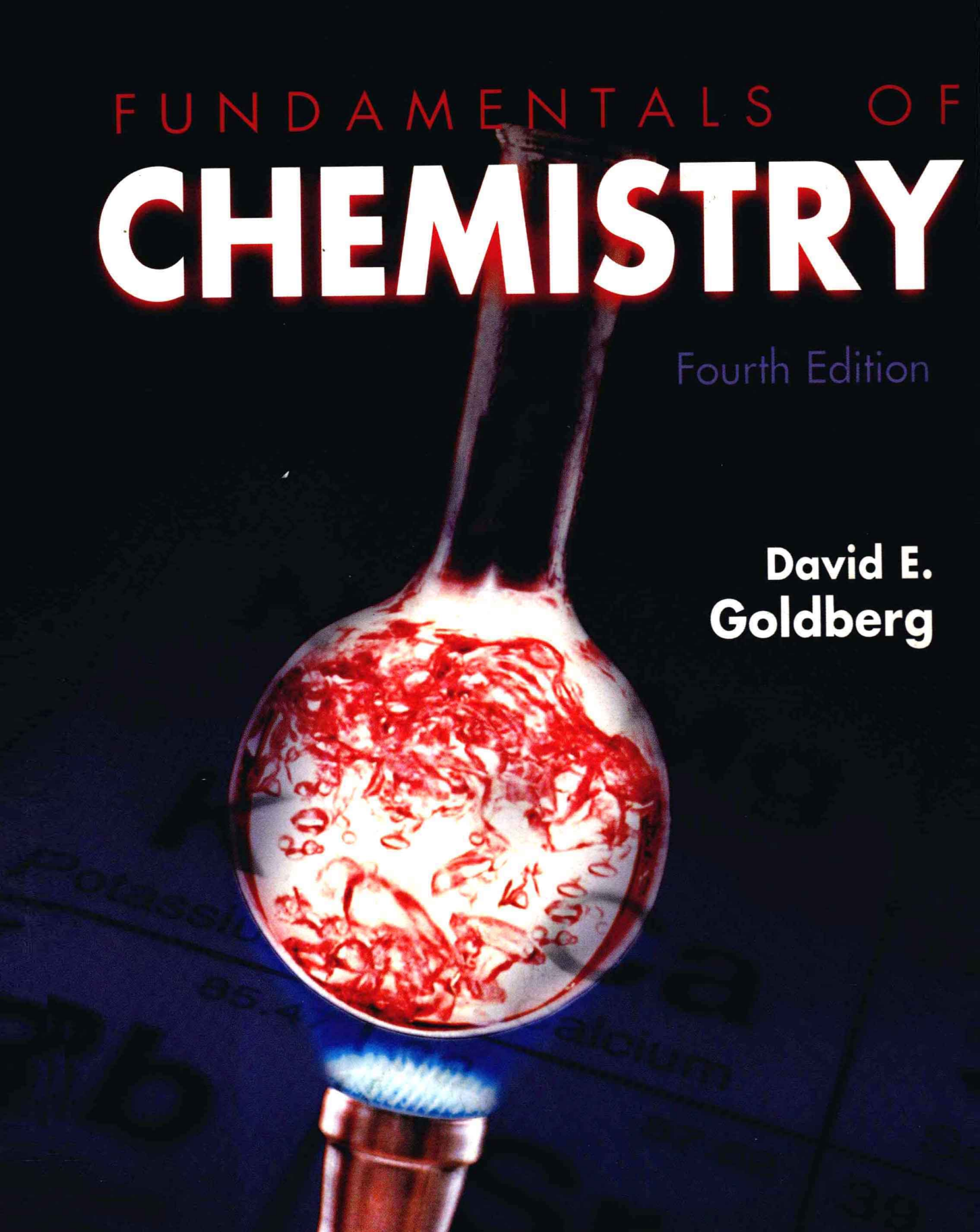
FUNDAMENTALS OF CHEMISTRY

Fourth Edition

David E. Goldberg



FUNDAMENTALS OF CHEMISTRY

Fourth Edition

David E. Goldberg

Brooklyn College

Mc Graw Hill **Higher Education**

Boston Burr Ridge, IL Dubuque, IA Madison, WI New York San Francisco St. Louis
Bangkok Bogotá Caracas Kuala Lumpur Lisbon London Madrid Mexico City
Milan Montreal New Delhi Santiago Seoul Singapore Sydney Taipei Toronto

FUNDAMENTALS OF CHEMISTRY, FOURTH EDITION

This book is printed on acid-free paper.

