg/min, set the IV rate at 3 mL/hr (minimum).

To infuse 60 mcg/min, set the IV rate at 18 mL/hr (maximum). A dosage range of 10 to 60 mcg/min is equal to a flow rate of 3 to 18 mL/hr.

Dimensional Analysis Setup for Example 2

Calculate the lower dosage.

Calculate upper dosage.

A dosage range of 10-60 mcg/min is equal to a flow rate of 3-18 mL/hr.

Develop a titration table using 10-mcg increments. Set up the proportion using the minimum to determine the dosage change of 10 mcg/min.

So, for each change of 10 mcg/min, the incremental IV flow rate is 3 mL/hr.

Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
10 mcg/min **(minimum)**	3 mL/hr
20 mcg/min	6 mL/hr
30 mcg/min	9 mL/hr
40 mcg/min	12 mL/hr
50 mcg/min	15 mL/hr
60 mcg/min **(maximum)**	18 mL/hr

Example 3: Levophed (norepinephrine bitartrate) has been ordered to titrate at 3 mcg/min to 10 mcg/min, and the rate should be increased at 1 mcg/min to maintain blood pressure and keep systolic blood pressure greater than 100 mm Hg. The solution contains 2 mg Levophed in 250 mL D_5W. Develop a titration table at 1-mcg increments. The pump delivers in tenths.

Step 1: Calculate the dose per hour using the upper and lower dosages.

Step 2: Convert mcg to mg to match the available strength.

1,000 mcg = 1 mg

180 mcg = 0.18 mg

600 mcg = 0.6 mg

Step 3: Calculate the rate in mL/hr

To infuse 3 mcg/min, set the IV rate at 22.5 mL/hr (minimum)

To infuse 10 mcg/min, set the IV rate at 75 mL/hr. A dosage range of 3-10 mcg/min is equal to a flow rate of 22.5-75 mL/hr.

Dimensional Analysis Setup for Example 3

Calculate the lower dosage.

Calculate the upper dosage.

A dosage range of 3-10 mcg/min is equal to a flow rate of 22.5-75 mL/hr.

Find the incremental flow rate for a dosage rate change of 1 mcg/min by setting up a ratio proportion.

The proportion is:

So, for each change of 1 mcg/min, the incremental IV flow rate is 7.5 mL/hr.

Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
3 mcg/min **(minimum)**	22.5 mL/hr
4 mcg/min	30 mL/hr
5 mcg/min	37.5 mL/hr
6 mcg/min	45 mL/hr
7 mcg/min	52.5 mL/hr
8 mcg/min	60 mL/hr
9 mcg/min	67.5 mL/hr
10 mcg/min **(maximum)**	75 mL/hr

POINTS TO REMEMBER

- • Potent medications in the critical care setting should be administered by an electronic infusion device.
- • Accurate calculation of dosages and client monitoring are essential when clients are receiving potent medications by IV infusion.

- • Double-checking of calculations is essential to ensure correct dosage administration.
- • Titration of medications requires careful adjustment of dosages to obtain a desirable client outcome.
- • Know the institution's policy relating to titration of medications.
- • **Do not** exceed the upper dose limit for titrated medications.
- • **Always** be familiar with the calibration of the infusion pump being used to administer IV medications.
- • The use of infusion pumps **does not** relieve the responsibility of the nurse to critically think.

PRACTICE PROBLEMS

Calculate the following as indicated. Unless stated otherwise, infusion pumps deliver in whole mL/hr.

- 1. A client weighing 50 kg is to receive a Dobutamine solution of 250 mg in 500 mL D5W ordered to titrate between 2.5 and 5 mcg/kg/min.
  - a. Determine the flow rate setting for an infusion pump. _____
  - b. If the IV flow rate is being maintained at 25 mL/hr after several titrations, what is the dosage infusing per minute? _____
- 2. Order: Epinephrine at 30 mL/hr. The solution available is 2 mg of epinephrine in 250 mL D_5W. Calculate the following:
  - a. mg/hr _____
  - b. mcg/hr _____
  - c. mcg/min _____
- 3. Aminophylline 0.25 g is added to 500 mL D_5W to infuse at 20 mL/hr. Calculate the following:
- mg/hr _____
- 4. Order: Pitocin at 25 mL/hr. The solution contains 20 units of Pitocin in 1,000 mL Ringer's Lactate.
- Calculate the number of units per hour the client is receiving. _____
- 5. Order: 3 mcg/kg/min of Nipride RTU.
- Available: 50 mg of Nipride RTU in 250 mL D_5W. Client's weight is 60 kg.
- Calculate the flow rate in mL/hr that will deliver this dosage. _____
- 6. A nitroglycerin drip is infusing at 3 mL/hr. The solution available is 50 mg of nitroglycerin in 250 mL D_5W. Calculate the following:
  - a. mcg/hr _____
  - b. mcg/min _____
- 7. Order: Procainamide to titrate at 2 mg/min to the maximum of 6 mg/min. The available solution is procainamide 2 g in 250 mL D_5W. Develop a titration table in 2-mg/min increments up to the maximum dose.

Answers on pp. 593-594

CLINICAL REASONING

Scenario: Isuprel is ordered for a client at the rate of 3 mcg/min with a solution containing Isuprel 1 mg in 250 mL D_5W. The nurse performed the following calculation to determine the rate by pump in mL/hr.

- • Calculated the dosage per hour:

- • Converted 180 mcg to milligrams to match the units in the solution strength:
- 180 mcg = 0.018 mg
- • Calculated the rate in mL/hr:
- 1 mg : 250 mL = 0.018 mg : *x* mL
- *x* = 250 × 0.018
- *x* = 4.5 = 5 mL/hr

- a. What error did the nurse make in her calculation to determine the rate in mL/hr? _____
- b. What could be the potential outcome of the error? _____
- c. What should the rate be in mL/hr? _____
- d. What preventive measures could have been taken by the nurse? _____

Answers on 594

NGN Case Study

Learning Objectives:

- 1. Calculate dosages in mcg/min, mcg/hr, and mg/min.
- 2. Calculate dosages in mg/kg/hr, mg/kg/min, and mcg/kg/min, mcg/kg/hr.

Case Scenario: The client is in the intensive care unit for respiratory failure, is placed on a mechanical ventilator, and needs to be given sedation for comfort. Propofol is ordered for sedation at 15 mcg/kg/min. The client weighs 188 pounds. The solution available is Propofol 1,000 mg in 100 mL of D_5W. The electronic infusion device can be programed to tenths. Which actions are appropriate in planning care for this client? **Select all that apply.**

- 1. Calculate the client weight as 85.5 kg.
- 2. Calculate the patient weight as 413.6 kg.
- 3. Calculate the dose of propofol as 1282.5 mcg/min.
- 4. Calculate the dose of propofol as 6204 mcg/min.
- 5. Program the electronic infusion device for 7.7 mL/hr.
- 6. Program the electronic infusion device for 38.5 mL/hr.
- 7. Program the electronic infusion device for 16.9 mL/hr.

Reference: Morris: *Calculate with confidence*, ed 8, St Louis, Elsevier, copyright 2022.

Case Study answers and rationales can be found on Evolve.

CHAPTER REVIEW

Calculate the dosages as indicated. Use the labels where provided. Unless stated otherwise, pump is capable of delivering in a whole number of mL.

- 1. Client is receiving Isuprel at 30 mL/hr. The solution available is 2 mg of Isuprel in 250 mL D_5W. Calculate the following:
  - a. mg/hr _____
  - b. mcg/hr _____
  - c. mcg/min _____

- 2. Infuse dopamine 800 mg in 500 mL D_5W at 30 mL/hr. Calculate the dosage in mcg/hr and mcg/min.
- Available:

    - a. mcg/hr _____
    - b. mcg/min _____
    - c. Calculate the number of milliliters you will add to the IV for this dosage. _____
- 3. Infuse Sodium Nitroprusside at 30 mL/hr. The solution available is 50 mg sodium nitroprusside in 250 mL 0.9% NS.
- Available:

- Calculate the following:
    - a. mcg/hr _____
    - b. mcg/min _____
    - c. Number of milliliters you will add to the IV for this dosage _____
- 4. Order: Lidocaine 2 g in 250 mL D_5W to infuse at 60 mL/hr. Calculate the following:
    - a. mg/hr _____
    - b. mg/min _____
- 5. Order: Aminophylline 0.25 g to be added to 250 mL of D_5W. The order is to infuse over 6 hr.
- Available:

    - a. Calculate the dosage in mg/hr the client will receive. _____
    - b. Calculate the number of milliliters you will add to the IV for this dosage. _____
- 6. A client is receiving Pronestyl at 30 mL/hr. The solution available is 2 g Pronestyl in 250 mL D_5W. Calculate the following:
    - a. mg/hr _____
    - b. mg/min _____
- 7. Order: Pitocin (oxytocin) at 40 mL/hr. The solution available is 30 units of Pitocin in 1,000 mL of D_5W. Calculate the following:
    - a. units/hr _____
    - b. units/min _____
- 8. A client is receiving bretylium at 45 mL/hr. The solution available is 2 g bretylium in 500 mL D_5W. Calculate the following:
    - a. mg/hr _____
    - b. mg/min _____
- 9. A client is receiving nitroglycerin 50 mg in 250 mL D_5W. The order is to infuse 500 mcg/min.
- What flow rate in mL/hr would be needed to deliver the ordered dosage? _____
- 10. Dopamine has been ordered to maintain a client's blood pressure; 400 mg dopamine has been placed in 500 mL D_5W to infuse at 35 mL/hr.

- How many milligrams are being administered per hour? _____
- 11. A client is receiving Isuprel 2 mg in 250 mL D_5W. The order is to infuse at 20 mL/hr. Calculate the following:
  - a. mg/hr _____
  - b. mcg/hr _____
  - c. mcg/min _____
- 12. Order: 1 g of aminophylline in 1,000 mL D_5W to infuse over 10 hr.
- Calculate the dosage in mg/hr the client will receive. _____
- 13. A client is receiving lidocaine 2 g in 250 mL D_5W. The solution is infusing at 22 mL/hr. Calculate the following:
  - a. mg/hr _____
  - b. mg/min _____
- 14. Order: Esmolol 2.5 g in 250 mL 0.9% NS at 30 mL/hr. Calculate the following:
  - a. mg/hr _____
  - b. mg/min _____
- 15. Order: Dobutamine 500 mg in 500 mL D_5W to infuse at 30 mL/hr.
- Calculate the following:
  - a. mcg/hr _____
  - b. mcg/min _____
- 16. Order: Dopamine 400 mg in 500 mL 0.9% NS to infuse at 200 mcg/min.
- Calculate the rate in mL/hr. _____
- 17. Order: Magnesium sulfate 3 g/hr.
- Available: 25 g of 50% magnesium sulfate in 300 mL D_5W.
- What rate in mL/hr would be needed to administer the required dose? _____
- 18. Order: Nipride 50 mg in 250 mL D_5W to infuse at 2 mcg/kg/min. Client's weight is 120 lb.
- Calculate the dosage per minute. _____
- 19. Order: Dobutamine 250 mg in 500 mL of D_5W at 3 mcg/kg/min. The client weighs 80 kg.
- What dosage in mcg/min should the client receive? _____
- 20. Order: Infuse 1 g of aminophylline in 1,000 mL of D_5W at 0.7 mg/kg/hr. The client weighs 110 lb.
  - a. Calculate the dosage in mg/hr. _____
  - b. Calculate the dosage in mg/min. _____
  - c. Reference states no more than 20 mg/min. Is the order safe? _____
- 21. Norepinephrine (Levophed) 2 to 6 mcg/min has been ordered to maintain a client's systolic blood pressure at 100 mm Hg. The solution concentration is 2 mg in 500 mL D_5W.
- Determine the flow rate in mL/hr. _____
- 22. Esmolol is to titrate between 50 to 75 mcg/kg/min. The client weighs 60 kg. The solution strength is 5,000 mg of esmolol in 500 mL D_5W.
  - a. Determine the flow rate for an infusion pump. _____
  - b. The titration rate is at 24 mL/hr. What is the dosage infusing per minute? _____
- 23. Order: Dobutamine 500 mg in 250 mL D_5W to infuse at 10 mcg/kg/min. The client weighs 65 kg.
- Calculate the flow rate in mL/hr. _____
- 24. A client is receiving lidocaine 1 g in 500 mL D_5W at a rate of 20 mL/hr. Calculate the following:
  - a. mg/hr _____
  - b. mg/min _____
- 25. Esmolol 1.5 g in 250 mL D_5W has been ordered at a rate of 100 mcg/kg/min for a client weighing 102.4 kg. Determine the following:
  - a. dosage in mcg/min _____
  - b. rate in mL/hr _____
- 26. Order: Dopamine 400 mg in 500 mL D_5W to infuse at 20 mL/hr. Determine the following:
  - a. mg/min _____
  - b. mcg/min _____
- 27. Order: Diltiazem HCl 125 mg in 100 mL D_5W to infuse at 20 mg/hr.
- Available:

- Determine the following:
  - a. How many milliliters will you add to the IV? _____
  - b. Determine the rate in mL/hr. (Consider the medication in the volume.) _____
- 28. Order: 2 g Pronestyl in 500 mL D_5W to infuse at 2 mg/min.
- Determine the rate in mL/hr. _____
- 29. Dopamine is ordered at a rate of 3 mcg/kg/min for a client weighing 95.9 kg. The solution strength is 400 mg dopamine in 250 mL D_5W. Determine the flow rate for an IV pump. The pump is capable of delivering in tenths of an mL. _____
- 30. Infuse Dobutamine 250 mg in 500 mL D_5W at 5 mcg/kg/min. The client weighs 143 lb. Concentration of solution is 500 mcg per mL. How many mcg of dobutamine will be infused per minute? _____ per hour? _____
- 31. A medication has been ordered at 2 to 4 mcg/min to maintain a client's systolic BP greater than 100 mm Hg. The medication being titrated has 8 mg of medication in 250 mL D_5W. Determine the IV rate for 2 to 4 mcg range. Then assume that after several changes in mL/hr have been made, the BP has stabilized at a rate of 5 mL/hr. How many mcg/min is the client receiving at this rate? Determine the flow rate for an IV pump capable of delivering in tenths of an mL.
  - a. _____ Flow rate for 2-4 mcg range
  - b. _____ mcg per/min at 5 mL /hr
- 32. Order: Nitroglycerin to titrate at 40 mcg/min for chest pain to a maximum of 100 mcg/min. The solution contains 40 mg of nitroglycerin in 250 mL D_5W. Develop a titration table from minimum to maximum dose in 20-mcg/min increments. The pump is capable of delivering in tenths.
- 33. Order: Levophed 4 mcg/min to maintain BP systolic greater than 100 mm Hg to a maximum of 12 mcg/min. Available solution: Levophed 4 mg in 500 mL D_5W. Develop a titration table in 2-mcg/min increments.
- 34. A solution of lorazepam 4 mg in 100 mL 0.9% NS to infuse at 1 mg/hr. Determine the infusion rate.
- 35. A solution of Amiodarone 900 mg in 500 mL of D_5W to infuse at 0.5 mg/min. Determine the infusion rate to deliver the ordered dosage. (The pump is capable of delivering in tenths of an mL.)

Answers on pp. 594-600

For additional practice problems, refer to the Advanced Calculations section of the Critical Care Dosages section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

ANSWERS

Chapter 23

Answers to Practice Problems

- 1. a. Step 1: Conversion: Equivalent: 1,000 mcg = 1 mg.
- Therefore 250 mg = 250,000 mcg.
- Step 2: 250,000 mcg : 500 mL = *x* mcg : 1 mL

- Concentration of solution is 500 mcg/mL.
- Step 3: Calculate dosage range.
- Lower dosage:

- Upper dosage:

- Step 4: Convert dosage range to mL/min.
- Lower dosage:

- Upper dosage:

- Step 5: Convert mL/min to mL/hr.

- A dosage range of 2.5-5 mcg/kg/min is equal to a flow rate of 15-30 mL/hr.
- b. Determine dosage infusing per minute at 25 mL/hr:
- 500 mcg : 1 mL = *x* mcg : 25 mL
- *x* = 12,500 mcg/hr
- 12,500 mcg ÷ 60 min = 208.3 mcg/min
- 2. a.

- b. Convert milligrams to micrograms
- (1,000 mcg = 1 mg).
- 0.24 mg = 240 mcg/hr
- c. Convert mcg/hr to mcg/min.

- 3. a. Change grams to milligrams. (Note that you were asked to calculate mg/hr.)
- 0.25 g = 250 mg (1 g = 1,000 mg)
- b. Calculate mg/hr.

- 4. *Note:* Calculate units per hour only.

- The client is receiving 0.5 units/hr.

- 5. Step 1: Determine the dosage per minute.

- Step 2: Convert to dosage per hour.

- Step 3: Convert to like units (1,000 mcg = 1 mg).
- 10,800 mcg = 10.8 mg
- Calculate flow rate (mL/hr).

- 6.a.

  Convert to micrograms (1,000 mcg = 1 mg).

- 0.6 mg/hr = 600 mcg/hr
- b. Convert mcg/hr to mcg/min.

- 7. Step 1: Calculate the dose per hour using the lower and upper dosages.

- Step 2: Convert mg to g to match the available strength.
- 1,000 mg = 1 g
- 120 mg = 0.12 g
- 360 mg = 0.36 g

Step 3: Calculate the rate in mL/hr

To infuse 2 mg/min, set the IV rate at 15 mL/hr (minimum).

To infuse 6 mg/min, set the IV rate at 45 mL/hr (maximum).

A dosage range of 2-6 mg/min is equal to a flow rate of 15-45 mL/hr.

Set up proportion to determine the dosage of 2 mg/min.

So for a change of 2 mg/min, the incremental IV flow rate is 15 mL/hr.

Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
2 mg/min (minimum)	15 mL/hr
4 mg/min	30 mL/hr
6 mg/min **(maximum)**	45 mL/hr

Note: This problem could also be done using dimensional analysis.

Answers to Clinical Reasoning Questions

- a. The nurse made the error in the second step (converting 180 mcg to mg to match the units in the solution strength). This led to the error in the mL/hr rate.

- b. The error would result in an incorrect IV rate in mL/hr; the answer obtained is used to determine the rate in mL/hr. Use of 0.018 mg would net an incorrect answer.

- c. The rate in mL/hr should be 45 mL/hr and not 5 mL/hr.

- d. The nurse should have double-checked the math at each step. In addition, having another nurse check the calculation may have helped in recognizing the error in calculation.

Answers to Chapter Review

- 1. a. Calculate the dosage per hr.

- b. Convert milligrams to micrograms
- (1,000 mcg = 1 mg).
- 1,000 × 0.24 mg/hr = 240 mcg/hr
- c. Convert mcg/hr to mcg/min.

- 2. Step 1: Determine dosage per hour.

- a. Step 2: Convert milligrams to micrograms
- (1,000 mcg = 1 mg).
- 48 mg/hr × 1,000 = 48,000 mcg/hr
- b. Step 3: Convert mcg/hr to mcg/min.

- c. 400 mg : 5 mL = 800 mg : *x* mL
- *or*

Answer: 10 mL. The dosage ordered is greater than what is available. Therefore you will need more than 5 mL to administer the dosage.

Alternate solution:

80 mg : 1 mL = 800 mg : *x* mL

or

- 3. a. Determine dosage per hour.

- Convert milligrams to micrograms
- (1,000 mcg = 1 mg).
- 6 mg/hr × 1,000 = 6,000 mcg/hr
- b. Convert mcg/hr to mcg/min.

- c.

Answer: 2 mL. The dosage ordered is contained in a volume of 2 mL.

- Alternate solution: 25 mg : 1 mL = 50 mg : *x* mL
- *or*

- 4. a. Convert metric weight to the same as answer requested. Convert grams to milligrams.
- 1 g = 1,000 mg; therefore 2 g = 2,000 mg

- b. Convert mg/hr to mg/min.

- 5. a. Step 1: Convert grams to milligrams
- (1,000 mg = 1 g).
- 0.25 g = 250 mg
- Step 2: Calculate mg/hr.

- b. 500 mg : 20 mL = 250 mg : *x* mL
- *or*

- Answer: 10 mL. The dosage ordered is less than the available strength; therefore you will need less than 20 mL to administer the dosage.
- Alternate solution: 25 mg : 1 mL = 250 mg : *x* mL
- *or*

- 6. a. Convert grams to milligrams (1,000 mg = 1 g).
- 2 g = 2,000 mg
- Calculate mg/hr.

- b. Convert mg/hr to mg/min.

- 7. a. Step 1: Calculate units/hr.

- b. Step 2: Calculate units/min.

- 8. a. Change metric measures to same as question.
- 2 g = 2,000 mg (1 g = 1,000 mg)
- Calculate mg/hr.

- b. Change mg/hr to mg/min.

- 9. Determine dosage per hour.

- Convert micrograms to milligrams to match the available strength.
- 1,000 mcg = 1 mg
- 30,000 mcg/hr = 30 mg/hr
- Calculate flow rate in mL/hr.

- Set at 150 mL/hr to deliver 500 mcg/min.
- 10.

- 11. a. Calculate mg/hr.

- b. Convert milligrams to micrograms
- (1,000 mcg = 1 mg).
- 0.16 mg × 1,000 = 160 mcg/hr
- c. Convert mcg/hr to mcg/min (60 min = 1 hr).

- 12. Convert metric weight to same as question.
- 1,000 mg = 1 g
- Calculate mg/hr.

- 13. a. Convert grams to milligrams.

- 14. Convert g to mg.
- 2.5 g = 2,500 mg (1 g = 1,000 mg)
- a.

- b. Convert mg/hr to mg/min.

- 15. a. Calculate mg/hr.

- Convert milligrams to micrograms
- (1,000 mcg = 1 mg).
- 30 mg = 30,000 mcg/hr
- b. Convert mcg/hr to mcg/min.

- 16. Determine dosage per hour.

- Convert micrograms to milligrams
- (1,000 mcg = 1 mg).
- 12,000 mcg ÷ 1,000 = 12 mg/hr
- Calculate the mL/hr.

- 17.

- 18. Convert weight in pounds to kilograms
- (2.2 lb = 1 kg).
- 120 lb ÷ 2.2 = 54.54 = 54.5 kg
- Calculate dosage per minute.

- 19. No conversion of weight is required.

- 20. a. Convert weight in pounds to kilograms
- (2.2 lb = 1 kg).
- 110 lb ÷ 2.2 = 50 kg
- Calculate the dosage per hour.

- b. Calculate the dosage per minute.

- c. The dosage is safe; it falls within the safe range.
- 21. Step 1: Convert to like units.
- Equivalent: 1,000 mcg = 1 mg
- Therefore 2 mg = 2,000 mcg
- Step 2: Calculate the concentration of solution in mcg per mL.

- Lower dosage: 4 mcg : 1 mL = 2 mcg : *x* mL

- Upper dosage: 4 mcg : 1 mL = 6 mcg : *x* mL

- Step 3: Convert mL/min to mL/hr.

- A dosage range of 2-6 mcg/min is equal to a flow rate of 30-90 mL/hr.
- 22. Step 1: Convert to like units of measurement.
- Equivalent: 1,000 mcg = 1 mg
- Therefore 5,000 mg = 5,000,000 mcg
- Step 2: Calculate the concentration of solution in mcg per mL.

- The concentration of solution is
- 10,000 mcg per mL.
- Step 3: Calculate the dosage range.

- Step 4: Convert the dosage range to mL/min.
- 10,000 mcg : 1 mL = 1,000 mcg : *x* mL
- Lower dosage: 10,000 mcg : 1 mL = 3,000 mcg : *x* mL

- Upper dosage: 10,000 mcg : 1 mL = 4,500 mcg : *x* mL

- Step 5: Convert mL/min to mL/hr.

- a. A dosage range of 50-75 mcg is equal to a flow rate of 18-27 mL/hr.
- b. Determine the dosage per minute infusing at 24 mL/hr.

- 23. Calculate the dosage per minute for the client.

- Determine the dosage per hour.

- Convert to like units.
- 1,000 mcg = 1 mg
- 39,000 mcg/hr = 39 mg/hr
- Calculate mL/hr flow rate.

- Answer: To deliver a dosage of 10 mcg/kg/min, set the flow rate at 20 mL/hr (gtt/min).
- 24. a. Convert grams to milligrams.
- 1 g = 1,000 mg
- Calculate mg/hr.

- b. Convert mg/hr to mg/min.

- Answer: At the rate of 20 mL/hr, the client is receiving a dosage of 40 mg/hr or 0.7 mg/min.
- 25. a. 10,240 mcg/min
- b. 102 mL/hr
- Calculate the dosage per minute.

- Convert mcg/min to mg/min.
- 10,240 mcg ÷ 1,000 = 10.24 = 10.2 mg/min
- Convert mg/min to mg/hr.

- Calculate flow rate.
- 1 g = 1,000 mg; 1.5 g = 1,500 mg
- 1,500 mg : 250 mL = 612 mg : *x* mL
- 1,500 *x* = 250 × 612

- 26. a. 0.27 mg/min
- b. 270 mcg/min
- Calculate the mg/hr infusing.
- 500 mL : 400 mg = 20 mL : *x* mg

- Calculate the mg/min infusing.

- Calculate the mcg/min.
- 1,000 mcg = 1 mg
- 0.27 mg/min = 270 mcg/min
- 27. a. 5 mg : 1 mL = 125 mg : *x* mL
- *or*

- Answer: 25 mL. The dosage ordered is more than the available strength. Therefore you will need more than 5 mL to administer the dosage.

- Alternate solution:
- 25 mg : 1 mL = 125 mg : *x* mL
- *or*

- b. 25 mL (med) + 100 mL IV solution = 125 mL (total fluid volume)
- 125 mg : 125 mL = 20 mg : *x* mL

- 28. Calculate the dosage per hour.

- Convert grams to milligrams.
- 1,000 mg = 1 g; 2 g = 2,000 mg
- Calculate mL/hr.

- 29. Calculate the dosage per minute.

- Convert mcg/min to mcg/hr.

- Convert mcg/hr to mg/hr (1,000 mcg = 1 mg).
- 17,262 mcg/hr ÷ 1,000 = 17.26 = 17.3 mg/hr
- Calculate the IV flow rate.
- 400 mg : 250 mL = 17.3 mg : *x* mL

- To infuse 3 mcg/kg/min, set the rate at 10.8 mL/hr. The rate is not rounded to 11 mL/hr because the IV pump is capable of delivering in tenths of an mL.
- 30. Convert lb to kg (2.2 lb = 1 kg).
- 143 lb ÷ 2.2 = 65 kg
- Find concentration per minute (mcg/min).

- Find concentration per hour.

- The concentration of dobutamine infused per minute is 325 mcg/min and 19,500 mcg/hr.
- 31. a. Convert mcg/min to mcg/hr.

- Convert mcg/hr to mg/hr (1,000 mcg = 1 mg).
- 120 mcg/hr ÷ 1,000 = 0.12 mg/hr
- Calculate the lower mL/hr flow rate.

- 8 mg : 250 mL = 0.12 mg : *x* mL

- The flow rate for the lower 2 mcg/min dosage is 3.8 mL/hr.
- Calculate the upper 4 mcg/min flow rate.
- Convert mcg/min to mcg/hr.

- Convert mcg/hr to mg/hr (1,000 mcg = 1 mg).
- 240 mcg/hr ÷ 1,000 = 0.24 mg/hr
- Calculate the upper mL/hr flow rate.
- 8 mg : 250 mL = 0.24 mg : *x* mL

- The flow rate for the upper 4 mcg/min = 7.5 mL/hr. The flow rate range to titrate a dosage of 2-4 mcg/min is 3.8-7.5 mL/hr (mL/hr is not rounded; pump capable of delivering in tenths of an mL).
- b. Calculate the dosage infusing at 5 mL/hr.

- Convert mg/hr to mcg/hr (1,000 mcg = 1 mg).
- 0.16 mg/hr × 1,000 = 160 mcg/hr
- Convert mcg/hr to mcg/min.

- At the flow rate of 5 mL/hr, the client is now receiving 2.7 mcg/min.
- 32. Step 1: Calculate the dose per hour using the lower and upper dosages.

- Step 2: Convert mcg to mg to match the available strength.
- 1,000 mcg = 1 mg
- 2,400 mcg = 2.4 mg
- 6,000 mcg = 6 mg
- Step 3: Calculate the rate in mL/hr

- To infuse 40 mcg/min, set the IV rate at 15 mL/hr (minimum)

- To infuse 100 mcg/min, set the IV rate at 37.5 mL/hr (maximum).
- A dosage of 40 to 100 mcg/min is equal to 15 to 37.5 mL/hr.
- Set up proportion to determine the dosage change of 20 mcg/min.

