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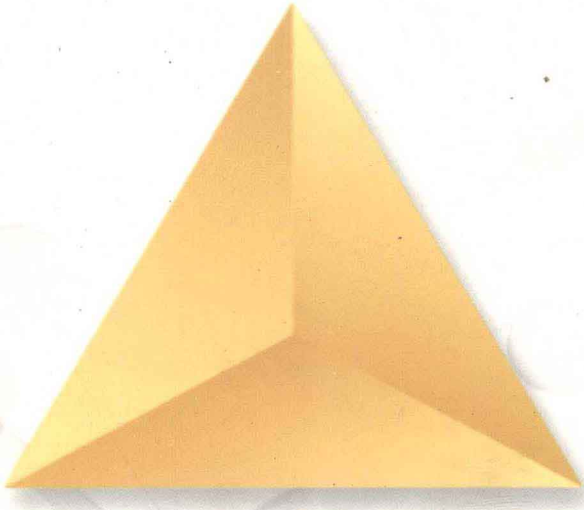

CHEMISTRY

THE CENTRAL SCIENCE

BROWN | LeMAY | BURSTEN

Tenth Edition

Chemistry

The Central Science

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Chemistry

To our students, whose enthusiasm
and curiosity have often inspired us,
and whose questions and suggestions
have sometimes taught us.

Preface

To the Instructor

Philosophy

This is the tenth edition of a text that has enjoyed unprecedented success over its many editions. It is fair to ask why there needs to be yet another edition. The answer in part lies in the nature of chemistry itself, a dynamic science in a process of continual discovery. New research leads to new applications of chemistry in other fields of science and in technology. A textbook that purports to introduce chemistry to students who have only a limited prior acquaintance with it should reflect that dynamic, changing character. We want the text to convey the excitement that scientists experience in making new discoveries and contributing to our understanding of the physical world.

In addition, the teaching of chemistry is also continuously changing. New ideas about how to present chemistry are being offered by teachers of chemistry, and many of these new ideas are reflected in how the textbook is organized and the ways in which individual topics are presented. In addition, new technologies and new devices to assist students in learning lead to new ways of presenting learning materials: the Internet, computer-based classroom projection tools, and more effective means of testing, to name just a few. All of these factors impact on how the text and the accompanying supplementary materials are modified from one edition to the next.

Our aim in revising the text has been to ensure that the text remains a central, indispensable learning tool for the student. It is the one device that can be carried everywhere and used at any time, and as such, it is a one-stop source of all the information that the student is likely to need for learning, skill development, reference, and test preparation. We believe that students are more enthusiastic about learning chemistry when they see its importance to their own goals and interests. With this in mind, we have highlighted many important applications of chemistry in everyday life. At the same time, the text provides the background in modern chemistry that students need to serve their professional interests and, as appropriate, to prepare for more advanced chemistry courses.

If the text is to support your role as teacher effectively, it must be addressed to the students. We have done our best to keep our writing clear and interesting and the book attractive and well-illustrated. Furthermore, we have provided numerous in-text study aids for students, including carefully placed descriptions of problem-solving strategies. Together, we have logged many years of teaching experience. We hope this is evident in our pacing and choice of examples.

A textbook is only as useful to students as the instructor permits it to be. This book is loaded with many features that can help students learn and that can guide them as they acquire both conceptual understanding and problem-solving skills. But the text and all the supplementary materials provided to support its use must work in concert with the instructor. There is a great deal for the students to use here, too much for all of it to be absorbed by any one student. You, the instructor, are the guide to a proper use of the book. Only with your active help will the students be able to fully utilize all that the text and its supplements offer. Students care about grades, of course, but with encouragement, they can also care about learning just because the subject matter is interesting. Please consider emphasizing features of the book that can materially enhance student appreciation of chemistry, such as the *Chemistry at Work* and *Chemistry and Life* boxes that show how chemistry impacts modern life and its relationship to health and life processes. Learn to use, and urge students to use, the rich Internet resources available. Emphasize conceptual understanding, and place less emphasis on simple manipulative, algorithmic problem-solving. Spending less time on solving a variety of gas law problems, for example, can open up opportunities to talk about chemistry and the environment.

Organization and Contents

In the present edition the first five chapters give a largely macroscopic, phenomenological view of chemistry. The basic concepts introduced—such as nomenclature, stoichiometry, and thermochemistry—provide necessary background for many of the laboratory experiments usually performed in general chemistry. We believe that an early introduction to thermochemistry is desirable because so much of our understanding of chemical processes is based on considerations of energy change. Thermochemistry is also important when we come to a discussion of bond enthalpies. We have continued to refine our approach to teaching thermodynamics in general chemistry. It is no easy matter to walk the narrow pathway between—on the one hand—trying to teach too much at too high a level and—on the other—resorting to oversimplifications. As with the book as a whole, the emphasis has been on imparting conceptual understanding, as opposed to presenting equations into which students are supposed to plug numbers.