International 1 2 3 4 5 6 7 8 9 0 VNH/VNH 0 9 8 7 6 5 4 3
Domestic 1 2 3 4 5 6 7 8 9 0 VNH/VNH 0 9 8 7 6 5 4 3

ISBN 0–07–247224–3
ISBN 0–07–121463–1 (ISE)

Publisher: *Kent A. Peterson*
Sponsoring editor: *Thomas D. Timp*
Senior developmental editor: *Shirley R. Oberbroeckling*
Senior project manager: *Gloria G. Schiesl*
Senior production supervisor: *Laura Fuller*
Media project manager: *Jodi K. Banowetz*
Senior media technology producer: *Jeffry Schmitt*
Designer: *K. Wayne Harms*
Cover/interior designer: *Scan Communications Group Inc.*
Cover images: Flask: *Getty Images/L. Lefkowitz;* Background Image: *PhotoDisc-Technology Perspectives*
Lead photo research coordinator: *Carrie K. Burger*
Compositor: *The GTS Companies*
Typeface: *10/12 Times Roman*
Printer: *Von Hoffmann Corporation*

The credits section for this book begins on page 657 and is considered an extension of the copyright page.

Library of Congress Cataloging-in-Publication Data

Goldberg, David E. (David Elliott), 1932–
Fundamentals of chemistry / David E. Goldberg. — 4th ed.
p. cm.
Includes index.
ISBN 0–07–247224–3 (acid-free paper)
1. Chemistry. I. Title.

QD33.2.G65 2004
540—dc21 2002044878
CIP

INTERNATIONAL EDITION ISBN 0–07–121463–1

To my students,
who have taught me
a great deal

Preface

Chemistry is a dynamic and rapidly changing field. It is an extraordinarily interesting subject to study and an intriguing one to teach. The diversity of knowledge of the beginning student presents a unique challenge to the student and to the teacher. *This text is written primarily for use in courses designed to prepare students who wish to pursue a science major requiring a comprehensive course in general chemistry. These students, in most cases, have never taken a course in chemistry or have had limited instruction in the basic math that is required to solve chemistry problems, so a chemistry course can be very threatening to them.*

To address this issue, this text has two major goals:

1. To provide a clear, consistent methodology that a student can follow to develop conceptual and quantitative problem-solving skills.
2. To engage the student by relying heavily on analogies that relate chemistry to daily life.

Develop Problem-Solving Skills

ORGANIZING THEIR THOUGHTS

Students have numerous demands on their time, so helping them organize their thoughts and identifying the key concepts is important. This book has several ways to accomplish this task.

Chapter outline and learning objectives At the beginning of every chapter, the outline of the chapter is listed. The learning objectives are presented to alert the students to the key concepts covered in the chapter. These objectives are also a valuable study tool for the students when they are reviewing.

Review Clues At the beginning of each chapter, there is a list of Review Clues. These clues provide the students the opportunity to go back to previous sections in the book or to Appendix 1 and review or relearn material pertinent to the present chapter.

Summarizing what they have learned Summarizing the chemistry within a chapter can appear daunting. The book guides the student through the summary of the material, ensuring that the student again identifies the key concepts.

VARIOUS PROBLEM-SOLVING METHODS

Many problems are worded so as to show the students that very different questions may sound similar and that the same question may be presented in very different words. This will encourage students to understand concepts rather than memorize solutions.

All Examples have the solutions following the stated problem. The solutions range from a simple statement (Example 1.4 on page 6) to a short explanation (Example 3.1 on page 77) to a step-by-step solution (Example 7.13 on page 193). There are also side-by-side examples with the general method for the technique presented on the left and a specific example of the method on the right (pages 192–93).

After most numbered Examples, a practice problem is presented for the students to practice the problem-solving method. The students will then use these methods to solve the end-of-chapter problems.

Up to 20 **new** end-of-chapter problems have been added to each chapter. All problems have new variables while maintaining the same skill patterns. The end-of-chapter problems provide practice for the student using the skills presented in the chapter. Answers for the problems numbered in red are provided in Appendix 5.

New to this edition is a correlation to ChemSkill Builder by James D. Spain and Harold J. Peters. ChemSkill Builder is an online electronic homework program that generates questions for students in a randomized fashion with a constant mix of variables. Log on at www.chemskillbuilder.com.

SELF-TESTING AND REVIEWING

Snapshot Review A Snapshot Review subsection concludes each section of the book, giving a sentence or two to emphasize a significant point and then a problem or two for student self-testing. The answers to the Snapshot Review problems are presented before the end-of-chapter problems.

Self-Tutorial This end-of-chapter section presents problems in simple form designed as teaching devices. Many are from everyday life, and they emphasize the importance of identifying the information needed to answer questions. By considering different terms that look or sound alike in a single problem, the students can more easily distinguish and learn both. (See Problems 5.2, 5.3, and 5.4 on pages 153 and 154.)