- So, for each change of 20 mcg/min, the incremental IV flow rate is 7.5 mL/hr.

  Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
40 mcg/min **(minimum)**	15 mL/hr
60 mcg/min	22.5 mL/hr
80 mcg/min	30 mL/hr
100 mcg/min **(maximum)**	37.5 mL/hr

- 33. Step 1: Calculate the dose per hour using the lower and upper dosages.

- Step 2: Convert mcg/hr to available strength.
- 1,000 mcg = 1 mg
- 240 mcg = 0.24 mg
- 720 mcg = 0.72 mg
- Step 3: Calculate the rate in mL/hr.

- To infuse 4 mcg/min, set the IV rate at 30 mL/hr (minimum).

- To infuse 12 mcg/min, set the IV rate at 90 mL/hr (maximum).
- A dosage of 4-12 mcg/min is equal to 30-90 mL/hr. Set up a proportion to determine the dosage change of 2 mcg/min.

- For each change of 2 mcg/min, the incremental flow rate is 15 mL/hr.

  Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
4 mcg/min **(minimum)**	30 mL/hr
6 mcg/min	45 mL/hr
8 mcg/min	60 mL/hr
10 mcg/min	75 mL/hr
12 mcg/min **(maximum)**	90 mL/hr

- 34.

- 35. Calculate the dosage per hr.

- Calculate the mL/hr.

- x = 16.7 mL/hr (mL/hr is not rounded; pump capable of delivering in tenths of a mL)

Nurses are accountable for ensuring that clients receive the “right dosage” of medication, as well as verifying that the dosage is appropriate and safe for a client before administration of medications. Information relating to the safe dosage for a medication is provided by the manufacturer. This information may be indicated on the medication label or package insert, or it may be found in a medication reference. Experts agree that medication administration and calculation of dosages for children provide uniques challenge for nurses and that children are a vulnerable population and have a higher potential for experiencing adverse effects and harm from medication errors than adults. Therefore accuracy in dosage calculation, determining if the dosage is in the safe dose range for the child, validating calculations, being knowledgeable about the medication being administered (e.g., about possible adverse reactions, indications for use) before administration of medications, and using appropriate measuring devices to administer medications safely to children becomes even more of a priority.

Causes of medication errors with pediatric clients that have been documented in literature include confusion between adult and pediatric formulation; calculation errors due to multiple calculations to individualize dosages on the basis of age, weight, mg/kg, or body surface area (BSA); and use of inaccurate measuring devices (e.g., household teaspoons) as opposed to devices such as oral dosing devices for small-volume doses. There are multiple factors that impact medication dosing for children and make them more susceptible to adverse effects of medication, including a higher percentage of water composing body weight; size; variable weight and body surface area (BSA); and physiological capabilities (e.g., immaturity of systems, differences in rate of medication absorption and excretion) that differ in comparison to adults.

To maximize drug effects and minimize adverse reactions before administering medications to children, the nurse must carefully calculate the dose and know whether the ordered dose is safe. Accuracy is always important when calculating medication dosages. For infants and children, exact and careful mathematics takes on even greater importance. Nurses must adhere to pediatric protocols and guidelines and always use a reference to verify medication orders to ensure medications are correct and safe. In many health care institutions, the pharmacy supplies medications in unit doses to reduce the chance of error. This, however, does not alleviate the nurse’s responsibility from verifying that the prescribed dose is accurate and safe.

SAFETY ALERT!

There is a higher risk of death as a result of medication errors in children than in adults. The nurse is responsible for verifying that the dosage is correct and safe for administration.

The safe administration of medications to infants and children requires knowledge of the methods used in calculating dosages as well as application of the “six rights” of medication administration (right medication, right dosage, right time, right route, right client, right documentation) when working with pediatric clients and families. Nurses are also responsible for educating families regarding medication administration.

Dosages based on body weight are also referred to as weight-based dosing (based on the weight of the client). This is an important factor used to calculate medication dosages for children and adults, for oncology medications, and for specialized client populations such as older adults and critically ill clients. Dosing of medication is also done based on body surface area (BSA), measured in square meters (m^2) and based on height and weight of the client. Many oncology medications and medications used for children and the critically ill are based on the BSA.

Dosing based on body weight and BSA for adults and children will be discussed in this chapter.

Older Adults (Geriatrics)

As already discussed (see Chapter 9), the increasing population of older adults (geriatrics) requires special consideration in medication administration. As with children, age-related physiological factors affect medication dosing; these include poor circulation, slower absorption, and decreased excretory function. Another factor is polypharmacy (the use of multiple medications by one person), which increases the chance of drugs interacting with one another and consequently affecting the action of a medication (i.e., minimizing or increasing the desired effect of a medication). Dosages of medications for a geriatric client are usually smaller. Nurses must check drug references and reliable internet sites for information related to the medications being administered. Package inserts for medications, which give recommended dosages for geriatric clients, should be checked.

As already stated, the nurse has the responsibility of determining whether a dose is safe for an individual client. This applies to both children and adults. The determination of a safe dose, which will be discussed later in this chapter, is done by comparing the ordered dosage of a medication to the recommended dosage provided by the drug manufacturer or from a reputable resource. If a dosage is higher than normal, it may be unsafe, and a

dosage lower than normal may not produce the desired therapeutic effect. While it is not the responsibility of the nurse to order a medication dosage, **the nurse is legally responsible for notifying the prescriber regarding dosages that are incorrect or unsafe for administration.**

SAFETY ALERT!

You are legally responsible for recognizing incorrect and unsafe dosages and for alerting the prescriber.

Pediatric Medication Dosages

The nurse must be able to determine whether a prescribed pediatric dosage is within the recommended safe range. It is imperative that the nurse check reputable medication resources for specific dosage details. The recommended dose or dosage range can be found in the package insert, or on the medication label. Other references that may be checked for more in-depth and additional information on a medication are drug formularies at the institution, the Physician's Desk Reference (PDR), United States Pharmacopeia, medication guidebooks, and the manufacturer's website prescribing information. Various pocket-size pediatric medication handbooks are also available; one that is widely used is *The Harriett Lane Handbook* (Johns Hopkins Hospital, 2019).

SAFETY ALERT!

To ensure safe practice, when in doubt, consult a reliable source. Always double-check dosages by comparing the prescribed dose with the recommended safe dose.

Principles Relating to Basic Calculations

Before calculating medications for the child or infant, some guidelines are helpful.

- • Calculation of pediatric dosages, as with adult dosages, involves the use of ratio and proportion, the formula method, or dimensional analysis to determine the amount of medication to administer.
- • Pediatric dosages are much smaller than those for an adult. Micrograms are used a great deal. The tuberculin syringe (1-mL capacity) is used to administer very small dosages.
- • Intramuscular (IM) dosages are usually not more than 1 mL for small children and older infants; however, this can vary with the size of the child. The recommended IM dosage for small infants is not more than 0.5 mL.
- • The recommended subcutaneous (subcut) dosage for children is not more than 0.5 mL.
- • Dosages that are less than 1 mL may be measured in tenths of a milliliter or with a tuberculin syringe in hundredths of a milliliter.
- • Medications in pediatrics are not generally rounded off to the nearest tenth but may be administered with a tuberculin syringe (measured in hundredths) to ensure accuracy.
- • All answers must be labeled.
- • Know your institution's policy on the rounding of pediatric dosages.

Calculation of Dosages Based on Body Weight

Most medications based on body weight are based on the client's weight in kilograms (kg). Therefore nurses must be competent in converting weights, including converting pounds, pounds and ounces, and grams to kilograms. Conversion of weights, as well as the methods used, were discussed

in Chapter 8. The conversion factors related to weight are:

- • 1 kg = 2.2 lb
- • 1 lb = 16 oz
- • 1 kg = 1,000 g

Because most medications are based on body weight in kilograms, it is essential to review again the conversion of weights to kilograms. Let's do some sample problems with weight conversions.

Converting Pounds to Kilograms

RULE

To convert pounds to kilograms, use the conversion factor: 1 kg = 2.2 lb, divide by 2.2, and express the weight to the nearest tenth.

Example 1: Convert a child's weight of 30 lb to kilograms

Solution:

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

Example 2: Convert an infant's weight of 14 lb and 6 oz to kilograms.

Solution:

Ratio and Proportion (Linear Format)

Dimensional Analysis

SAFETY ALERT!

Use caution when converting ounces to a fraction of a pound. Also, after converting the ounces to pounds, remember to add the answer to the remaining whole pounds to get the total pounds. Convert the total pounds to kg.

Example 3: Convert the weight of a 157-lb adult to kilograms.

Solution:

Ratio and Proportion (Linear Format)

Dimensional Analysis

Converting Kilograms to Pounds

RULE

To convert kilograms to pounds, use the conversion factor: 1 kg = 2.2 lb, multiply by 2.2, and express the weight to the nearest tenth.

Example 1: Convert a child's weight of 24.3 kg to pounds.

Solution:

Ratio and Proportion (Linear Format)

Dimensional Analysis

Example 2: Convert an adult's weight of 70.2 kg to pounds.

Solution:

Ratio and Proportion (Linear Format)

Dimensional Analysis

Infants 0 to 4 weeks old (neonates) and premature infants may also be given medications. The scale will convert the child's weight in grams, or the weight may be reported in grams, rather than kilograms. Therefore it may be necessary for the nurse to convert the weight in grams to kilograms.

Converting Grams to Kilograms

RULE

To convert grams to kilograms, use the conversion factor 1 kg = 1,000 g, dividing the number of grams by 1,000 or moving the decimal point three places to the left. Round kilograms to the nearest tenth.

Example 1: Convert an infant's weight of 3,000 g to kilograms.

Solution:

Ratio and Proportion (Linear Format)

Dimensional Analysis

Example 2: Convert an infant's weight of 1,350 g to kilograms.

Solution:

Ratio and Proportion (Linear Format)

Dimensional Analysis

Note: Remember that ratio and proportion can also be written in a fraction format and used to do conversions.

Dimensional Analysis

POINTS TO REMEMBER

- • 2.2 lb = 1 kg, 1 kg = 1,000 g, 1 lb = 16 oz
- • To convert from pounds to kilograms, divide the number of pounds by 2.2. Carry the division to the hundredths place, and round the weight to the nearest tenth as indicated.
- • To convert from kilograms to pounds, multiply the number of kilograms by 2.2 and round the weight to the nearest tenth as indicated.
- • If the child's weight is in ounces and pounds, convert the ounces to the nearest tenth of a pound, and then add the answer to pounds to get the total pounds. Convert the total pounds to kilograms, and round to the nearest tenth as indicated.
- • To convert from grams to kilograms, divide by 1000 or move the decimal point three places to the left. Round kilograms to the nearest tenth as indicated.

PRACTICE **PROBLEMS**

Convert the following weights in pounds to kilograms. Round to the nearest tenth as indicated.

- 1. 15 lb = _____ kg
- 2. 68 lb = _____ kg
- 3. 31 lb = _____ kg
- 4. 52 lb = _____ kg
- 5. 204.2 lb = _____ kg
- 6. 8 lb 4 oz = _____ kg
- 7. 5 lb 12 oz = _____ kg
- 8. 100¼ lb = _____ kg
- 9. 92¾ lb = _____ kg

Convert the following weights in kilograms to pounds. Round to the nearest tenth as indicated.

- 10. 21.3 kg = _____ lb
- 11. 17.7 kg = _____ lb
- 12. 22 kg = _____ lb
- 13. 15 kg = _____ lb
- 14. 34 kg = _____ lb
- 15. 71.4 kg = _____ lb
- 16. 73 kg = _____ lb
- 17. 98.3 kg = _____ lb

Convert the following weights in grams to kilograms. Round to the nearest tenth as indicated.

- 18. 1,450 g = _____ kg
- 19. 2,900 g = _____ kg
- 20. 1,875 g = _____ kg

Answers on 646

Before beginning to calculate dosages based on weight, let's review some terminology that will be used and that you will need to be familiar with.

Recommended dosage (also referred to as the *safe dosage*)—This information comes from a reputable medication reference, the medication label, or a package insert. The recommended dosage for children and adults is clearly indicated. The recommended dosage can be stated as weight based and usually in kilograms, such as mg/kg, mcg/kg, and so on. On occasion, the dosage may be expressed as mg/lb. The recommended dosage may also be stated in terms of the body surface area (BSA), which is measured in square meters (m^2). Recommended dosages may state, for example, mg/kg for a 24-hour period to be given in one or more divided dosages, or may specify other time intervals. A range is sometimes indicated for the recommended dosage and referred to as a safe dosage range (SDR). This is the minimum and maximum safe dosage for a medication as stated by an approved medication reference.

Single dose—A dose of medication administered one time or on an as-needed basis. It may be indicated as "per dose." For example, a medication in a medication reference guide may state 2 mg/kg/dose as the recommended dosage.

Total daily dose—The total amount of a medication that may be administered in a 24-hour period. Sometimes the total amount daily may be stated. "Daily" or "per day" is usually used to indicate a 24-hour period.

Divided dosage—Represents the dosage to be given at specific time intervals (e.g., "three divided dosages," "q6h," and so on). This is obtained by dividing the dosage for 24 hours by the frequency, or number of times, an individual will receive the medication.

Dosage range—The minimum to maximum dose for a medication (e.g., 10–20 mg/kg) to be therapeutic.

Determining if the dosage is safe—This is decided by comparing the ordered dosage with the recommended dosage.

Verification of safe doses recommended by body weight (for a child or adult) requires having the following information: weight of the client (usually in kg), the prescriber's order, and the weight-based information from a reputable reference. This information is used to determine whether a dose is safe or not following a systematic approach, such as the following:

- • Convert the client's weight from lb to kg if necessary, and round kg to the nearest tenth.
- • Calculate the safe dose by multiplying the weight of the client in kg by the recommended dosage from the reputable medication reference (rounded to the nearest tenth). This can be done also using ratio and proportion or dimensional analysis.
- • Compare the recommended dosage for the individual client with the ordered dose.
- • Determine if the dose is safe. If the dosage is safe, calculate the amount to give the ordered dosage. If the dosage is not safe (unsafe), notify the prescriber to verify the order before administering the medication.

Let's begin by looking at examples with children.

Single-Dose Medications

This may be indicated in the reference as "per dose" or indicated with a slash (/) mark ("/dose").

- Example 1: The prescriber orders Narcan 1.2 mg IV stat for a child who weighs 12 kg.
- According to *The Harriet Lane Handbook* (a reputable reference), the recommended dose for a child weighing less than 20 kg is 0.1 mg/kg/dose.
- Step 1: Convert weight to kg if necessary. No conversion of weight is required. The child's weight is in kg, and the recommended dosage is stated as 0.1 mg/kg.
- Step 2: Multiply the child's weight in kg by the recommended dose from the reference.

. The safe dose of Narcan for the child weighing 12 kg is 1.2 mg/dose. The calculation of the safe dose could also be done by ratio and proportion or dimensional analysis. (Refer to the setup shown for this problem.)

- Step 3: Decide if the dose is safe by comparing the ordered and the recommended dosage. The dose ordered is 1.2 mg. **The dose is safe** because the dose that is ordered is the same as the safe dose recommended for the child.
- Step 4: Calculate the dosage to administer, using ratio and proportion, the formula method, or dimensional analysis.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

The safe dose of Narcan for a child weighing 12 kg is 1.2 mg/dose.

Now that we have determined the dose ordered for the child is safe, let's calculate the dosage to administer.

Order: Narcan (naloxone hydrochloride) 1.2 mg IV stat

Available:

Solution:

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Formula Method

Dimensional Analysis

- Example 2: The prescriber orders Ofirmev (acetaminophen) 700 mg IV q6h prn for pain for a child who weighs 94.6 lb. According to *The Harriet Lane Handbook,* for a child age 2-12 years or an adolescent/adult weighing less than 50 kg, the recommended dose is 15 mg/kg/dose q6h, or 12.5 mg/kg/dose q4h IV, up to a maximum of 75 mg/kg/24 hr.

Determine if the dosage ordered is safe. If the dosage is safe, calculate the number of milliliters to add to the IV.

Available:

- Step 1: First, convert the child's weight from lb to kg using any of the methods already shown.

Ratio and Proportion (Linear Format)

- Step 2: Calculate the recommended dosage. Note the recommended dosage from the reference you will be using is for q6h and for a weight less than 50 kg. Multiply the child's weight in kg by the recommended dose from the reference.

- This can also be done using ratio and proportion or dimensional analysis. (Refer to Example 1.)
- Step 3: Compare the recommended safe dose for the child with the ordered dose and decide if the dose is safe. The recommended dose for the child weighing 43 kg is 645 mg/dose. The dose ordered is 700 mg q6h. The dosage is **not safe;** it is more than the recommended safe dosage for this child. The nurse would need to notify the prescriber to validate why the dose ordered is more than the recommended dosage; there may be factors that warrant a larger dose.

Note: **Because the dose ordered is not safe, we will not be calculating the number of mL to add to the IV.**

Single-Dose Range Medications

Some single-dose medications can indicate a minimum and maximum range for a medication. The nurse will then need to calculate the minimum and maximum safe dosage.

- Example 3: The prescriber orders Vistaril 15 mg IM q4h prn for nausea. The child weighs 38 lb. According to *The Harriet Lane Handbook,* the recommended dosage is 0.5 to 1 mg/kg/dose q4h prn. Determine if the dosage ordered is safe.

Solution:

- Step 1: First convert the child's weight in lb to kg and round to the nearest tenth of a kg.

Ratio and Proportion (Linear Format)

Note: Refer to the conversion of weights at the beginning of the chapter if necessary for an alternate format for setting up a ratio and proportion and using dimensional analysis for converting weights.

- Step 2: Calculate the recommended dosage. Note the recommended dosage is stated as a range, 0.5 to 1 mg/kg/dose. Calculate the minimum and maximum safe dose range. Multiply the child's weight in kg by the mg/kg/dose.
- **Minimum per dose:**

- **Maximum per dose:**

The safe dosage range of Vistaril for a child weighing 17.3 kg is 8.7 mg/dose-17.3 mg/dose.

The calculation of minimum and maximum dose can also be done using ratio and proportion or dimensional analysis.

Ratio and Proportion (Linear Format)

Dimensional Analysis

- Step 3: Decide if the dosage ordered is safe. The safe recommended dosage is 8.7 mg to 17.3 mg/dose. The dose is safe, because the ordered dose of 15 mg IM q4h falls within the range of 8.7 mg to 17.3 mg/dose.
- Step 4: Calculate the dosage to administer the ordered dose.
- Order: Vistaril 15 mg IM q4h prn for nausea
- Available:

Note: A ratio and proportion setup in fraction format, the formula method, or dimensional analysis could have been used to calculate the dose.

Calculating Daily Doses

With some medications, the recommended dose is stated as a total daily dose, which can be indicated in the reference as “per day” with a slash mark, “/day,” “/24 hr,” or “daily,” indicating that the total daily dose is divided into a number of individual doses throughout the day (e.g., “50 mg/kg/day in divided doses q8h,” “four divided doses at q6h intervals”). When the total daily dosage indicates that the dose is divided at specific time intervals, in addition to calculating the total daily dosage, the total daily dose has to be divided to find the amount for a specific time interval (divided dose). The recommended divided dose is then compared to the ordered dose to determine whether the dose is safe.

Let’s look at some examples.

- Example 4: Order: Gentamicin 50 mg IVPB q8h for a child weighing 40 lb. According to *The Harriet Lane Handbook,* the recommended dosage for a child is 7.5 mg/kg/24 hr divided q8h. Determine if the dosage ordered is safe.
- Step 1: Convert the child’s weight from lb to kg using any of the methods for converting weights presented in this chapter and in earlier chapters on converting.

Ratio and Proportion (Linear Format)

- Step 2: Calculate the total daily dosage allowed for the child weighing

Note: 24 hr could be stated as daily or per day (/day).

This could also be calculated using ratio and proportion or dimensional analysis.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

The total daily dosage for this child is 136.5 mg/24 hr

- Step 3: Now divide the total daily dosage by the number of times the medication will be administered to the client in 24 hours. In this example, the dose is to be given q8h, so the client would receive three (3) doses in a day (24 hr) q8h = 24 ÷ 8 = 3
- Total daily dosage: 136.5 mg ÷ 3 = 45.5 mg per dose
- Step 4: Now compare the recommended dose for the child with the ordered dose and decide if the dose is safe. The ordered dose is 50 mg q8h, and the recommended dose is 45.5 mg/dose (or q8h). The dose is **not safe** because the ordered dose is more than the recommended safe dose. Remember to contact the prescriber to discuss the order. Factors such as the child's medical condition might warrant a larger dose.

Note: When dosages are compared for safety, it may be easier to calculate how many total milligrams or micrograms are ordered. This way usually involves multiplication rather than division. This will require one calculation, as opposed to two, and may decrease the chance of errors because fewer errors are usually made with multiplication than with division.

In this example, you could eliminate the division to find the amount per dose by using the total daily dosage.

Daily dosage according to this order, in this case:

50 mg q8h = 50 mg/dose × 3 doses/day = 150 mg/day (24 hr)

Decide if the ordered daily dose is safe. The ordered daily dosage is 150 mg, and the allowable safe daily dosage is 136.5 mg/24 hr. The dosage ordered is not safe, because 150 mg/day exceeds 136.5 mg/24 hr (per day).

- Example 5: Order: Penicillin V Potassium 125 mg p.o. q6h for a child weighing 36 lb.
- According to *The Harriet Lane Handbook,* the recommended dose p.o for a child is 25-75 mg/kg/day divided q6-8hr. Determine if the dose ordered is safe. If the dose is safe, calculate the number of milliliters needed to administer the dose.
- Available: Penicillin V Potassium oral solution 250 mg per 5 mL
- Step 1: Convert the child's weight from lb to kg.

Ratio and Proportion (Linear Format)

- Step 2: Calculate the recommended total daily dose for the child. (The recommended dosage range is 25-75 mg/kg/day.) Because the recommended dose is stated as a range, calculate the minimum and maximum dosage. (This can be done using ratio and proportion or dimensional analysis.)
- **Minimum total daily dosage:**

- **Maximum total daily dosage:**

- The safe daily dosage range for a child weighing 16.4 kg is 410-1,230 mg/day.
- Step 3: Now divide the minimum and maximum daily dosage by the number of times the medication will be administered in 24 hours. In this example, the medication is to be given q6h, so the child will receive four (4) doses in a day.
- 24 hr ÷ 6 = 4
- **Minimum total daily dosage:** 410 mg ÷ 4 = 102.5 mg per dose (or q6h)
- **Maximum total daily dosage:** 1, 230 mg ÷ 4 = 307.5 mg per dose (of q6h)
- The safe dose range for this child is 102.5-307.5 mg per dose (or q6h).
- Step 4: Compare the recommended dose for the child with the ordered dose. The ordered dose is 125 mg q6h, and the recommended dose range is 102.5-307.5 mg/dose. The ordered **dose is safe** because it is within the range of the recommended safe dose.
- **Alternate Solution:** Using the total daily dosage.
- The dose ordered is 125 mg q6h (24 ÷ 6 = 4 doses per day).

- . The ordered **dose is safe** because it falls within the range of 410-1,230 mg/day.
- Step 5: The dose ordered is **safe**. Calculate the milliliters to administer the dose (using the formula method, ratio and proportion (linear or fraction format), or dimensional analysis).

Ratio and Proportion (Linear Format)

- Example 6: Amoxicillin 30 mg p.o. q12h for an infant weighing 2,600 g. According to *The Harriet Lane Handbook,* the recommended dosage is 20-30 mg/kg/day divided q12h. Determine if the dosage ordered is safe.
- Step 1: Convert the weight in g to kg using any of the methods for weight conversion. g to kg is converting within the metric system (one metric unit to another metric unit); therefore movement of decimals can be used to convert the weight.
- **Conversion factor**: 1 kg = 1,000 g; 2,600 = 2.6 kg
- Step 2: Calculate the lowest and highest recommended total daily dosage for the infant.
- The recommended dosage from the reference is a range.
- **Minimum total daily dosage:**

- **Maximum total daily dosage:**

- The total daily dosage for an infant weighing

- Step 3: Divide the minimum and maximum total daily dosage by the number of times the infant will receive doses in 24 hours. In this example, the dose is to be given q12h, so the infant will receive two (2) doses in a day.
- 24 hr ÷ 12 = 2
- **Minimum total daily dose:** 52 mg ÷ 2 = 26 mg/dose (or q12h)
- **Maximum total daily dose:** 78 mg ÷ 2 = 39 mg/dose (or q12h)
- The safe dose range for the infant weighing 2.6 kg is 26-39 mg/dose.
- Step 4: Compare the recommended dose for the infant with the ordered dose and determine if the dose is safe. The ordered dose is 30 mg q12h, and the recommended safe dose range is 26-39 mg/dose. The **dose is safe** because the ordered dose falls within the recommended safe range.

Note: The steps in this example could be calculated using ratio and proportion or dimensional analysis. Also, the total daily dosage could be used to determine whether the dose is safe. Refer to examples previously given for setup of problems using these methods.

SAFETY ALERT!

Remember that to avoid medication errors, it is imperative to calculate a safe dosage for a child and compare it to the dosage ordered. Verify dosages that are **lower or higher** than the recommended dosage with the prescriber **before** administering the medication. The nurse is legally liable for any medication administered.

Adult Dosages Based on Body Weight

The information that has been provided regarding the calculation of dosages for children based on weight can also be applied to adults. The same methods (i.e., ratio and proportion, dimensional analysis) can be used. Let's look at some examples.

- Example 1: Order: Gentamicin Sulfate 135 mg IV q8h for an adult client weighing 175 lb. According to *Clayton's Basic Pharmacology for Nurses* (2020), the recommended dosage is 3-5 mg/kg/day in two or three doses or 5-7 mg/kg once daily. Determine if the dosage ordered is safe.
- Step 1: Convert the weight in lb to kg. Conversion factor: 2.2 lb = 1 kg.
- 175 lb ÷ 2.2 = 79.54 = 79.5 kg (rounded to the nearest tenth)
- Step 2: Calculate the recommended dosage (using 3-5 mg/kg/day; medication is ordered q8h; client would receive three doses in a day).
- **Minimum total daily dosage:**

- **Maximum total daily dosage:**

- The recommended dosage per day for a client weighing 79.5 kg is 238.5-397.5 mg/day.
- Step 3: Determine the amount the client will receive per dose. Divide the total daily dosage by the number of times the medication will be administered. In this example, the medication is ordered q8h, so the client will receive three doses in a day.
- **Minimum total daily dosage:** 238.5 mg ÷ 3 = 79.5 mg/dose
- **Maximum total daily dosage:** 397.5 mg ÷ 3 = 132.5 mg/dose
- The recommended dosage per dose is 79.5-132.5 mg/dose.
- Step 4: Compare the safe recommended dose to the ordered dose and determine if the dose is safe. The ordered **dose is not safe** because 135 mg q8h is outside of the dosage range (79.5-132.5 mg/dose). Remember that determining whether the dose is safe can also be done by using the total daily dosage. 135 mg q8h = 135 mg × 3 = 405 mg/day, which is outside the recommended dosage range of 238.5-397.5 mg/day. Therefore the ordered **dose is not safe**. The nurse will need to contact the prescriber because the ordered dose is more than the recommended dose. Also, there may be a reason for the higher dose of medication (e.g., client condition).
- Example 2: Order: granisetron hydrochloride 0.75 mg IV 30 minutes before chemotherapy for an adult client weighing 165 lb. According to *Mosby's* 2020 *Nursing Drug Reference,* the recommended dosage is 10 mcg/kg over 5 min, 30 min before the start of cancer chemotherapy. Determine if the ordered dose is safe.
- Step 1: Convert the weight in lb to kg. Conversion factor: 2.2 lb = 1 kg.
- 165 lb ÷ 2.2 = 75 kg
- Step 2: Calculate the recommended dose.
-

- The dose required for a client weighing 75 kg is 750 mcg.
- Step 3: Compare the safe recommended dose to the ordered dose and determine if the dose is safe. Conversion factor: 1,000 mcg = 1 mg.
- 0.75 mg = 750 mcg (0.75 × 1,000) (ordered dose converted to mcg to match the reference ([mcg/kg]).
- The **dose is safe**. The ordered dose of 0.75 mg (750 mcg) is the same as the recommended safe dose.