The next four chapters (Chapters 6–9) deal with electronic structure and bonding. Here we have made several significant changes, particularly in the presentation of atomic orbitals. New *Closer Look* boxes deal with radial probability functions and the nature of antibonding orbitals. The focus of the text then changes to the next level of the organization of matter: the states of matter (Chapters 10 and 11) and solutions (Chapter 13). Also included in this section is an applications chapter on the chemistry of modern materials (Chapter 12), which builds on the student's understanding of chemical bonding and intermolecular interactions. This chapter has received a major revision, in keeping with the rapid pace of change in technology. It has been reorganized to emphasize the classification of materials according to their uses (materials for structure, materials for electronics, etc.). In addition, new topics such as light-emitting polymers and materials for nanotechnology have been added.

The next several chapters examine the factors that determine the speed and extent of chemical reactions: kinetics (Chapter 14), equilibria (Chapters 15–17), thermodynamics (Chapter 19), and electrochemistry (Chapter 20). Also in this section is a chapter on environmental chemistry (Chapter 18), in which the concepts developed in preceding chapters are applied to a discussion of the atmosphere and hydrosphere. We have further revised and refined our introduction to equilibrium constants in Chapter 15. The chapter on thermodynamics has been carefully reworked to give students a better sense of how the macroscopic and microscopic views of entropy are connected.

After a discussion of nuclear chemistry (Chapter 21), the final chapters survey the chemistry of nonmetals, metals, organic chemistry, and biochemistry (Chapters 22–25). These chapters are developed in a parallel fashion and can be treated in any order.

Our chapter sequence provides a fairly standard organization, but we recognize that not everyone teaches all the topics in exactly the order we have chosen. We have therefore made sure that instructors can make common changes in teaching sequence with no loss in student comprehension. In particular, many instructors prefer to introduce gases (Chapter 10) after stoichiometry or after thermochemistry rather than with states of matter. The chapter on gases has been written to permit this change with *no* disruption in the flow of material. It is also possible to treat the balancing of redox equations (Sections 20.1 and 20.2) earlier, after the introduction of redox reactions in Section 4.4. Finally, some instructors like to cover organic chemistry (Chapter 25) right after bonding (Chapter 9). With the exception of the discussion of stereochemistry (which is introduced in Section 24.3), this, too, is a seamless move.

We have introduced students to descriptive organic and inorganic chemistry by integrating examples throughout the text. You will find pertinent and relevant examples of "real" chemistry woven into all the chapters as a means to illustrate principles and applications. Some chapters, of course, more directly address the properties of elements and their compounds, especially Chapters 4, 7, 12, 18, and 22–25. We also incorporate descriptive organic and inorganic chemistry in the end-of-chapter exercises.

Changes in this edition

Some of the changes in the tenth edition made in individual chapters have already been mentioned. More broadly, we have introduced a number of new features that are general throughout the text. *Chemistry: The Central Science* has traditionally been valued for its clarity of writing, its scientific accuracy and currency, its strong end-of-chapter exercises, and its consistency in level of coverage. In making changes, we have made sure not to compromise those characteristics. At the same time, we have responded to feedback received from the faculty and students who used the ninth edition. Sections that have seemed most difficult to students have in many cases been rewritten and augmented with improved artwork. In order to make the text easier for students to use, we have continued to employ an open, clean design in the layout of the book. Illustrations that lend themselves to a more schematic, bolder presentation of the underlying principles have been introduced or revised from earlier versions. The art program in general has been strengthened, to better convey the beauty, excitement, and concepts of chemistry to students. The chapter-opening photos have been integrated into the introduction to each chapter, and thus made more relevant to the chapter's contents.

We have continued to use the What's Ahead overview at the opening of each chapter, introduced in the ninth edition. *Concept links* ( ) continue to provide easy-to-see cross-references to pertinent material covered earlier in the text. The essays titled *Strategies in Chemistry*, which provide advice to students on problem solving and "thinking like a chemist," continue to be an important feature. A new in-chapter feature is the *Give It Some Thought* exercises. These are informal, rather sharply focused questions that give students opportunities to test whether they are actually "getting it" as they read along. We have added more conceptual exercises to the end-of-chapter exercises. A new category of end-of-chapter exercises, *Visualizing Concepts*, has been added to every chapter. These exercises are designed to facilitate concept understanding through use of models, graphs, and other visual materials. They precede the regular end-of-chapter exercises and are identified in each case with the relevant chapter section number. New Multi-Focus Graphics have been added. These graphics depict topics in macroscopic, microscopic, symbolic and conceptual representation so students learn to see chemistry the way scientists do, from a variety of perspectives. The *Integrative Exercises*, which give students the opportunity to solve more challenging problems that integrate concepts from the present chapter with those of previous chapters, have also been increased in number.

