PRINCIPLES *of* General, Organic, & Biological Chemistry

Janice Gorzynski Smith

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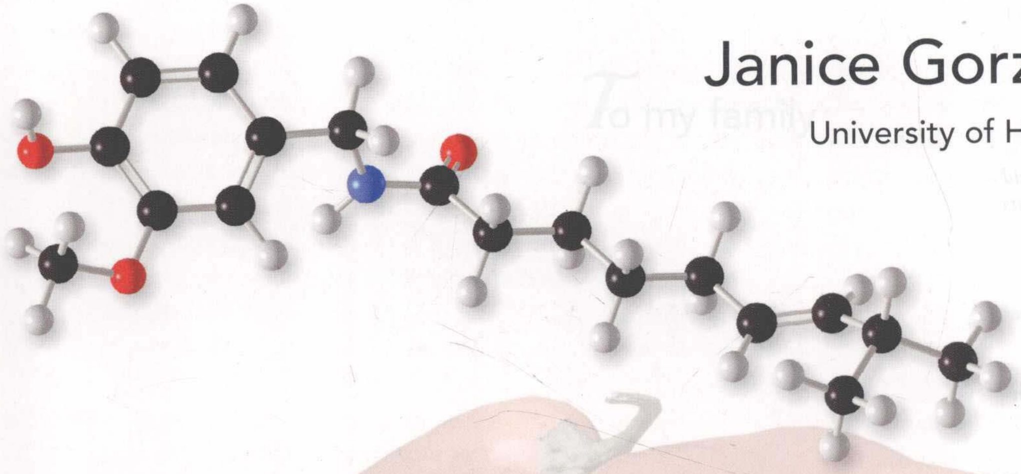

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PRINCIPLES OF GENERAL, ORGANIC, & BIOLOGICAL CHEMISTRY

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To my family

About the Author

Janice Gorzynski Smith was born in Schenectady, New York, and grew up following the Yankees, listening to the Beatles, and water skiing on Sacandaga Reservoir. She became interested in chemistry in high school, and went on to major in chemistry at Cornell University where she received an A.B. degree *summa cum laude.* Jan earned a Ph.D. in Organic Chemistry from Harvard University under the direction of Nobel Laureate E. J. Corey, and she also spent a year as a National Science Foundation National Needs Postdoctoral Fellow at Harvard. During her tenure with the Corey group she completed the total synthesis of the plant growth hormone gibberellic acid.

Following her postdoctoral work Jan joined the faculty of Mount Holyoke College, where she was employed for 21 years. During this time she was active in teaching organic chemistry lecture and lab courses, conducting a research program in organic synthesis, and serving as department chair. Her organic chemistry class was named one of Mount Holyoke's "Don't-miss courses" in a survey by *Boston* magazine. After spending two sabbaticals amidst the natural beauty and diversity in Hawai‘i in the 1990s, Jan and her family moved there permanently in 2000. She is a faculty member at the University of Hawai‘i at Mānoa, where she has taught a one-semester organic and biological chemistry course for nursing students as well as the two-semester organic chemistry lecture and lab courses. She has also served as the faculty advisor to the student affiliate chapter of the American Chemical Society. In 2003, she received the Chancellor's Citation for Meritorious Teaching.

Jan resides in Hawai‘i with her husband Dan, an emergency medicine physician. She has four children: Matthew and Zachary (scuba photo on p. 167); Jenna, a law student at Temple University in Philadelphia; and Erin, a 2006 graduate of Brown University School of Medicine and co-author of the *Student Study Guide/Solutions Manual* for this text. When not teaching, writing, or enjoying her family, Jan bikes, hikes, snorkels, and scuba dives in sunny Hawai‘i, and time permitting, enjoys travel and Hawaiian quilting.

Preface

Students who are planning a career within the allied health field are required to gain exposure to the many ways in which chemistry is intrinsic to and influences life. This textbook is written for students who have an interest in nursing, nutrition, environmental science, food science, and a wide variety of other health-related professions. The content of this book is designed for an introductory chemistry course with no chemistry prerequisite, and is suitable for either a one- or two-semester course. This text relates the principal concepts of general, organic, and biological chemistry to the world around us, and in this way illustrates how chemistry explains many aspects of daily life.

The learning style of today's students relies heavily on visual imagery. In this text, new concepts are introduced one at a time, keeping the basic themes in focus, and breaking down complex problems into manageable chunks of information. Relevant, interesting applications are provided for all basic chemical concepts. Diagrams and figures are annotated to help teach concepts and reinforce the major themes of chemistry, while molecular art illustrates and explains common everyday phenomena. Students learn step-by-step problem solving throughout the chapter within sample problems and *How To* boxes. Students are given enough detail to understand basic concepts, such as how oral contraceptives prevent pregnancy and how a catalytic converter removes pollutants from automobile exhaust.

Teaching chemistry for over 20 years at both a private liberal arts college and a large state university has given me a unique perspective with which to write this text. I have found that students arrive with vastly different levels of preparation and widely different expectations for their college experience. As an instructor and now an author I have tried to channel my love and knowledge of chemistry into a form that allows this spectrum of students to understand chemical science more clearly, and then see everyday phenomena in a new light. My interactions with thousands of students in my long teaching career have profoundly affected the way I teach and write about chemistry. My hope is that this text and its Learning System will help students better understand and appreciate the world of chemistry. Please feel free to email me with any comments or questions at jgsmith@hawaii.edu.