Engaging Student Interest

ANALOGIES

Frequent use of analogies to daily life helps students understand that chemistry problems are not significantly different from everyday problems. For example, calculations involving dozens of pairs of socks and moles of diatomic molecules can be carried out by the same methods (Problems 7.8 and 7.9 on page 200). Oxidizing and reducing agents can be compared conceptually to dish

towels and wet dishes (Example 16.11 on page 434). Specific heat calculations are like those involving room rates at a hotel (Example 14.5 on page 378).

REAL-WORLD PROBLEMS

Students are engaged in the study of a topic by use of a real-world problem. The students easily understand by frequently using analogies to apply the scientific concept to a normal daily event. In working with conceptual problems, the use of chemistry in the real world is brought alive to the student. (See Problem 7.123 on page 204.)

ITEMS OF INTEREST

Periodically throughout the book the students will find Items of Interest within the textual material. These items demonstrate the use of chemistry in the present and future. An example is the industrial Solvay process in Chapter 8 on page 222.

ART PROGRAM

Today's students are much more visually oriented than any previous generation and many are principally visual learners. We have attempted to develop this style of learning through the expanded use of color and illustrations. Each chapter is amply illustrated with accurate, colorful diagrams that clarify difficult concepts and enhance learning.

Content Changes in the Fourth Edition

Chapter One—*New* practice problem; addition of *new* end-of-chapter problems
Chapter Two—*New* example; addition of 20 *new* end-of-chapter problems
Chapter Three—*New* introduction to subatomic particles (Section 3.3); *new* examples and practice problems
Chapter Four—*New* information on wavelength
Chapter Five—Addition of *new* end-of-chapter problems
Chapter Six—*New* information on naming binary compounds; more detailed information on writing formulas; more detailed information on naming acids
Chapter Seven—Addition of *new* end-of-chapter problems
Chapter Eight—More detailed information on types of chemical reactions; addition of *new* end-of-chapter problems
Chapter Nine—*New* table on Electrolytic Properties; *new* end-of-chapter problems
Chapter Ten—*New,* a simple way to determine limiting questions has been introduced; added margin notes; *new* practice problem; *new* example and practice problem; addition of *new* end-of-chapter problems

Chapter Eleven—*New* practice problem; addition of *new* end-of-chapter problems
Chapter Twelve—Addition of *new* end-of-chapter problems
Chapter Thirteen—Addition of *new* end-of-chapter problems
Chapter Fourteen—Addition of *new* end-of-chapter problems
Chapter Fifteen—Explanation of Henry's law is added; *new* section on Percent by Mass with three *new* examples and practice problems and a Snapshot Review; *new* end-of-chapter problems
Chapter Sixteen—Addition of *new* end-of-chapter problems
Chapter Seventeen—A clearer explanation of rates of reaction; addition of *new* end-of-chapter problems
Chapter Eighteen—Addition of *new* end-of-chapter problems
Chapter Nineteen—Introduces condensed formula; a clearer explanation of isomers with a new practice problem; addition of *new* end-of-chapter problems
Chapter Twenty—Clearer explanation on nuclear radioactivity; *new* step-by-step example on half-life; addition of *new* end-of-chapter problems

Supplemental Materials

INSTRUCTOR RESOURCES

Instructor's Manual and Solution Manual is found in the *Fundamentals of Chemistry,* 4th edition Online Learning Center under Instructor Center at http://www.mhhe.com/goldberg. The Instructor's Manual contains the test bank of questions, suggestions on how to organize the course, and complete solutions to the end-of-chapter problems not in Appendix 5.

Instructor Testing and Resource CD-ROM contains the electronic format of the test bank questions allowing instructors to edit or create their own test templates. The Test Bank is formatted for easy integration into the course management systems PageOut, WebCT, and Blackboard.

Digital Content Manager CD-ROM is a multimedia collection of visual resources allowing instructors to utilize artwork from the text in multiple formats to create customized classroom presentation, visual-based tests and quizzes, dynamic course content, or attractive support materials. The Digital Content Manager is a cross-platform CD containing an image library, a photo library, and a table library.

ChemSkill Builder is an online tool containing more than 1500 algorithmically generated questions, each with tutorial feedback. There is a direct correlation between student time investment in this program and increased problem-solving ability. A record of student work is maintained in an online gradebook so that homework can be done at home, in a dorm room, or in a university lab. Log on at www.chemskillbuilder.com.

STUDENT RESOURCES

Online Learning Center is a comprehensive, exclusive website that provides the student access to Web-related activities such as quizzing and other study tools. Log on at http://www.mhhe.com/goldberg.

