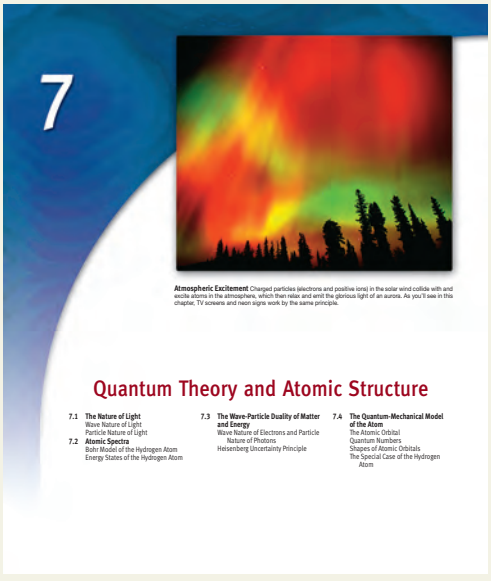
A VISUAL TOUR THROUGH THE FEATURES OF THE TEXT

Many pedagogical tools are interwoven throughout the chapters to guide students on their learning journey.

Chapter Openers

Each chapter begins with a thought-provoking *opener figure and legend* that relate to the main topic of the chapter. The chapter opening page also contains the *Chapter Outline* that shows the sequence of topics and subtopics, and the final paragraph of the introduction, called *In This Chapter,* ties the main topics to the outline. In the margin next to the introduction, *Concepts and Skills to Review* refers to key material from earlier chapters that you should understand before you start reading the current one.

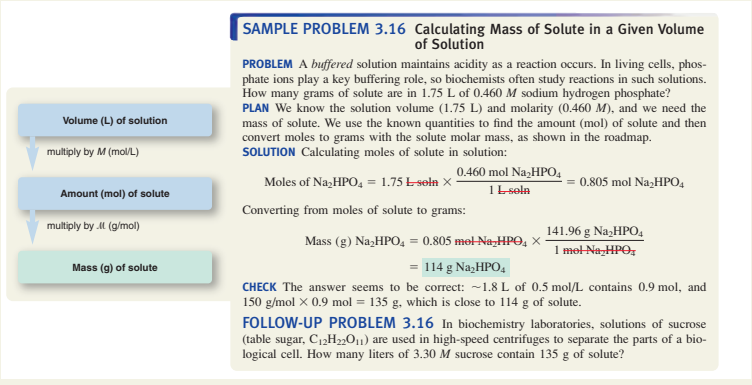


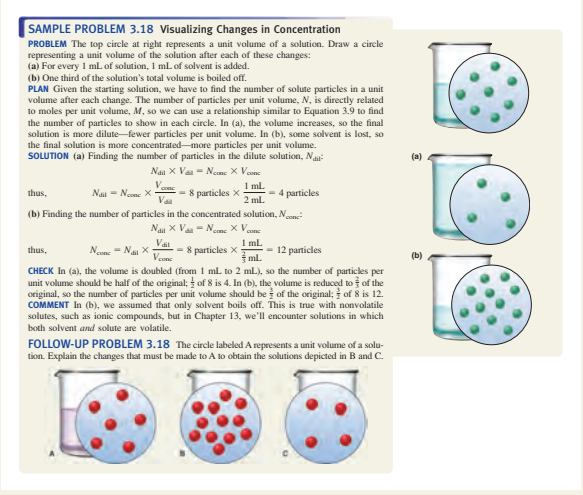
Problem Solving

A worked-out *sample problem* appears whenever an important new concept or skill is introduced, and the problem-solving approach helps you think through all problems logically and systematically. The stepwise approach, based on the universally accepted four-step approach of plan, solve, check, and practice, is used consistently for every sample problem in the text. These steps are as follows:

- **Plan:** analyzes the problem so that you can use what is known to find what is unknown. This step develops the habit of thinking through the solution before performing calculations. Most quantitative problems are accompanied in the margin by a *roadmap*, a flow diagram that leads you visually through the planned steps for each specific problem.
- **Solution:** presents the calculation steps *in the same order* as they are discussed in the plan and shown in the roadmap.
- **Check:** fosters the habit of going over your work with a rough calculation to make sure the answer is both chemically and mathematically reasonable—a great way to avoid careless errors. In many cases, following the check is a *Comment* that provides an additional insight, alternative approach, or common mistake to avoid.
- **Follow-up Problem:** presents a similar problem to provide immediate practice, with an abbreviated multistep solution appearing at the end of the chapter.