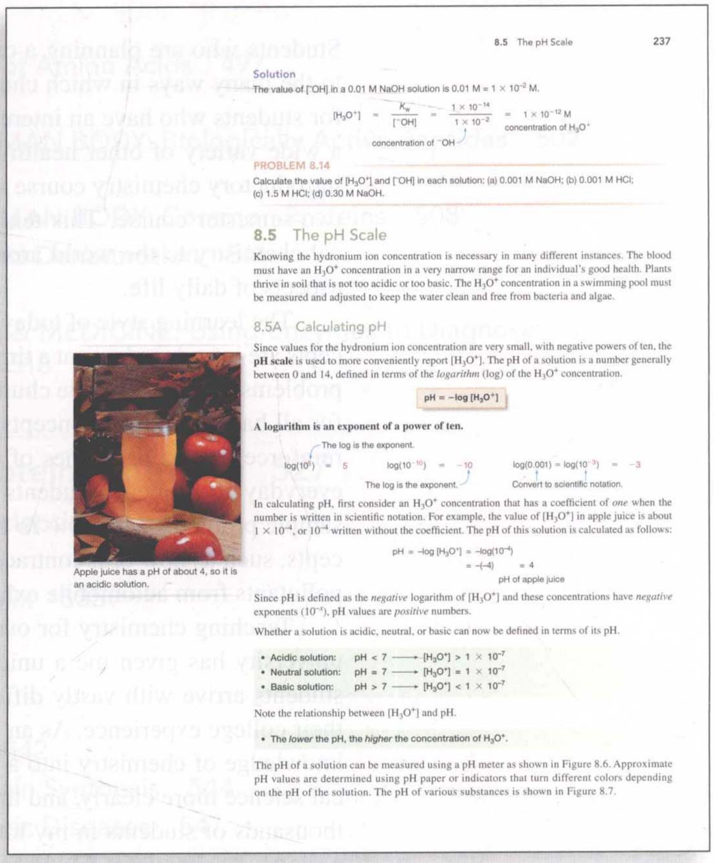
The Construction of a Learning System

Writing a textbook and its supporting learning tools is a multifaceted endeavor. McGraw-Hill's 360° Development Process is an ongoing, market-oriented approach to building accurate and innovative Learning Systems. It is dedicated to continual large scale and incremental improvement, driven by multiple customer feedback loops and checkpoints. This is initiated during the early planning stages of new products and intensifies during the development and production stages, and then begins again upon publication, in anticipation of the next version of each print and digital product. This process is designed to provide a broad, comprehensive spectrum of feedback for refinement and innovation of learning tools for both student and instructor. The 360° Development Process includes market research, content reviews, faculty and student focus groups, course- and product-specific symposia, accuracy checks, and art reviews, all guided by carefully selected Content Advisors.

The Learning System Used in *Principles of General, Organic, & Biological Chemistry*

Writing Style

A succinct writing style weaves together key points of general, organic, and biological chemistry, along with attention-grabbing applications to consumer, environmental, and health-related fields. Concepts and topics are broken into small chunks of information that are more easily learned.



8.5 The pH Scale 237

Solution

The value of $[^-\text{OH}]$ in a 0.01 M NaOH solution is 0.01 M = 1×10^{-2} M.

$$[\text{H}_3\text{O}^+] = \frac{K_w}{[^-\text{OH}]} = \frac{1 \times 10^{-14}}{1 \times 10^{-2}} = 1 \times 10^{-12}\ \text{M}$$

concentration of $^-$OH

concentration of H_3O^+

PROBLEM 8.14

Calculate the value of $[\text{H}_3\text{O}^+]$ and $[^-\text{OH}]$ in each solution: (a) 0.001 M NaOH; (b) 0.001 M HCl; (c) 1.5 M HCl; (d) 0.30 M NaOH.

8.5 The pH Scale

Knowing the hydronium ion concentration is necessary in many different instances. The blood must have an H_3O^+ concentration in a very narrow range for an individual's good health. Plants thrive in soil that is not too acidic or too basic. The H_3O^+ concentration in a swimming pool must be measured and adjusted to keep the water clean and free from bacteria and algae.

8.5A Calculating pH

Since values for the hydronium ion concentration are very small, with negative powers of ten, the **pH scale** is used to more conveniently report $[\text{H}_3\text{O}^+]$. The pH of a solution is a number generally between 0 and 14, defined in terms of the *logarithm* (log) of the H_3O^+ concentration.

$$\boxed{\text{pH} = -\log\,[\text{H}_3\text{O}^+]}$$

Apple juice has a pH of about 4, so it is an acidic solution.

A logarithm is an exponent of a power of ten.

The log is the exponent.

$$\log(10^5) = 5 \qquad \log(10^{-10}) = -10 \qquad \log(0.001) = \log(10^{-3}) = -3$$

The log is the exponent. Convert to scientific notation.

In calculating pH, first consider an H_3O^+ concentration that has a coefficient of *one* when the number is written in scientific notation. For example, the value of $[\text{H}_3\text{O}^+]$ in apple juice is about 1×10^{-4}, or 10^{-4} written without the coefficient. The pH of this solution is calculated as follows:

$$\begin{aligned}\text{pH} = -\log\,[\text{H}_3\text{O}^+] &= -\log(10^{-4}) \\ &= -(-4) \quad = 4\end{aligned}$$

pH of apple juice

Since pH is defined as the *negative* logarithm of $[\text{H}_3\text{O}^+]$ and these concentrations have *negative* exponents (10^{-x}), pH values are *positive* numbers.

Whether a solution is acidic, neutral, or basic can now be defined in terms of its pH.