ChemSkill Builder challenges the student's knowledge of introductory chemistry with an array of individualized problems. The ChemSkill

Builder reference in the text lets the student know which section of ChemSkill Builder to practice for the chemical skills relating to the specific content of the text. Log on at www.chemskillbuilder.com.

How to Study Science is written by Fred Drewes of Suffolk County Community College. This excellent workbook offers students helpful suggestions for meeting the considerable challenge of a science course. It offers tips on how to take notes and how to get the most out of laboratories, as well as how to overcome science anxiety. The book's unique design helps to stir critical thinking skills, while facilitating careful note taking in the part of the student.

3000 Solved Problems in Chemistry is written by David E. Goldberg. This Schaum's solved problem manual provides 3000 solved problems. It provides problem-solving strategies and helpful hints in studying.

How to Solve Word Problems in Chemistry, also written by David E. Goldberg, focuses on techniques for solving word problems.

Acknowledgments

The preparation of a textbook is a family effort, and the quality of the final product is a reflection of the dedication of all the family members. First, I would like to thank my own family, without whose patience and support this project would not have been possible. Second, I would like to thank the scores of my fellow chemists and my students who have taught me much in the past and continue to do so. Learning is a never-ending process, and I continue to learn from my colleagues and students. I would also like to thank the members of my extended family at McGraw-Hill, without whom there would not have been a text: my developmental editor, Shirley Oberbroeckling, and my sponsoring editor, Kent Peterson. I gratefully acknowledge the invaluable help of the following dedicated reviewers, who provided expert suggestions and the needed encouragement to improve the text:

Shawn Allin
Lamar University

Kelly Boebinger
Crafton Hills College

Simon Bott
University of Houston

Donald Bowman
Central Virginia Community College

Dave Bradley
Northeast Mississippi Community College

Kenneth Brown
NW Oklahoma State University

Marshall Cady
Indiana University–New Albany

Donald Cass
College of the Atlantic

James Chapman
Rockhurst University

Wayne Counts
Georgia Southwestern State University

Michael DeGregorio
College of San Mateo

Rosemary Effiong
University of Tennessee–Martin

Thomas Everton
Ventura College

Max Ferguson
Eastern Connecticut State University

Maria Chris Fermin-Ennis
Clayton College & State University

Ted Fickel
Los Angeles Valley College

Jean Fuller-Stanley
Wellesley College

Steven Funck
Harrisburg Area Community College–Harrisburg

Allan Gahr
Gordon College

Roy Garvey
North Dakota State University–Fargo

Thomas Greco
Millersville University

Gamini Gunawandena
Uta Valley State College

Fathi Halaweish
South Dakota State University

James Hardcastle
Texas Woman's University

Ryan Harden
Central Lakes College

Richard Hartmann
University of Wisconsin–Milwaukee

Michael Hay
Pennsylvania State University–Beaver

Michael Heath
Ivy Tech

Grant Holder
Appalachian State University

Gary Holmes
Butler County Community College

Paul Horton
Indian River Community College

Roger House
Moraine Valley Community College

Sally Irwin
Maui Community College

T. Gerald Jackson
University of South Alabama–Mobile

Anton Jensen
Central Michigan University

Martha Joseph
Westminster College

Mohammed Karim
Tennessee State University

Doug Klein
Texas A&M University

Susan Klein
Manchester College

Beata Knoedler
Springfield College

Christa Knotts
Garrett Community College

Richard Langley
Stephen F. Austin University

Gerald Laule
Seminole State College

Laurie LeBlanc
Cuyamaca College

Micaela Leonida
Fairleigh Dickinson–Teaneck

Jimmy Li
College of San Mateo

Joel Liebman
University of Massachusetts–Boston

Glenn Lo
Nicholls State University

John Lowbridge
Madisonville Community College

Scott Luaders
Quincy University

Lynn Maelia
Mount St. Mary College

Lois Marquardt-Casper
Los Angeles Trade Technical College

Garrett McGowan
Alfred University

Lauren McMills
Ohio University

Robert Mentore
Ramapo College of New Jersey

Qui-Chee Mir
Pierce College–Puyallup

Shuping Mpuru
Lenoir Community College

Mary Bethe Neely
University of Colorado–Colorado Springs

Karen Nordell
Lawrence University

Brian Nordstrom
Emory Riddle Aeronautical University–Prescott

Ron Offley
New Mexico State University

Robert Paine
Rochester Institute of Technology

Maria Parr
Trinity College

Said Pazirandeh
College of the Canyons

Jim Phillips
University of Wisconsin–Eau Claire

James Purcell
Manor College

Fred Redmore
Highland Community College

Mike Rodgers
Southeast Missouri State University

Beatriz Ruiz Silva
Los Angeles Trade Technical College

Stanley Rzucidco
Pennsylvania State University

Allen Scism
Central Missouri State University

Carmen Simone
Casper College

Anne Skinner
Williams College

Jane Slezak
Fulton Montgomery Community College

Janice Smith
York College of Pennsylvania

Steven Socal
McHenry County College

Melinda Sorrenson
University of Louisiana–Lafayette

Marjorie Squires
Felician College

Nanette Stevens
Wake Forest University

Margaret Suerth
Illinois Valley Community College

Gershon Sugar
Essex County College

Xiaoping Sun
West Virginia University Institute of Technology

Paris Svoronos
Queensboro Community College

Erach Talaty
Wichita State University

David Taylor
Slippery Rock University

Stephen Templin
Cardinal Stritch University

Gary Trammell
University of Illinois–Springfield

Ana Vande Linde
University of Wisconsin–Stout

Phillip Voegel
Midwestern State University

Shawn White
University of Maryland

Daniel Williams
Kennesaw State University

Stanley Wolfowitz
Essex County College

Meishan Zhao
University of Chicago

Priscilla Zia
Saddleback College

To the Student

This book is designed to help you learn the fundamentals of chemistry. To be successful, you must master the concepts of chemistry and acquire the mathematical skills that are necessary to solve problems in this quantitative science. If your algebra is rusty, you should polish it up. Appendix 1 reviews the algebra used in basic chemistry and also shows how to avoid mistakes while solving chemistry problems with your scientific calculator. The factor label method is introduced in Chapter 2 to show you how to use units to help with problem solutions. You can help yourself by using the standard symbols and abbreviations for various quantities (such as *m* for mass, m for meter, mol for moles, and *M* for molarity). Always use the proper units with your numerical answers; it makes a big difference whether your roommate's pet is 4 inches long or 4 feet long!

Many laws, generalizations, and rules are presented in the study of basic chemistry. Most students can master these. Successful students, however, not only know them, but also know *when to use each one*. Word problems are the biggest hurdle for most students who do have difficulty with chemistry. The best way to learn to do word problems is to practice intensively. Review the Examples and do the Practice Problems until you feel confident that you understand the concepts and techniques involved. (Do not try to memorize solutions; there are too many different ways to ask the same questions, and many similar-sounding questions are actually quite different.) Do the Snapshot Review items at the end of each section. Do as many of the end-of-chapter problems as you possibly can to see whether you have mastered the material.

You should not try to speed-read chemistry. Mere reading of a section will not generally enable full comprehension of the material. You must be able to solve the problems to be sure that you have really mastered the concepts. Many of the problems sound alike but are very different (for example, Problems 5.5, 7.8, 7.9, and 11.11), and many others sound different but are essentially the same (for example, 3.6, 5.10, 8.2, and 8.14). These will help you develop careful reading habits and prepare you for the questions asked on examinations.

Problems from everyday life that are analogous to scientific problems are included to help you understand certain points better (for example, Problems 7.8 and 7.9). Other problems are first presented in parts to help you work through the solution and later appear as a single question, as is more likely to occur on examinations. Some of the problems are very easy; these are generally intended to emphasize an important point. After solving one of these problems, ask yourself why such a question was asked. Make sure you understand the point.

Make sure you understand the scientific meaning of each new term introduced. For example, the word *significant* as used in Chapter 2 means something entirely different from its meaning in everyday conversation; be sure you understand the difference. Key terms are **boldfaced** when they are first introduced in the text. A list of these terms is given at the end of each chapter. A complete glossary of all important terms is provided at the end of the book.

Other materials to aid your study include lists of standard symbols and abbreviations for variables, units, and subatomic particles, found in Appendix 2. A summary of the mathematical equations used in the book is presented in Appendix 3. The solutions to all Practice Problems and selected end-of-chapter problems are provided in Appendices 4 and 5, respectively. The selected end-of-chapter problem numbers are printed in red. A periodic table is printed inside the front cover of the book, and a table of the elements appears inside the back cover. Let these tools help you succeed!