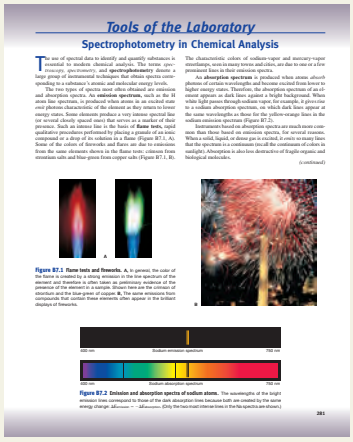
In this edition, in addition to sample problems involving only calculations, a large number of **molecular-scene sample problems** utilize depictions of chemical species to solve quantitative problems.



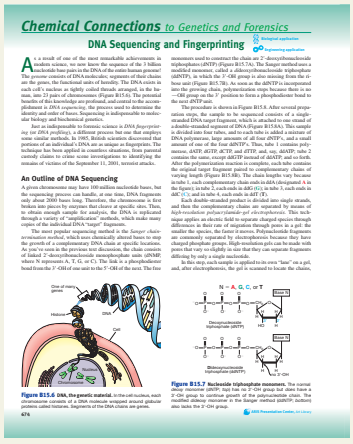


Applications

Tools of the Laboratory essays describe the key instruments and techniques that chemists use in modern practice to obtain the data that underlie their theories.


Tools of the Laboratory
Spectrophotometry in Chemical Analysis

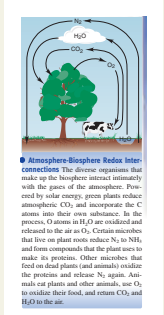
Chemical Connections essays show the interdisciplinary nature of chemistry by applying chemical principles directly to related scientific fields, including physiology, geology, biochemistry, engineering, and environmental science.


Chemical Connections to Genetics and Forensics
DNA Sequencing and Fingerprinting

Gallery features show how common and unusual substances and processes relate to chemical principles. You'll learn how a towel dries you, why bubbles in a drink are round, why contact-lens rinse must have a certain concentration, and many other intriguing facts about everyday applications.

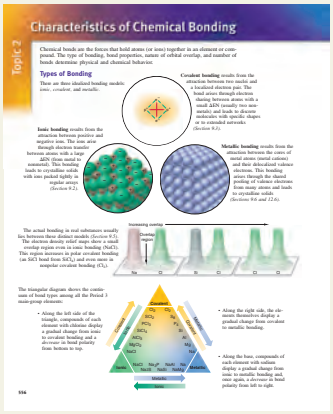

GALLERY
Properties of a Liquid

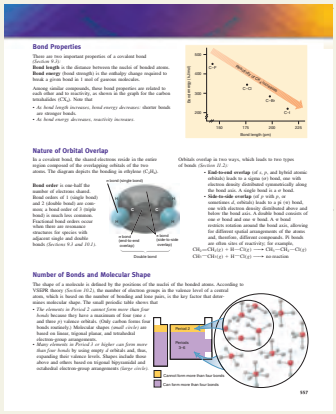
Margin notes are brief, lively explanations that apply ideas presented in the text. You'll learn how water controls the temperature of your body and our planet, how crime labs track illegal drugs, how gas behavior affects lung function, how fat-free chips and decaf coffee are made, in addition to handy tips for memorizing relationships, and much more.


Atmosphere-Biosphere Redox Interconnections

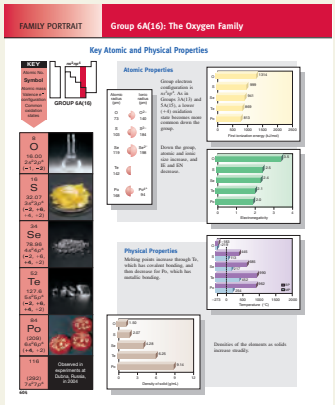
Illustrated Summaries of Facts and Concepts

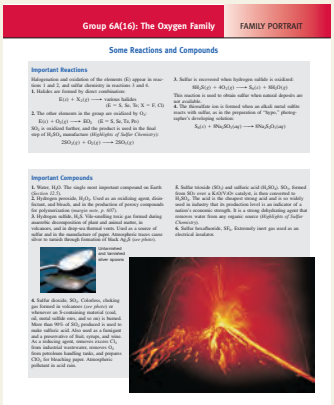
The multipage *Interchapter* is a Perspective on the Properties of the Elements that reviews major concepts from Chapters 7–13, covering atomic and bonding properties and their resulting effects on element behavior.