- Acidic solution: $\text{pH} < 7 \longrightarrow [\text{H}_3\text{O}^+] > 1 \times 10^{-7}$
- Neutral solution: $\text{pH} = 7 \longrightarrow [\text{H}_3\text{O}^+] = 1 \times 10^{-7}$
- Basic solution: $\text{pH} > 7 \longrightarrow [\text{H}_3\text{O}^+] < 1 \times 10^{-7}$

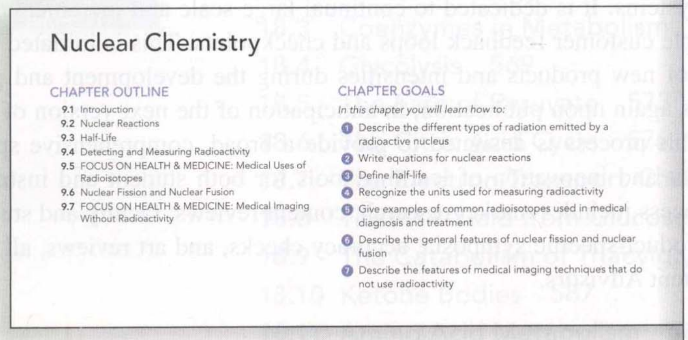
Note the relationship between $[\text{H}_3\text{O}^+]$ and pH.

- The *lower* the pH, the *higher* the concentration of H_3O^+.

The pH of a solution can be measured using a pH meter as shown in Figure 8.6. Approximate pH values are determined using pH paper or indicators that turn different colors depending on the pH of the solution. The pH of various substances is shown in Figure 8.7.

Chapter Goals, Tied to End-of-Chapter Key Concepts

Chapter Goals at the beginning of each chapter identify what students will learn, and are tied numerically to the end-of-chapter Key Concepts, which serve as bulleted summaries of the most important concepts for study.



Nuclear Chemistry

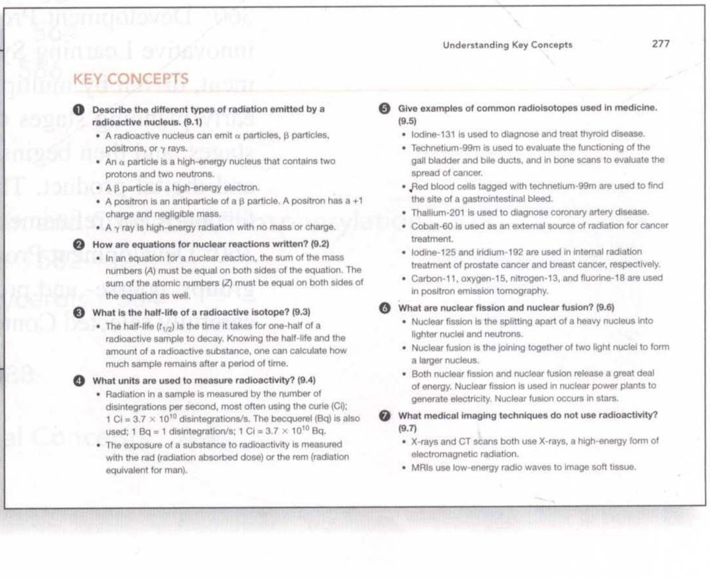
CHAPTER OUTLINE

9.1 Introduction
9.2 Nuclear Reactions
9.3 Half-Life
9.4 Detecting and Measuring Radioactivity
9.5 FOCUS ON HEALTH & MEDICINE: Medical Uses of Radioisotopes
9.6 Nuclear Fission and Nuclear Fusion
9.7 FOCUS ON HEALTH & MEDICINE: Medical Imaging Without Radioactivity

CHAPTER GOALS

In this chapter you will learn how to:

❶ Describe the different types of radiation emitted by a radioactive nucleus
❷ Write equations for nuclear reactions
❸ Define half-life
❹ Recognize the units used for measuring radioactivity
❺ Give examples of common radioisotopes used in medical diagnosis and treatment
❻ Describe the general features of nuclear fission and nuclear fusion
❼ Describe the features of medical imaging techniques that do not use radioactivity



Understanding Key Concepts 277

KEY CONCEPTS

❶ **Describe the different types of radiation emitted by a radioactive nucleus. (9.1)**
- A radioactive nucleus can emit α particles, β particles, positrons, or γ rays.
- An α particle is a high-energy nucleus that contains two protons and two neutrons.
- A β particle is a high-energy electron.
- A positron is an antiparticle of a β particle. A positron has a +1 charge and negligible mass.
- A γ ray is high-energy radiation with no mass or charge.

❷ **How are equations for nuclear reactions written? (9.2)**
- In an equation for a nuclear reaction, the sum of the mass numbers (*A*) must be equal on both sides of the equation. The sum of the atomic numbers (*Z*) must be equal on both sides of the equation as well.

❸ **What is the half-life of a radioactive isotope? (9.3)**
- The half-life ($t_{1/2}$) is the time it takes for one-half of a radioactive sample to decay. Knowing the half-life and the amount of a radioactive substance, one can calculate how much sample remains after a period of time.

❹ **What units are used to measure radioactivity? (9.4)**
- Radiation in a sample is measured by the number of disintegrations per second, most often using the curie (Ci); 1 Ci = 3.7×10^{10} disintegrations/s. The becquerel (Bq) is also used; 1 Bq = 1 disintegration/s; 1 Ci = 3.7×10^{10} Bq.
- The exposure of a substance to radioactivity is measured with the rad (radiation absorbed dose) or the rem (radiation equivalent for man).