POINTS TO REMEMBER

- • Most weight-based medications are based on body weight in kg.
- • To calculate dosages based on weight, the weight of the client is converted to the same unit of weight as the reference (e.g., lb to kg). The medication reference indicates the amount of medication per kg (e.g., 10 mg/kg).
- • To calculate the dosage based on weight, there is a systematic approach:
    - 1. Convert the weight to kilograms if needed and round kilograms to the nearest tenth.
    - 2. Determine the total daily recommended dosage.
    - 3. To determine the dose that should be given each time (i.e., q6h), divide the total daily dosage by the number of times the medication will be administered in 24 hours.
    - 4. Compare the ordered dose with the safe recommended dose and determine if the dosage ordered is safe.
    - 5. Calculate the dosage to administer using ratio and proportion, the formula method, or dimensional analysis.
- • Determining whether a dose is safe can also be determined by comparing the total daily dose.
- • When the recommended dosage is stated in a range, calculate the minimum and maximum dosage for the medication.
- • Ask the prescriber to verify any discrepancies in dosage that are less than the recommended dose and more than the recommended dose. Remember that factors such age, weight, and medical conditions can cause differences in the dosage of medications.
- • Use appropriate resources to obtain the recommended dosage for a medication.
- • Dosages less than the recommended dose may not be effective in achieving the therapeutic effect.
- • For medications that are weight based, the calculations and steps are the same for adults and children.

PRACTICE **PROBLEMS**

Round weights and dosages to the nearest tenth where indicated. Use labels where provided to answer the questions.

- 21. A child weighs 35 lb and has an order for Keflex (cephalexin) 150 mg p.o. q6h.
- Available:

-
    - a. What is the recommended dosage in mg/kg/day? _____
    - b. What is the child's weight in kilograms to nearest tenth? _____
    - c. What is the safe dosage range for this child? _____
    - d. Is the dosage ordered safe? (Prove mathematically.) _____
    - e. How many milliliters will you administer for each dosage? _____
- 22. According to *The Harriet Lane Handbook*, the recommended dosage of clindamycin oral solution is 10-40 mg/kg/24 hr divided q6-8 hr. The child weighs 40 kg. (Base calculations on the medication being administered q6h.)
    - a. What is the maximum dosage for this child in 24 hours? _____
    - b. What is the divided dosage range? _____
- 23. The recommended initial dosage of mercaptopurine is 1.5-2.5 mg/kg/day p.o. The child weighs 44 lb.
    - a. What is the child's weight in kilograms? _____
    - b. What is the initial safe daily dosage range for this child? _____
- 24. A 44-lb child has an order for Erythromycin oral suspension 250 mg p.o. q6h. The usual dosage for children under 50 lb is 30 to 50 mg/kg/day in divided dosages q6h.
    - a. What is the child's weight in kilograms? _____
    - b. What is the safe range of dosage for this child in 24 hours? _____
    - c. Is the dosage ordered safe? (Prove mathematically.) _____

- 25. Refer to the Amphotericin B insert to calculate the dosage for an adult weighing 66.3 kg with good cardiorenal function. _____

- 26. A child with esophageal candidiasis weighs 12 lb, 6 oz. The recommended dose of IV fluconazole is 6 mg/kg on the first day, followed by 3 mg/kg once daily for 2 weeks.
  - a. What is the child's weight in kilograms to the nearest tenth? _____
  - b. What is the first dosage for this child? _____
  - c. What is the subsequent dosage for this child? _____

Answers on 646

Calculating Dosages Using Body Surface Area

Body surface area (BSA) is used to calculate safe dosages for infants, children, and selected adult populations. Examples of types of medications that may require BSA-based dosing include chemotherapy medications and medications given to clients who have severe burns, receiving radiation treatment, and those with renal disease. BSA is the total surface area of the body expressed in square meters (m^2). BSA is calculated using the height and weight measurements. BSA can be determined using a special BSA slide ruler, BSA calculator, Nomogram chart, or a mathematical formula. BSA calculators can be found on the internet.

The two methods commonly used to calculate a BSA are the use of a nomogram and the use of a BSA formula. Both methods will be discussed in this text.

Use of a Nomogram to Determine BSA

The nomogram provides an estimate of the BSA. The nomogram can be used to calculate the BSA for both children and adults for heights up to 240 cm (95 inches) and weights up to 180 lb. (There is an adult nomogram available for adults weighing more than 180 pounds.) The West nomogram is the best known BSA chart (Figure 24.1). The West nomogram has the height in inches and centimeters on the left and the weight in pounds and kilograms on the right. There is a box within the West nomogram that is used for children of normal height and weight. Normal height and weights are determined by growth and development charts. If the child is of a normal height and weight for his or her age, the BSA can be determined from weight alone. For example, a child weighing 70 lb and of normal height has a BSA of 1.10 m^2. To determine the BSA using the West nomogram, place a ruler extending from the height column on the left to the weight in the far right-hand column. The estimated BSA for the child is where the line intersects the surface area (SA) column. For example, by using the far right and left scales, you will find that a child who weighs 50 lb and is 36 in tall has a BSA of 0.8 m^2. If the ruler is slightly off the height or weight, the BSA will be incorrect. **Always** base the BSA on current height and weight measurements.

Figure 24.1 West nomogram for estimation of body surface area. The surface area is indicated where a straight line that connects the height and weight levels intersects the surface area column or, if the patient is roughly of average size, from the weight alone *(enclosed area)*. (From Kliegman RM, St. Geme JW, Blum NJ, Shah SS, Tasker RC, Wilson KM: *Nelson textbook of pediatrics,* ed 21, Philadelphia, 2020, Saunders. Nomogram modified from the data of E. Boyd by C.D. West. See also Briars GL, Bailey BJ: Surface area estimation: pocket calculator v nomogram, *Arch Dis Child* 70:246–247, 1994.)

SAFETY ALERT!

The increments and spaces on the BSA are **not consistent.** Be certain that you read the numbers and the calibration values between them carefully. To use the normal column on the West nomogram, check reliable resources such as a pediatric growth and development chart. **Do not** guess on the normal height and weight.

PRACTICE **PROBLEMS**

Refer to the nomogram and determine the BSA (expressed in square meters) for the following children of normal height and weight.

- 27. For a child weighing 30 lb _____
- 28. For a child weighing 42 lb _____
- 29. For a child weighing 52 lb _____
- 30. For a child weighing 44 lb _____
- 31. For a child weighing 11 lb _____
- 32. For a child weighing 20 lb _____

Using the nomogram, calculate the following BSAs.

- 33. A child who is 90 cm long and weighs 50 lb _____
- 34. A child who is 60 cm long and weighs 10 lb _____
- 35. A baby who weighs 13 lb and is 19 inches long _____
- 36. A child who weighs 30 lb and is 32 inches tall _____
- 37. A child who weighs 13 kg and is 65 cm tall _____
- 38. A child who is 19 inches long and weighs 5 lb _____

Answers on 647

Calculating BSA Using a Formula

The BSA can be calculated using a formula. To use the formula, you need the height and weight (adults and children) and a calculator that has the square root (

) function. The formula used is based on the units in which the measurements are obtained. One formula uses metric measurements and the other household measurements. Notice that the difference in the formulas, in addition to the measurements used (metric versus household), is the difference in the denominators.

Let's look at examples using the metric formula.

Example 1: Calculate the BSA for a child who weighs 23 kg and whose height is 128 cm. Express BSA to the nearest hundredth.

Problem setup:

BSA $(m^2)^2$ =

Steps:

- 1. Multiply the weight in kg by the height in cm.
- 2. Divide the product obtained in Step 1 by 3,600.
- =

=

- 3. Enter the square root symbol (√) into the calculator.

- = 0.903
- 4. Round the final BSA in square meters to the nearest hundredth.
- 0.903 = 0.9 m^2
- BSA = 0.9 m^2

Example 2: Calculate the BSA for an adult who weighs 100 kg and whose height is 180 cm. Express BSA to the nearest hundredth. Follow the steps outlined in Example 1.

BSA $(m^2)^2$ =

=

= 2.236 = 2.24 m^2

BSA = 2.24 m^2

Now let's look at examples using household formula.

Example 1: Calculate the BSA for a child who weighs 25 lb and is 32 inches tall. Express the BSA to the nearest hundredth.

Problem setup:

BSA $(m^2)^2$ =

Steps:

- 1. Multiply the weight in lb by the height in inches.
- 2. Divide the product obtained in step 1 by 3,131.
- =

=

- 3. Enter the square root symbol (√) into the calculator.

- = 0.504
- 4. Round the final BSA in square meters to the nearest hundredth.
- 0.504 = 0.5 m^2
- BSA = 0.5 m^2

Example 2: Calculate the BSA for an adult who weighs 143.7 lb and is 61.2 in tall. Express the BSA to the nearest hundredth. Follow the steps outlined in Example 1.

(m^2) =

=

=

= 1.675 = 1.68 m^2

BSA = 1.68 m^2

SAFETY ALERT!

Round the final answer **only** to the nearest hundredth to obtain a more accurate BSA for medication dosage. When using the calculator, don't forget the last step of pressing the square root function.

It is important to point out the slight variation in m^2 calculated by the metric and household methods because of rounding used to convert centimeters to inches: 1 inch = 2.54 cm, although it is rounded to 2.5 cm and used. Let's look at an example to illustrate this. Calculate the BSA of an adult whose weight is 95 kg (209 lb) and height is 180 cm (72 in).

Metric BSA

(m^2) =

=

=

= 2.179 = 2.18 m^2

Household BSA

(m^2) =

=

=

= 2.192 = 2.18 m^2

Notice that either metric or household measurement result in essentially the equivalent BSA.

Technological Advances

It is important to note that computer technology is being used more today and has made available applications that can be downloaded onto devices such as iPhones that can calculate the BSA after the data are input.

PRACTICE **PROBLEMS**

Determine the BSA for each of the following clients using a formula. Express the BSA to the nearest hundredth.

- 39. An adult whose weight is 95.5 kg and height is 180 cm _____
- 40. A child whose weight is 10 kg and height is 70 cm _____
- 41. A child whose weight is 4.8 lb and height is 21 inches _____
- 42. An adult whose weight is 170 lb and height is 67 inches _____
- 43. A child whose weight is 92 lb and height is 35 inches _____
- 44. A child whose weight is 24 kg and height is 92 cm _____

Answers on 647

POINTS TO REMEMBER

- • The West nomogram provides an estimate of BSA using height and weight.
- • There is a box within the West nomogram for children of normal height and weight based on growth and development charts; in this nomogram, the BSA can be determined from the weight alone.
- • An error can be made in the BSA if the ruler is slightly off the height and weight.
- • The formula method to calculate BSA is more accurate than use of the nomogram.
- • The formulas used to calculate BSA are as follows:
- Metric BSA (m^2) =

- Household BSA (m^2) =

Determining BSA with a Formula Requires Use of a Calculator

- • Multiply height × weight (cm × kg, or lb × inches).
- • Divide by 3,600 or 3,131, depending on the units of measure (divide by 3,600 if measures are in metric units [cm, kg] and by 3,131 if measures are in household units [inches, lb]).
- • Enter the square root sign (

) to arrive at BSA in square meters.

- • Round square meters to hundredths (two decimal places).
- • There are applications available today that can be downloaded onto mobile devices that have computer programs that calculate the BSA.

Dosage Calculation Based on BSA

As already mentioned, there are medications that provide the recommended dosages according to the BSA. The method used to determine the safe dosage based on weight are the same for calculating a dosage based on the BSA and determining whether the ordered dose is safe. To calculate the recommended dose based on the BSA, the nurse will need to do the following:

- • Calculate the BSA or verify the client's BSA from a source such as the client's current medical record.
- • Calculate the recommended dose using a reputable reference and a formula, ratio and proportion, or dimensional analysis.
- **Formula method**—The BSA of the client (adult or child) is multiplied by the recommended dosage from the reference to obtain the recommended dosage.
- **Ratio and proportion**—The known ratio is the BSA in square meters, obtained from an appropriate reference (e.g., medication insert, pediatric medication handbook).
- **Dimensional analysis**—The starting fraction is the BSA-based dosage from the reference.
- • Compare the recommended dose to the ordered dose and decide whether the dosage is safe.

Let's look at some examples.

- Example 1: Order: Vincristine 1.5 mg IV every Tuesday for a child who weighs 23 kg and is 126 cm tall. According to *Mosby's 2020 Nursing Drug Reference,* the recommended dose for vincristine is 1-2 mg/m^2/wk. Determine if the dose is safe.

Solution:

- Step 1: Calculate the BSA using the metric formula.
- BSA $(m^2)^2$ =

=

=

= 0.897

-

= 2.179 = 2.18 m^2

- BSA = 0.9 m^2
- Step 2: Calculate the recommended dose. (***Note:*** There is a range, so calculate the minimum and maximum dosage.) Multiply the child's BSA by the recommended dose from the medication reference.
- **Formula Method:**
- **Minimum dose:**

- **Maximum dose:**

- The safe dosage range for vincristine for this child is 0.9-1.8 mg /per week.
- Step 3: **The dosage is safe**, because the ordered dose of 1.5 mg falls within the recommended safe dose range of 0-9-1.8 mg per week.

Determining the recommended dose can also be done using ratio and proportion and dimensional analysis. The setup using those methods will be shown only for this example.

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

- Example 2: Carboplatin 500 mg IV has been ordered on Day 1 for a client with advanced ovarian cancer. The client weighs 125 lb and is 63 in tall, with a BSA of 1.59 m^2. According to *Mosby's 2020 Drug Reference* the recommended dosage is 300 mg/m^2. Determine if the dose ordered is safe.
- Step 1: Although the BSA is given, it needs to be validated to make certain it is correct. Use the **household formula** to validate the BSA.
- BSA (m^2) =

  =

  =

  = 1.585
- BSA = 1.59 m^2
- The BSA for the client is correct.
- Step 2: Calculate the recommended dose using the client's BSA and the recommended dose from the reference.

- Step 3: Compare the recommended dose with the ordered dose. The recommended dose for this client is 477 mg (single dose), and the ordered dose is 500 mg (single dose). **The dose is not safe** for this client. Notify the prescriber to clarify the order before administering. The

recommended dose could also be calculated using ratio and proportion or dimensional analysis. Refer to Example 1 for the setup using these methods.

POINTS TO REMEMBER

- • Always check a dosage against BSA in square meter recommendations using appropriate resources (e.g., PDR, medication insert, drug reference book, pediatric medication handbook).
- • When you know the BSA, the dosage is determined by multiplying the BSA by the recommended dosage. (This is used when the recommended dosage is written by using the average dosage per square meter.) Ratio and proportion or dimensional analysis can also be used.
- • To determine whether a child's dosage is safe, a comparison must be made between what is ordered and the calculation of the dosage based on BSA.
- • If a dosage seems to be unsafe, consult the prescriber and verify the dosage before administering the dose.

IV Therapy and Children

Pediatric IV Administration

Administration of IV fluids to children is very specific because of their physiological development. Microdrop sets are used for infants and small children; electronic devices are used to control the rate of delivery. The rate of infusion for infants and children must be carefully monitored. The IV drop rate must be slow for small children to prevent complications such as cardiac failure because of fluid overload. Various IV devices decrease the size of the drop to "mini" or "micro" drop or 1/60 mL, thus delivering 60 minidrops or microdrops per milliliter. IV medications may be administered to a child over a period of time (several hours) or on an intermittent basis. For intermittent medication administration, several methods of delivery are used, including the following:

- **Small-volume IV bags**—These may be used if the child has a primary IV line in place. A secondary tubing set is attached to a small-volume IV bag, and the piggyback method is used.

Volume control sets—Are used frequently to administer IV fluids hourly and intermittent IV medications to children. These are often referred to by their trade name which include: Buretrol, Volutrol, or Soluset. A volume control set consists of a calibrated chamber with a 150 mL capacity that connects to an IV solution. (Figure 24.2 shows a typical system that consists of a calibrated chamber.) When used to regulate IV fluid infusion, the nurse fills the chamber every 1 to 2 hours as needed with fluid directly from the IV solution. The chamber is calibrated in small increments. Small, prescribed amounts of fluid are added to the chamber, and the clamp above the chamber is fully closed. This protects the client from receiving more fluid than intended. This is especially important with children.

Figure 24.2 Volume-controlled device (buretrol). (From Potter PA, Perry AG, Stockert P, Hall A: *Essentials for nursing practice,* ed 9, St Louis, 2019, Mosby.)

For the intermittent medication administration, the nurse injects the medication through the injection port at the top of the chamber, and adds an appropriate amount of IV fluid to dilute the medication, and it is infused over a specific period of time (see Figure 24.2). An IV flush (small amount of IV fluid) is administered immediately after the medication is infused.

An electronic controller or pump may also be used to administer intermittent IV medications. When used, the electronic device sounds an alarm when the Buretrol chamber is empty. Volume control devices may also be used in the adult setting for clients with fluid restrictions.

SAFETY ALERT!

IV infusions should be monitored as frequently as every hour. A solution to flush the IV tubing is administered after the medication.

Regardless of the method used for medication administration in children, **a solution to flush the IV tubing is administered after the medication.** The purpose of the flush is to make sure the medication has cleared the tubing and the total dosage has been administered. Most institutions flush with normal saline solution as opposed to heparin. The amount of fluid used varies according to the length of the tubing from the medication source to the infusion site. **When IV medications are diluted for administration, the policy for including medication volume as part of the volume specified for dilution varies from institution to institution, as does the amount of flush. When flow rates (gtt/min, mL/hr) are calculated, it varies from institution to institution as to whether the flush is included. The nurse is responsible for checking the protocol at the institution to ensure that the correct procedure is followed.**

Note: In the sample calculations that follow, a 15-mL volume will be used as a flush unless otherwise specified, and the medication volume will be considered as part of the total dilution volume. The flush will not be considered in the total volume.

SAFETY ALERT!

An excessively high concentration of an IV medication can cause vein irritation and potentially life-threatening effects. Dilution calculation is essential for the nurse.

Calculating IV Medications Using a Volume Control Set

A calibrated buretrol can be used to administer medications manually by using a roller clamp rather than a pump. In this case, it is necessary to use the formula presented in Chapter 21 or dimensional analysis and calculate gtt/min. Remember, buretrols are volume control devices and have a drop factor of 60 gtt/mL.

x gtt/min =

Example: An antibiotic dose of 100 mg in 2 mL is to be diluted in 20 mL of D_5W to infuse over 30 minutes. A 15-mL flush follows. The administration set is a microdrop (buretrol). (The policy of the institution is to treat the medication volume as part of the total dilution volume.)

- Step 1: Read the medication label, and determine what volume the 100-mg dosage is contained in. This is 2 mL.
- Step 2: Allow 18 mL of D_5W to run into the buretrol, and then add the 2 mL containing the 100 mg of medication. Roll the buretrol between your hands to allow medication to mix thoroughly. (2 mL + 18 mL = 20 mL for volume.)
- Step 3: Determine the flow rate necessary to deliver the medication plus the flush in 30 minutes.

Total volume is 20 mL. Infusion time is 30 minutes.

Answer: x = 40 gtt/min; 40 microgtt/min

Note: If the flush is considered with the intermittent medication, note that the total volume will be diluted medication + flush, and then proceed with calculations (gtt/min, mL/hr).

Dimensional Analysis

- Step 4: Adjust the IV flow rate to deliver 40 microgtt/min (40 gtt/min).
- Step 5: Label the buretrol with the medication name, dosage, and medication infusing label.
- Step 6: When administration of the medication is completed, add the 15-mL flush, and continue to infuse at 40 microgtt/min. Replace the label with a flush infusing label.
- Step 7: When the flush is completed, restart the primary line and remove the flush infusing label. Document the medication according to institution policy on the medication administration record (MAR) or in the computer and the volume of fluid on the intake and output (I&O) sheet according to agency policy.

TIPS FOR CLINICAL PRACTICE

To express the volume of gtt/min in mL/hr, remember that a microdrop administration set delivers 60 gtt/mL; therefore gtt/min = mL/hr. In this case, if the gtt/min = 40, then the mL/hr = 40.

As already mentioned, the buretrol can be used along with an electronic controller or pump. When used as previously stated, the electronic device will sound an alarm each time the buretrol empties. Let's examine the calculation necessary if the buretrol is used along with the pump or a controller. Calculations for which the buretrol is used with a pump or controller are done in mL/hr. Let's use the same example shown previously to illustrate the difference in calculation steps.

- Example 1: An antibiotic dose of 100 mg in 2 mL is to be diluted in 20 mL of D_5W to infuse over 30 minutes. A 15-mL flush follows. An infusion controller is used, and the tubing is a microdrop buretrol.
- The same Steps 1 and 2 as shown in the previous example for buretrol only are followed.
- Step 1: Calculate the flow rate for this microdrop.
- Total volume is 20 mL; the flush is not considered in the volume.
- Step 2: Total volume is 20 mL. Infusion time is 30 minutes. To calculate the IV rate in mL/hr, use ratio and proportion, dimensional analysis, or the formula method, as shown in Chapter 21. Refer to Chapter 21 if necessary to review the setup for the various methods. (Ratio and proportion and dimensional analysis are shown for Examples 1 and 2)

Solution:

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

- Example 2: An antibiotic dose of 150 mg in 1 mL is to be diluted in 35 mL NS to infuse over 45 minutes. A 15-mL flush follows. A infusion pump will be used.
- Total volume is 35 mL. Infusion time is 45 minutes. Calculate mL/hr rate.

Solution:

Ratio and Proportion (Linear Format)

Ratio and Proportion (Fraction Format)

Dimensional Analysis

PRACTICE **PROBLEMS**

Determine the volume of solution that must be added to the buretrol in the following problems. Then determine the flow rate in gtt/min for each IV using a microdrop, and indicate mL/hr for a controller. (For all problems, use the medication volume as part of the total diluent volume.)

- 45. An IV medication dosage of 500 mg is ordered to be diluted to 30 mL and infuse over 50 minutes with a 15-mL flush to follow. The dosage of medication is contained in 3 mL. Determine the following:
  - a. Dilution volume _____
  - b. Rate in gtt/min _____
  - c. Rate in mL/hr _____
- 46. The volume of a 20-mg dosage of medication is 2 mL. Dilute to 15 mL, and administer over 45 minutes with a 15-mL flush to follow. Determine the following:
  - a. Dilution volume _____
  - b. Rate in gtt/min _____
  - c. Rate in mL/hr _____

Answers on 647

Calculation of Daily Fluid Maintenance

Fluid overload or dehydration can pose a great threat to infants or young children. Nurses, therefore, must monitor not only the amount of medication but also the amount of fluid a child receives. The fluid a child receives over a 24-hour period is referred to as daily fluid maintenance needs (amount of fluid needed to maintain normal hydration). Daily fluid maintenance is also sometimes referred to as daily fluid requirements (DFR). The daily fluid maintenance includes both oral and parenteral fluids. The amount of maintenance fluid required depends on the weight of the child expressed in kilograms (kg). It does not include replacement for losses through vomiting, diarrhea, or fever. (See Table 24.1 for formula used to calculate the daily fluid maintenance.)

TABLE 24.1

Daily Fluid Maintenance Formula

• 100 mL/kg/day for the first 10 kg of body weight

• 50 mL/kg/day for the next 10 kg of body weight

• 20 mL/kg/day for each kg above 20 kg of body weight

Let's look at examples calculating the daily fluid maintenance and the hourly rate. (The IV pump is programmable in whole numbers.)

Example 1: Child who weighs 7 kg

Example 2: Child weighs 14 kg

Example 3: A child weighs 35 lb

- Step 1: Convert 35 lb to kg. Conversion factor: 2.2 lb = 1 kg.
- 35 lb ÷ 2.2 = 15.9 kg
- Step 2: Apply formula to calculate the daily fluid maintenance.

Note: In addition to the methods shown, ratio and proportion and dimensional analysis may be used to calculate the daily fluid maintenance.

PRACTICE **PROBLEMS**

Determine the daily fluid maintenance and the hourly rate. (IV pump is programmable in whole numbers.)

- 47. Child weighs 13 kg
  - a. Daily fluid maintenance _____ mL/day
  - b. rate _____ mL/hr
- 48. Infant weighs 3,300 g
  - a. Daily fluid maintenance _____ mL/day
  - b. rate _____ mL/hr

Answers on 647

POINTS TO REMEMBER

IV Therapy and Children

- • Pediatric IV medications are diluted for administration. It is important to know the institution's policy as to whether the medication volume is included as part of the total dilution volume.
- • A flush is used after administration of IV medications in children. The volume of the flush will vary depending on the length of the IV tubing from the medication source.
- • Check the institution's policy as to whether the volume of the flush is added to the diluted medication volume.
- • Pediatric medication administration requires frequent assessment.
- • Daily fluid maintenance is sometimes referred to as daily fluid requirements.
- • The amount of maintenance fluid required is based on the child's weight in kg.
- • Daily fluid maintenance formula:
  - • 100 mL/kg/day for first 10 kg of body weight
  - • 50 mL/kg/day for next 10 kg of body weight
  - • 20 mL/kg/day for each kg above 20 kg of body weight

Pediatric Oral and Parenteral Medications

Several methods have been presented to determine dosages for children in this chapter. It is important, however, to bear in mind that although the dosage may be determined according to weight, BSA, and other methods, the dosage to administer is calculated by using the same methods as for adults (ratio and proportion, the formula method, or dimensional analysis). It is important to remember the following differences with children's dosages.

Remember:

- • Dosages are smaller for children than for adults.
- • Most oral medications for infants and small children come in liquid form to facilitate swallowing.
- • The oral route is preferred; however, when necessary, medications are administered by the parenteral route.
- • Not more than 1 mL is injected IM for small children and older infants; small infants should not receive more than 0.5 mL by IM injection.
- • Parenteral dosages are frequently administered with a tuberculin syringe.

SAFETY ALERT!

When in doubt, always double-check pediatric dosages with another nurse to decrease the chance of an error. Never assume! Think before administering.

CLINICAL **REASONING**

Scenario: According to *The Harriet Lane Handbook,* the recommended dosage for a child for ibuprofen as an antipyretic is 5-10 mg/kg/dose q6-8h p.o. The 7-month-old weighs 18½ lb. The prescriber ordered 20 mg p.o. q6h for a temperature above 102° F. The infant's temperature is 102.8° F, and the nurse is preparing to administer the medication. The nurse believes the dosage is low but administers the medication based on the dosage being safe because it is below the safe dosage range. Several hours have passed, and the infant's temperature continues to increase.

- a. What is the required single dosage for this infant? _____
- b. What should the nurse's actions have been and why? _____
- c. What preventive measures could have been taken by the nurse in this situation? _____

Answers on 647

NGN Case Study

Learning Objectives:

- 1. Convert body weight from pounds to kilograms.
- 2. Calculate dosages based on milligram per kilogram.
- 3. Determine whether a dosage is safe.

Case Scenario: The parents of an 18-month-old, bring their child into the emergency department because the child is fussy, not wanting to eat, and pulling at his left ear. An assessment is completed and the physician determines the child has an ear infection. The child weighs 20 pounds. The physician orders amoxicillin suspension 275 mg orally every 12 hours. Amoxicillin suspension is available as 250 mg per 5 mL. The recommended dose for amoxicillin is 20-40 mg/kg/day divided q12h po. Round weight to the nearest tenth.

Use an X to indicate which potential solutions are correct and incorrect based on the scenario provided.

Potential Solution	Correct	Incorrect
The child weighs 9.1 kg.		
The child weighs 44 kg.		
The recommended dosage is 91 to 182 mg/dose q12h.		
The recommended dosage is 440 to 880 mg/dose q12h.		
The minimum total dosage is 182 mg/daily and the maximum total dosage is 364 mg/daily.		
The minimum total dosage is 880 mg/daily and the maximum total dosage is 1760 mg/daily.		
The dose is unsafe for the child.		
The dose is safe for the child.		

Reference: Morris: *Calculate with confidence,* ed 8, St Louis, Elsevier, copyright 2022. (*Harriet Lane Handbook* for the dosage.)

Case Study answers and rationales can be found on Evolve.

CHAPTER **REVIEW**

Read the dosage information or label given for the following problems. Express body weight conversion to the nearest tenth where indicated and dosages to the nearest tenth.