Characteristics of Chemical Bonding


Bond Properties

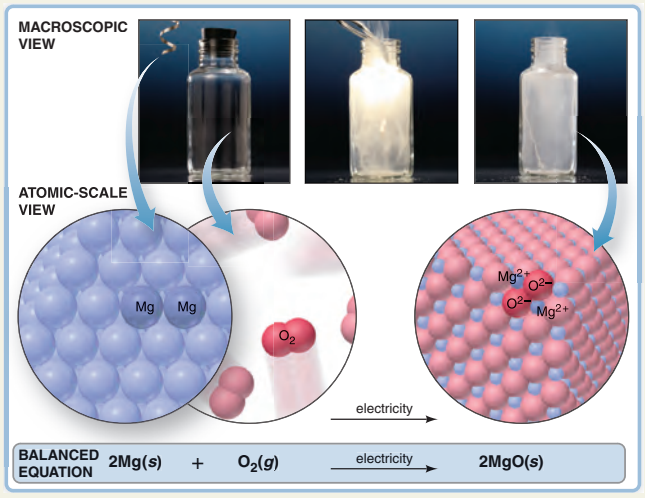
Family Portraits (within Chapter 14) display the atomic and physical properties of each main group of elements and present their representative chemical reactions and some important compounds.


FAMILY PORTRAIT
Group 6A(16): The Oxygen Family
Key Atomic and Physical Properties


Group 6A(16): The Oxygen Family
FAMILY PORTRAIT
Some Reactions and Compounds

Three-Level Illustrations

A hallmark of this text, the three-level illustrations help you connect the macroscopic and molecular levels of reality with the symbolic level in the form of a chemical equation.



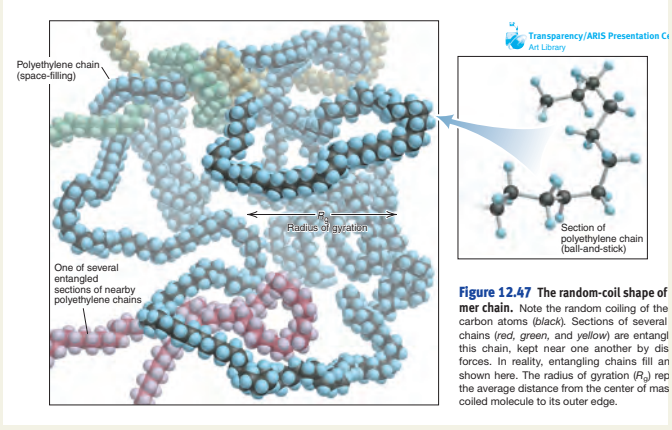


Figure 12.47 The random-coil shape of mer chain. Note the random coiling of the carbon atoms (*black*). Sections of several chains (*red*, *green*, and *yellow*) are entangl this chain, kept near one another by dis forces. In reality, entangling chains fill an shown here. The radius of gyration (R_g) rep the average distance from the center of mas coiled molecule to its outer edge.

Accurate, Cutting-Edge Molecular Models

Author and illustrator worked side by side to create ground-breaking visual representations.