New essays in our well-received *Chemistry at Work* and *Chemistry and Life* series emphasize world events, scientific discoveries, and medical breakthroughs that have occurred since publication of the ninth edition. We maintain our focus on the positive aspects of chemistry, without neglecting the problems that can arise in an increasingly technological world. Our goal is to help students appreciate the real-world perspective of chemistry and the ways in which chemistry affects their lives.

You'll also find that we've

- Revised the end-of-chapter Exercises, with particular focus on the black-numbered exercises (those not answered in the Appendix).
- Integrated more conceptual questions into the end-of-chapter material. For the convenience of instructors, these are identified by the **CQ** annotation in the Annotated Instructor's Edition, but not in the student edition of the text.
- Added new eLaboratory Exercises in the end-of-chapter material. These exercises allow students to develop and practice the skills they learn from the chapter in a simulated laboratory, available in software that accompanies the text. The realistic setting helps students see how problem-solving in chemistry applies in practice.
- Updated the eMedia Exercises in the end-of-chapter material. These exercises take advantage of the integrated media components and extend students' understanding, using the advantages that interactive, media-rich presentations offer.
- Continued the practice of using an eMedia Activity icon in the margins to indicate where students can extend understanding of a concept or topic by looking at an activity located on the Web site or the Accelerator CD-ROM.
- Carried the stepwise Analyze, Plan, Solve, Check problem-solving strategy into nearly all of the Sample Exercises of the book to provide additional guidance in problem solving.
- Expanded the use of dual-column problem-solving strategies in many Sample Exercises to more clearly outline the process underlying mathematical calculations, thereby helping students to better perform mathematical calculations.

To the Student

Chemistry: The Central Science, Tenth Edition, has been written to introduce you to modern chemistry. As authors, we have, in effect, been engaged by your instructor to help you learn chemistry. Based on the comments of students and instructors who have used this book in its previous editions, we believe that we have done that job well. Of course, we expect the text to continue to evolve through future editions. We invite you to write to us to tell us what you like about the book so that we will know where we have helped you most. Also, we would like to learn of any shortcomings, so that we might further improve the book in subsequent editions. Our addresses are given at the end of the Preface.

Advice for learning and studying chemistry

Learning chemistry requires both the assimilation of many new concepts and the development of analytical skills. In this text we have provided you with numerous tools to help you succeed in both. We have provided details of the features of this text in the "walk-through" on pages xxxii–xxxv. You will find it helpful to examine those features.

If you are going to succeed in your course in chemistry, you will have to develop good study habits. Science courses, and chemistry in particular, make different demands on your learning skills than other types of courses. We offer the following tips for success in your study of chemistry:

Don't fall behind! As your chemistry course moves along, new topics will build on material already presented. If you don't keep up in your reading and problem solving, you will find it much harder to follow the lectures and discussions on current topics. "Cramming" just before an exam has been shown to be an ineffective way to study any subject, chemistry included.

Focus your study. The amount of information you will be expected to learn can sometimes seem overwhelming. It is essential to recognize those concepts and skills that are particularly important. Pay attention to what your instructor is emphasizing. As you work through the Sample Exercises and homework assignments, try to see what general principles and skills they deal with. Use the What's Ahead feature at the beginning of each chapter to help orient you to what is important in each chapter. A single reading of a chapter will simply not be enough for successful learning of chapter concepts and problem-solving skills. You will need to go over assigned materials more than once. Don't skip the Give It Some Thought features, Sample Exercises, and Practice Exercises. They are your guide to whether you are actually learning the material.

Keep good lecture notes. Your lecture notes will provide you with a clear and concise record of what your instructor regards as the most important material to learn. Use your lecture notes in conjunction with this text; that's your best way to determine which material to study.

Skim topics in the text before they are covered in lecture. Reviewing a topic before lecture will make it easier for you to take good notes. First read the introduction and Summary, then quickly read through the chapter, skipping Sample Exercises and supplemental sections. Pay attention to the titles of sections and subsections, which give you a feeling for the scope of topics. Try to avoid thinking that you must learn and understand everything right away.