❺ **Give examples of common radioisotopes used in medicine. (9.5)**
- Iodine-131 is used to diagnose and treat thyroid disease.
- Technetium-99m is used to evaluate the functioning of the gall bladder and bile ducts, and in bone scans to evaluate the spread of cancer.
- Red blood cells tagged with technetium-99m are used to find the site of a gastrointestinal bleed.
- Thallium-201 is used to diagnose coronary artery disease.
- Cobalt-60 is used as an external source of radiation for cancer treatment.
- Iodine-125 and iridium-192 are used in internal radiation treatment of prostate cancer and breast cancer, respectively.
- Carbon-11, oxygen-15, nitrogen-13, and fluorine-18 are used in positron emission tomography.

❻ **What are nuclear fission and nuclear fusion? (9.6)**
- Nuclear fission is the splitting apart of a heavy nucleus into lighter nuclei and neutrons.
- Nuclear fusion is the joining together of two light nuclei to form a larger nucleus.
- Both nuclear fission and nuclear fusion release a great deal of energy. Nuclear fission is used in nuclear power plants to generate electricity. Nuclear fusion occurs in stars.

❼ **What medical imaging techniques do not use radioactivity? (9.7)**
- X-rays and CT scans both use X-rays, a high-energy form of electromagnetic radiation.
- MRIs use low-energy radio waves to image soft tissue.

Macro-to-Micro Illustrations

Visualizing molecular-level representations of macroscopic phenomena is critical to the understanding of any chemistry course. Many illustrations in this text include photos or drawings of everyday objects, paired with their molecular representation, to help students visualize and understand the chemistry behind ordinary things. Many illustrations of the human body include magnifications for specific anatomic regions, as well as representations at the microscopic level, for today's visual learners.

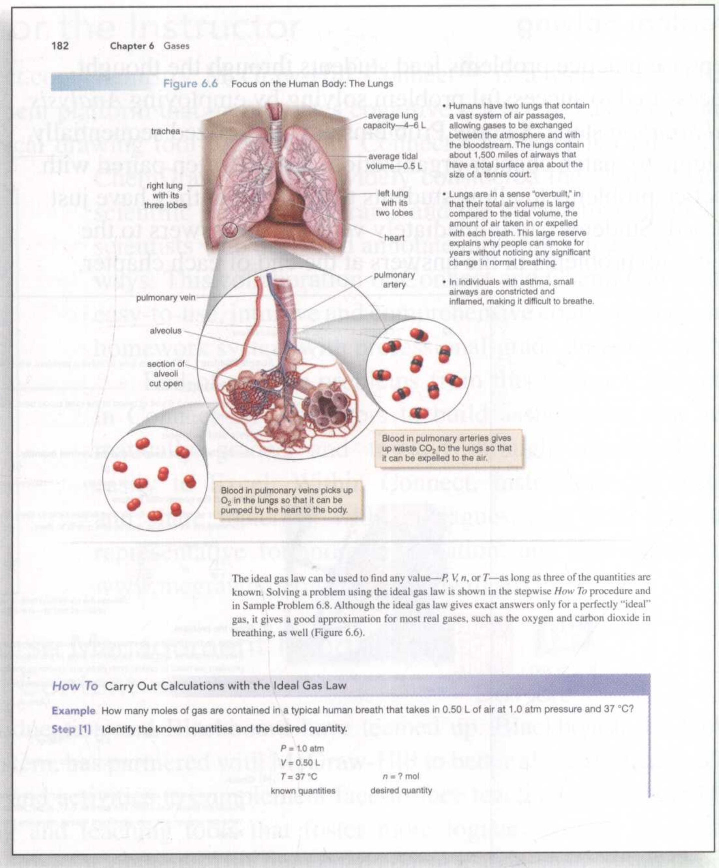


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Figure 6.6 Focus on the Human Body: The Lungs

- Humans have two lungs that contain a vast system of air passages, allowing gases to be exchanged between the atmosphere and with the bloodstream. The lungs contain about 1,500 miles of airways that have a total surface area about the size of a tennis court.
- Lungs are in a sense "overbuilt," in that their total air volume is large compared to the tidal volume, the amount of air taken in or expelled with each breath. This large reserve explains why people can smoke for years without noticing any significant change in normal breathing.
- In individuals with asthma, small airways are constricted and inflamed, making it difficult to breathe.

Blood in pulmonary arteries gives up waste CO_2 to the lungs so that it can be expelled to the air.

Blood in pulmonary veins picks up O_2 in the lungs so that it can be pumped by the heart to the body.

The ideal gas law can be used to find any value—*P*, *V*, *n*, or *T*—as long as three of the quantities are known. Solving a problem using the ideal gas law is shown in the stepwise *How To* procedure and in Sample Problem 6.8. Although the ideal gas law gives exact answers only for a perfectly "ideal" gas, it gives a good approximation for most real gases, such as the oxygen and carbon dioxide in breathing, as well (Figure 6.6).

How To Carry Out Calculations with the Ideal Gas Law

Example How many moles of gas are contained in a typical human breath that takes in 0.50 L of air at 1.0 atm pressure and 37 °C?

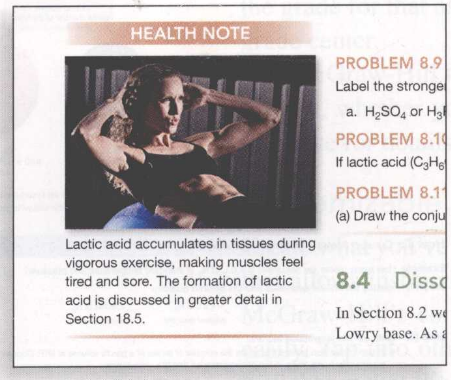
Step [1] **Identify the known quantities and the desired quantity.**

$P = 1.0$ atm
$V = 0.50$ L
$T = 37$ °C
known quantities

$n = ?$ mol
desired quantity

Applications

Relevant, interesting applications of chemistry to everyday life are included for all basic chemical concepts. These are interspersed in margin-placed Health Notes, Consumer Notes, and Environmental Notes, as well as sections entitled "Focus on Health & Medicine," "Focus on the Environment," and "Focus on the Human Body."