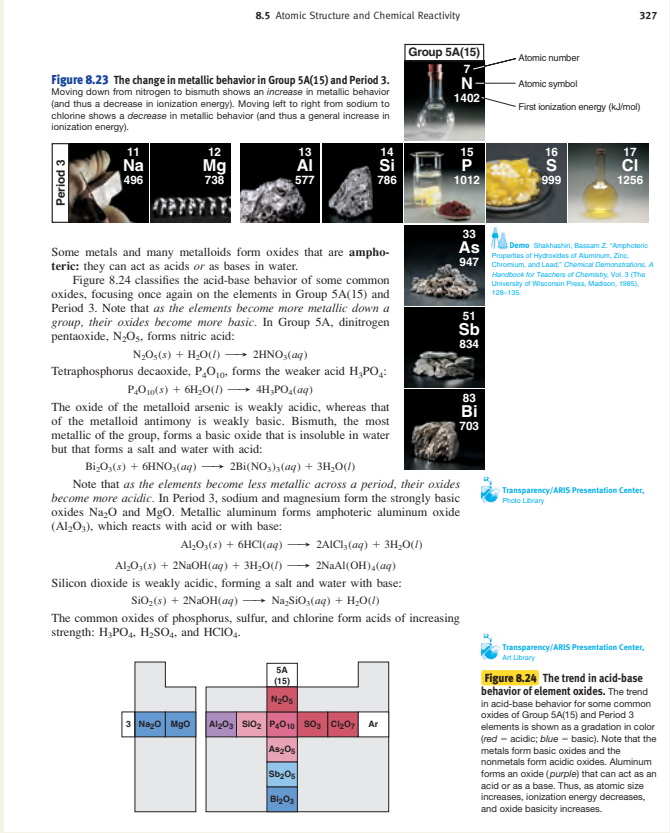


Figure 8.23 The change in metallic behavior in Group 5A(15) and Period 3. Moving down from nitrogen to bismuth shows an *increase* in metallic behavior (and thus a decrease in ionization energy). Moving left to right from sodium to chlorine shows a *decrease* in metallic behavior (and thus a general increase in ionization energy).

Some metals and many metalloids form oxides that are **amphoteric:** they can act as acids *or* as bases in water.

Figure 8.24 classifies the acid-base behavior of some common oxides, focusing once again on the elements in Group 5A(15) and Period 3. Note that *as the elements become more metallic down a group, their oxides become more basic.* In Group 5A, dinitrogen pentaoxide, N_2O_5, forms nitric acid:

$$N_2O_5(s) + H_2O(l) \longrightarrow 2HNO_3(aq)$$

Tetraphosphorus decaoxide, P_4O_{10}, forms the weaker acid H_3PO_4:

$$P_4O_{10}(s) + 6H_2O(l) \longrightarrow 4H_3PO_4(aq)$$

The oxide of the metalloid arsenic is weakly acidic, whereas that of the metalloid antimony is weakly basic. Bismuth, the most metallic of the group, forms a basic oxide that is insoluble in water but that forms a salt and water with acid:

$$Bi_2O_3(s) + 6HNO_3(aq) \longrightarrow 2Bi(NO_3)_3(aq) + 3H_2O(l)$$

Note that *as the elements become less metallic across a period, their oxides become more acidic.* In Period 3, sodium and magnesium form the strongly basic oxides Na_2O and MgO. Metallic aluminum forms amphoteric aluminum oxide (Al_2O_3), which reacts with acid or with base:

$$Al_2O_3(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3H_2O(l)$$

$$Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \longrightarrow 2NaAl(OH)_4(aq)$$

Silicon dioxide is weakly acidic, forming a salt and water with base:

$$SiO_2(s) + 2NaOH(aq) \longrightarrow Na_2SiO_3(aq) + H_2O(l)$$

The common oxides of phosphorus, sulfur, and chlorine form acids of increasing strength: H_3PO_4, H_2SO_4, and $HClO_4$.

Figure 8.24 The trend in acid-base behavior of element oxides. The trend in acid-base behavior for some common oxides of Group 5A(15) and Period 3 elements is shown as a gradation in color (*red* = acidic; *blue* = basic). Note that the metals form basic oxides and the nonmetals form acidic oxides. Aluminum forms an oxide (*purple*) that can act as an acid or as a base. Thus, as atomic size increases, ionization energy decreases, and oxide basicity increases.

Page Layout

Author and pager collaborated on page layout to ensure that all figures, tables, margin notes, and sample problems are as close as possible to their related text.

Section Summaries and Chapter Perspective

Concise summary paragraphs conclude each section, immediately restating the major ideas just covered. Each chapter ends with a brief perspective that places its topics in the context of previous and upcoming chapters.