- 1. Lasix 10 mg IV stat is ordered for a child weighing 22 lb. The recommended dose is 1–2 mg/kg/dose. Is the dosage ordered safe? (Prove mathematically.) _____
- 2. Furadantin oral suspension 25 mg p.o. q6h is ordered for a child weighing 37.4 lb. Recommended dosage is 5–7 mg/kg/24 hr divided q6h.
- Available: Furadantin oral suspension 25 mg per 5 mL.
    - a. What is the child's weight in kilograms to the nearest tenth? _____
    - b. What is the dosage range for this child? _____
    - c. Is the dosage ordered safe? (Prove mathematically.) _____
    - d. How many milliliters must be given per dosage to administer the ordered dosage? Calculate the dose if the order is safe. _____
- 3. Cefaclor 225 mg p.o. q8h is ordered for a child weighing 35 kg. _____
- Available:
- Is the dosage ordered safe? (Prove mathematically.) _____
- 4. Vibramycin 50 mg p.o. q12h is ordered for a child weighing 30 lb. The recommended dosage is 2.2–4.4 mg/kg/day in two divided doses. Is the dose ordered safe? (Prove mathematically.) _____
- 5. Cleocin 150 mg p.o. q8h is ordered for a child weighing 36 lb. The recommended dosage is 10 to 40 mg/kg/day divided q6-8h. _____
- Available:
- _____
    - a. Is the dosage ordered safe? (Prove mathematically.) _____
    - b. How many milliliters would you need to administer one dosage? Calculate the dose if the order is safe.
- 6. Keflex (cephalexin) suspension 250 mg p.o. q6h is ordered for a child weighing 66 lb. The usual pediatric dosage is 25 to 50 mg/kg/day q6h.
- Available: Keflex suspension 250 mg per 5 mL.
    - a. Is the dosage ordered safe? (Prove mathematically.) _____
    - b. How many milliliters would you need to administer one dosage? Calculate the dose if the order is safe. _____
- 7. A 40-lb child who is 5 years old has an order for midazolam 1.5 mg IV stat. The recommended dose for a child 6 months-5 years is 0.05-0.1 mg/kg/dose. Is the dosage ordered safe? _____

Using the formula method for calculating BSA, determine the BSA in the following clients, and express answers to the nearest hundredth.

- 8. A 15-year-old who weighs 100 lb and is 55 inches tall _____
- 9. An adult who weighs 60.9 kg and is 130 cm tall _____
- 10. A child who weighs 55 lb and is 45 inches tall _____
- 11. An adult who weighs 65 kg and is 132 cm tall _____
- 12. An infant who weighs 6 kg and is 55 cm long _____
- 13. A child who weighs 42 lb and is 45 inches tall _____
- 14. An adult who weighs 74 kg and is 160 cm tall _____
- 15. An adult who weighs 150 lb and is 70 inches tall _____

Calculate the daily fluid maintenance and the hourly rate for questions 16-18: (Pump is programmed in whole milliliters unless otherwise indicated.)

- 16. Child weighing 25 kg
  - a. Daily fluid maintenance _____ mL/day
  - b. IV rate _____ mL/hr
- 17. Child weighing 77 lb
  - a. Daily fluid maintenance _____ mL/day
  - b. IV rate _____ mL/hr
- 18. Infant weighing 4,200 g
  - a. Daily fluid maintenance _____ mL/day
  - b. IV rate _____ mL/hr (pump capable of delivering in tenths).

For questions 19-20, round the answer in mg to the nearest tenth.

- 19. An adult weighs 72.7 kg and is 200 cm tall. The recommended dose for cisplatin is
- 50-70 mg per m^2 every 3-4 weeks for a client with advanced bladder cancer. Determine the BSA using the formula. Calculate the safe dosage range.
  - a. BSA_____
  - b. Dosage range _____ mg
- 20. A child weighs 21 lb and is 30 inches in height. The recommended dose for vincristine is 1-2 mg per m^2 once weekly. Determine the BSA using the formula. What is the dosage range for the child?
  - a. BSA _____
  - b. Dosage range _____ mg

Determine the flow rate in gtt/min for each IV using a microdrip, then indicate mL/hr for a controller. (Consider the medication volume as part of the total dilution volume, as shown in the chapter.)

- 21. A child is to receive 10 units of a medication. The dosage of 10 units is contained in 1 mL. Dilute to 30 mL and infuse in 20 minutes. A 15-mL flush is to follow. Medication is placed in a buretrol. Determine the rate in:
  - a. gtt/min_____
  - b. mL/hr _____
- 22. A child is to receive 80 mg of a medication. The dosage of 80 mg is contained in 2 mL. Dilute to 80 mL and infuse in 60 minutes. A 15-mL flush is to follow. Medication is placed in a buretrol. Determine the rate in:
  - a. gtt/min _____
  - b. mL/hr_____
- 23. A dosage of 250 mg in 5 mL has been ordered diluted to 40 mL and infused in 45 minutes. A 15-mL flush follows. Medication is placed in a buretrol. Determine the rate in:
  - a. gtt/min_____
  - b. mL/hr _____
- 24. Order: Digoxin 0.1 mg p.o. daily.
- Available:

- _____
- 25. Order: Tegretol 0.25 g p.o. t.i.d.
- Available:

- _____
- Calculate the dosages below. Use the labels where provided. Calculate to the nearest hundredth where necessary.
- 26. Order: Gentamicin 7.3 mg IM q12h.
- Available: 20 mg per 2 mL

- _____
- 27. Order: Nebcin (tobramycin sulfate) 60 mg IV q8h.
- Available:

- _____
- Calculate the dosages to be given. Round answers to the nearest tenth as indicated (express answers in milliliters).
- 28. Order: Tylenol 0.4 g p.o. q4h p.r.n. for temp greater than 101° F.
- Available: Tylenol elixir labelled 160 mg per 5 mL _____
- 29. Order: Methotrexate 35 mg IV daily once a week (on Tuesdays).
- Available:

- _____
- 30. Order: Amikacin 150 mg IV q8h.
- Available:

- _____
- 31. Order: Dilantin 62.5 mg p.o. b.i.d.
- Available: Dilantin oral suspension labeled 125 mg per 5 mL _____

- 32. Order: Albuterol 3 mg p.o. b.i.d.
- Available:

- _____
- 33. Order: Methylprednisolone 14 mg IV q6h.
- Available:

- _____
- 34. Order: Famotidine 20 mg p.o. b.i.d.
- Available:

- _____
- Round weights and dosages to the nearest tenth as indicated.
- 35. Order: Ceclor (cefaclor) 180 mg p.o. q12h. The infant weighs 10 lb.

- a. Is the dosage ordered safe? (Prove mathematically.) _____
- b. How many milliliters will you need to administer the dosage? Calculate the dose to administer if the dosage is safe. _____

- 36. Acetaminophen (Ofirmev) 525 mg IV q4h is ordered for a child weighing 92.4 lb. According to *The Harriet Lane Handbook,* the dosage for a child (age 2-12 years) or adolescent/adult weighing less than 50 kg is 15 mg/kg/dose q6h, or 12.5 mg/kg/dose q4h IV up to a maximum of 75 mg/kg/24 hr.
  - a. What is the safe dosage for this child? _____
  - b. Is the dosage ordered safe? _____

Round dosages and weights to the nearest tenth as indicated.

- 37. Order: Minoxidil for a child weighing 31 lb. The recommended dosage range is 0.1-0.2 mg/kg/24 hr.
- What is the safe dosage range for this child? _____
- 38. A client weighs 140.8 lb. According to a reputable drug reference, the recommended initial dose of diltiazem is 0.25 mg/kg as a bolus.
- What is the initial dose for this client? _____
- 39. A client weighs 147 lb and has an order for Amikacin 550 mg IV q12h. According to *Mosby's 2020 Nursing Drug Reference*, the recommended dosage for Amikacin is 15 mg/kg/day in two divided doses.
- Is the dose ordered for the client safe? (Provide a mathematical rationale.) _____
- 40. A client with testicular cancer has a BSA of 1.7 m^2. According to *Mosby's 2020 Nursing Drug Reference*, the recommended dosage for Bleomycin IV 1-2 times a week is 10-20 units/m^2.
- Determine the recommended dosage for this client. _____

Answers on pp. 648-652

ANSWERS

Chapter 24 Answers to Practice Problems

- 1. 6.8 kg
- 2. 30.9 kg
- 3. 14.1 kg
- 4. 23.6 kg
- 5. 92.8 kg
- 6. 3.8 kg
- 7. 2.6 kg
- 8. 45.6 kg
- 9. 42.2 kg
- 10. 46.9 lb
- 11. 38.9 lb
- 12. 48.4 lb
- 13. 33 lb
- 14. 74.8 lb
- 15. 157.1 lb
- 16. 160.6 lb
- 17. 216.3 lb

- 18. 1.5 kg
- 19. 2.9 kg
- 20. 1.9 kg

NOTE

Any of the methods presented in Chapter 24 can be used to calculate dosages; not all are shown in the Answer Key.

- 21.
  - a. 25 to 50 mg/kg/day
  - b. Convert weight first (2.2 lb = 1 kg).
  - 35 ÷ 2.2 = 15.9 kg
  - c. 25 mg : 1 kg = *x* mg : 15.9 kg
  - *x* = 397.5 mg/day
  - 50 mg : 1 kg = *x* mg : 15.9 kg
  - *x* = 795 mg/day
  - *or*
  - Dosage range is 397.5 to 795 mg/day.
  - d. The dosage ordered falls within the range that is safe (150 mg × 4 = 600 mg). 600 mg/day falls within the 397.5 to 795 mg/day range.
  - e. 250 mg : 5 mL = 150 mg : *x* mL
  - *or*
  - × 5 mL = *x* mL
  - *x* = 3 mL
- 22.
  - a. 10 mg : 1 kg = *x* mg : 40 kg
  - *x* = 400 mg/day
  - *or*

- 40 mg : 1 kg = *x* mg : 40 kg
- *x* = 1,600 mg/day
- *or*

- Answer: 1,600 mg/day is the maximum dosage.
- b. q6h = 24 ÷ 4 = 4 doses per day
- 400 mg ÷ 4 = 100 mg q6h
- 1,600 mg ÷ 4 = 400 mg q6h
- Answer: 100-400 mg q6h is the divided dosage range (400 mg q6h is maximum divided dose).

- 23. Convert the child's weight to kilograms
- (2.2 lb = 1 kg).
  - a. 44 lb ÷ 2.2 = 20 kg
  - b.

2.5 mg : 1 kg 5 *x* mg : 20 kg

- *x* = 50 mg/day
- *or*

- 30-50 mg/day (initial safe daily dosage range).

- 24. Convert weight (2.2 lb = 1 kg).
  - a. 44 lb ÷ 2.2 = 20 kg
  - b. 30 mg : 1 kg = *x* mg : 20 kg
  - *x* = 600 mg/day
  - *or*

- 50 mg : 1 kg = *x* mg : 20 kg
- *x* = 1,000 mg/day
- *or*

- 600-1,000 mg/day
- c. The dosage ordered is safe.
- 250 mg × 4 = 1,000 mg. 1,000 mg falls within the safe range.

- 25. No weight conversion is required.
- 0.25 mg : 1 kg = *x* mg : 66.3 kg
- *x* = 16.57 = 16.6 mg
- *or*

- Answer: 16.6 mg is the dosage for the adult.
- 26. Convert weight (2.2. lb = 1 kg, 16 oz = 1 lb).
- 6 oz ÷ 16 = 0.37 lb = 0.4 lb (to nearest tenth)
- Total weight in pounds = 12.4 lb
  - a. 12.4 lb ÷ 2.2 = 5.63 = (5.6 kg to nearest tenth)
  - b. 6 mg : 1 kg = *x* mg : 5.6 kg
  - *x* = 33.6 mg
  - *or*

- Answer: 33.6 mg for the first dose.
- c. 3 mg : 1 kg = *x* mg : 5.6 kg
- *x* = 16.8 mg
- *or*

    - Answer: 16.8 mg daily for the subsequent dose.
- 27. 0.6 m^2
- 28. 0.78 m^2
- 29. 0.9 m^2
- 30. 0.8 m^2
- 31. 0.28 m^2
- 32. 0.44 m^2
- 33. 0.8 m^2
- 34. 0.28 m^2
- 35. 0.32 m^2
- 36. 0.58 m^2
- 37. 0.54 m^2
- 38. 0.18 m^2
- 39. m^2 =

- = 2.185 = 2.19 m^2
- Answer: 2.19 m^2
- 40. m^2 =

- = 0.44 m^2
- Answer: 0.44 m^2
- 41. m^2 =

- = 0.178 = 0.18 m^2
- Answer: 0.18 m^2
- 42. m^2 =

- = 1.907 = 1.91 m^2
- Answer: 1.91 m^2

- 43. m^2 =
- = 1.014 = 1.01 m^2
- Answer: 1.01 m^2
- 44. m^2 =
- = 0.783 = 0.78 m^2
- Answer: 0.78 m^2
- 45.
  - a. **Dilution volume: 27 mL**
  - b. *x* gtt/min =

- x =

=

= 36 gtt/min

- *or*
- Use a ratio and proportion to determine mL/hr first. Remember that with a buretrol when a pump or controller is not used, mL/hr = gtt/min.
- 30 mL : 50 min = x mL : 60 min
- *or*

=

- Answer: x = 36 gtt/min; 36 microgtt/min
- c. 36 mL/hr

- 46.
  - a. Dilution volume: 13 mL
  - b. x gtt/min =

- x =

=

= 20 gtt/min

- *or*
- Use a ratio and proportion and determine mL/hr first.
- 15 mL : 45 min = x mL : 60 min
- *or*

=

- Answer: x = 20 gtt/min; 20 microgtt/min
- c. 20 mL/hr

- 47.
  - a.

Total: 1,000 mL/day + 150 mL/day = 1,150 mL/day

- Answer: 1,150 mL/day or per 24 hr
- b. *x* mL/hr =

= 47.9

- *x* = 48 mL/hr
- Answer: 48 mL/hr

- 48. Convert weight: Equivalent: 1 kg = 1,000 g
- 3,300 g ÷ 1,000 = 3.3 kg
  - a.

Answer: 330 mL/day or per 24 hr

- b. *x* mL/hr =

= 13.7

- *x* = 14 mL/hr

Answer: 14 mL/hr

Answers to Clinical Reasoning Questions

- a. 42-84 mg/dose
- b. Contact the prescriber; the dosage is too low.
- The dose is not safe because it is below the recommended therapeutic dose to be effective in decreasing the child's temperature.
- c. The nurse should have notified the prescriber immediately so that the order could be revised. The child's temperature indicates an underdosage that is not safe. Do not assume it is safe because the dosage is lower than the recommended dosage.

Answers to Chapter Review

- 1. Convert weight (2.2 lb = 1 kg).
  - a. 22 lb ÷ 2.2 = 10 kg
  - b.

The dosage ordered for this child is safe. 10 mg falls within the range of 10-20 mg per dose.

- 2. Convert child's weight in lb to kg.
- 2.2 lb = 1 kg
  - a. 37.4 lb ÷ 2.2 = 17 kg
  - b.

Answer: The dosage range is 85-119 mg/day.

  - q6h = 4 dosages
  - 85 mg ÷ 4 = 21.25 mg = 21.3 mg per dose (q6h)
  - 119 mg ÷ 4 = 29.75 mg = 29.8 mg per dose (q6h)
  - The divided dosage range is 21.3-29.8 mg per dose.
  - The dosage ordered is 25 mg q6h.
  - c. The dosage ordered is safe because 25 mg × 4 doses = 100 mg/day. It falls within the range of 85-119 mg/day. The dosage q6h also falls within the divided dosage range of 21.3-29.8 mg q6h.
  - d. 25 mg : 5 mL = 25 mg : *x* mL
  - *or*
  -

× 5 mL = *x* mL
  - *x* = 5 mL
  - Answer: Give 5 mL per dose. The dosage ordered is contained in 5 mL.
- 3. No conversion of weight is required. The child's weight is in kilograms, and the recommended dosage is expressed in kilograms (20 mg/kg/day).

- q8h = 3 dosages
- 700 mg ÷ 3=

- 233.33 = 233.3 mg per dosage
- The dosage ordered is not safe. 225 mg × 3 = 675 mg/day. 675 mg/day is less than 700 mg/day and the dose being given q6h is less than 233.3 mg. Check with prescriber. Dose may be too low to be effective.
- 4. Convert the child's weight in pounds to kilograms. The recommended dosage is expressed in kilograms (2.2-4.4 mg/kg/day) (2.2 lb = 1 kg).
- 30 lb = 30 ÷ 2.2 = 13.6 kg

- q12h = 2 dosages
- 29.9 mg ÷ 2 = 15 mg per dose.
- 59.8 mg ÷ 2 = 29.9 mg per dose.
- 50 mg × 2 = 100 mg/day. The dosage is not safe; notify the prescriber. 100 mg/day is greater than 29.9-59.8 mg/day. Also, the dose being administered q12h exceeds the recommended dosage.
- 5. Convert the child's weight in pounds to kilograms.
    - a. The recommended dosage is stated in kilograms
    - (10-40 mg/kg/day) (2.2 lb = 1 kg).
    - 36 lb = 36 ÷ 2.2 = 16.4 kg

    - The medication is given q6-8h. The dosage in this problem is ordered q8h.
    - 24 ÷ 8 = dosages
    - 164 mg ÷ 3 = 54.7 mg per dose
    - 656 mg ÷ 3 = 218.7 mg per dose
    - The dosage ordered is 150 mg q8h.
    - 150 mg × 3 = 450 mg/day.
    - The dosage is safe. 450 mg/day falls within the range of 164-656 mg/day. Also, the dose being administered q8h falls within the range of 54.7-218.7 mg per dose.
    - b. 75 mg : 5 mL = 150 mg : *x* mL
    - *or*

    - × 5 mL = *x* mL
    - *x* = 10 mL
    - Answer: Give 10 mL per dose. The dosage ordered is more than the available dosage strength.
    - Therefore you will need more than 5 mL to administer the dose.
- 6.
    - a. Convert the child's weight in pounds to kilograms. The recommended dosage is expressed in kilograms (25-50 mg/kg) (2.2 lb = 1 kg).
    - 66 lb = 66 ÷ 2.2 = 30 kg

- The safe range is 750-1,500 mg/day.
- The medication is given in divided dosages.
- The dosage ordered is q6h.
- 24 ÷ 6 = 4 dosages
- 750 mg ÷ 4 = 187.5 mg/per dosage
- 1,500 mg ÷ 4 = 375 mg/per dosage
- The dosage range is 187.5-375 mg per dose q6h.
- 250 mg × 4 = 1,000 mg/day. This is a safe dosage because the total dosage falls within the safe range for 24 hr, and the divided dosage also falls within the safe range.
- b. You would give 5 mL for one dosage.
- 250 mg : 5 mL = 250 mg : *x* mL
- *or*
-

  × 5 mL = *x* mL
- *x* = 5 mL
- The dosage ordered is contained in 5 mL; therefore you will need to administer 5 mL.

- 7. Convert the child's weight in pounds to kilogram. The recommended dosage is expressed in kilograms
- (0.05-0.1 mg/kg/dose).
- 40 lb = 40 ÷ 2.2 = 18.2 kg

- The dose range for this child is 0.9-1.8 mg per dose.
- The dose ordered is safe. 1.5 mg falls within the range of 0.9-1.8 mg per dose.
- 8. m^2 =

=

=

- = 1,325
- Answer: 1.33 m^2
- 9. m^2 =

=

=

- = 1.482
- Answer: 1.48 m^2
- 10. m^2 =

=

=

-

= 0,888

- Answer: 0.89 m^2
- 11. m^2 =

=

=

-

= 1.543

- Answer: 1.54 m^2
- 12. m^2 =

=

=

- = 0.301
- Answer: 0.3 m^2
- 13. m^2 =

=

=

- = 0,776
- Answer: 0.78 m^2
- 14. m^2 =

=

=

-

= 1,831

- Answer: 1.81 m^2
- 15. m^2 =

=

=

-

= 1,831

- Answer: 1.83 m^2
- 16.
    - a.

Total: 1,000 mL/day + 500 mL/day + 100 mL/day = 1,600 mL/day

- Answer: 1,600 mL/day or per 24 hr

- b. x mL/hr =

= 66.6

- x = 67 mL/hr
- Answer: 67 mL/hr

- 17. Convert weight:
- Equivalent: 2.2 lb = 1 kg
- 77 lb ÷ 2.2 = 35 kg
- a.

Total: 1,000 mL/day + 500 mL/day +300 mL/day = 1,800 mL/day

- Answer: 1,800 mL/day or per 24 hr
- b. x mL/hr =

- x = 75 mL/hr
- Answer: 75 mL/hr

- 18. Convert weight:
- Equivalent: 1 kg = 1,000 g
- 4,200 g ÷ 1,000 = 4.2 kg
- a.

Answer: 420 mL/day or per 24 hr

- b. x mL/hr =

  = 17.5
- x = 17.5 mL/hr
- Answer: 17.5 mL/hr (pump capable of delivering in tenths of an mL)

- 19.
  - a. m^2 =

    =

    =

    =

    = 2.009
  - Answer: 2.01 m^2
  - b.

- Answer: 100.5-140.7 mg q wk.

- 20.
  - a. m^2 =

    =

    =

  - = 0,448
  - Answer: 0.45 m^2
  - b.

Answer: Dosage range is 0.5-0.9 mg.

- 21. *x* gtt/min =

- *x*

- *x* = 90 gtt/min
- *or*
- mL/hr determined with ratio and proportion 30 mL : 20 min = *x* mL : 60 min
- *or*

- =

- a. 90 gtt/min; 90 microgtt/min
- b. 90 mL/hr

- 22. *x* gtt/min =
- *x* =
- *x* = 80 gtt/min
- *or*
- Determine mL/hr.
- 80 mL : 60 min = *x* mL : 60 min
- =
    - a. 80 gtt/min; 80 microgtt/min
    - b. 80 mL/hr
- 23. *x* gtt/min =

- *x* =
- *x* = 53 gtt/min
- *or*
- Determine mL/hr.
- 40 mL : 45 min = *x* mL : 60 min
- =
    - a. 53 gtt/min; 53 microgtt/min
    - b. 53 mL/hr
- 24. 0.05 mg : 1 mL = 0.1 mg : *x* mL
- *or*
- × 1 mL = *x* mL
- Answer: 2 mL. The dosage ordered is more than the available strength; therefore you will need more than 1 mL to administer the dosage.
- 25. Conversion required. Equivalent: 1,000 mg = 1 g.
- Therefore 0.25 g = 250 mg.
- 100 mg : 5 mL = 250 mg : *x* mL
- *or*

- × 5 mL = *x* mL
- Answer: 12.5 mL. The dosage ordered is greater than the available strength; therefore you will need more than 5 mL to administer the dosage.
- 26. 20 mg : 2 mL = 7.3 mg : *x* mL
- *or*

- × 2 mL = *x* mL
- Answer: 0.73 mL. The dosage ordered is less than the available strength; therefore you will need less than 2 mL to administer the dosage.
- 27. 20 mg : 2 mL = 60 mg : *x* mL
- *or*

- × 2 mL = *x* mL
- Answer: 6 mL. The dosage ordered is more than the available strength; therefore you will need more than 2 mL to administer the dosage.
- 28. Conversion required. Equivalent: 1,000 mg = 1 g.
- Therefore 0.4 g = 400 mg.
- 160 mg : 5 mL = 400 mg : *x* mL
- *or*

- × 5 mL = *x* mL
- Answer: 12.5 mL. The dosage ordered is more than the available strength; therefore you will need more than 5 mL to administer the dosage.
- 29. 25 mg : 1 mL = 35 mg : *x* mL
- *or*

- × 1 mL = *x* mL
- Answer: 1.4 mL. The dosage ordered is more than the available strength; therefore you will need more than 1 mL to administer the dosage.
- 30. 250 mg : 1 mL = 150 mg : *x* mL
- *or*

- × 1 mL = *x* mL
- Answer: 0.6 mL. The dosage ordered is less than the available strength; therefore you will need less than 1 mL to administer the dosage.
- Alternate solution: 500 mg : 2 mL = 150 mg : *x* mL
- *or*

- × 2 mL = *x* mL
- 31. 125 mg : 5 mL = 62.5 mg : *x* mL
- *or*

- × 5 mL = *x* mL
- Answer: 2.5 mL. The dosage ordered is less than the available strength; therefore you will need less than 5 mL to administer the dosage.
- 32. 2 mg : 5 mL = 3 mg : *x* mL
- *or*

× 5 mL = *x* mL

- Answer: 7.5 mL. The dosage ordered is more than the available strength; therefore you will need more than 5 mL to administer the dosage.
- 33. 40 mg : 1 mL = 14 mg : *x* mL
- *or*

-

× 1 mL = *x* mL

- Answer: 0.35 = 0.4 mL rounded to the nearest tenth. The dosage ordered is less than the available strength; therefore you will need less than 1 mL to administer the dosage.
- 34. 40 mg : 5 mL = 20 mg : *x* mL
- *or*

-

× 5 mL = *x* mL

- Answer: 2.5 mL. The dosage ordered is less than the
- available strength; therefore you will need less than
- 5 mL to administer the dosage.
- 35.
    - a. Convert the child's weight in pounds to kilograms. The recommended dosage is expressed in kilograms (20 mg/kg/day) (2.2 lb = 1 kg).
    - 10 lb = 10 ÷ 2.2 = 4.5 kg
    - The medication is given in two divided doses q12h.
    - The dosage for the child is ordered q12h.
    - 24 ÷ 12 = 2 doses.
    - 90 mg ÷ 2 = 45 mg per dose
    - 180 mg × 2 = 360 mg/day
    - Notify the prescriber; the dosage is too high (not safe).
    - 360 mg/day is greater than 90 mg/day. In addition, the dose the child is receiving q12h exceeds the dose recommended.
    - b. The volume to be administered is not calculated because the dosage ordered is not safe.
- 36.
    - a. Convert the child's weight in pounds to kilograms (2.2 lb = 1 kg). The recommended dosage is in kilograms, and the dosage is ordered q4h. The dosage is determined using 12.5 mg/kg/dose.
    - 92.4 lb = 92.4 ÷ 2.2 = 42 kg

    - The safe dosage for this child is 525 mg/dose.
    - b. The dosage ordered for the child is safe. For this child's weight, 525 mg/dose is the recommended dosage, and 525 mg is the ordered dosage.
- 37. Convert the child's weight in pounds to kilograms. The recommended dosage is in kilograms 0.1-0.2 mg/kg/24 hr. Conversion factor:
- 2.2 lb = 1 kg.
- 31 lb = 31 ÷ 2.2 = 14.1 kg

- The safe dosage range for this child is 1.4-2.8 mg/day.
- 38.
    - a. Convert the client's weight to kg. Conversion factor:
    - 2.2 lb = 1 kg.
    - 140.8 lb ÷ 2.2 = 64 kg
    - b. Calculate the recommended initial dose for this client.

    - Answer: The initial dose for the client is 16 mg.
- 39.
    - a. Convert the client's weight to kg. Conversion factor:
    - 2.2 lb = 1 kg.
    - 147 lb ÷ 2.2 = 66.81 = 66.8 kg
    - b. Calculate the recommended dose for the client.

    - The recommended daily dose for the client is 1,002 mg/day.
    - Determine the divided dose
    - (q12h = 2 × day; 24 hr ÷ 12 = 2).
    - 1,002 mg ÷ 2 = 501 mg
    - c. Determine if the dose ordered for the client is safe.

- The ordered dose is 550 mg q12h. 550 mg × 2 = 1,100 mg /day. The dose is not safe because the ordered dose (550 mg q12h) is more than the recommended dose. Also, the divided dose is more than what is recommended per dose. Contact the prescriber about the ordered dose and verify the order before administering.

- 40. Calculate the range of dosage from minimum to maximum.

- The recommended dosage for this client is 17-34 units.

For additional practice problems, refer to the Pediatric Dosages section of the Elsevier's Interactive Drug Calculation Application, Version 1, on Evolve.

unknown - Section 44 (Page 454)

Solve the following calculation problems. Remember to apply the principles learned in the text relating to dosages. Use labels where provided. Shade in the dosage on the syringe where provided.

- 1. Order: Amoxicillin and clavulanate potassium 300 mg p.o. q8h (ordered according to dose of amoxicillin).
- Available:

- 2. Order: Latuda 60 mg p.o. daily.
- Available:

-
    - a. How many tablets of which dosage strength will you use to administer the ordered dosage? _____
    - b. Provide the rationale for your answer. _____
- 3. Order: Bactrim DS 1 tab p.o. q12h for 14 days.
- Available:

-
    - a. Indicate by letter which tablets the nurse would choose to administer to the client based on the order. _____
    - b. Provide the rationale for your answer. _____
- 4. Order: Heparin 6,500 units subcut daily. (Express your answer in hundredths.)
- Available:

- 5. Order: Flagyl 0.5 g p.o. b.i.d. for 7 days.
- Available:

- 6. Order: Amphotericin B 75 mg in 1,000 mL D_5W to infuse over 6 hr daily. The reconstituted solution contains 50 mg per 10 mL.
- Available:

- - a. How many milliliters will the nurse add to the IV solution? _____
  - b. The IV is to infuse in 6 hr by infusion pump. Calculate the IV flow rate in mL/hr. _____
- 7. The recommended dose of Retrovir for adults with symptomatic HIV infection is 1 mg/kg infused over 1 hour q4h. Determine dosage for a client weighing 110 lb. _____
- 8. Order: Bosulif 0.5 g p.o. daily.
- Available:

- - a. How many tablets will the nurse administer? _____
  - b. What are the directions for administration? _____
- 9. Order: Tazicef 0.25 g IV q12h.
- Available:

Size	Amount of diluent to be added (mL)	Approximate available volume (mL)	Approximate ceftazidime concentration (mg/mL)
Intramuscular			
1-gram vial	3	3.6	280
Intravenous			
1-gram vial	10	10.6	95
2-gram vial	10	11.2	18

- a. Using the information provided, what concentration will the nurse prepare? _____
- b. How many milliliters will the nurse administer? _____

- 10. Order: Neurontin 900 mg p.o. b.i.d.