HEALTH NOTE

Lactic acid accumulates in tissues during vigorous exercise, making muscles feel tired and sore. The formation of lactic acid is discussed in greater detail in Section 18.5.

PROBLEM 8.9

Label the stronge

a. H_2SO_4 or H_3

PROBLEM 8.10

If lactic acid (C_3H_6

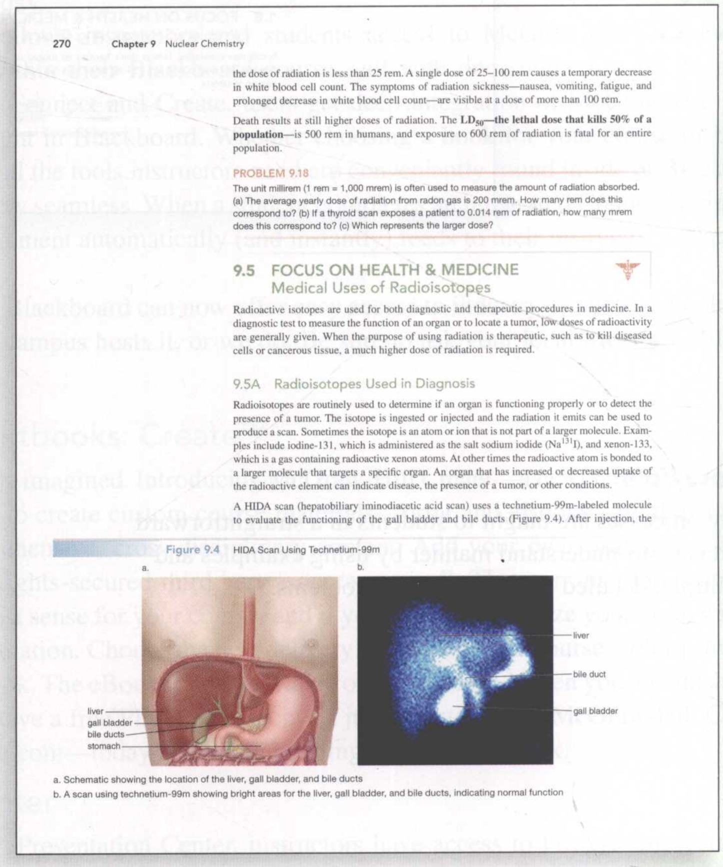
PROBLEM 8.11

(a) Draw the conju

8.4 Disso

In Section 8.2 we

Lowry base. As a



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the dose of radiation is less than 25 rem. A single dose of 25–100 rem causes a temporary decrease in white blood cell count. The symptoms of radiation sickness—nausea, vomiting, fatigue, and prolonged decrease in white blood cell count—are visible at a dose of more than 100 rem.

Death results at still higher doses of radiation. The **LD_{50}—the lethal dose that kills 50% of a population**—is 500 rem in humans, and exposure to 600 rem of radiation is fatal for an entire population.

PROBLEM 9.18

The unit millirem (1 rem = 1,000 mrem) is often used to measure the amount of radiation absorbed. (a) The average yearly dose of radiation from radon gas is 200 mrem. How many rem does this correspond to? (b) If a thyroid scan exposes a patient to 0.014 rem of radiation, how many mrem does this correspond to? (c) Which represents the larger dose?

9.5 FOCUS ON HEALTH & MEDICINE
Medical Uses of Radioisotopes

Radioactive isotopes are used for both diagnostic and therapeutic procedures in medicine. In a diagnostic test to measure the function of an organ or to locate a tumor, low doses of radioactivity are generally given. When the purpose of using radiation is therapeutic, such as to kill diseased cells or cancerous tissue, a much higher dose of radiation is required.

9.5A Radioisotopes Used in Diagnosis

Radioisotopes are routinely used to determine if an organ is functioning properly or to detect the presence of a tumor. The isotope is ingested or injected and the radiation it emits can be used to produce a scan. Sometimes the isotope is an atom or ion that is not part of a larger molecule. Examples include iodine-131, which is administered as the salt sodium iodide ($Na^{131}I$), and xenon-133, which is a gas containing radioactive xenon atoms. At other times the radioactive atom is bonded to a larger molecule that targets a specific organ. An organ that has increased or decreased uptake of the radioactive element can indicate disease, the presence of a tumor, or other conditions.

A HIDA scan (hepatobiliary iminodiacetic acid scan) uses a technetium-99m-labeled molecule to evaluate the functioning of the gall bladder and bile ducts (Figure 9.4). After injection, the