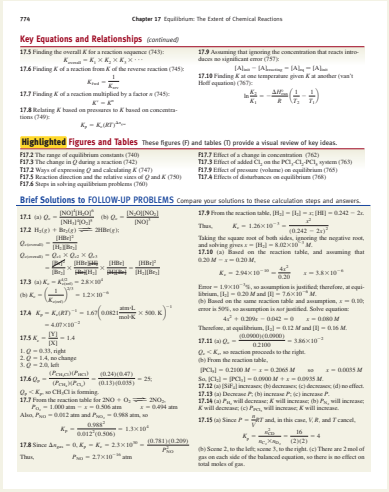
Section Summary

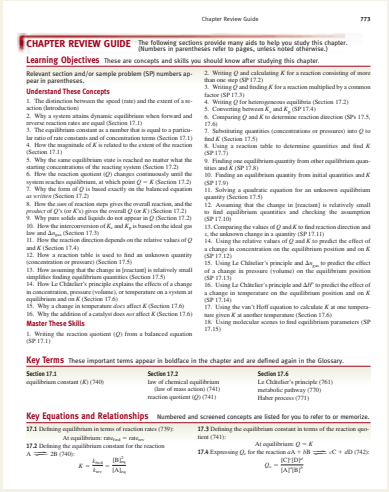
A stepwise process converts a molecular formula into a Lewis structure, a *two-dimensional* representation of a molecule (or ion) that shows the placement of atoms and distribution of valence electrons among bonding and lone pairs. • When two or more Lewis structures can be drawn for the same relative placement of atoms, the actual structure is a hybrid of those resonance forms. • Formal charges are often useful for determining the most important contributor to the hybrid. • Electron-deficient molecules (central Be or B) and odd-electron species (free radicals) have less than an octet around the central atom but often attain an octet in reactions. • In a molecule (or ion) with a central atom from Period 3 or higher, the atom can hold more than eight electrons because it is larger and uses *d* orbitals to expand its valence shell.

Chapter Review Guide

A rich assortment of study aids ends each chapter to help you review its content.

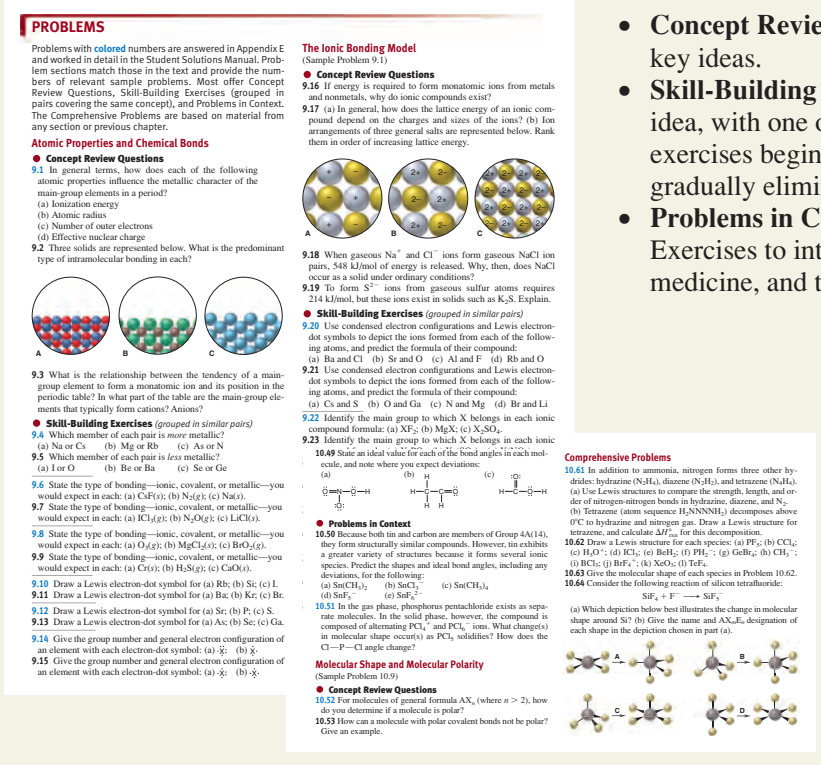
- **Learning Objectives** are listed, with section and/or sample problem numbers, to focus you on key concepts and skills.
- **Key Terms** that are boldfaced within the chapter are listed here by section (with page numbers) and defined again in the end-of-book Glossary.
- **Key Equations and Relationships** are screened and numbered within the chapter and listed here with page numbers.
- **Highlighted Figures and Tables** are listed with page numbers so that you can review their essential content.
- **Brief Solutions to Follow-up Problems** double the number of worked problems by offering multistep calculations at the end of the chapter, rather than just numerical answers at the back of the book.





End-of-Chapter Problems

An exceptionally large number of problems end each chapter. These include three types of problems keyed by chapter section followed by a number of comprehensive problems:



- **Concept Review Questions** test your qualitative understanding of key ideas.
- **Skill-Building Exercises** are presented in pairs that cover a similar idea, with one of each pair answered in the back of the book. These exercises begin with simple questions and increase in difficulty, gradually eliminating your need for multistep directions.
- **Problems in Context** apply the skills learned in the Skill-Building Exercises to interesting scenarios, including examples from industry, medicine, and the environment.
- **Comprehensive Problems,** based on realistic applications, are more challenging and rely on concepts and skills from any section of the current chapter or from previous chapters.

Moreover, in this edition, 140 **molecular-scene problems** are included.