Learning System

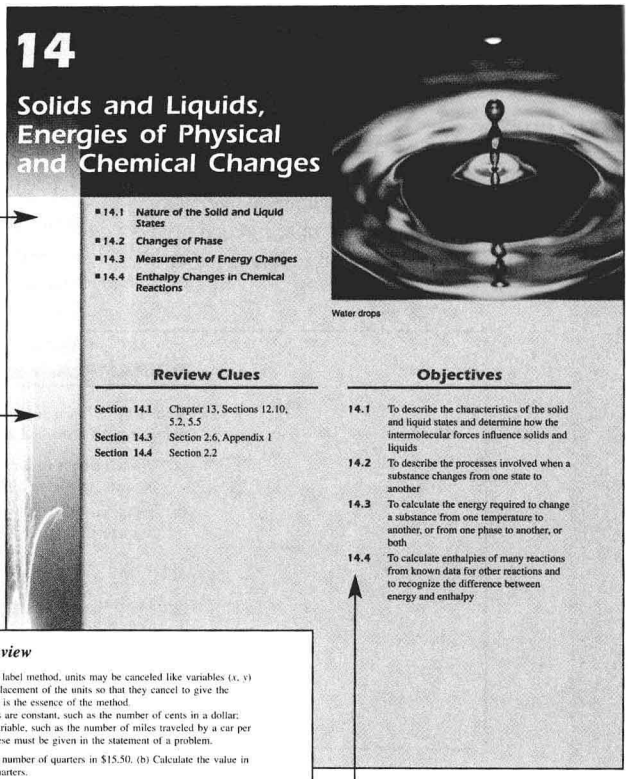
Clear, Consistent Methodology

Chapter Outline

Each chapter begins with an outline that introduces the students to the topics to be presented. This outline also provides the instructor with a quick topic summary for organizing lecture material.

Review Clues

Most chapters have a set of *Review Clues* listed on the chapter's opening page. The students can easily decide if they are ready for the concepts to be presented in the chapter or if they need to go to the clue areas and review material already presented.



14

Solids and Liquids, Energies of Physical and Chemical Changes

- 14.1 Nature of the Solid and Liquid States
- 14.2 Changes of Phase
- 14.3 Measurement of Energy Changes
- 14.4 Enthalpy Changes in Chemical Reactions

Water drops

Review Clues

Section 14.1 Chapter 13, Sections 12.10, 5.2, 5.5
Section 14.3 Section 2.6, Appendix 1
Section 14.4 Section 2.2

Objectives

14.1 To describe the characteristics of the solid and liquid states and determine how the intermolecular forces influence solids and liquids
14.2 To describe the processes involved when a substance changes from one state to another
14.3 To calculate the energy required to change a substance from one temperature to another, or from one phase to another, or both
14.4 To calculate enthalpies of many reactions from known data for other reactions and to recognize the difference between energy and enthalpy

Snapshot Review

At the end of each major section within the chapter, a *Snapshot Review* appears. Students are provided a short synopsis of the section and then asked a question or two to test their comprehension of the concept(s). Answers for the *Snapshot Review* questions are provided at the end of each chapter.

Snapshot Review

- In the factor label method, units may be canceled like variables (x, y) in algebra. Placement of the units so that they cancel to give the desired units is the essence of the method.
- Some factors are constant, such as the number of cents in a dollar; others are variable, such as the number of miles traveled by a car per hour, and these must be given in the statement of a problem.

A. (a) Calculate the number of quarters in $15.50. (b) Calculate the value in dollars of 217 quarters.

Summary

At the end of each chapter is a summary designed to help students identify important concepts and help them review for quizzes and tests.

Summary

In aqueous solutions of ionic compounds, the ions act independently of each other. Soluble ionic compounds are written as their separate ions. You must be familiar with the solubility rules presented in Chapter 8 and recognize that the following types of compounds are strong electrolytes: strong acids in solution, soluble metallic hydroxides, and salts. (Salts, which can be formed as the products of reactions of acids with bases, include all ionic compounds except strong acids and bases and metallic oxides and hydroxides.) Compounds must be *both ionic and soluble* to be written in the form of their separate ions. (Section 9.1)

A net ionic equation describes the actual reaction between ions of compounds in aqueous solution. Ions that do not change at all during the reaction are omitted from the equation; these ions are called spectator ions. One net ionic equation may describe the reactions of many compounds. For example, the net ionic equation

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

summarizes all the reactions described by the statement: "Any soluble silver salt reacts with any soluble ionic chloride to produce (the insoluble) silver chloride." The equation also gives the mole ratios, which the statement does not.

Net ionic equations are balanced only if the numbers of atoms of each element and the net charge on each side of the equation are all balanced. (Section 9.2)

Items for Special Attention

- Strong acids react completely with water to form ions in solution. Metal hydroxides and salts are ionic in the solid state, as well as in solution; however, in the solid state, such compounds are written as complete compounds because the ions are not independent of each other.
- Pure HCl is a strong electrolyte (even though it does not conduct electricity) because its aqueous solution conducts well.
- Most ionic compounds are composed of only one type of positive ion and one type of negative ion. (Of course, more than one of each type of ion may be present in each formula unit.)
- You may be feeling confused about what should be included in net ionic equations. It is easier to remember what should be left out: *Only ions in solution that remain unchanged in solution* should be left out to produce net ionic equations; all other species must be included. Thus, insoluble compounds (ionic or not), covalent compounds, elements, and ions that change in any way between reactants and products are all included. Remembering what to omit—the spectator ions—is much easier!