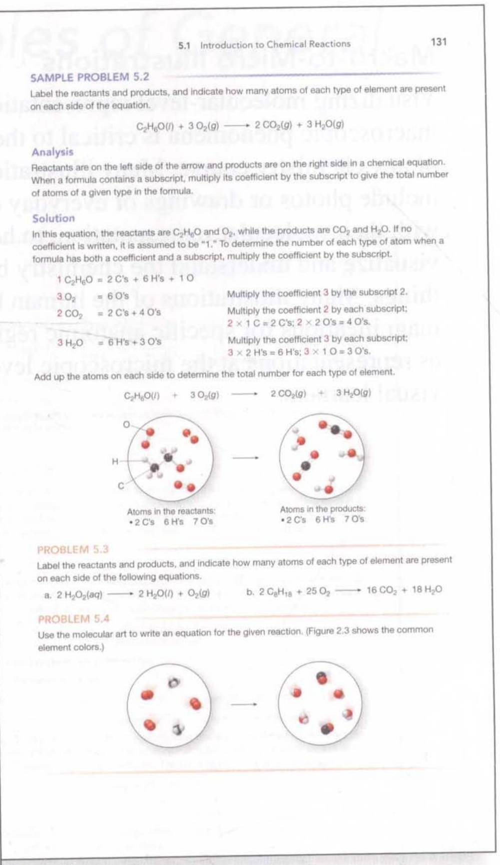
Figure 9.4 HIDA Scan Using Technetium-99m

a. Schematic showing the location of the liver, gall bladder, and bile ducts

b. A scan using technetium-99m showing bright areas for the liver, gall bladder, and bile ducts, indicating normal function

Problem Solving

Stepwise practice problems lead students through the thought process tied to successful problem solving by employing *Analysis and Solution* steps. Sample Problems are categorized sequentially by topic to match chapter organization, and are often paired with practice problems to allow students to apply what they have just learned. Students can immediately verify their answers to the follow-up problems in the answers at the end of each chapter.



5.1 Introduction to Chemical Reactions 131

SAMPLE PROBLEM 5.2

Label the reactants and products, and indicate how many atoms of each type of element are present on each side of the equation.

$$C_2H_6O(l) + 3\ O_2(g) \longrightarrow 2\ CO_2(g) + 3\ H_2O(g)$$

Analysis

Reactants are on the left side of the arrow and products are on the right side in a chemical equation. When a formula contains a subscript, multiply its coefficient by the subscript to give the total number of atoms of a given type in the formula.

Solution

In this equation, the reactants are C_2H_6O and O_2, while the products are CO_2 and H_2O. If no coefficient is written, it is assumed to be "1." To determine the number of each type of atom when a formula has both a coefficient and a subscript, multiply the coefficient by the subscript.

$1\ C_2H_6O$ = 2 C's + 6 H's + 1 O
$3\ O_2$ = 6 O's — Multiply the coefficient 3 by the subscript 2.
$2\ CO_2$ = 2 C's + 4 O's — Multiply the coefficient 2 by each subscript; 2 × 1 C = 2 C's; 2 × 2 O's = 4 O's.
$3\ H_2O$ = 6 H's + 3 O's — Multiply the coefficient 3 by each subscript; 3 × 2 H's = 6 H's; 3 × 1 O = 3 O's.

Add up the atoms on each side to determine the total number for each type of element.

$$C_2H_6O(l) + 3\ O_2(g) \longrightarrow 2\ CO_2(g) + 3\ H_2O(g)$$

Atoms in the reactants:
• 2 C's 6 H's 7 O's

Atoms in the products:
• 2 C's 6 H's 7 O's

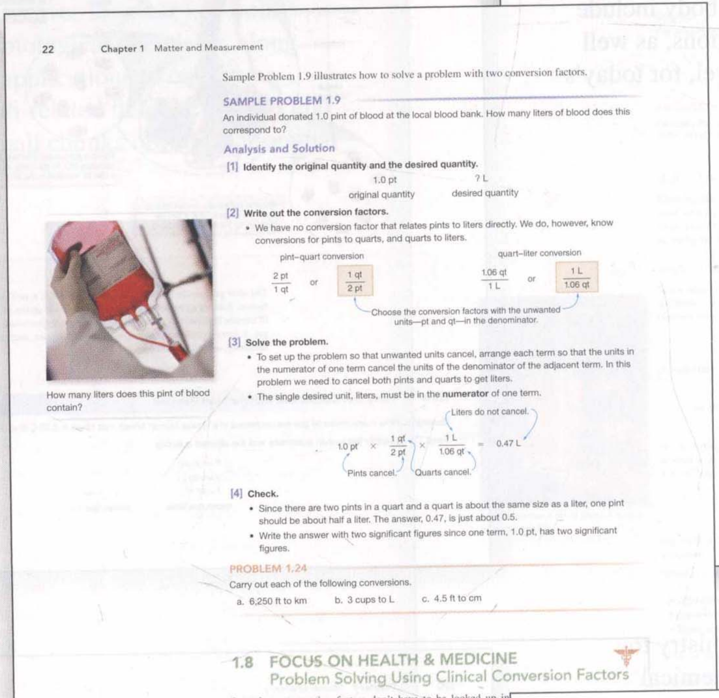
PROBLEM 5.3

Label the reactants and products, and indicate how many atoms of each type of element are present on each side of the following equations.

a. $2\ H_2O_2(aq) \longrightarrow 2\ H_2O(l) + O_2(g)$
b. $2\ C_8H_{18} + 25\ O_2 \longrightarrow 16\ CO_2 + 18\ H_2O$

PROBLEM 5.4

Use the molecular art to write an equation for the given reaction. (Figure 2.3 shows the common element colors.)



22 Chapter 1 Matter and Measurement

Sample Problem 1.9 illustrates how to solve a problem with two conversion factors.

SAMPLE PROBLEM 1.9

An individual donated 1.0 pint of blood at the local blood bank. How many liters of blood does this correspond to?

Analysis and Solution

[1] **Identify the original quantity and the desired quantity.**

1.0 pt — original quantity
? L — desired quantity

[2] **Write out the conversion factors.**

- We have no conversion factor that relates pints to liters directly. We do, however, know conversions for pints to quarts, and quarts to liters.

pint–quart conversion: $\frac{2\ \text{pt}}{1\ \text{qt}}$ or $\boxed{\frac{1\ \text{qt}}{2\ \text{pt}}}$

quart–liter conversion: $\frac{1.06\ \text{qt}}{1\ \text{L}}$ or $\boxed{\frac{1\ \text{L}}{1.06\ \text{qt}}}$

Choose the conversion factors with the unwanted units—pt and qt—in the denominator.