- How many of which capsules would be best to administer to the client? _____
- 11. Order: Transfuse 1 unit packed red blood cells (250 mL) over 3 hr. The administration set delivers 10 gtt/mL. At what rate in gtt/min should the IV infuse? _____
- 12. Order: Keytruda 200 mg in 100 mL 0.9% NS IV over 30 min by infusion pump.
- Available:

- a. How many mL of Keytruda will you add to the IV bag? _____
- b. Determine the IV rate. _____

- 13. Calculate the infusion time for an IV of 1,000 mL of D_5NS infusing at 60 mL/hr. Express time in hours and minutes. _____
- 14. The prescriber orders Septra Suspension 60 mg p.o. b.i.d. for a child weighing 12 kg. The pediatric medication reference states that Septra Suspension contains trimethoprim (TMP) 40 mg and sulfamethoxazole (SMZ) 200 mg in 5 mL oral suspension, and the safe dosage of the medication is based on trimethoprim. According to *The Harriet Lane Handbook,* the safe dosage is 8 to 12 mg/kg/day divided b.i.d. Is the dosage ordered safe? _____
- 15. A medicated IV of 100 mL is to infuse at a rate of 50 mL/hr.
- a. Determine the infusion time. _____
- b. The IV was started at 10:00 am. When will it be completed? (State time in military and traditional time.) _____
- 16. A client is to receive 10 mcg/min nitroglycerin IV. The concentration of solution is 50 mg of nitroglycerin in 250 mL D_5W. What should the flow rate be (in mL/hr) to deliver 10 mcg/min? _____
- 17. Order: Humulin Regular 6 units and Humulin NPH 16 units subcut at 7:30 am.
- What is the total units the nurse will administer? _____

- 18. A dosage of 500 mg of a medication in a volume of 3 mL is to be diluted to 55 mL to infuse over 50 minutes. A 20-mL flush is to follow.
- - a. What is the dilution volume? _____
  - b. At what rate in gtt/min should the IV infuse? (Administration set is a microdrop.) _____
  - c. Indicate the rate in mL/hr. _____
- 19. Calculate the body surface area (BSA), using the formula, for a child who weighs 102 lb and is 51 inches tall. Calculate the BSA to the nearest hundredth. _____
- 20. Acyclovir IV is to be administered to a child who has herpes simplex encephalitis. The child weighs 13.6 kg and is 60 cm tall. The recommended dosage is 500 mg/m^2. Use the formula to calculate the BSA.
- Available:

- - a. What is the BSA? (Express your answer to the nearest hundredth.) _____
  - b. What will the dosage be? _____
  - c. Calculate the number of milliliters to administer. _____
- 21. Prepare the following strength solution: 2/5 strength Ensure Plus 250 mL. _____
- 22. Calculate the amount of dextrose and NaCl in 2 L of D_5 ¼ NS.
- - a. Dextrose _____ g
  - b. Sodium chloride _____ g
- 23. 500 mL D_5W was to infuse in 3 hours at 28 gtt/min (28 macrogtt/min). The drop factor is 10 gtt/mL. After 1½ hours, you notice 175 mL has infused.
- - a. Recalculate the IV flow rate. _____
  - b. Determine the percentage of change. _____
  - c. State the course of action. _____
- 24. Order: Infuse D_5W 500 mL with 20,000 units heparin at 25 mL/hr. Determine the following:
- _____units/hr
- 25. Order: Morphine sulfate 80 mg in 250 mL of IV fluid to infuse at a rate of 20 mL/hr.
- Determine the dosage in mg/hr the client is receiving. _____
- 26. Order: Diltiazem HCl (cardizem) 25 mg IV over 2 minutes.
- Available:

- - a. How many milliliters will the nurse add to the IV? _____
  - b. How many milliliters will the nurse infuse per minute? _____
- 27. Order: Cipro 0.5 g p.o. q12h.
- Available: Cipro tablets labeled 250 mg.
- How many tablets will be needed for 10 days of therapy? _____
- 28. Order: Lanoxin (digoxin) 0.375 mg p.o. stat.

- Available: Scored tablets labeled 125 mcg, 250 mcg, and 500 mcg.
- - a. Which Lanoxin tablet(s) will the nurse use to prepare the dosage? _____
  - b. How many tablets should the client receive? _____
- 29. Order: Digoxin 0.125 mg IV daily for 7 days.
- Available:

- - a. How many milliliters will the nurse administer? _____
  - b. Shade the dosage in on the syringe provided.

For problems 30-31, round weight to the nearest tenth as indicated.

- 30. The heparin protocol at an institution is: Bolus client with 80 units/kg of body weight and start drip at 14 units/kg/hr. Using the heparin protocol, determine the following for a client weighing 242 lb.
- - a. Heparin bolus dosage _____
  - b. Infusion rate for the heparin IV drip _____
- 31. Order: 20 units/kg/hr heparin IV. The client weighs 88 kg.
- How many units will the client receive per hour? _____
- 32. Order: Digoxin 0.375 mg IV push (infused slowly over 5 minutes).
- Available: Digoxin 0.25 mg per mL.
- - a. How many milliliters should the nurse administer? _____
  - b. At what rate in mL/min should the IV infuse? _____
- 33. Order: Morphine 8 mg IV q4h p.r.n. (infusion not to exceed 10 mg/4 min).
- Available: Morphine 10 mg per mL.
- - a. How many milliliters will the nurse administer? _____
  - b. How many minutes will it take for the IV to infuse? _____
- 34. Refer to the chart below and calculate the client's fluid intake in milliliters.

  ORAL INTAKE IV INTAKE

  4 oz gelatin 100 mL

  2 oz water

  12 oz apple juice

- What is the client's intake in mL? _____
- Refer to the Heparin Weight-Based Protocol provided below to answer question 35.
- - 1. Bolus heparin at 80 units/kg.
  - 2. Begin intravenous infusion of heparin at 18 units/kg/hr using 25,000 units heparin in 250 mL D_5W for 1,000 units per mL.
  - 3. Adjust intravenous heparin daily based on APTT results.
  - - • APTT less than 35 sec: Rebolus with 80 units/kg and increase rate by 4 units/kg/hr.
    - • APTT 35-45 sec: Rebolus with 40 units/kg and increase rate by 2 units/kg/hr.
    - • APTT 46-70 sec: **No change.**
    - • APTT 71-90 sec: Decrease rate by 2 units/kg/hr.
    - • APTT greater than 90 sec: **Stop heparin** infusion for 1 hour and decrease rate by 3 units/kg/hr.

- 35. Client weighs 187 lb. Determine the bolus dose of heparin and the initial intravenous rate of heparin. The APTT is reported as being 43 seconds. Determine the rebolus and adjust the intravenous rate based on the APTT results. (The pump is capable of delivering in tenths of a milliliter.)
- 36. A client is ordered to begin Levophed (norepinephrine bitartrate) at 4 mcg/min to maintain blood pressure and titrate to maintain systolic blood pressure greater than 100 mm Hg to a maximum of 12 mcg/min. Available solution is Levophed 8 mg in 1,000 mL D_5W. Develop a titration table from minimum to maximum dose in 2-mcg/min increments. (The IV pump is calibrated in whole mL.)
- 37. Versed (midazolam) 10 mcg/kg IV is ordered for sedation of a client. The client weighs 127.2 lb. How many mcg should the client receive? (Round weight to the nearest tenth.) _____
- 38. Order: Gemzar 900 mg IV weekly.
- Available:

- How many mL will the nurse add to the IV? _____
- 39. Using a full-strength normal saline (0.9%) solution, prepare 180 mL of 1/3 strength normal saline solution, diluted with sterile water for wound care. Express answer in mL. _____
- 40. Refer to the following medication orders and correct them according to the ISMP published list of Error Prone Abbreviations and Symbols.
  - a. MS 4 mg sc q4h prn pain _____
  - b. Digoxin .375 mg p.o. qd _____
- 41. Order: Ultram 0.1 g po q6h prn for pain.
- Available:

- How many tab(s) will the nurse administer? _____
- 42. Order: Vitamin K (phytonadione) 2.5 mg subcut stat.
- Available:

  - a. How many mL will the nurse administer? _____
  - b. Shade the dosage on the syringe provided.

- 43. Order: Unasyn 1,550 mg IV q6h.
- Available: Refer to label and portion of the package insert.

Unasyn Vial Size	Volume of Diluent to Be Added	Withdrawal Volume
1.5 g	3.2 mL	4 mL
3 g	6.4 mL	8 mL

- How many mL will the nurse administer? _____
- 44. Order: Demerol 40 mg IM and Vistaril 25 mg q4h prn for pain.
- Available: Demerol 50 mg per mL and Vistaril 50 mg per mL.
- - a. What is the total dose in mL the nurse will administer? _____
  - b. Shade the dosage on the syringe provided.

- 45. Order: Vincristine 4 mg IV q Thursday for a child who weighs 45 kg and is 155 cm. The recommended dose of Vincristine is 1-2 mg/m^2 in a single dose weekly. (Use the BSA Formula.) Round dosage to nearest tenth.
- Available:

- - a. Is the dose ordered safe? (Prove mathematically.)
  - b. If the dosage ordered is safe, calculate the mL you would administer. _____
  - If not safe, explain why and describe what you should do. _____
- 46. Calculate the I & O from 7 am–3 pm.
- A client has IV fluids D_5 ½ NS with 20 mEq potassium chloride (KCl) infusing at 75 mL/hr at 7 am. An order is received to increase the IV fluid to 100 mL/hr at 10 am. The IV fluids are held for 1 hour while Ampicillin 1 g in 100 mL of 0.9% NS is infused from 12 pm to 1 pm. The client consumes the following:

  Breakfast: 1½ glasses of cranberry juice (glass = 6 oz)
  2½ cups of tea (cup = 8 oz)
  Lunch: ¾ can of gingerale (can = 12 oz)
  ½ bowl of broth (bowl = 6 oz)
  4 oz ice cream

- The client voids four times during the shift: 375 mL, 250 mL, 400 mL, and 300 mL of urine.
- Intake _____ mL
- Output _____ mL

- 47. A continuous heparin infusion is to begin at 15 units/kg/hr for a client weighing 82 kg. Available: 25,000 units of heparin in 250 mL D_5W. Calculate the mL/hr (the pump is capable of delivering in tenths of an mL).
- _____ mL/hr
- For questions 48-50, calculate the daily fluid maintenance and hourly IV rate using the following formula:

  100 mL/kg/day for the first 10 kg of body weight

  50 mL/kg/day for next 10 kg of body weight

  20 mL/kg/day for each kg of body weight above 20 kg

- 48. Child weighs 32 kg
- Infuse _____ mL of _____ mL/hr (pump delivers in tenths of an mL).
- 49. Infant weighs 2,500 g
- Infuse _____ mL at _____ mL/hr (pump delivers in tenths of an mL)
- 50. Child weighs 78 lb (round weight to the nearest tenth)
- Infuse _____ mL at _____ mL/hr (pump delivers in whole mL)
- For questions 51-52, determine BSA to the nearest hundredth and dosages to the nearest tenth.
- 51. An adult client weighs 135 lb and is 62 in tall. The recommended dose for Gemzar IV for clients with ovarian cancer is 1,000 mg/m^2. Determine the BSA using the formula, and calculate the safe dose for the client.
  - a. BSA _____
  - b. Dosage in mg _____
- 52. An adult client weighs 92.7 kg and is 185 cm tall. The recommended dose for Bleomycin IV for the treatment of testicular carcinoma is 10-20 $units/m^2$ weekly or twice a week. The client is receiving 35 units IV weekly. Determine the BSA using the formula, and determine if the dose is safe.
  - a. BSA _____
  - b. Dosage range _____
  - c. Is the dosage safe? (Provide a mathematical rationale.) _____

Answers on pp. 668-674

ANSWERS

NOTE

Calculations may be performed using the formula method, ratio and proportion, or dimensional analysis.

- 1. 400 mg : 5 mL = 300 mg: *x* mL
- *or*

- 300 mg400 mg×5 mL=x mL

- Answer: 3.8 mL
- 2. Answer: 2 tabs (1 40-mg tablet and 1 20-mg tablet). This would be the least number of tablets to administer the ordered dosage.
- 3. a. Tablets B: Bactrim DS.
- b. The prescriber's order indicates DS, which means double strength; therefore the client should be given the tabs that are labeled DS.
- 4. 10,000 units : 1 mL = 6,500 units : *x* mL
- *or*
- 6,500 units10,000 units×1 mL=x mL

- Answer: 0.65 mL

- 5. Conversion is required. Equivalent: 1,000 mg = 1 g
- Therefore 0.5 g = 500 mg
- 500 mg : 1 tab = 500 mg : *x* tab
- *or*
- 500 mg500 mg×1 tab=x tab

- Answer: 1 tab
- 6. a. 50 mg : 10 mL = 75 mg : *x* mL
- *or*

- 75 mg50 mg×10 mL=x mL

- Answer: 15 mL
- b. Determine mL/hr.
- *x* mL/hr = 1,000 mL6 hr

; *x* = 166.6 = 167 mL/hr

- Answer: 167 mL/hr

NOTE

Problem 6 could also be done by using a ratio and proportion, as illustrated in Chapter 21.

- 7. Convert weight in pounds to kilograms. Equivalent:
- 2.2 lb = 1 kg
- Therefore 110 lb ÷ 2.2 = 50 kg
- 50 kg × 1 mg/kg=50 mg

- Answer: 50 mg
- 8. a. Conversion is required. Equivalent: 1 g = 1,000 mg
- Therefore 0.5 g = 500 mg
- 500 mg : 1 tab = 500 mg : *x* tab
- *or*

- 500 mg500 mg×1 tab=x tab

- Answer: 1 tab
- b. Do not crush or cut tablet.
- 9. a. 95 mg per mL (Vial is 1 g.)
- b. Conversion is required. 1,000 mg = 1 g
- Therefore 0.25 g = 250 mg
- 95 mg : 1 mL = 250 mg : *x* mL
- *or*
- 250 mg95 mg×1 mL=x mL

- Answer: 2.63 mL = 2.6 mL
-

- 10. Answer: 2 caps: 1 300-mg cap and 1 600-mg cap). Administer the least amount of capsules to the client to administer the ordered dosage.
- 11. **Step 1:** Determine mL/hr.
- *x* mL/hr = 250 mL3 hr

; *x* = 83.3 = 83 mL/hr
- **Step 2:** Calculate gtt/min.

- *x* gtt/min = 83 mL×10 gtt/mL60 min

- *x* = 13.8 = 14 gtt/min
- Answer: 14 macrogtt/min; 14 gtt/min
- The shortcut method could also have been used to do the problem.
- 12. a. 25 mg : 1 mL = 200 mg : *x* mL
- *or*
- 200 mg25 mg×1 mL=x mL

- Answer: 8 mL
- Alternate solution:
- 100 mg : 4 mL = 200 mg : *x* mL
- *or*
- 200 mg100 mg×4 mL=x mL

- b. 100 mL : 30 min = *x* mL : 60 min
- Answer: 200 mL/hr
- Alternate solution:
-

- 13.

- 60 min = 1 hr
-

- Answer: 16 hr + 40 min
- 14. No weight conversion required. Weight is stated in kg.
-

- Divided dosage: 96 mg/day ÷ 2 = 48 mg b.i.d.
- 144 mg/day ÷ 2 = 72 mg b.i.d.
- The safe dosage range is 96-144 mg/day.
- The divided dosage range is 48-72 mg b.i.d.
- Answer: The prescriber ordered 60 mg b.i.d. The dosage is safe (60 mg × 2 = 120 mg); it falls within the safe dosage range.
- 15.

-
    - a. 2 hr
    - b. 12 noon or 12 pm (10:00 am and 2 hours); military time: 1200
- 16. Determine the dosage per hour.
-

- Convert mcg to mg to match solution.
- 1,000 mcg = 1 mg, therefore
- 600 mcg = 0.6 mg

- Calculate mL/hr.
- 50 mg : 250 mL = 0.6 mg : *x* mL
- *or*
- 50 mg250 mg=0.6 mgx mL

- *x* = 3 mL/hr
- Answer: To deliver 10 mcg/min, set the flow rate at 3 mL/hr (gtt/min).
- 17. 22 units (Humulin Regular 6 units + Humulin NPH 16 units)

- 18. a. 52 mL
- b. *x* gtt/min = 55 mL×60 gtt/mL50 min

- *x* = 66 gtt/min
- Answer: 66 microgtt/min; 66 gtt/min. The shortcut method could also have been used to do this problem.
- c. 66 mL/hr (gtt/min with a microdrop 5 mL/hr)
- 19. 102 (lb)×51 (in)3,131=1.66=1.288=1.29 m2

- Answer: 1.29 m^2

- 20. a. 13.6 (kg)×60 (cm)3,600=0.226=0.475=0.48 m2

- Answer: 0.48 m^2
- b.

- Answer: 240 mg
- c. 50 mg : 1 mL = 240 mg : *x* mL
- *or*
- 240 mg50 mg×1 mL=x mL

- Answer: 4.8 mL. The dosage ordered is greater than the available strength; therefore you will need more than 1 mL to administer the dosage.
- Alternate solution:
- 1,000 mg : 20 mL = 240 mg : *x* mL
- *or*
- 1,000 mg20 mL=240 mgx mL

- *or*

- 240 mg1,000 mg×20 mL=x mL

- 21. 25

  × 250 mL = *x* mL
- 5005=x

- *x* = 100 mL of Ensure Plus
- 250 mL – 100 mL = 150 mL (water)
- Therefore you would add 150 mL of water to 100 mL of Ensure Plus to make 250 mL 2/5-strength Ensure Plus.
- 22. 1 L = 1,000 mL; therefore 2 L = 2,000 mL
- - a. Dextrose: 5 g : 100 mL = *x* g : 2,000 mL
    - 100x100=10,000100

    - *or*
    - 5 g100 mL=x g2,000 mL

    - *x* = 100 g dextrose

- b. NaCl: 0.225 g : 100 mL = *x* g : 2,000 mL
- 100x100=450100

- *or*
- 0.225 g100 mL=x g2,000 mL

- *x* = 4.5 g NaCl

NOTE

Remember that ¼ NS (sodium chloride) is written as 0.225.

- 23. Time remaining: 3 hr – 1.5 hr = 1.5 hr (1½)
- Volume remaining: 500 mL – 175 mL = 325 mL
- a. **Step 1:** Calculate mL/hr.
- 325 mL ÷ 1.5 hr = 216.6 = 217 mL/hr
- **Step 2:** Calculate the gtt/min.
- *x* gtt/min = 217 mL×10 gtt/mL60 min

- x = 217 × 16=2176

- *x* = 36 gtt/min; 36 macrogtt/min
- The IV rate would have to be changed to 36 gtt/min (36 macrogtt/min).
- b. **Step 3:** Determine the percentage of change.
- 36−2828=828=0.285=29%

- c. Course of action: Assess the client, and notify the prescriber. This increase is greater than 25%. The order may have to be revised.
- Alternate calculation without percents:
- Ordered rate ± (ordered rate ÷ 4) 5 acceptable IV readjustment rate
- 28 (28 macrogtt/min) + (28 ÷ 4) = 28 + 7 = 35 gtt/min; 35 macrodrop per min
- 28 (28 macrogtt/min) – (28 ÷ 4) = 28 – 7 = 21 gtt/min; 21 macrodrop per min
- The safe range is 21 gtt/min (21 macrogtt/min) to 35 gtt/min (35 macrogtt/min). 36 macrogtt/min (36 gtt/min) is more than the acceptable range.

NOTE

In problem 23, in addition to determining mL/hr, another method could be used to determine the drop factor constant and then gtt/min calculated using the drop factor constant.

- 24. Calculate the units/hr infusing.
- 500 mL : 20,000 units = 25 mL : *x* units
- 500x500=500,000500

- *x* = 1,000 units/hr
- An IV of 500 mL containing 20,000 units of heparin infusing at 25 mL/hr is administering 1,000 units /hr.
- 25. 80 mg : 250 mL = *x* mg : 20 mL

- 250x250=16,00250=6.4

- *x* = 6.4 mg/hr
- 26. a. 5 mg : 1 mL = 25 mg : *x* mL
- 25 mg5 mg×1 mL=x mL

- *x* = 5 mL
- **Alternate solution:**
- 25 mg : 5 mL = 25 mg : *x* mL
- *or*
- 25 mg25 mg×5 mL=x mL

- *x* = 5 mL
- This setup would yield the same answer of 5 mL.
- b. 5 mL2 min=2.5 mL/min

- 27. 1,000 mg = 1 g
- 0.5 g = 500 mg
- Answer: 40 tabs (2 tabs per dose × 2 = 4 tabs;
- 4 tabs × 10 days = 40 tabs)
- 28. 1,000 mcg = 1 mg 0.375 mg = 375 mcg
- - a. Give the client one 250-mcg tab and one
  - 125-mcg tab.

- 250−mcg tab+125−mcg tab_375 mcg

- b. 2 tabs (one 250-mcg tab and one 125-mcg tab) Give the least number of tablets without scoring.

- 29. a. No conversion necessary; use the dosage strength indicated on the label in mg (0.5 mg per 2 mL).
- 0.5 mg : 2 mL = 0.125 mg : *x* mL
- *or*
- 0.125 mg0.5 mg×2 mL=x mL

- *x* = 0.5 mL
- b.

- 30. Convert weight: 2.2 lb = 1 kg
- 242 lb ÷ 2.2 = 110 kg
- a.

- b.

- 31.

- 32. a. 0.25 mg : 1 mL = 0.375 mg : *x* mL
- *or*
- 0.375 mg0.25 mg×1 mL=x mL

- Answer: 1.5 mL
- b. 1.5 mL : = min 5 *x* mL : 1 min
- 5*x* = 1.5
- *x* = 0.3 mL/min
- 33. a. 10 mg : 1 mL = 8 mg : *x* mL
- *or*
- 8 mg10 mg×1 mL=x mL

- Answer: 0.8 mL
- b. 10 mg : 4 min = 8 mg : *x* min
- 10x10=3210

- *x* = 3.2 min

NOTE

Any of the problems could also be done using dimensional analysis or the formula method.

- 34. Conversion is required. Equivalent: 30 mL = 1 oz
- Total oz = 18 oz
- 18 oz × 30 = 540 mL
- 540 mL (p.o.) + 100 mL (IV) = 640 mL
- Answer: 640 mL
- 35. **Step 1:** Convert the client's weight to kilograms.
- Equivalent: 1 kg = 2.2 lb
- 187 lb ÷ 2.2 = 85 kg
- **Step 2:** Calculate the heparin bolus dosage.
- 80 units/

× 85

= 6,800 units. The client should receive 6,800 units IV heparin as a bolus.

- Determine the volume (mL) the client would receive.
- The concentration of heparin is 1,000 units per mL.
- 1,000 units: 1 mL = 6,800 units: *x* mL
- 1,000x1,000=6,8001,000

- x=6,8001,000

- *x* = 6.8 mL (bolus is 6.8 mL)
- **Step 3:** Calculate the infusion rate (18 units/kg/hr).
- 18 units/

/hr × 85

= 1,530 units/hr. Determine the rate in mL/hr at which to set the infusion device using the concentration of 1,000 units per mL.

- 1,000 units: 1 mL = 1,530 units: *x* mL
- 1,000x1,000=1,5301,000

- x=1,5301,000

- *x* = 1.53 = 1.5 mL/hr (not rounded to a whole number because the pump is capable of delivering in tenths of an mL)
- The client's APTT is 43 sec. According to the protocol, rebolus with 40 units/kg, and increase the rate by 2 units/kg/hr.
- **Step 4:** Calculate the dosage of heparin rebolus and the continuous infusion increase based on the APTT according to the protocol.
- Calculate the dosage (units) of heparin rebolus.
- 40 units/

× 85

= 3,400 units

- Determine the volume (mL) to administer 3,400 units.
- 1,000 units : 1 mL = 3,400 units : *x* mL
- 1,000x1,000=3,4001,000

- x=3,4001,000

- *x* = 3.4 mL (bolus)
- Now determine the infusion rate increase
- (2 units/kg/hr × kg).
- 2 units/

/hr × 85

= 170 units/hr

- The infusion rate should be increased by 170 units/hr.
- Calculate the adjustment in hourly infusion rate (mL/hr).
- 1,000 units : 1 mL = 170 units : *x* mL

- 1,000x1,000=1701,000

- x=1701,000

- x = 0.17 = 0.2 mL/hr
- The rate should be increased by 0.2 mL/hr.
- **Increase rate:**
- 1.5 mL/hr(current rate)+0.2 mL/hr(increase)_1.7 mL/hr(new infusion rate; not rounded to a whole number because pump is capable of delivering in tenth

- 36. **Step 1:** Calculate the dosage per hour using the upper and lower dosages.
-

- **Step 2:** Convert mcg/hr to match the available strength.
- Equivalent: 1,000 mcg = 1 mg
- 240 mcg = 0.24 mg
- 720 mcg = 0.72 mg
- **Step 3:** Calculate rate in mL/hr for upper and lower dosage.
- 8 mg : 1,000 mL = 0.24 mg : x mL
- 8x8=1,000×0.248

- 8x8=2408

- x=2408

- *x* = 30 mL/hr
- To infuse 4 mcg/min, set the infusion pump at 30 mL/hr.
- 8 mg : 1,000 mL = 0.72 mg : *x* mL
- 8x8=1,000×0.728

- 8x8=7208

- x=7208

- *x* = 90 mL/hr
- To infuse 12 mcg/min, set the infusion pump at 90 mL/hr.
- Dosage range of 4-12 mcg/min is equal to an IV flow rate of 30-90 mL/hr.
- **Step 4:** Set up a proportion to determine the incremental flow rate for a dosage rate change of 2 mcg/min.

- 4 mcg/min30 mL/hr=2 mcg/minx mL/hr

- 4x4=604

- x=604

- x = 15 mL/hr
- For each dosage change of 2 mcg/min, the incremental flow rate is 15 mL/hr.
- Set up a titration table.

  Titration Table

Dosage Rate (mcg/min)	Flow Rate (mL/hr)
4 mcg/min **(minimum)**	30 mL/hr
6 mcg/min	45 mL/hr
8 mcg/min	60 mL/hr
10 mcg/min	75 mL/hr
12 mcg/min **(maximum)**	90 mL/hr

- 37. 1. Convert weight: Equivalent: 2.2 lb = 1 kg
- 127.2 lb ÷ 2.2 = 57.8 kg
- 2. 10 mcg/

  × 57.8

= 578 mcg

- Answer: 578 mcg
- 38. 38 mg : 1 mL = 900 mg : *x* mL
- *or*
- 900 mg38 mg×1 mL=x mL

- *x* = 23.68 = 23.7 mL
- Answer: 23.7 mL
- 39. No conversion required.
- 13×180 mL=x mL

- x=1803

- *x* = 60 mL
- Answer: You need 60 mL of solute (normal saline) to prepare the desired solution (180 mL of 1/3 strength). The total to make is 180 mL. The amount of solvent needed, therefore, is:
- 180 mL – 60 mL = 120 mL (solvent/sterile water). To make 180 mL of 1/3 strength normal saline, mix 60 mL of full-strength normal saline and 120 mL of sterile water.
- 40. a. Morphine Sulfate 4 mg subcut q4h prn pain
- b. Digoxin 0.375 mg p.o. daily (every day)
- 41. A conversion is required. Equivalent: 1,000 mg = 1 g
- 0.1 g = 100 mg
- 50 mg : 1 tab = 100 mg : *x* tab
- *or*

- 100 mg50 mg×1 tab=x tab

- Answer: 2 tabs
- 42. 10 mg : 1 mL = 2.5 mg : *x* mL
- *or*
- 2.5 mg10 mg×1 mL=x mL

- - a. Answer: 0.25 mL. The available dosage strength is more than the ordered dosage. Therefore the nurse would need less than 1 mL to administer the ordered dosage.
  - b.