Chapter Objectives

A list of objectives, based on the major concepts covered in the chapter, enables the students to preview the material and become aware of the topics they are expected to master.

Items for Special Attention

Appearing at the end of every chapter, this unique section highlights and emphasizes key concepts that often confuse students. This section anticipates students' questions and problem areas and helps them avoid many pitfalls.

Engage Students with Analogy

Examples

Many of the examples used within the textual material draw on analogies to common everyday life events such as conceptually comparing dish towels and wet dishes to oxidizing and reducing agents.

EXAMPLE 16.11

A dish towel used to dry dishes can be classified as a drying agent, and the dishes can be classified as wetting agents.

(a) What happens to the drying agent in the process of drying the dishes? What happens to the wetting agent? What happens to the water?

(b) When an oxidation-reduction reaction occurs, what happens to the reducing agent, the oxidizing agent, and the electrons?

Solution

(a) The dish towel is the drying agent; it gets wet. The dishes are the wetting agents; they get dry. The water is transferred from the wetting agent to the drying agent.

(b) The electrons in an oxidation-reduction reaction act like the water in part (a): They are transferred from the reducing agent to the oxidizing agent. The reducing agent is oxidized; the oxidizing agent is reduced. ■

trons occupy *s* subshells. Hydrogen and helium also are in this block, and we have to remember to shift helium to a place beside hydrogen for this purpose. The six periodic groups at the right of the table constitute the *p* block; their last electrons go into *p* subshells. The transition metals belong to the *d* block, and the *f* block consists of the inner transition metals.

Note the similarity between the number of elements in each period in a particular block and the maximum number of electrons permitted in the corresponding type subshell:

Type of subshell or block	*Maximum number of electrons in subshell*	*Number of elements in each period in a particular block*
s	2	2
p	6	6
d	10	10
f	14	14

ChemSkill Builder 4.1

The electronic structure of atoms is the basis for the periodic behavior of the elements.

After each noble gas, a new shell of electrons is started, as is a new period of the periodic table. It turns out that electronic structure is the basis for the periodic behavior of the elements.

The four transition metal series arise because, for each of these elements, an electron has been added to the next-to-outermost shell. Addition of 10 electrons to the 3*d* subshell *after the completion of the* 4*s subshell* causes 10 elements to occur after calcium to be the first elements in their periodic groups. The second and third transition series occur because the 4*d* and 5*d* subshells fill after the

ChemSkill Builder

New to this edition is a correlation to ChemSkill Builder by James D. Spain and Harold J. Peters. ChemSkill Builder is an online electronic homework program that generates questions for students in a randomized fashion with a constant mix of variables. Log on at www.chemskillbuilder.com.

Problem-Solving Methods

Self-Tutorial Problems

This end-of-chapter section presents problems in simple form designed as teaching devices. Many are from everyday life, and they emphasize the importance of identifying the information needed to answer questions, thus advancing analytical skills.

Self-Tutorial Problems

8.1 Assign the following types to one of the five classes of reactions presented in Section 8.3:

Reactants	Products
(a) 1 compound	2 elements
(b) 2 compounds	2 different compounds
(c) 1 element + 1 compound	1 element + 1 compound
(d) 1 compound	1 element + 1 compound
(e) 1 compound + O_2	2 or more compounds
(f) 1 element + 1 compound	1 compound
(g) 2 elements	1 compound

8.2 What is the difference, if any, among (a) the reaction of sodium with bromine, (b) the combination of sodium and bromine, and (c) the formation of sodium bromide from its elements?

8.3 Which, if any, of the common acids exist completely in the form of ions (a) in aqueous solution and (b) as a pure compound?

8.4 Explain how to recognize that O_2 and ZnO will not react with each other in a single substitution reaction.

8.5 Are oxides of reactive metals or oxides of unreactive metals more likely to decompose into their two elements when heated?

8.6 Which table in this chapter should be used when working with single substitution reaction, and which ones with double substitution reactions?