[3] **Solve the problem.**

- To set up the problem so that unwanted units cancel, arrange each term so that the units in the numerator of one term cancel the units of the denominator of the adjacent term. In this problem we need to cancel both pints and quarts to get liters.
- The single desired unit, liters, must be in the **numerator** of one term.

$$1.0\ \text{pt} \times \frac{1\ \text{qt}}{2\ \text{pt}} \times \frac{1\ \text{L}}{1.06\ \text{qt}} = 0.47\ \text{L}$$

Liters do not cancel.
Pints cancel.
Quarts cancel.

[4] **Check.**

- Since there are two pints in a quart and a quart is about the same size as a liter, one pint should be about half a liter. The answer, 0.47, is just about 0.5.
- Write the answer with two significant figures since one term, 1.0 pt, has two significant figures.

How many liters does this pint of blood contain?

PROBLEM 1.24

Carry out each of the following conversions.

a. 6,250 ft to km b. 3 cups to L c. 4.5 ft to cm

1.8 FOCUS ON HEALTH & MEDICINE
Problem Solving Using Clinical Conversion Factors

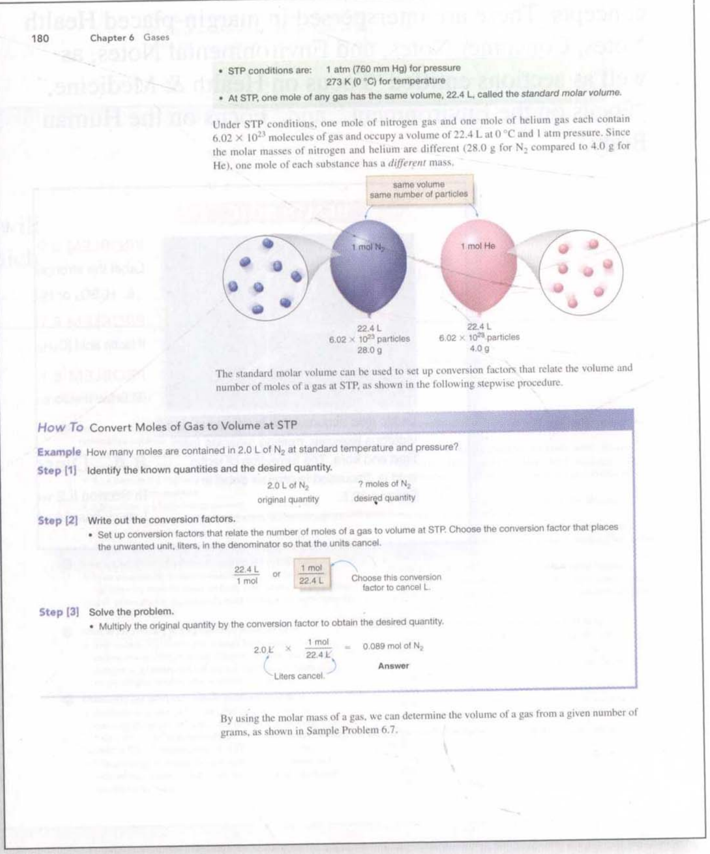
Sometimes conversion factors don't have to be looked up in problem. If a drug is sold as a 250-mg tablet, this fact becomes ligrams to tablets.

$\frac{250\ \text{mg}}{1\ \text{tablet}}$ or $\frac{1\ \text{tablet}}{250\ \text{mg}}$

mg–tablet conversion factors

How To's

Key processes are taught to students in a straightforward and easy-to-understand manner by using examples and multiple, detailed steps to solving problems.



180 Chapter 6 Gases

- STP conditions are: 1 atm (760 mm Hg) for pressure
  273 K (0 °C) for temperature
- At STP, one mole of any gas has the same volume, 22.4 L, called the *standard molar volume.*

Under STP conditions, one mole of nitrogen gas and one mole of helium gas each contain 6.02×10^{23} molecules of gas and occupy a volume of 22.4 L at 0 °C and 1 atm pressure. Since the molar masses of nitrogen and helium are different (28.0 g for N_2 compared to 4.0 g for He), one mole of each substance has a *different* mass.

The standard molar volume can be used to set up conversion factors that relate the volume and number of moles of a gas at STP, as shown in the following stepwise procedure.

How To Convert Moles of Gas to Volume at STP

Example How many moles are contained in 2.0 L of N_2 at standard temperature and pressure?

Step [1] Identify the known quantities and the desired quantity.

2.0 L of N_2 — original quantity
? moles of N_2 — desired quantity

Step [2] Write out the conversion factors.

- Set up conversion factors that relate the number of moles of a gas to volume at STP. Choose the conversion factor that places the unwanted unit, liters, in the denominator so that the units cancel.

$\frac{22.4\ \text{L}}{1\ \text{mol}}$ or $\boxed{\frac{1\ \text{mol}}{22.4\ \text{L}}}$ Choose this conversion factor to cancel L.

Step [3] Solve the problem.