- 43. Conversion is required. Equivalent: 1 g = 1,000 mg
- 1,550 mg = 1.55 g
- 3 g : 8 mL = 1.55 g : *x* mL
- *or*
- 1.55 g3 g×8 mL=x mL

- x=12.43=4.13=4.1 mL

- Answer: 4.1 mL; 4.13 rounded to the nearest tenth. The available dosage strength is more than the ordered dosage. Therefore the nurse will need less than 8 mL to administer the ordered dosage.
- 44. **Step 1:** Calculate each medication:
- Demerol: 50 mg : 1 mL = 40 mg : *x* mL
- *or*
- 40 mg50 mg×1 mL=x mL

- Answer: 0.8 mL (Demerol)
- Vistaril: 50 mg : 1 mL = 25 mg : *x* mL
- *or*
- 25 mg50 mg×1 mL=x mL

- Answer: 0.5 mL (Vistaril)
- Answer: 0.8 mL of Demerol is needed and 0.5 mL of Vistaril. The available strengths for both medications is more than the dosage ordered. Therefore the nurse would need less than 1 mL to administer each medication.
- **Step 2:** Add the two medications together to obtain the total volume you will administer.
- - a. Demerol 0.8 mL + Vistaril 0.5 mL = 1.3 mL. The total dose in mL the nurse will administer is 1.3 mL.
  - b.

- 45. Determine the BSA.

- - a. Dosage not safe. 4 mg falls outside the range of 1.4 to 2.8 mg per (weekly) dose.
  - b. Because the dosage is not safe, the milliliters to administer is not calculated, and the prescriber would be notified.
- 46. **Step 1:** Determine IV intake

- Ampicillin 100 mL (12p–1p) = 100 mL × 1 hr = 100 mL
- Total IV intake = 725 mL
- **Step 2:** Determine p.o. intake
- Cranberry juice 6 oz × 1½ = 9 oz
- Tea 8 oz × 2½ = 20 oz
- Gingerale 12 oz × ¾ = 9 oz
- Broth 6 oz × ½ = 3 oz
- Ice cream 4 oz
- Total oz = 45 oz
- Convert oz to mL: Equivalent 1 oz = 30 mL
- 45 oz × 30 = 1,350 mL
- **Step 3:** IV intake 725 mL + p.o. intake 1,350 mL = 2,075 mL
- Answer: Total intake = 2,075 mL
- **Step 4:** Total output: 375 mL + 250 mL + 400 mL + 300 mL = 1,325 mL
- Answer: Total output: 1,325 mL
- 47. **Step 1:**
- No weight conversion required; weight is in kilograms.
- Determine the number of units/hr based on client's weight in kilograms.
- 15 units/

/hr × 82

requires 1,230 units/hr of heparin.

- **Step 2:**
- Calculate the IV rate in mL/hr that delivers the client's hourly dose of heparin.
- 25,000 units: 250 mL = 1,230 units: *x* mL

- 25,000x25,000=307,50025,000

- x=307,50025,000

- *x* = 12.3 mL/hr
- Answer: 12.3 mL/hr will deliver the client's hourly dose of 1,230 units. The rate is stated in tenths; the pump is capable of delivering in tenths of a milliliter.
- 48. No weight conversion required; child's weight is in kilograms.
- Child's weight = 32 kg
- **Step 1:** Determine the mL/day using the formula.
-

- Answer: 1,740 mL/day or per 24 hr
- **Step 2:** Determine ml/hr.
- *x* mL/hr = 1,740 mL24 hr

= 72.5 mL/hr

- Answer: 72.5 mL/hr will deliver 1,740 mL/24 hr or per day. Pump capable of delivering in tenths of a milliliter.
- 49. **Step 1:** Weight conversion required. Convert weight to kilograms. Equivalent: 1 kg = 1,000 g
- 2,500 g ÷ 1,000 = 2.5 kg
- **Step 2:** Select and apply appropriate formula.
- 100 mL/

/day × 2.5

= 250 mL/day or per 24 hr

- Answer: 250 mL/day or per 24 hr
- **Step 3:** Determine mL/hr.
- *x* mL/hr = 250 mL24 hr

= 10.41 = 10.4 mL/hr

- Answer: 10.4 mL/hr; 10.41 rounded to the nearest tenth of a milliliter. The pump is capable of delivering in tenths of a milliliter.
- 50. Weight conversion is required. Convert weight to kilograms. Equivalent: 2.2 lb = 1 kg
- 78 lb ÷ 2.2 = 35.45 = 35.5 kg
- **Step 1:** Determine the mL/day using the formula.
-

- **Step 2:** Determine mL/hr
- *x* mL/hr = 1,810 mL24 hr

= 75.4 mL/hr = 75 mL/hr

- The pump is capable of delivering in whole mL; therefore mL/hr is rounded to a whole number.

- 51. a. BSA (m^2) = 135(lb)×62(in)3,131=2.673
- = 1.634 = 1.63 m^2
- Answer: 1.63 m^2
- b.
- Answer: 1,630 mg
- 52. a. BSA (m^2) = 92.7(kg)×185(cm)3,600=4.763
- = 2.182 = 2.18 m^2
- Answer: BSA = 2.18 m^2
- b.
- Answer: The dosage range for this client is 21.8-43.6 units/wk.
- c. The dosage is safe; 35 units falls within the recommended dosage range of 21.8-43.6 units/wk.

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unknown - Section 46 (Page 472)

Introduction to Appendix Table of Contents

- Appendix A: **Apothecary System,** 678
- Appendix B: **FDA and ISMP Lists of Look-Alike Drug Names With Recommended Tall Man Letters,** 680
- Appendix C: **TJC "Do Not Use" List of Abbreviations,** 686
- Appendix D: **ISMP List of Error-Prone Abbreviations, Symbols, and Dose Designations,** 687
- Appendix E: **ISMP List of High-Alert Medications in Acute Care Settings,** 694
- Appendix F: **ISMP List of High-Alert Medications in Community/Ambulatory Healthcare,** 695

Appendixes B, D, E, and F © Institute for Safe Medication Practices (ISMP), 2016. All rights reserved. Retrieved from http://www.ismp.org/Tools/errorproneabbreviations.pdf. Visit www.ismp.org for more medication safety information, or to report medication errors or near misses to the ISMP Medication Errors Reporting Program (MERP).

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unknown - Section 47 (Page 474)

Appendix A

Apothecary System

As noted in Chapter 6, the **apothecary system** is an antiquated system of measurement. The system is sometimes referred to as the fraction system because parts of a unit are expressed by using fractions, with the exception of the fraction one-half, which is expressed as *ss* or

. The notations in this system are unusual and confusing, and errors have been identified from its use. The system also uses roman numerals and has inaccuracies that contribute to its use being unsafe. Recommendations from major national agencies focusing on client (patient) safety, including the Institute for Safe Medication Practices (ISMP), The Joint Commission (TJC), and the US Food and Drug Administration (FDA), included not using this system for safe practice, not using it in medication administration, and elimination of its use in favor of the metric system.

Some of the medication dosing cups used to administer liquid medications still have the apothecary measure drams (approximately the size of a teaspoon) indicated on them. The apothecary measures and symbols have been included on the ISMP's list of Error-Prone Abbreviations, Symbols, and Dose Designations. A brief discussion of apothecary units and their equivalents appears here so that they can be differentiated from acceptable units of measure. **Remember to use metric equivalents.**

Apothecary Units:

- • The grain is the basic unit for weight.
- • Volume measures include minim (approximately the size of a drop), dram (approximately the size of a teaspoon), and ounce (which is the same as the household ounce).
- • Many of the household measures originated from the apothecary (e.g., ounce, which is still in use).

Apothecary Units Abbreviation/Symbols

Unit	Abbreviation	Symbol
grain	gr	N/A
ounce	oz	ʒ
dram	dr	ʒ
minim	m	N/A

*ss,

—Apothecary symbol for ½

Below is a partial listing of some of the common Apothecary–Metric Approximate Equivalents:

Volume	Weight
1 oz = 30 mL	15 gr = 1 g (1,000 mg)
15-16 m = 1 mL	1 gr = 60-65 mg

Volume	Weight
	gr ½ or
1 dr = 4-5 mL	
	= 30 mg
	gr ¼ = 15 mg
1 m = 1 gtt	gr ⅙ = 10 mg
	gr 1/100 = 0.6 mg
	gr 1/150 = 0.4 mg

Apothecary/Metric Approximate Equivalent Clock

SAFETY ALERT!

Do not use the following error-prone abbreviations and symbols. Always differentiate them from acceptable units of measure if they are used. Always clarify to be safe and prevent errors before proceeding with any order using them. **The use of error-prone abbreviations and symbols can cause harm!**

DO NOT USE:

gr (grains; apothecary unit of weight): Confused with metric gram

(minim): Mistaken for mL

(dram; apothecary drop): Mistaken for 3

(ounce; apothecary symbol): Obsolete

ss,

(one half; apothecary symbol for ½): Mistaken for 55

unknown - Section 48 (Page 479)

Appendix B

FDA and ISMP Lists of Look-Alike Drug Names With Recommended Tall Man Letters

Institute for Safe Medication Practices

FDA and ISMP Lists of Look-Alike Drug Names with Recommended Tall Man Letters

Since 2008, ISMP has maintained a list of drug name pairs and trios with recommended, **bolded** tall man (uppercase) letters to help draw attention to the dissimilarities in look-alike drug names. The list includes mostly generic-generic drug name pairs, although a few brand-brand or brand-generic name pairs are included. The US Food and Drug Administration (FDA) list of drug names with recommended tall man letters was initiated in 2001 with the agency's Name Differentiation Project (www.ismp.org/sc?id=520).

While numerous studies between 2000 and 2016 have demonstrated the ability of tall man letters alone or in conjunction with other text enhancements to improve the accuracy of drug name perception and reduce errors due to drug name similarity,[1-9] some studies have suggested that the strategy is ineffective.[10-12] The evidence is mixed due in large part to methodological differences and significant study limitations. Nevertheless, while gaps still exist in our full understanding of the role of tall man lettering in the clinical setting, there is sufficient evidence to suggest that this simple and straightforward technique is worth implementing as one among numerous strategies to mitigate the risk of errors due to similar drug names. To await irrefutable, scientific proof of effectiveness minimizes and undervalues the study findings and anecdotal evidence available today13 that support this important risk-reduction strategy. As such, the use of tall man letters has been endorsed by ISMP, The Joint Commission (recommended but not required), the US Food and Drug Administration (as part of its Name Differentiation Project), as well as other national and international organizations, including the World Health Organization and the International Medication Safety Network (IMSN).[14]

Table 1 provides an alphabetized list of FDA-approved established drug names with recommended tall man letters.

Table 2 provides an alphabetized list of additional drug names with recommendations from ISMP regarding the use and placement of tall man letters. This is not an official list approved by FDA. It is intended for voluntary use by healthcare practitioners, drug information vendors, and medication technology vendors. Any product label changes by manufacturers require FDA approval.

To promote standardization regarding which letters to present in uppercase, ISMP follows a tested methodology whenever possible called the CD3 rule.[15] The methodology suggests working from the left of the drug name first by capitalizing all the characters to the right once 2 or more dissimilar letters are encountered, and then, working from the right, returning 2 or more letters common to both words to lowercase letters. When the rule cannot be applied because there are no common letters on the right side of the name, the methodology suggests capitalizing the central part of the word only. When application of this rule fails to lead to the best tall man lettering option (e.g., makes names appear too similar, makes names hard to read based on pronunciation), an alternative option is considered.

ISMP suggests that the **bolded**, tall man lettering scheme provided by FDA and ISMP for the drug name pairs listed in **Tables 1** and **2** be followed to promote consistency.

Table 1

FDA-Approved List of Generic Drug Names with Tall Man Letters

Drug Name With Tall Man Letters	Confused With
aceta**ZOLAMIDE**	aceto**HEXAMIDE**
aceto**HEXAMIDE**	aceta**ZOLAMIDE**
bu**PROP**ion	bus**PIR**one
bus**PIR**one	bu**PROP**ion
chlorpro**MAZINE**	chlorpro**PAMIDE**
chlorpro**PAMIDE**	chlorpro**MAZINE**
clomi**PHENE**	clomi**PRAMINE**
clomi**PRAMINE**	clomi**PHENE**
cyclo**SERINE**	cyclo**SPORINE**
cyclo**SPORINE**	cyclo**SERINE**
DAUNOrubicin	**DOXO**rubicin
dimenhy**DRINATE**	diphenhydr**AMINE**
diphenhydr**AMINE**	dimenhy**DRINATE**
DOBUTamine	**DOP**amine

Drug Name With Tall Man Letters	Confused With
DOPamine	**DOBUT**amine
DOXOrubicin	**DAUNO**rubicin
glipi**ZIDE**	gly**BURIDE**
gly**BURIDE**	glipi**ZIDE**
hydr**ALAZINE**	hydr**OXY**zine – **HYDRO**morphone
HYDROmorphone	hydr**OXY**zine — hydr**ALAZINE**
hydr**OXY**zine	hydr**ALAZINE** – **HYDRO**morphone
medroxy**PROGESTER**one	methyl**PREDNIS**olone - methyl**TESTOSTER**one
methyl**PREDNIS**olone	medroxy**PROGESTER**one - methyl**TESTOSTER**one
methyl**TESTOSTER**one	medroxy**PROGESTER**one - methyl**PREDNIS**olone
mito**XANTRONE**	Not specified
ni**CAR**dipine	**NIFE**dipine
NIFEdipine	ni**CAR**dipine
predniso**LONE**	predni**SONE**
predni**SONE**	predniso**LONE**
risperi**DONE**	r**OPINIR**ole
r**OPINIR**ole	risperi**DONE**
sulf**ADIAZINE**	sulfi**SOXAZOLE**
sulfi**SOXAZOLE**	sulf**ADIAZINE**
TOLAZamide	**TOLBUT**amide
TOLBUTamide	**TOLAZ**amide
vin**BLAS**tine	vin**CRIS**tine
vin**CRIS**tine	vin**BLAS**tine

Table 2

ISMP List of Additional Drug Names with Tall Man Letters[***]

Drug Name With Tall Man Letters	Confused With
ALPRAZolam	**LOR**azepam — clonaze**PAM**
a**MIL**oride	am**LODIP**ine
am**LODIP**ine	a**MIL**oride
ARIPiprazole	**RABE**prazole
AVINza[*]	**INV**anz[*]
aza**CITID**ine	aza**THIO**prine
aza**THIO**prine	aza**CITID**ine
car**BAM**azepine	**OX**carbazepine
CARBOplatin	**CIS**platin
ce**FAZ**olin	cefo**TE**tan — cef**OX**itin — cef**TAZ**idime — cef**TRIAX**one
cefo**TE**tan	ce**FAZ**olin — cef**OX**itin — cef**TAZ**idime — cef**TRIAX**one
cef**OX**itin	ce**FAZ**olin — cefo**TE**tan — cef**TAZ**idime — cef**TRIAX**one
cef**TAZ**idime	ce**FAZ**olin — cefo**TE**tan — cef**OX**itin — cef**TRIAX**one
cef**TRIAX**one	ce**FAZ**olin - cefo**TE**tan – cef**OX**itin – cef**TAZ**idime
Cele**BREX**[*]	Cele**XA**[*]
Cele**XA**[*]	Cele**BREX**[*]
chlordiaze**POXIDE**	chlorpro**MAZINE**[**]
chlorpro**MAZINE**[**]	chlordiaze**POXIDE**
CISplatin	**CARBO**platin
clo**BAZ**am	clonaze**PAM**
clonaze**PAM**	clo**NID**ine — clo**ZAP**ine — clo**BAZ**am — **LOR**azepam

Drug Name With Tall Man Letters	Confused With
clo**NID**ine	clonaze**PAM** – clo**ZAP**ine — Klono**PIN***
clo**ZAP**ine	clonaze**PAM** — clo**NID**ine
DACTINomycin	**DAPTO**mycin
DAPTOmycin	**DACTIN**omycin
DEPO-Medrol*	**SOLU**-Medrol*
diaze**PAM**	dil**TIAZ**em
dil**TIAZ**em	diaze**PAM**
DOCEtaxel	**PACL**itaxel
DOXOrubicin**	**IDA**rubicin
DULoxetine	**FLU**oxetine — **PAR**oxetine
e**PHED**rine	**EPINEPH**rine
EPINEPHrine	e**PHED**rine
epi**RUB**icin	eri**BUL**in
eri**BUL**in	epi**RUB**icin
fenta**NYL**	**SUF**entanil
flavox**ATE**	fluvoxa**MINE**
FLUoxetine	**DUL**oxetine — **PAR**oxetine
flu**PHENAZ**ine	fluvoxa**MINE**
fluvoxa**MINE**	flu**PHENAZ**ine - flavox**ATE**
guai**FEN**esin	guan**FACINE**
guan**FACINE**	guai**FEN**esin
Huma**LOG***	Humu**LIN***
Humu**LIN***	Huma**LOG***
hydr**ALAZINE****	hydro**CHLORO**thiazide – hydr**OXY**zine**
hydro**CHLORO**thiazide	hydr**OXY**zine** — hydr**ALAZINE****
HYDROcodone	oxy**CODONE**
HYDROmorphone**	morphine — oxy**MOR**phone
HYDROXYprogesterone	medroxy**PROGESTER**one**
hydr**OXY**zine**	hydr**ALAZINE**** — hydro**CHLORO**thiazide
IDArubicin	**DOXO**rubicin** – idaru**CIZU**mab
idaru**CIZU**mab	**IDA**rubicin
in**FLIX**imab	ri**TUX**imab
INVanz*	**AVIN**za*
ISOtretinoin	tretinoin
Klono**PIN***	clo**NID**ine
La**MIC**tal*	Lam**ISIL***
Lam**ISIL***	La**MIC**tal*
lami**VUD**ine	lamo**TRI**gine
lamo**TRI**gine	lami**VUD**ine
lev**ETIRA**cetam	lev**OCARN**itine — levo**FLOX**acin
lev**OCARN**itine	lev**ETIRA**cetam
levo**FLOX**acin	lev**ETIRA**cetam
LEVOleucovorin	leucovorin
LORazepam	**ALPRAZ**olam — clonaze**PAM**
medroxy**PROGESTER**one**	**HYDROXY**progesterone
met**FORMIN**	metro**NIDAZOLE**
methazol**AMIDE**	meth**IMA**zole — met**OL**azone

Drug Name With Tall Man Letters	Confused With
meth**IMA**zole	met**OL**azone – methazol**AMIDE**
met**OL**azone	meth**IMA**zole — methazol**AMIDE**
metro**NIDAZOLE**	met**FORMIN**
metyra**PONE**	metyro**SINE**
metyro**SINE**	metyra**PONE**
mi**FEPRIS**tone	mi**SOPROS**tol
mi**SOPROS**tol	mi**FEPRIS**tone
mito**MY**cin	mito**XANTRONE****
mito**XANTRONE****	mito**MY**cin
Nex**AVAR***	Nex**IUM***
Nex**IUM***	Nex**AVAR***
ni**CAR**dipine**	ni**MOD**ipine – **NIFE**dipine**
NIFEdipine**	ni**MOD**ipine — ni**CAR**dipine**
ni**MOD**ipine	**NIFE**dipine** – ni**CAR**dipine**
Novo**LIN***	Novo**LOG***
Novo**LOG***	Novo**LIN***
OLANZapine	**QUE**tiapine
OXcarbazepine	car**BAM**azepine
oxy**CODONE**	**HYDRO**codone — Oxy**CONTIN***– oxy**MOR**phone
Oxy**CONTIN***	oxy**CODONE** – oxy**MOR**phone
oxy**MOR**phone	**HYDRO**morphone**/ — oxy**CODONE** – Oxy**CONTIN***
PACLitaxel	**DOCE**taxel
PARoxetine	**FLU**oxetine — **DUL**oxetine
PAZOPanib	**PONAT**inib
PEMEtrexed	**PRALA**trexate
penicill**AMINE**	penicillin
PENTobarbital	**PHEN**obarbital
PHENobarbital	**PENT**obarbital
PONATinib	**PAZOP**anib
PRALAtrexate	**PEME**trexed
Pri**LOSEC***	**PRO**zac*
PROzac*	Pri**LOSEC***
QUEtiapine	**OLANZ**apine
qui**NID**ine	qui**NINE**
qui**NINE**	qui**NID**ine
RABEprazole	**ARIP**iprazole
ranitidine	ri**MANTA**dine
rif**AMP**in	rif**AXIM**in
rif**AXIM**in	rif**AMP**in
ri**MANTA**dine	ra**NITI**dine
Risper**DAL***	r**OPINIR**ole**
risperi**DONE****	r**OPINIR**ole**
ri**TUX**imab	in**FLIX**imab
romi**DEP**sin	romi**PLOS**tim
romi**PLOS**tim	romi**DEP**sin
r**OPINIR**ole**	Risper**DAL***— risperi**DONE****
Sand**IMMUNE***	Sando**STATIN***

Drug Name With Tall Man Letters	Confused With
Sando**STATIN***	Sand**IMMUNE***
s**AX**agliptin	**SIT**agliptin
SEROquel*	**SINE**quan*
SINEquan*	**SERO**quel*
SITagliptin	s**AX**agliptin — **SUMA**triptan
Solu-**CORTEF***	**SOLU**-Medrol*
SOLU-Medrol*	Solu-**CORTEF*** — **DEPO**-Medrol*
SORAfenib	**SUNI**tinib
SUFentanil	fenta**NYL**
sulf**ADIAZINE****	sulfa**SALA**zine
sulfa**SALA**zine	sulf**ADIAZINE****
SUMAtriptan	**SIT**agliptin — **ZOLM**itriptan
SUNItinib	**SORA**fenib
TEGretol*	**TREN**tal*
tia**GAB**ine	ti**ZAN**idine
ti**ZAN**idine	tia**GAB**ine
tra**MAD**ol	tra**ZOD**one
tra**ZOD**one	tra**MAD**ol
TRENtal*	**TEG**retol*
val**ACY**clovir	val**GAN**ciclovir
val**GAN**ciclovir	val**ACY**clovir
ZOLMitriptan	**SUMA**triptan
Zy**PREXA***	Zyr**TEC***
Zyr**TEC***	Zy**PREXA***

**Brand names always start with an uppercase letter. Some brand names incorporate tall man letters in initial characters and may not be readily recognized as brand names. An asterisk follows all brand names on the ISMP list.*

***These drug names are also on the FDA list.*

****The ISMP list is not an official list approved by FDA. It is intended for voluntary use by healthcare practitioners and drug information and technology vendors. Any manufacturers' product label changes require FDA approval.*

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unknown - Section 49 (Page 485)

Appendix C

TJC “Do Not Use” List of Abbreviations

Official “Do Not Use” List

- This list is part of the Information Management standards

- Does not apply to preprogrammed health information technology systems (i.e. electronic medical records or CPOE systems), but remains under consideration for the future

Organizations contemplating introduction or upgrade of such systems should strive to eliminate the use of dangerous abbreviations, acronyms, symbols and dose designations from the software.

Official “Do Not Use” List

Do Not Use	Potential Problem	Use Instead
U, u (unit)	Mistaken for “0” (zero), the number “4” (four) or “cc”	Write “unit”
IU (International Unit)	Mistaken for IV (intravenous) or the number 10 (ten)	Write “International Unit”
Q.D., QD, q.d., qd (daily)	Mistaken for each other	Write “daily”
Q.O.D., QOD, q.o.d, qod (every other day)	Period after the Q mistaken for “I” and the “O” mistaken for “I	Write “every other day”
Trailing zero (X.0 mg)*	Decimal point is missed	Write X mg
Lack of leading zero (.X mg)		Write 0.X mg
MS	Can mean morphine sulfate or magnesium sulfate	Write “morphine sulfate”
		Write “magnesium sulfate”
MSO_4 and $MgSO_4$	Confused for one another	

[1]Applies to all orders and all medication-related documentation that is handwritten (including free-text computer entry) or on pre-printed forms.

[*]**Exception:** A "trailing zero" may be used only where required to demonstrate the level of precision of the value being reported, such as for laboratory results, imaging studies that report size of lesions, or catheter/tube sizes. It may not be used in medication orders or other medication-related documentation.

Development of the "Do Not Use" List

In 2001, The Joint Commission issued a *Sentinel Event Alert* on the subject of medical abbreviations. A year later, its Board of Commissioners approved a National Patient Safety Goal requiring accredited organizations to develop and implement a list of abbreviations not to use. In 2004, The Joint Commission created its "Do Not Use" List to meet that goal. In 2010, NPSG.02.02.01 was integrated into the Information Management standards as elements of performance 2 and 3 under IM.02.02.01.

6/19

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For more information

- • Contact the Standards Interpretation Group at 630-792-5900.
- • Complete the Standards Online Question Submission Form.

unknown - Section 50 (Page 488)

Appendix D

ISMP List of Error-Prone Abbreviations, Symbols, and Dose Designations

ISMP List of Error-Prone Abbreviations, Symbols, and Dose Designations

The abbreviations, symbols, and dose designations in the **Table** below were reported to ISMP through the ISMP National Medication Errors Reporting Program (ISMPMERP) and have been misinterpreted and involved in harmful or potentially harmful medication errors. These abbreviations, symbols, and dose designations should **NEVER** be used when communicating medical information verbally, electronically, and/or in handwritten applications. This includes internal communications; verbal, handwritten, or electronic prescriptions; handwritten and computer-generated medication labels; drug storage bin labels; medication administration records; and screens associated with pharmacy and prescriber computer order entry systems, automated dispensing cabinets, smart infusion pumps, and other medication-related technologies.