8.7 Which of the following compounds ar

NH_3 H_2O $HClO_3$ C

LiH AsH_3 H_3PO_4

8.8 Classify each of the following as an ac a basic anhydride:

N_2O_3 MgO Li_2O SO

8.9 What type of reaction is the followi

8.11 Explain how a catalyst resembles a marriage broker.

8.12 Rewrite the following equations with integral coefficients:

(a) $CoF_2(s) + \frac{1}{2} F_2(g) \rightarrow CoF_3(s)$

(b) $NH_3(g) + \frac{5}{4} O_2(g) \rightarrow NO(g) + \frac{3}{2} H_2O(g)$

(c) $CuBr(s) + \frac{1}{2} Br_2(\ell) \rightarrow CuBr_2(s)$

(d) $\frac{2}{3} H_3PO_4(aq) + MgCO_3(s) \rightarrow \frac{1}{3} Mg_3(PO_4)_2(s) + H_2O(\ell) + CO_2(g)$

(e) $CoCl_3(s) + \frac{1}{2} Co(s) \rightarrow \frac{3}{2} CoCl_2(s)$

8.13 Write a balanced chemical equation for each of the following reactions:

(a) $SO_2(g) + Cl_2(g) \rightarrow SO_2Cl_2(\ell)$

(b) $SO_2(g) + PCl_5(s) \rightarrow SOCl_2(\ell) + POCl_3(\ell)$

8.14 What products are expected in each of the following cases?

(a) $KClO_3$ is heated in the presence of MnO_2 as a catalyst.

(b) $KClO_3$ is heated in the presence of MnO_2.

(c) $KClO_3$ and MnO_2 are heated together.

(d) $KClO_3$ is heated.

8.15 What type of substance can act as an acid but does not have hydrogen written first in its formula?

8.16 Give two reasons why the following reaction produces products:

$Ba(HCO_3)_2(aq) + H_2SO_4(aq) \rightarrow$

Side-by-Side Problem-Solving Method

To understand and help apply a step-by-step problem-solving method to various problems, students will find examples with the general method for the problem-solving technique presented in the left column and a specific example of the method presented in the right column.

Steps	Example
Step 1: Change the percentages to numbers of grams (by assuming that 100.00 g of sample is present). On exams, state that you are assuming a 100-g sample.	Because the size of the sample does not matter in determining an empirical formula, you can assume a 100.00-g sample. That way, the percentages given are automatically equal numerically to the numbers of grams of the elements. For example: $100.00 \text{ g compound}\left(\frac{27.87 \text{ g P}}{100.00 \text{ g compound}}\right) = 27.87 \text{ g P}$ From the percentage
Step 2: For each element, convert the number of grams to the number of moles.	27.87 g P and 72.13 g S $27.87 \text{ g P}\left(\frac{1 \text{ mol P}}{30.97 \text{ g P}}\right) = 0.8999 \text{ mol P}$ $72.13 \text{ g S}\left(\frac{1 \text{ mol S}}{32.06 \text{ g S}}\right) = 2.250 \text{ mol S}$
Step 3: Try to get an integral ratio by dividing *all* the numbers of moles by the magnitude of the smallest number of moles. This will make at least one number an integer.	$\frac{0.8999 \text{ mol P}}{0.8999} = 1.000 \text{ mol P}$ $\frac{2.250 \text{ mol S}}{0.8999} = 2.500 \text{ mol S}$
Step 4: If necessary, multiply *all* the numbers of moles by the same small integer to clear fractions. Round off the result to an integer only when the number of moles is within 1% of the integer. Always use at least three significant	$1.000 \text{ mol P} \times 2 = 2.000 \text{ mol P}$ $2.500 \text{ mol S} \times 2 = 5.000 \text{ mol S}$ The empirical formula is P_2S_5.

Find more help at the Goldberg website at www.mhhe.com/goldberg

ChemSkill Builder is . . .

Accessible
Assignable
Algorithmic

This easy-to-use program provides students with the tutorial practice they need to master the concepts covered in their chemistry courses. ChemSkill Builder contains more than 1500 algorithmically-generated questions, each with tutorial feedback. Use ChemSkill Builder to assign homework. All assignments and grading are completed online. This is the end of grading homework as we know it!

Features and Benefits of ChemSkill Builder

- Scores are saved online each time students complete a section. Students no longer need to hand in floppy disks for grading.
- Scores are automatically transferred to the online class file so the instructor can provide credit for the work done. **No handing in homework. No grading homework!**
- Questions that are presented in a randomized fashion with a constant mix of variables—no two students receive the same questions. This provides plenty of opportunity for practice.
- Answers are checked immediately, and fully worked out solutions are presented in response to wrong answers. This program teaches students problem-solving skills!
- Subscriptions may be purchased online or via your campus bookstore. Substantial discounts are offered when packaged with a McGraw-Hill textbook. Contact your local McGraw-Hill representative for more details.

Log on today! www.chemskillbuilder.com