- Multiply the original quantity by the conversion factor to obtain the desired quantity.

$$2.0\ \cancel{\text{L}} \times \frac{1\ \text{mol}}{22.4\ \cancel{\text{L}}} = 0.089\ \text{mol of}\ N_2$$

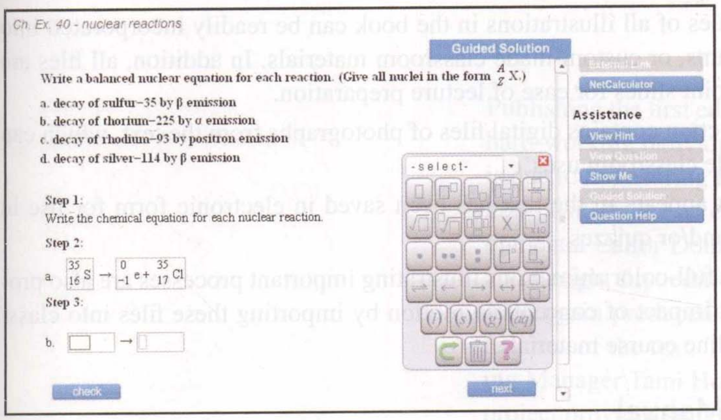
Liters cancel.
Answer

By using the molar mass of a gas, we can determine the volume of a gas from a given number of grams, as shown in Sample Problem 6.7.

Supplements for the Instructor

www.mcgrawhillconnect.com/chemistry McGraw-Hill Connect™ is a web-based, interactive assignment and assessment platform that incorporates cognitive science to customize the learning process. The chemical drawing tool found within Connect Chemistry is CambridgeSoft's ChemDraw, which is widely considered the "gold standard" of scientific drawing programs and the cornerstone application for scientists who draw and annotate molecules, reactions, and pathways. This collaboration of Connect and ChemDraw features an easy-to-use, intuitive and comprehensive course management and homework system with professional-grade drawing capabilities.

End-of-chapter problems from this textbook are served up in Connect for instructors to build assignments that are automatically graded and tracked through reports that export easily to Excel. Within Connect, instructors can also create and share materials with colleagues. Ask your McGraw-Hill representative for more information, and then check it out at www.mcgrawhillconnect.com/chemistry.



Ch. Ex. 40 - nuclear reactions

Write a balanced nuclear equation for each reaction. (Give all nuclei in the form $^{A}_{Z}X$.)

a. decay of sulfur−35 by β emission
b. decay of thorium−225 by α emission
c. decay of rhodium−93 by positron emission
d. decay of silver−114 by β emission

Step 1:
Write the chemical equation for each nuclear reaction.

Step 2:

a. $^{35}_{16}S \rightarrow {}^{0}_{-1}e + {}^{35}_{17}Cl$

Step 3:

b. $\square \rightarrow \square$

Blackboard® Course Management Integration with McGraw-Hill Content

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Presentation Center

Within the Instructor's Presentation Center, instructors have access to PowerPoint lecture outlines, which appear as ready-made presentations that combine art and lecture notes for each chapter of the text. For instructors who prefer to create their lectures from scratch, all illustrations, photos, and tables are pre-inserted by chapter into blank PowerPoint slides.

An online digital library within Connect contains photos, artwork, animations, and other media types that can be used to create customized lectures, visually enhanced tests and quizzes, compelling course websites, or attractive printed support materials. All assets are copyrighted by McGraw-Hill Higher Education, but can be used by instructors for classroom purposes. The visual resources in this collection include:

- **Art** Full-color digital files of all illustrations in the book can be readily incorporated into lecture presentations, exams, or custom-made classroom materials. In addition, all files are pre-inserted into PowerPoint slides for ease of lecture preparation.
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- **Tables** Every table that appears in the text has been saved in electronic form for use in classroom presentations and/or quizzes.
- **Animations** Numerous full-color animations illustrating important processes are also provided. Harness the visual impact of concepts in motion by importing these files into classroom presentations or online course materials.

Instructor's Solutions Manual

This supplement contains complete, worked out solutions for all the end-of-chapter problems in the text. It can be found within the Instructor's Resources for this text on the Connect Companion website at www.mhhe.com/smithprinciples.

Computerized Test Bank Online

A comprehensive bank of test questions prepared by Kathy Thrush Shaginaw/Particular Solutions, Inc. is provided within a computerized test bank, enabling professors to create paper and online tests or quizzes in an easy-to-use program that allows instructors to prepare and access tests or quizzes anywhere, at any time. Instructors can create or edit questions, or drag-and-drop questions, to prepare tests quickly and easily. Tests may be published to their online course, or printed for paper-based assignments.

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Supplements for the Student

Student Study Guide/Solutions Manual

The *Student Study Guide/Solutions Manual,* prepared by Erin Smith Berk and Janice Gorzynski Smith, begins each chapter with a detailed chapter review that is organized around chapter goals and key concepts. The Problem Solving section provides a number of examples for solving each type of problem essential to that chapter. The Self-Test section of each chapter quizzes on chapter highlights, with answers provided. Finally, each chapter ends with the solutions to all in-chapter problems, as well as the solutions to all odd-numbered end-of-chapter problems.

ConnectPlus eBook

McGraw-Hill ConnectPlus eBook takes digital texts beyond a simple PDF. With the same content as the printed book, but optimized for the screen, ConnectPlus has embedded media, including animations and videos, which bring concepts to life and provide "just in time" learning for students. Additionally, fully integrated homework allows students to interact with the questions in the text and determine if they're gaining mastery of the content, and can also be assigned by the instructor.

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List of *How To's*

How To boxes provide detailed instructions for key procedures that students need to master. Below is a list of each *How To* and where it is presented in the text.

List of Applications

Applications make any subject seem more relevant and interesting—for nonmajors and majors alike. The following is a list of the most important biological, medicinal, and environmental applications that have been integrated throughout *Principles of General, Organic, & Biological Chemistry.* Each chapter opener showcases an interesting and current application relating to the chapter's topic.