Table

Error-Prone Abbreviations, Symbols, and Dose Designations

Error-Prone Abbreviations, Symbols, and Dose Designations	Intended Meaning	Misinterpretation	Best Practice
Abbreviations for Doses/Measurement Units			
cc	Cubic centimeters	Mistaken as u (units)	Use mL
IU[**]	International unit(s)	Mistaken as IV (intravenous) or the number 10	Use unit(s) (International units can be expressed as units alone)
l **ml**	Liter Milliliter	Lowercase letter l mistaken as the number 1	Use L (UPPERCASE) for liter Use mL (lowercase m, UPPERCASE L) for milliliter
MM or M **M or K**	Million Thousand	Mistaken as thousand Mistaken as million M has been used to abbreviate both million and thousand (M is the Roman numeral for thousand)	Use million Use thousand
Ng or ng	Nanogram	Mistaken as mg Mistaken as nasogastric	Use nanogramor nanog
U or u[**]	Unit(s)	Mistaken as zero or the number 4, causing a 10-fold overdose or greater (e.g., 4U seen as 40 or 4u seen as 44) Mistaken as cc, leading to administering volume instead of units	Use unit(s)

Error-Prone Abbreviations, Symbols, and Dose Designations	Intended Meaning	Misinterpretation	Best Practice
		(e.g., 4useenas 4cc)	
µg	Microgram	Mistaken as mg	Use mcg
Abbreviations for Route of Administration			
AD, AS, AU	Right ear, left ear, each ear	Mistaken as OD, OS, OU (right eye, left eye, each eye)	Use right ear, left ear, or each ear
IN	Intranasal	Mistaken as IM or IV	Use NAS (all UPPERCASE letters) or intranasal
IT	Intrathecal	Mistaken as intratracheal, intratumor, intratympanic, or inhalation therapy	Use intrathecal
OD, OS, OU	Right eye, left eye, each eye	Mistaken as AD, AS, AU (right ear, left ear, each ear)	Use right eye, left eye, or each eye
Per os	By mouth, orally	The os was mistaken as left eye (OS, oculus sinister)	Use PO, by mouth, or orally
SC, SQ, sq, or sub q	Subcutaneous(ly)	SC and sc mistaken as SL or sl (sublingual) SQ mistaken as "5 every" The q in sub q has been mistaken as "every"	Use SUBQ (all UPPERCASE letters, without spaces or periods between letters) or subcutaneous(ly)
Abbreviations for Frequency/Instructions for Use			
HS	Half-strength	Mistaken as bedtime	Use half-strength
hs	At bedtime, hours of sleep	Mistaken as half-strength	Use HS (all UPPERCASE letters) for bedtime
o.d. or OD	Once daily	Mistaken as right eye (OD, oculus dexter), leading to oral liquid medications administered in the eye	Use daily
Q.D., QD, q.d., or qd[**]	Every day	Mistaken as q.i.d., especially if the period after the q or the tail of a handwritten q is misunderstood as the letter i	Use daily
Qhs	Nightly at bedtime	Mistaken as qhr (every hour)	Use nightly or HS for bedtime
Qn	Nightly or at bedtime	Mistaken as qh (every hour)	Use nightly or HS for bedtime
Q.O.D., QOD, q.o.d., or qod[**]	Every other day	Mistaken as qd (daily) or qid (four times daily), especially if the "o" is poorly written	Use every other day
q1d	Daily	Mistaken as qid (four times daily)	Use daily
q6PM, etc.	Every evening at 6 PM	Mistaken as every 6 hours	Use daily at 6 PM or 6 PM daily
SSRI	Sliding scale regular insulin	Mistaken as selective-serotonin reuptake inhibitor	Use sliding scale (insulin)
SSI	Sliding scale insulin	Mistaken as Strong Solution of Iodine (Lugol's)	
TIW or tiw	3 times a week	Mistaken as 3 times a day or twice in a week	Use 3 times weekly
BIW or biw	2 times a week	Mistaken as 2 times a day	Use 2 times weekly

Error-Prone Abbreviations, Symbols, and Dose Designations	Intended Meaning	Misinterpretation	Best Practice
UD	As directed (ut dictum)	Mistaken as unit dose (e.g., an order for "dil**TIAZ**em infusion UD" was mistakenly administered as a unit [bolus] dose)	Use as directed
Miscellaneous Abbreviations Associated with Medication Use			
BBA	Baby boy A (twin)	B in BBA mistaken as twin B rather than gender (boy)	When assigning identifiers to newborns, use the mother's last name, the baby's gender (boy or girl), and a distinguishing identifier for all multiples (e.g., Smith girl A, Smith girl B)
BGB	Baby girl B (twin)	B at end of BGB mistaken as gender (boy) not twin B	
D/C	Discharge or discontinue	Premature discontinuation of medications when D/C (intended to mean discharge) on a medication list was misinterpreted as discontinued	Use discharge and discontinue or stop
IJ	Injection	Mistaken as IV or intrajugular	Use injection
OJ	Orange juice	Mistaken as OD or OS (right or left eye); drugs meant to be diluted in orange juice may be given in the eye	Use orange juice
Period following abbreviations (e.g., mg., mL.)[†]	mg or mL	Unnecessary period mistaken as the number 1, especially if written poorly	Use mg, mL, etc., without a terminal period
Drug Name Abbreviations			
To prevent confusion, avoid abbreviating drug names entirely. Exceptions may be made for multi-ingredient drug formulations, including vitamins, when there are electronic drug name field space constraints; however, drug name abbreviations should NEVER be used for any medications on the *ISMP List of High-Alert Medications* (in Acute Care Settings [www.ismp.org/node/103], Community/Ambulatory Settings [www.ismp.org/node/129], and Long-Term Care Settings [www.ismp.org/node/130]). Examples of drug name abbreviations involved in serious medication errors include:			
Antiretroviral medications (e.g., DOR, TAF, TDF)	DOR: doravirine TAF: tenofovir alafenamide TDF: tenofovir disoproxil fumarate	DOR: Dovato (dolutegravir and lami**VUD**ine) TAF: tenofovir disoproxil fumarate TDF: tenofovir alafenamide	Use complete drug names
APAP	acetaminophen	Not recognized as acetaminophen	Use complete drug name
ARAA	vidarabine	Mistaken as cytarabine ("ARA C")	Use complete drug name
AT II and AT III	AT II: angiotensin II (Giapreza) AT III: antithrombin III (Thrombate III)	AT II (angiotensin II) mistaken as AT III (antithrombin III) AT III (antithrombin III) mistaken as AT II (angiotensin II)	Use complete drug names
AZT	zidovudine (Retrovir)	Mistaken as azithromycin, aza**THIO**prine, or aztreonam	Use complete drug name
CPZ	Compazine (prochlorperazine)	Mistaken as chlorpro**MAZINE**	Use complete drug name
DTO	diluted tincture of opium or deodorized tincture of opium (Paregoric)	Mistaken as tincture of opium	Use complete drug name
HCT	hydrocortisone	Mistaken as hydro**CHLORO**thiazide	Use complete drug name
HCTZ	hydro**CHLORO**thiazide	Mistaken as hydrocortisone (e.g., seen as HCT250 mg)	Use complete drug name
MgSO4[**]	magnesium sulfate	Mistaken as morphine sulfate	Use complete drug name
MS, MSO4[**]	morphine sulfate	Mistakenasmagnesiumsulfate	Use complete drug name

Error-Prone Abbreviations, Symbols, and Dose Designations	Intended Meaning	Misinterpretation	Best Practice
MTX	methotrexate	Mistakenas mito**XANTRONE**	Use complete drug name
Na at the beginning of a drug name (e.g., Na bicarbonate)	Sodium bicarbonate	Mistaken as no bicarbonate	Use complete drug name
NoAC	novel/new oral anticoagulant	Mistaken as no anticoagulant	Use complete drug name
OXY	oxytocin	Mistaken as oxy**CODONE**, Oxy**CONTIN**	Use complete drug name
PCA	procainamide	Mistaken as patient-controlled analgesia	Use complete drug name
PIT	Pitocin (oxytocin)	Mistaken as Pitressin, a discontinued brand of vasopressin still referred toas PIT	Use complete drug name
PNV	prenatal vitamins	Mistaken as penicillin VK	Use complete drug name
PTU	propylthiouracil	Mistaken as Purinethol (mercaptopurine)	Use complete drug name
T3	Tylenol with codeine No. 3	Mistaken as liothyronine, which is sometimes referred to as T3	Use complete drug name
TAC or tac	triamcinolone or tacrolimus	Mistaken as tetracaine, Adrenalin, and cocaine; or as Taxotere, Adriamycin, and cyclophosphamide	Use complete drug names Avoid drug regimen or protocol acronyms that may have a dual meaning or may be confused with other common acronyms, even if defined in an order set
TNK	TNKase	Mistaken as TPA	Use complete drug name
TPA or tPA	tissue plasminogen activator, Activase (alteplase)	Mistaken as TNK (TNKase, tenecteplase), TXA (tranexamic acid), or less often as another tissue plasminogen activator, Retavase (retaplase)	Use complete drug names
TXA	tranexamic acid	Mistaken as TPA (tissue plasminogen activator)	Use complete drug name
ZnSO4	zinc sulfate	Mistaken as morphine sulfate	Use complete drug name
	Stemmed/Coined Drug Names		
Nitro drip	nitroglycerin infusion	Mistaken as nitroprusside infusion	Use complete drug name
IV vanc	Intravenous vancomycin	Mistaken as Invanz	Use complete drug name
Levo	levofloxacin	Mistaken as Levophed (norepinephrine)	Use complete drug name
Neo	Neo-Synephrine, a well known but discontinued brand of phenylephrine	Mistaken as neostigmine	Use complete drug name
Coined names for compounded products (e.g., magic mouthwash, banana bag, GI cocktail, half and half, pink lady)	Specific ingredients compounded together	Mistaken ingredients	Use complete drug/product names for all ingredients Coined names for compounded products should only be used if the contents are standardized and readily available for reference to prescribers, pharmacists, and nurses

Error-Prone Abbreviations, Symbols, and Dose Designations	Intended Meaning	Misinterpretation	Best Practice
Number embedded in drug name (not part of the official name) (e.g., 5-fluorouracil, 6-mercaptopurine)	fluorouracil mercaptopurine	Embedded number mistaken as the dose or number of tablets/capsules to be administered	Use complete drug names, without an embedded number if the number is not part of the official drug name
Dose Designations and Other Information			
1/2 tablet	Half tablet	1 or 2 tablets	Use text (half tablet) or reduced font-size fractions (½ tablet)
Doses expressed as Roman numerals (e.g., V)	5	Mistaken as the designated letter (e.g., the letter V) or the wrong numeral (e.g., 10 instead of 5)	Use only Arabic numerals (e.g., 1, 2, 3) to express doses
Lack of a leading zero before a decimal point (e.g., .5 mg)**	0.5 mg	Mistaken as 5 mg if the decimal point is not seen	Use a leading zero before a decimal point when the dose is less than one measurement unit
Trailing zero after a decimal point (e.g., 1.0 mg)**	1 mg	Mistaken as 10 mg if the decimal point is not seen	Do not use trailing zeros for doses expressed in whole numbers
Ratio expression of a strength of a single-entity injectable drug product (e.g., EPINEPHrine 1:1,000; 1:10,000; 1:100,000)	1:1,000: contains 1 mg/mL 1:10,000: contains 0.1 mg/mL 1:100,000: contains0.01mg/mL	Mistaken as the wrong strength	Express the strength in terms of quantity per total volume (e.g., **EPINEPH**rine 1 mg per 10 mL) **Exception:** combination local anesthetics (e.g., lidocaine 1% and **EPINEPH**rine 1:100,000)
Drug name and dose run together (problematic for drug names that end in the letter l [e.g., propranolol20 mg; TEGretol300 mg])	propranolol 20 mg **TEG**retol 300 mg	Mistaken as propranolol 120 mg Mistaken as **TEG**retol 1300 mg	Place adequate space between the drug name, dose, and unit of measure
Numerical dose and unit of measure run together (e.g., 10mg, 10Units)	10 mg 10 mL	The m in mg, or U in Units, has been mistaken as one or two zeros when flush against the dose (e.g., 10mg, 10Units), risking a 10- to 100-fold overdose	Place adequate space between the dose and unit of measure
Large doses without properly placed commas (e.g., 100000 units; 1000000 units)	100,000 units 1,000,000 units	100000 has been mistaken as 10,000 or 1,000,000 1000000 has been mistaken as 100,000	Use commas for dosing units at or above 1,000 or use words such as 100 thousand or 1 million to improve readability **Note:** Use commas to separate digits only in the US; commas are used in place of decimal points in some other countries
Symbols			

Error-Prone Abbreviations, Symbols, and Dose Designations	Intended Meaning	Misinterpretation	Best Practice
	Dram	Symbol for dram mistaken as thenumber3	Use the metric system
	Minim	Symbol for minim mistaken as mL	
[†]			
x1	Administer once	Administer for 1 day	Use explicit words (e.g., for 1 dose)
> and <	More than and less than	Mistaken as opposite of intended Mistakenly have used the Incorrect symbol <mistaken as the number 4 when handwritten (e.g., <10 mlsreadas40)	Use more than or less than
↑ and ↓[†]	Increase and decrease	Mistaken as opposite of Intended Mistakenly have used the Incorrect symbol ↑ mistaken as the letter T, leading to misinterpretation as the start of a drug name, or mistaken as the numbers4 or 7	Use increase and decrease
/ (slash mark)[†]	Separates two doses or indicates per	Mistaken as the number 1 (e.g.,25unlts/10 units misread as 25 units and 110 units)	Use per rather than a slash mark to separate doses
@[†]	At	Mistaken as the number 2	Use at
[†]	And	Mistaken as the number 2	Use and
+[†]	Plus or and	Mistaken as the number 4	Use plus, and, or in addition to
°	Hour	Mistaken as a zero (e.g., q2° seen as q20)	Use hr, h, or hour
Φ or ø[†]	Zero, null sign	Mistaken as the numbers 4, 6, 8, and 9	Use 0 or zero, or describe intent using whole words
#	Pound(s)	Mistaken as a number sign	Use the metric system (kg or g) rather than pounds Use lb if referring to pounds

Apothecary or Household Abbreviations

Explicit apothecary or household measurements may **ONLY** be safely used to express the directions for mixing dry ingredients to prepare topical products (e.g., dissolve 2 capfuls of granules per gallon of warm water to prepare a magnesium sulfate soaking aid). Otherwise, metric system measurements should be used.

gr	Grain(s)	Mistaken as gram	Use the metric system (e.g., mcg g)

Error-Prone Abbreviations, Symbols, and Dose Designations	Intended Meaning	Misinterpretation	Best Practice
dr	Dram(s)	Mistaken as doctor	Use the metric system (e.g., mL)
min	Minim(s)	Mistaken as minutes	Use the metric system (e.g., mL)
oz	Ounce(s)	Mistaken as zero or 0_2	Use the metric system (e.g., mL)
tsp	Teaspoon(s)	Mistaken as tablespoon(s)	Use the metric system (e.g., mL)
tbsp or Tbsp	Tablespoon(s)	Mistaken as teaspoon(s)	Use the metric system (e.g., mL)

Common Abbreviations with Contradictory Meanings	**Contradictory Meanings**	**Correction**

For additional information and tables from Neil Davis (MedAbbrev.com) containing additional examples of abbreviations with contradictory or ambiguous meanings, please visit: www.ismp.org/ext/638.

B	Breast, brain, or bladder	Use breast, brain, or bladder
C	Cerebral, coronary, or carotid	Use cerebral, coronary, or carotid
D or d	Day or dose (e.g., parameter-based dosing formulas using D or d [mg/kg/d] could be interpreted as either day or dose [mg/kg/day or mg/kg/dose]; or x3d could be interpreted as either 3 days or 3 doses)	Use day or dose
H	Hand or hip	Use hand or hip
I	Impaired or improvement	Use impaired or improvement
L	Liver or lung	Use liver or lung
N	No or normal	Use no or normal
P	Pancreas, prostate, preeclampsia, or psychosis	Use pancreas, prostate, preeclampsia, or psychosis
S	Special or standard	Use special or standard
SS or ss	Single strength, sliding scale (insulin), signs and symptoms, or ½ (apothecary) SS has also been mistaken as the number 55	Use single strength, sliding scale, signs and symptoms, or one-half or ½

[**] On The Joint Commission's "**Do Not Use**" list

[†] Relevant mostly in handwritten medication information

In the **Table**, error-prone abbreviations, symbols, and dose designations that are included on The Joint Commission's "**Do Not Use**" list (Information Management standard IM.02.02.01) are identified with a double asterisk (**) and must be included on an organization's "**Do Not Use**" list. Error-prone abbreviations, symbols, and dose designations that are relevant mostly in handwritten communications of medication information are highlighted with a dagger (†).

While the abbreviations, symbols, and dose designations in the **Table** should **NEVER** be used, not allowing the use of **ANY** abbreviations is exceedingly unlikely. Therefore, the person who uses an organization-approved abbreviation must take responsibility for making sure that it is properly interpreted. If an uncommon or ambiguous abbreviation is used, and it should be defined by the writer or sender. Where uncertainty exists, clarification with the person who used the abbreviation is required.

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Appendix E

ISMP List of High-Alert Medications in Acute Care Settings

ISMP List of High-Alert Medications in Acute Care Settings

High-alert medications are drugs that bear a heightened risk of causing significant patient harmwhen they are used in error. Although mistakes may or may not be more common with these drugs, the consequences of an error are clearly more devastating to patients. We hope you will use this list to determine which medications require special safeguards to reduce the risk of errors. This may include strategies such as standardizing the ordering, storage, preparation, and administration of these products; improving access to information about these drugs; limiting access to high-alert medications; using auxiliary labels; employing clinical decision support and automated alerts; and using redundancies such as automated or independent double checks when necessary. (Note: manual independent double checks are not always the optimal error-reduction strategy and may not be practical for all of the medications on the list.)

Classes/Categories of Medications

adrenergic agonists, IV (e.g., **EPINEPH**rine, phenylephrine, norepinephrine)

adrenergic antagonists, IV (e.g., propranolol, metoprolol, labetalol)

anesthetic agents, general, inhaled and IV (e.g., propofol, ketamine)

antiarrhythmics, IV (e.g., lidocaine, amiodarone)

antithrombotic agents, including:

anticoagulants (e.g., warfarin, low molecular weight heparin, unfractionated heparin)

direct oral anticoagulants and factor Xa inhibitors (e.g., dabigatran, rivaroxaban, apixaban, edoxaban, betrixaban, fondaparinux)

direct thrombin inhibitors (e.g., argatroban, bivalirudin, dabigatran)

glycoprotein IIb/IIIa inhibitors (e.g., eptifibatide)

thrombolytics (e.g., alteplase, reteplase, tenecteplase)

cardioplegic solutions

chemotherapeutic agents, parenteral and oral

dextrose, hypertonic, 20% or greater

dialysis solutions, peritoneal and hemodialysis

epidural and intrathecal medications

inotropic medications, IV (e.g., digoxin, milrinone)

insulin, subcutaneous and IV

liposomal forms of drugs (e.g., liposomal amphotericin B) and conventional counterparts (e.g., amphotericin B desoxycholate)

moderate sedation agents, IV (e.g., dexmedetomidine, midazolam, LORazepam)

moderate and minimal sedation agents, oral, for children (e.g., chloral hydrate, midazolam, ketamine [using the parenteral form])

opioids, including:

IV

oral (including liquid concentrates, immediate- and sustained-release formulations)

transdermal

neuromuscular blocking agents (e.g., succinylcholine, rocuronium, vecuronium)

parenteral nutrition preparations

sodium chloride for injection, hypertonic, greater than 0.9% concentration

sterile water for injection, inhalation and irrigation (excluding pour bottles) in containers of 100 mL or more

sulfonylurea hypoglycemics, oral (e.g., chlorproPAMIDE, glimepiride, glyBURIDE, glipiZIDE, TOLBUTamide)

EPINEPHrine, IM, subcutaneous

epoprostenol (e.g., Flolan), IV

Insulin U-500 (special emphasis*)

magnesium sulfate Injection

methotrexate, oral, nononcologic use

nitroprusside sodium for Injection

opium tincture

oxytocin, IV

potassium chloride for injection concentrate

potassium phosphates injection

promethazine injection

vasopressin, IV and Intraosseous

*_All forms of insulin, subcutaneous and IV, are considered a class of high-alert medications. Insulin U-500 has been singled out for special emphasis to bring attention to the need for distinct strategies to prevent the types of errors that occur with this concentrated form of insulin._

Background

Based on error reports submitted to the ISMP National Medication Errors Reporting Program (ISMP MERP), reports of harmful errors in the literature, studies that identify the drugs most often involved in harmful errors, and input from practitioners and safety experts, ISMP created and periodically updates a list of potential high-alert medications. During June and July 2018, practitioners responded to an ISMP survey designed to identify which medications were most frequently considered high-alert medications. Further, to assure relevance and completeness, the clinical staff at ISMP and members of the ISMP advisory board were asked to review the potential list. This list of medications and medication categories reflects the collective thinking of all who provided input.

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Abbreviation definitions: IV—intravenous IM—intramuscular

unknown - Section 52 (Page 498)

Appendix F

ISMP List of High-Alert Medications in Community/Ambulatory Health Care

ISMP List of *High-Alert* Medications in Community/Ambulatory Healthcare

High-alert medications are drugs that bear a heightened risk of causing significant patient harm when they are used in error. Although mistakes may or may not be more common with these drugs, the consequences of an error are clearly more devastating to patients. We hope you will use this list to determine which medications require special safeguards to reduce the risk of errors and minimize harm. This may include strategies like providing mandatory patient education; improving access to information about these drugs; using auxiliary labels and automated alerts; employing automated or independent double checks when necessary; and standardizing the prescribing, storage, dispensing, and administration of these products.

antiretroviral agents (e.g., efavirenz, lami**VUD**ine, raltegravir, ritonavir, combination antiretroviral products)

chemotherapeutic agents, oral (excluding hormonal agents) (e.g., cyclophosphamide, mercaptopurine, temozolomide)

hypoglycemic agents, oral

immunosuppressant agents (e.g., aza**THIO**prine, cyclo**SPORINE**, tacrolimus)

insulin, all formulations

opioids, all formulations

pediatric liquid medications that require measurement

pregnancy category X drugs (e.g., bosentan, **ISO**tretinoin)

car**BAM**azepine

chloral hydrate liquid, for sedation of children

heparin, including unfractionated and low molecular weight heparin

met**FORMIN**

methotrexate, non-oncologic use

midazolam liquid, for sedation of children

propylthiouracil

warfarin

Background

Based on error reports submitted to the ISMP Medication Errors Reporting Program (ISMP MERP), reports of harmful errors in the literature, and input from practitioners and safety experts, ISMP created a list of potential high-alert medications. During June-August 2006, 463 practitioners responded to an ISMP survey designed to identify which medications were most frequently considered high-alert drugs by individuals and organizations. In 2008, the preliminary list and survey data as well as data about preventable adverse drug events from the ISMP MERP, the Pennsylvania Patient Safety Reporting System, the FDA MedWatch database, databases from participating pharmacies, public litigation data, literature review, and a small focus group of ambulatory care pharmacists and medication safety experts were evaluated as part of a research study funded by an Agency for Healthcare Research and Quality (AHRQ) grant. This list of drugs and drug categories reflects the collective thinking of all who provided input. This list was created as part of the AHRQ funded project “Using risk models to identify and prioritize outpatient high-alert medications” (Grant # 1P20HS017107-01).

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Index

Page numbers followed by *b*, *f*, and *t* indicated boxes, figures, and tables, respectively.

A

, 152*t*
aa, 152*t*
Abbreviations
on medication labels, 180, 186*f*, 192
in medication orders, 151, 151*b*
commonly used, 152*t*
"Do Not Use" List for, 151, 686
of medication names, 155
for units of measure, 152*t*
for scheduling medications, 173*t*
U and IU, 84
for units of measure in metric system, 72*b*, , 73*b*
a.c. (ac), 152*t*
Access devices, vascular, 474-475, 474*f*
Acronyms, on medication orders, 151*b*, 155
Activated partial thromboplastin time (APTT), 549
AcuDose Rx, 170
Acute Care Guidelines for Timely Administration of Scheduled Medications, 136
ad lib, 152*t*
ADC. *See* Automated dispensing cabinets
Addition
of decimals, 28-29, 28*b*
of fractions, 11-12, 11*b*
ADD-Vantage system, 397-398, 397*f*, 478-479, 479*f*
Administration
dosages and, 191
medication, 124-148, 144*b*
"30-minute rule" for, 135
chapter review for, 145-148
client education about, 138-139
critical thinking and, 130, 130*b*
documentation of, 166, 168
in elderly, 131-133, 133
equipment used for, 141-144, 142*b*, , 144*b*
factors that influence medication dosages and action in, 130-131
home care considerations for, 139-140
for mentally ill persons, 137
military time for, 173
practice problems for, 145, 147
rights of, 133-138, 133*b*, , 134*b*, , 136*b*
scheduled medications in, time-critical *vs.* non-time-critical, 135-136
scheduling medication times in, 173

abbreviations for, 173*t*
technology in, 172-173
time and frequency, errors due to, 136
use of technology in, 169
route of, 140-141
on medication labels, route of, 186-188, 187*b*, 187*f*, 188*f*
in medication orders, 155
Adult dosage calculation, based on weight, 601-652, 602*b*
basic calculation, principles relating to, 603
body weight, 603
Adult dosages, based on body weight, 618-620, 619*b*-620*b*
Alerts, on medication labels, 190, 190*f*
amp, 152*t*
Ampule, 334, 334*f*
Ante meridian (am, AM), 113, 152*t*
Anticoagulant medications, 549
Apidra (glulisine), 430
Apothecary system, 81-87, 84*b*., 84*f*., 678-679
chapter review for, 85-86
answers to, 87
medication errors, 81
metric system *vs*., , 81
one half, 81
practice problems for, 84-85
answers to, 86
APTT. *See* Activated partial thromboplastin time
aq, 152*t*
Aspart (NovoLog), 430
Assisted outpatient treatment (AOT), court-ordered, 137
Auto-injectors, 334
Automated dispensing cabinets (ADC), 128, 170
AZT, 155

B

Barcode medication delivery, 172, 172*f*
eMAR and, 172
Barcoding
for prevention of medication errors, 126
symbols, on medication labels, 188
Barrel, of syringe, 335
Basal/bolus insulin therapy, 446
Baxter Mini-Bag Plus, 478-479, 479*f*
b.i.d. (bid), 152*t*
b.i.w., 152*t*
Black box warning
on medication label, 194, 195*f*
“Black box” warning, 126
Blood administration tubing, 478, 478*f*
Body surface area (BSA)
for burn assessment, percentage and, 51-52
dosage calculation based on, 627-629, 628*b*., 629*b*
pediatric dosage calculation using, 622, 622*f*
using formula, 624-625, 624*b*., 625*b*
Body weight
conversion relating to, 111-113
Body weight, calculation of dosages based on, 603
Boiling point, 107
Bolus
insulin therapy, 446

intravenous, 475, 528
Borrowing, subtracting fractions using, 13-14, 13*b*
Brand name, on medication labels, 181, 181*f*
BSA. *See* Body surface area
BSA chart, 622*f*, , 623
Buccal tablets, 278, 278*f*
administration of, 140
Burn, percentage of, 51-52

C

°C. *See* Celsius

, 152*t*
CADD Solis PCA Ambulatory Infusion Pump, 481*f*
Calculations, heparin, 548-574, 559*b*
administration, 549
chapter review for, 561-568
answers to, 570-574
clinical reasoning on, 560
answers to, 570
of dosage
based on weight, 549, 555-559, 556*b*, , 556*f*, , 557*b*, , 558*b*, , 559*b*, , 561
IV solution, 552-555, 553*b*
subcutaneous, 551-552, 551*b*, , 552*b*
dosage strengths for, 549, 549*b*, , 551
NGN case study, 561
practice problems on, 559-560
answers to, 569-570
Calibrated droppers, 141-142, 142*f*, , 299, 299*b*, , 299*f*
Calibrated spoons, 142, 300, 300*f*, , 301*b*
Caplets, 277
caps, 152*t*
Capsules, 279-280
calculating dosages involving, 280-287, 280*b*, , 281*b*, , 282*b*, , 287*b*
dosage strength in, 280-281
maximum number in, 281*b*
practice problems for, 288-297, 326-330
determining the dosage, 287, 287*b*
gelatin, 279, 280*f*
opening, 280
problems, variation of, 286-287
ratio and proportion in, 44
sprinkle, 280
timed-release, 280*f*
types of, 279
variation of problems, 286
Carpuject, 334, 334*f*
Cartridge, 334, 334*f*
CBDA. *See* Computer-based drug administration
CD, 152*t*
Celsius, converting between Fahrenheit, 107-108, 108*f*, , 118

formulas for, 108-109
Centi, 71, 72*t*
Centigrade, converting between Fahrenheit, 107-108, 108*f*, , 118
formulas for, 108-109
Centimeters (cm), 70, 109
Central line, 474
Change, percent of, 59-60, 59*b*, , 61
Chart, for medication administration, 136
Charting
of IV fluid, 99*f*
of IV solutions, 471
of IV therapy, 528, 528*b*
Chemical name, on medication orders, 154, 154*f*
Chest circumference, 109
Chewable tablets, 279, 280*f*
Children
administering oral medications to, 143-144, 144*b*, , 144*f*
IV therapy and, 629-630, 630*b*, , 630*f*
medication errors in, 131
Client, right, 133
Client education, 138-139
Client identifiers, 133
Client's full name, in medication orders, 153
Clock, traditional *vs*. military, 119-120
cm (centimeters), 109
Combined medications, medication labels, 192-194, 193*b*, 193*f*, 194*f*
Comparison
of decimals, 27-28, 27*b*
of fractions, 8-10, 8*b*
of percents and ratios, 56
Completion times, 115-117
flow rate, intravenous calculations, 523-525, 523*b*
dimensional analysis, 525*b*
formula method, 524*b*
practice problems, 525-526
ratio and proportion (fraction format), 525*b*
ratio and proportion (linear format), 524*b*
Complex fraction, 8
Computer-based drug administration (CBDA), 169
Computer-controlled dispensing system, 170-171, 171*f*
Computer prescriber order entry (CPOE), medication errors and, 128
Computerized physician/practitioner order entry, 165
Computerized physician/prescriber order entry (CPOE), 151
Computers
for medication administration, 169
for medication orders, 151, 165
Concentration, after reconstitution, 385, 387, 392
Continuous IV infusions, 467
Continuous subcutaneous insulin infusion (CSII pump), 438
Control numbers, on medication labels, 191
Controlled substance schedule, medication labels for, 192
Conversion, 88-89, 89*b*, , 102*b*
between Celsius and Fahrenheit, 107-108, 108*f*, , 118
formulas for, 108-109
between systems, 93-95
chapter review for, 102-105, 118-120
answers to, 106, 120-121
of decimal to percent, 53-54, 53*b*, , 54*b*
defined, 88

equivalents to remember in, 88*t*
of fractions, 8
to percent, 53, 53*b*
methods of, 89-91
conversion factor, 89
dimensional analysis as, 92, 94-95
moving decimal points as, 89-90
using ratio and proportion as, 90-91, 90*b*
for military time, 113-115, 114*f*., 119-120
of percentages to fraction, decimals, and ratios, 52-54
practice problems for, 90, 92-93, 101-102, 109, 110-111, 112, 113, 115, 117
answers to, 106, 120-121
of ratio to percent, 54, 54*b*
relating to length, 109-111, 110*b*., 118
relating to weight, 111-113, 119
within same system, 92
Conversion factors, 257, 258
for converting between systems, 93, 94, 95
for dimensional analysis, 92
equivalents as, 90
for input and output, 96-100
for moving decimal points, 89-90
Coumadin, 6
Court-ordered assisted outpatient treatment, 137
CPOE. *See* Computerized physician/prescriber order entry
CR, 152*t*
Creams, in percentage, 51, 56
Critical care calculations, 575-600, 575*b*
chapter review for, 588-592
answers to, 594-600
clinical reasoning for, 587
answers to, 594
for developing titration table, 582-585, 582*t*., 583*b*., 584*b*., 584*t*., 585*b*., 585*t*., 594*t*., 600*t*
for dosages based on mcg/kg/min, 579-580, 579*b*., 580*b*
for dosages per hour or per minute, 577-578, 577*b*., 578*b*
of IV flow rates for titrated medications, 580-582, 580*b*., 581*b*-582*b*
for medications ordered in milligrams per minute, 578-579, 578*b*., 579*b*
NGN case study, 587
practice problems for, 586
answers to, 593-594
for rate in mL/hr, 576-577, 576*b*., 577*b*
Critical thinking, medication administration and, 130, 130*b*
Cross-cancellation, 14
Crushing tablets, 280
Cubic centimeter (cc), 75
for intake and output calculations, 96
Cup (c, C), 81
household/metric equivalents of, 82, 82*f*., 83*b*
in medication orders, 152*t*
metric equivalent of, 97
ounces in, 97

D

Daily doses, 615-618, 616*b*., 617*b*., 618*b*
Daily fluid maintenance, calculation of, 634-635, 634*b*-635*b*., 634*t*
Date
in medication administration records, 168
order was written, in medication order, 153
Deci, 71, 72*t*

Deciliter (dL), 73*b*
Decimal points
medication errors and, 23, 25
movement of
conversion by, 89-90
division by, 32-33, 32*b*
multiplication by, 30-31, 30*b*, , 31*b*
use of, 23
zeros after, 26*b*
zeros before, 26*b*
Decimals, 23-39, 25*b*, , 36*b*
adding and subtracting, 28-29, 28*b*
changing
to fractions, 35, 35*b*, , 36*b*
fractions to, 34-35, 34*b*
chapter review for, 36-39
answers to, 39
comparing value of, 27-28, 27*b*
definition of, 23
dividing, 31-33
by decimal, 32, 32*b*
by decimal movement, 32-33, 32*b*
by whole number, 32, 32*b*
multiplying, 29-31, 29*b*, , 30*b*
by decimal movement, 30-31, 31*b*
to percentage, conversion of, 53-54, 53*b*, , 54*b*, , 61
percentage to, conversion of, 52-54, 52*b*, , 60
place values for, 24, 24*b*
practice problems for, 26-27, 28, 29, 31, 34, 35
answers to, 39
in proportion, solving for *x*, , 43
reading and writing, 25-27, 25*b*, , 26*b*
rounding off, 33, 33*b*
Deka, 72*t*
Denominator
of fraction, 6, 7*f*, , 57
lowest common, 9
of ratio, 40
Depo-Provera label, 344, 344*f*
Desired (D), dosage, 239, 239*b*, , 240
Detemir (Levemir), 430
dil., 152*t*
Diluent, 384
Dimensional analysis, 627
in calculating injectable medications, 353-354, 355, 355*b*, , 356
conversions in
intake and output calculations, 97, 98
within same system, 92
steps for, 92*b*
between systems, 94, 95
in drops per minute using a formula, 497-502, 498*b*, , 499*b*, , 500*b*, , 501*b*, , 502*b*
practice problems, 503
for medications in units, 357-358, 358*b*, , 359
shortcut method for, 504, 504*b*, , 506*b*
practice problems, 505
Dimensional analysis method, 257-274
chapter review, 266-272
answers to, 273-274
dosage calculation using, 259, 264*b*

setting up, 262, 264*b*
steps in, 260
practice problems, 259, 259*b*, , 264
answers, 272, 272*b*, , 273, 273*b*
understanding the basics of, 257
make conversions using, 258, 258*b*, , 259*b*
performing conversions using, 258
Disintegrating tablets, 279
Displacement factor, 387
Distractions, medication errors and, 128
Distribution systems, medication, 169-172
barcode medication delivery in, 172, 172*f*
chapter review for, 176-177
answers to, 178
computer-controlled dispensing system in, 170-171, 171*f*
practice problems for, 174
answers to, 178
unit-dose system in, 170, 170*f*
Divided dosage, 610*b*
Dividend, 31
Division
of decimals, 31-33
by decimal, 32, 32*b*
by decimal movement, 32-33
by whole number, 32, 32*b*
of fractions, 15-16, 15*b*
Division factor, 503, 503*b*
Divisor, 31
“Do Not Use” List, 151, 686
Doctor’s orders, 165
Documentation
in medication administration, 166, 168, 169*b*
right, 136
Dosage(s)
administration, 191
body weight and, 111
calculating, for parenteral medications, 351-352, 352*b*
according to the syringe, 352
clinical reasoning for, 363
guidelines for, 352
maximum volume to administer, in single intramuscular site, 352*t*
with mixing medications, in same syringe, 359
practice problems for, 360-363
divided, 610*b*
expressed as ratio or percent, 183, 184*f*
factors that influence, 130-131
for heparin
based on weight, 549, 555-559, 556*f*, , 559*b*
for IV solutions, 552-555, 553*b*
subcutaneous, 551-552, 551*b*, , 552*b*, , 552*f*
in medications order, 155
percentages and, 51
range, 610*b*
recommended, 610*b*
right, 134-135
safe, 610*b*
single, 610-613, 610*b*, , 611*b*, , 612*b*, , 613*b*
total daily, 610*b*
in units, 348-349

usual, on medication labels, 191
Dosage calculation, 238-256
errors, 238*b*, , 242*b*
formula for, 238
involving tablets and capsules, 280-287, 280*b*, , 281*b*, , 282*b*, , 287*b*
dosage strength in, 280-281
maximum number in, 281*b*
practice problems for, 288-297, 326-330
of liquid oral medications, 297-298
other medication measurements used in, 83, 84*f*
points to remember, 242
ratio and proportion in, 44-45, 45*b*, , 216-237, 216*b*, , 219*b*, , 236*b*
chapter review for, 223-233
fraction format, 217-218, 217*b*
linear format, 217
practice problems for, 219-222
with reconstitution, for injectable solutions, 398-400
Dosage desired (D), 239, 239*b*, , 240
Dosage quality (Q), 239, 239*b*, , 240, 240*b*, , 242*b*
Dosage strength (H), 239, 239*b*, , 240, 260
after reconstitution, for injectable solution, 386, 386*f*, , 387
for heparin, 549, 549*b*, , 551*f*
on medication labels, 183-185, 183*f*, , 184*f*, , 185*b*
in parenteral labels, 344, 344*t*
Dosage unknown (x), 239, 239*b*, , 240, 242*b*
Dram, 81
Drop (gtt), in medication orders, 152*t*
Drop chamber, 494, 494*f*
Drop factor, 494, 494*f*
Drop factor constant, 503, 503*b*
Droppers, calibrated, 299, 299*b*, 299*f*
Drops, 83
Drug distribution systems, 165-177, 173*b*. *See also* Medication distribution system
Drug measurement, units or systems of, 240*b*
DS, 152*t*
Dual-scale version, of insulin syringe, 341, 342*f*

E

EC, 152*t*
Elderly, medication administration in, 131-133, 132*f*
Electronic infusion devices, 480-481, 481*f*, 575*b*
Electronic medication administration records (eMARs), 166, 167*b*, 167*f*
bar-code medication system and, 172
documentation of, 168
right documentation and, 136
Electronic volumetric pumps, 480
elix, 152*t*
Elixir, 297
eMARs. *See* Electronic medication administration records
Enoxaparin (Lovenox), 549, 550*f*
Enteral feeding, reconstitution of solutions for, 401-402, 401*f*, 402*b*
Enteral medications, 276
Enteric-coated tablets, 278
Equipments, intravenous, 466-488, 483*b*
ADD-Vantage system as, 397-398, 397*f*, 478-479, 479*f*
Baxter Mini-Bag Plus as, 478-479, 479*f*
chapter review on, 484-486
answers to, 488
clinical reasoning on, 484

answer to, 487
electronic infusion devices as, 480-481, 481*f*
infusion devices for home care setting as, 481-482, 482*b*
infusion set as, 475, 476*f*
IV piggyback as, 467, 477, 477*f*, 479*b*
needleless system as, 474, 475*b*
practice problems, 483-484
answers on, 487
primary and secondary lines as, 475-477, 476*f*
tandem piggyback setup as, 477*f*
volume control devices as, 479, 480*f*
Equivalents, 257, 258
among metric and household systems, 88, 88*t*
Errors, medication, 124-130, 127*b*
causes of, 127
consequences of, 124
contributing factors to, 127
decimal points and, 23, 25
due to documentation, 136
due to dosage errors, 134
due to incorrect transcription, 151
due to look-alike/sound-alike medications, 134
due to route of administration, 135
due to time and frequency of administration, 136
Error-Prone Abbreviations and, 151, 687-693
with heparin, 548-549
in high-alert medications, 128
with infusion pumps, 134
with insulin, 430
miscommunication of, 127
outcomes from, 124-125
polypharmacy and, 131
prevention of, 128-129, 128*b*
in elderly, 131-133, 132*f*
medication reconciliation for, 138
nurse's role in, 128-130, 129*f*
organizations involved in, 125-127
technological advances in, 128
Expiration date, on medication labels, 190-191, 190*f*, 191*b*
Extended-release tablets, 279
Extremes, of proportions, 41

F

Factor-label method, 257
Fahrenheit, converting between Celsius and, 107-108, 108*f*, 118
formulas for, 108-109
FDA. *See* Food and Drug Administration
Feeding, enteral, reconstitution of solutions for, 401-402, 401*f*, 402*b*
50 unit Lo-Dose, 341
Film tab, 279
Filter needle, 333
First fraction, 264
fl, 152*t*
fld, 152*t*
Flow rate, intravenous calculations of, 489-493, 493*b*
completion time, 523-525, 523*b*
dimensional analysis, 525*b*
formula method, 524*b*
practice problems, 525-526

ratio and proportion (fraction format), 525*b*
ratio and proportion (linear format), 524*b*
in drops per minute using a formula, 496-502
dimensional analysis, 497-502, 498*b*, 499*b*, 500*b*, 501*b*, 502*b*
in drops per minute with large volumes of fluid, 526, 526*b*
practice problems, 527
infusion and, 520-525
dimensional analysis, 521*b*, 522*b*
formula method, 521*b*, 522*b*
practice problems, 525-526
ratio and proportion (fraction format), 521*b*, 522*b*
ratio and proportion (linear format), 521*b*, 522*b*
for infusion pumps in mL/hr, 489-493, 490*b*
dimensional analysis, 491*b*, 492*b*
formula method, 490*b*, 491*b*
ratio and proportion (fraction format), 491*b*, 492*b*
ratio and proportion (linear format), 491*b*
in manually regulated IVs, 494-496, 494*f*, 495*b*, 495*f*, 496*b*
practice problems, 496
mL/hr when time period is less than, 1 hour, 492, 493*b*
dimensional analysis, 493*b*
formula method, 493*b*
ratio and proportion (fraction format), 493*b*
ratio and proportion (linear format), 492*b*
practice problems, 494
recalculation of, 516-519, 516*b*, 517*b*, 519*b*
course of action, 518*b*
determining the percentage of change, 519, 519*b*
dimensional analysis, 518*b*
practice problems, 520
shortcut method, 518*b*
using shortcut method, 517*b*
shortcut method for, 503-505, 503*b*, 504*b*, 506*b*
using dial-flow controller, 506-507, 506*f*, 507*b*
Food and Drug Administration (FDA), 548
in medication errors prevention, 81, 126
Form of preparation, on medication labels, 185, 185*b*
Formula method, 238-256
calculating a problem with an unknown with, 514-516, 514*b*, 515*b*, 516*b*
practice problems, 516
for calculating flow rates, 496-502, 497*b*
guidelines for calculating gtt/min, 497*b*
in calculating injectable medications, 353, 354, 355, 357
calculating using, 627
chapter review, 244-254
answers to, 256
double-check, 242*b*
for medications in units, 358-359
memorize, 242
practice problems, 243-244
answers to, 255-256
using, 239, 239*b*
Fraction format, 217-218, 217*b*
Fractional system, 81. *See also* Apothecary system
Fractions, 6-22
addition, 11-12, 11*b*
changing, to decimals, 34-35, 34*b*
changing decimals to, 35, 35*b*, 36*b*
chapter review for, 17-20, 22

comparing, 8-9, 8*b*
complex, 8
denominator of, 6, 7*f*, 57
lowest common, 9
dividing, 15-16, 15*b*
fundamental rules of, 9*b*
improper, 8
changed to improper fraction, 8
changed to mixed number, 12
mixed number, 8
multiplying, 14-15, 14*b*
numerator of, 6, 7*f*, 57
to percentage, conversion of, 53, 53*b*, 60
percentage to, conversion of, 52-54, 52*b*, 60
practice problems for, 10, 11, 16-17, 21
proper, 7
proportion as, 41, 42
solving for *x*, 43-44
ratio as, 40-41, 42
reducing, 10-11, 10*b*
subtracting, 12-14, 12*b*
using borrowing, 13-14, 13*b*
from whole number, 13, 13*b*
types of, 7-9
of whole number, 8
subtracting fractions from, 13, 13*b*
Fragmin (dalteparin sodium), 549
Freezing point, 107
Frequency, of administration, on medication orders, 156

G

Gastrostomy tube (GT), 152*t*
medications administered via, 280
Gauze, measurement of, 109
Gelatin capsule, 280*f*
Gelcaps, 279-280, 280*f*
Generic name
on medication labels, 179-180, 180*b*, 180*f*, 181*b*
on medication orders, 154, 154*b*, 154*f*
Geriatric dosage calculation, based on weight, 602, 602*b*
Glass, ounces in, 97
Glucose monitoring systems, 439
Glulisine (Apidra), 430
Glycemic control, 445
Gram (g), 73*b*, 74, 77*b*
to kilogram, converting, 607-608, 607*b*, 608*b*, 609*b*
in medication orders, 152*t*
GT. *See* Gastrostomy tube
gtt (drops), in medication orders, 152*t*

H

h, 152*t*
Handwritten medication administration record, 166, 166*f*, 167*b*
documentation of, 168
errors and, 169
HDC. *See* Hypodermocylsis
Head circumference, 110
Hecto, 72*t*
Heparin

errors on, 548-549
as high-alert medication, 548
intravenous (IV) solutions, 552, 553*b*
mL/hr from units/hr, 553-555, 553*b*, 554*b*, 555*b*
units per hour, 552-555, 553*b*
labels for, reading, 549-551, 551*b*, 551*f*
Heparin calculations, 548-574, 559*b*
administration, 549
chapter review for, 561-568
answers to, 570-574
clinical reasoning on, 560
answers to, 570
of dosage
based on weight, 549, 555-559, 556*b*, 556*f*, 557*b*, 558*b*, 559*b*, 561
IV solution, 552-555, 553*b*
subcutaneous, 551-552, 551*b*, 552*b*
dosage strengths for, 549, 549*b*, 551
NGN case study, 561
practice problems on, 559-560
answers to, 569-570
Heparin protocols, 555, 555*b*, 556*f*
Heparin sodium for injection
dosage strength for, 549*b*
reading, labels for, 549-551, 551*b*, 551*f*
Herbal medications, 139
High-alert medications, 127, 694, 695
heparin as, 548
insulin as, 429
Home care setting
infusion devices for, 481-482, 482*b*
medication administration in, 139-140
Household system, 81-87, 84*b*, 84*f*
chapter review for, 85-86
answers to, 87
metric equivalents of, 82, 83*b*
particulars of, 82, 82*f*, 83*b*
practice problems for, 84-85
answers to, 86
Household systems, equivalents among, 88
Household utensils, for medication dosages, 83
hr, 152*t*
Humalog insulin (lispro), 430
Hydrogen peroxide (H_2O_2), dilution of, 404
Hypodermic syringes
large-capacity, 339-343, 339*b*, 339*f*, 341*b*
small, 336
Hypodermocylsis (HDC), 467

I

Improper fraction, 8
changed to mixed number of, 12
changed to mixed number of, 8
Inch (in), metric equivalent of, 110, 110*b*
Incision, measurement of, 109
Infusion
flow rate, intravenous calculations, 520-525
dimensional analysis, 521*b*, 522*b*
formula method, 521*b*, 522*b*
practice problems, 525-526

ratio and proportion (fraction format), 521*b*, 522*b*
ratio and proportion (linear format), 521*b*, 522*b*
intravenous
administration by IV push, 529-532, 529*b*, 532*b*
injection ports, 475
intermittent, 467, 474, 474*f*
intermittent venous access devices and, 474
IV push and, 467
practice problems, administration by IV push, 532-533
sites for, 474
volumes of, 514
Infusion pumps, 481*f*, 482
calculating flow rates for, in mL/hr, 489-493, 490*b*
dimensional analysis, 491*b*, 492*b*
formula method, 490*b*, 491*b*
ratio and proportion (fraction format), 491*b*, 492*b*
ratio and proportion (linear format), 491*b*
medication errors with, 134
mL/hr when time period is less than, 1 hour, 492, 493*b*
dimensional analysis, 493*b*
formula method, 493*b*
ratio and proportion (fraction format), 493*b*
ratio and proportion (linear format), 492*b*
problems, 482
Infusion times, intravenous calculations of
for large volumes of fluid, 526, 526*b*
practice problems, 527
for small volumes of fluid, 527, 527*b*
practice problem, 528
total, 498, 526
from volume and hourly rate ordered, 498, 498*b*, 526
volumes and, 514, 526
Inhalation, medication administration via, 140-141
Initials, in medication administration records, 167*f*, 168
Input
calculation of, 96-100
dimensional analysis for, 97
defined, 96
dimensional analysis for, 97
flow sheet for, 96*f*
Insertion, medication administration via, 140
Instillation, medication administration via, 140
Institute for Safe Medication Practices (ISMP), 548
fractions and, 6
list of Error-Prone Abbreviations, 151, 687-693
in medication errors prevention, 125
metric measurement of medication, 81
Institute of Medicine (IOM), in medication errors prevention, 125
Insulin, 429-463, 451*b*
action times for, 432-435, 433*f*
practice problems, 435-436
appearance of, 436-437
basal/bolus, 446
chapter review on, 452-460
answers to, 461-463
clinical reasoning questions on, 452
answers to, 461-462
dosages, measured, 440
errors with, 430

as high-alert medications, 429
labels for, 430-432, 431*f*, 432*b*
measuring two types of, in same syringe, 447-450, 448*b*, 448*f*, 449*b*
orders for, 444-446, 445*b*
premixed, fixed, and combination, 437, 437*b*, 437*f*
preparing single dosage of, in insulin syringe, 447, 447*b*
regular, 430
types of, 430
U-100, 430
label for, 431*f*
measuring, 439-440, 440*b*
U-500, 430, 431, 432*b*
label for, 431*f*
Insulin administration, 438-441
in double-scale 1-mL syringe, 441*f*, 442, 442*b*
in Lo-Dose syringe, 440, 441*f*
1-mL (100-unit) capacity syringe, 440
practice problems on, 442-443
answers to, 461
in single-scale 1-mL syringe, 441*f*, 442
in U-100 syringe, 444
in U-500 syringe, 441*f*, 444
practice problems on, 444
via insulin pen, 439
via insulin pumps, 438-439, 438*f*
Insulin coverage, 445-446, 446*b*
Insulin glargine (Lantus), 430
Insulin pen, 439
Insulin pumps, 438-439, 438*f*
Insulin syringes, 143*f*, 341-343, 342*b*, 342*f*
double-scale, 440, 441*f*, 442*b*
Lo-Dose, 341, 342*f*, 440, 441*f*
measuring, two types of insulin in same, 447-450, 448*b*, 448*f*, 449*b*
practice problems on, 443
answers to, 461
single-scale, 440, 441*f*, 447*b*
U-500, 440, 441*f*
Intake and output (I&O)
calculation of, 96-100
conversion factor in, 96-100
dimensional analysis for, 97, 98
in charting, of intravenous (IV) solutions, 471
defined, 96
flow sheet for, 96, 96*f*, 100*f*
Intermediate insulin, 432, 434*f*
Intermittent IV infusions, 467
Intermittent IV infusions piggyback, intravenous calculations, 507-509
dimensional analysis, 508*b*, 509*b*
formula method, 508*b*, 509*b*
practice problems, 510-511
ratio and proportion (fraction format), 509*b*
ratio and proportion (linear format), 509*b*
Intermittent peripheral infusion devices (IPIDs), 474
Intermittent venous access devices, 474
International time, conversion between traditional and, 113-115, 114*f*, 119-120
International unit, 83
Interruptions, medication errors and, 128
Intradermal (ID) route, 140
of parenteral medications, 332

Intramuscular (IM) route, 140
maximum volume to administer, in single intramuscular site, 352*t*
Intranasal administration, 141
Intravenous (IV) bag, height of, 475
Intravenous (IV) bolus, 475
Intravenous calculations, 489-547
for administration of medications by IV push, 529-532, 529*b*, 532*b*
practice problems, 532-533
of amount of medication in a specific amount of solution, 512-513, 513*b*
dimensional analysis, 512*b*, 513*b*
practice problems, 513
ratio and proportion (fraction format), 512*b*, 513*b*
ratio and proportion (linear format), 512*b*
answers, 538-547, 538*b*
chapter review for, 533-537
answers to, 543-547, 543*b*, 546*b*
clinical reasoning, 533
answers to, 543
of flow rate, 489-493, 493*b*
completion time, 523-525, 523*b*
in drops per minute using a formula, 496-502, 497*b*
in drops per minute with large volumes of fluid, 526, 526*b*
infusion and, 520-525
for infusion pumps in mL/hr, 489-493, 490*b*, 493*b*
in manually regulated IVs, 494-496, 494*f*, 495*b*, 495*f*, 496*b*
mL/hr when time period is less than, 1 hour, 492, 493*b*
practice problems, 494
recalculation of, 516-519, 516*b*, 517*b*, 519*b*
shortcut method for, 503-505, 503*b*, 504*b*, 506*b*
using dial-flow controller, 506-507, 506*f*, 507*b*
of infusion times
for large volumes of fluid, 526, 526*b*
for small volumes of fluid, 527, 527*b*
total, 498, 526
from volume and hourly rate ordered, 498, 498*b*, 526
volumes and, 526
of intermittent IV infusions piggyback, 507-509
dimensional analysis, 508*b*, 509*b*
formula method, 508*b*, 509*b*
practice problems, 510-511
ratio and proportion (fraction format), 509*b*
ratio and proportion (linear format), 509*b*
in manually regulated, 494-496, 494*f*, 495*b*, 495*f*, 496*b*
practice problems, 496
Intravenous (IV) equipments, 466-488, 483*b*
ADD-Vantage system as, 397-398, 397*f*, 478-479, 479*f*
Baxter Mini-Bag Plus as, 478-479, 479*f*
chapter review on, 484-486
answers to, 488
clinical reasoning on, 484
answer to, 487
electronic infusion devices as, 480-481
infusion devices for home care setting as, 482*b*
infusion set as, 475, 476*f*
IV piggyback as, 467, 477, 477*f*, 479*b*
needleless system as, 474
practice problems on, 483-484
answers on, 487
primary and secondary lines as, 475-477, 476*f*

tandem piggyback setup as, 477*f*
volume control devices as, 479, 480*f*
Intravenous flow rate, 475
calculation of
completion time, 523-525, 523*b*
in drops per minute using a formula, 496-502, 497*b*
in drops per minute with large volumes of fluid, 526, 526*b*
infusion and, 520-525
infusion and completion time, 520-525
for infusion pumps in mL/hr, 489-493, 490*b*, 493*b*
with intermittent IV infusions piggyback, 507-509
in manually regulated IVs, 494-496, 494*f*, 495*b*, 495*f*, 496*b*
mL/hr when time period is less than, 1 hour, 492, 493*b*
practice problems, 494
recalculation of, 516-519, 516*b*, 517*b*, 519*b*
shortcut method for, 503-505, 503*b*, 504*b*, 506*b*
for titrated medications, 580-582, 580*b*, 581*b*-582*b*
using dial-flow controller, 506-507, 506*f*, 507*b*
Intravenous (IV) fluids
administration of, 475-482
methods used for, 480-482
calculating percentage of solute in, 471-473
charting of, 99*f*, 471, 472*f*
types of, 467, 467*b*
Intravenous (IV) infusion pumps
calculation of flow rates for, in mL/hr, 489-493, 490*b*, 493*b*
dimensional analysis, 491*b*, 492*b*
formula method, 490*b*, 491*b*
ratio and proportion (fraction format), 491*b*, 492*b*
ratio and proportion (linear format), 491*b*
mL/hr when time period is less than, 1 hour, 492, 493*b*
dimensional analysis, 493*b*
formula method, 493*b*
ratio and proportion (fraction format), 493*b*
ratio and proportion (linear format), 492*b*
Intravenous (IV) infusion set, 475
Intravenous infusion times, calculation of
for large volumes of fluid, 526, 526*b*
practice problems, 527
for small volumes of fluid, 527, 527*b*
practice problem, 528
using dimensional analysis, 527*b*
total, 498, 526
from volume and hourly rate ordered, 498, 498*b*, 526
volumes and, 514, 526
Intravenous infusions
administration by IV push, 529-532, 529*b*, 532*b*
dimensional analysis, 530*b*, 531*b*, 532*b*
formula method, 530*b*, 532*b*
practice problems, 532-533
ratio and proportion (fraction format), 530*b*, 531*b*, 532*b*
ratio and proportion (linear format), 530, 531*b*
injection ports, 475
intermittent, 467, 474, 474*f*
intermittent venous access devices and, 474
IV push and, 467
sites for, 474
volumes of, 526
Intravenous infusions piggyback, intermittent, calculation of, 507-509

dimensional analysis, 508*b*, 509*b*
formula method, 508*b*, 509*b*
practice problems, 510-511
ratio and proportion (fraction format), 509*b*
ratio and proportion (linear format), 509*b*
Intravenous (IV) injection ports, 475
Intravenous (IV) lines
centra, 474
peripheral, 474
peripherally inserted central catheter (PICC), 474
primary and secondary, 475-477, 476*f*
Intravenous (IV) medications, calculation using volume control set, 631-633, 631*b*, 632*b*, 633*b*
Intravenous (IV) orders, 471, 471*b*, 471*f*
Intravenous piggyback (IVPB), 152*t*, 467, 475, 479*b*
Intravenous push, 467
Intravenous (IV) route, 140
maximum volume to administer, in single intramuscular site, 352*t*
of parenteral medications, 332
Intravenous (IV) sites, 474
Intravenous (IV) solutions, 466-488, 467*b*, 482*b*
abbreviations for, 467, 468*b*
additives to, 468, 471*b*
chapter review on, 484-486
answers to, 488
charting of, 99*f*, 471, 472*f*
clinical reasoning on, 484
answer to, 487
components, 468
delivery methods, 467, 467*b*
heparin, calculation of, 552, 553*b*
mL/hr from units/hr, 553-555, 553*b*, 554*b*, 555*b*
units per hour, 552-555, 553*b*
labels for, 468, 469*f*, 470*f*
in percentage, 51, 55, 56
practice problems on, 483-484
answers on, 487
strength of, 468, 468*b*, 469*f*
Intravenous syringes, 339
Intravenous (IV) therapy
chapter review on, 484-486
answers to, 488
charting of, 471, 472*f*, 528, 528*b*
children and, 629-630, 630*b*, 630*f*
clinical reasoning on, 484
answer to, 487
delivery methods, 467, 467*b*
intake and output (I&O) in, charting of, 471, 472*f*
monitoring infusion of, 528
orders for, 471, 471*b*, 471*f*
points to remember on, 483*b*
practice problems on, 483-484
answers on, 487
push medications, 528-529, 529*b*, 532*b*
practice problems, 532-533
Intravenous tubing
calculation of IV flow rates and, 495
drop chamber, 494*f*
drop factor, 494*f*, 496*b*
macrodrop, 494*f*, 495-496, 496*b*

microdrop, 496
I&O. *See* Intake and output
IOM. *See* Institute of Medicine
Irrigation, of solutions and soaks, 404-405, 405*b*
ISMP. *See* The Institute for Safe Medication Practices
IV medication protocols, 466
IVPB. *See* Intravenous piggyback
IVSS, 152*t*

K

Kangaroo pump, 401, 401*f*
Kendra's Law, 137
Kilo, 71, 72*t*
Kilograms (kg), 73*b*
conversion of
grams to, 607-608, 607*b*, 608*b*, 609*b*
ounces to, 111-112
to pounds, 112, 606-607, 606*b*, 607*b*
pounds to, 111, 604-606, 604*b*, 605*b*, 606*b*
household equivalent of, 92
in medication orders, 152*t*
KVO, 152*t*

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