After lecture, carefully read the topics covered in class. As you read, pay attention to the concepts presented and to the application of these concepts in the Sample Exercises. Once you think you understand a Sample Exercise, test your understanding by working the accompanying Practice Exercise.

Learn the language of chemistry. As you study chemistry, you will encounter many new words. It is important to pay attention to these words and to know their meanings or the entities to which they refer. Knowing how to identify chemical substances from their names is an important skill; it can help you avoid painful mistakes on examinations. For example, "chlorine" and "chloride" refer to very different things.

Attempt the assigned end-of-chapter exercises. Working the exercises that have been selected by your instructor provides necessary practice in recalling and using the essential ideas of the chapter. You cannot learn merely by observing; you must be a participant. In particular, try to resist checking the *Student Solutions Manual* (if you have one) until you have made a sincere effort to solve the exercise yourself. If you really get stuck on an exercise, however, get help from your instructor, your teaching assistant, or another student. Spending more than 20 minutes on a single exercise is rarely effective unless you know that it is particularly challenging.

Make use of the online resources. Some things are more easily learned by discovery, and others are best shown in three dimensions. Use the Companion Website with GradeTracker or OneKey course management materials to this text to get the most out of your time in chemistry.

The bottom line is to work hard, study effectively, and use the tools that are available to you, including this textbook. We want to help you learn more about the world of chemistry and why chemistry is the central science. If you learn chemistry well, you can be the life of the party, impress your friends and parents, and . . . well, also pass the course with a good grade.

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A Student's Guide to Using this Text

THE FOLLOWING PAGES WALK YOU THROUGH some of the main features of this text and its integrated media components. This learning system was designed with you, the student, in mind. We hope you enjoy your study of chemistry—the central science.

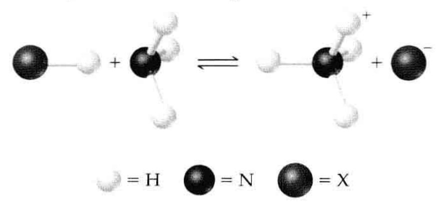
Building a Conceptual Framework

GIVE IT SOME THOUGHT

Why is the choice of indicator more crucial for a weak acid–strong base titration than for a strong acid–strong base titration?

VISUALIZING CONCEPTS

16.1 **(a)** Identify the Brønsted–Lowry acid and the Brønsted–Lowry base in the following reaction:



(b) Identify the Lewis acid and the Lewis base in the reaction. [Sections 16.2 and 16.11]

16.2 The following diagrams represent aqueous solutions of two monoprotic acids, HA (A = X or Y). The water

"What's Ahead" Sections At the beginning of each chapter, reading the "What's Ahead" sections will give you a sense of direction for studying the chapter and help you to recognize key ideas and relationships of the topics within the chapter.

"Give It Some Thought" Questions These new, informal, rather sharply focused questions will give you opportunities to test whether you are actually "getting it" as you study the material. Give these questions some real thought before you check your responses against the answers at the back of the book.

"Visualizing Concepts" Exercises Just before the end-of-chapter exercises, there are new Visualizing Concepts exercises that ask you to consider concepts through the use of models, graphs, and other visual materials. These exercises will help you develop a conceptual understanding of the key ideas in the chapter. There are additional conceptual exercises among the end-of-chapter exercises.

Problem Solving

SAMPLE EXERCISE 3.13 | Calculating an Empirical Formula

Ascorbic acid (vitamin C) contains 40.92% C, 4.58% H, and 54.50% O by mass. What is the empirical formula of ascorbic acid?

Solution

Analyze: We are to determine an empirical formula of a compound from the mass percentages of its elements.

Plan: The strategy for determining the empirical formula involves the three steps given in Figure 3.11.

Solve: We *first* assume, for simplicity, that we have exactly 100 g of material (although any mass can be used). In 100 g of ascorbic acid, we have

40.92 g C, 4.58 g H, and 54.50 g O.

Second, we calculate the number of moles of each element:

$$\text{Moles C} = (40.92 \text{ g C})\left(\frac{1 \text{ mol C}}{12.01 \text{ g C}}\right) = 3.407 \text{ mol C}$$

$$\text{Moles H} = (4.58 \text{ g H})\left(\frac{1 \text{ mol H}}{1.008 \text{ g H}}\right) = 4.54 \text{ mol H}$$

$$\text{Moles O} = (54.50 \text{ g O})\left(\frac{1 \text{ mol O}}{16.00 \text{ g O}}\right) = 3.406 \text{ mol O}$$

Third, we determine the simplest whole-number ratio of moles by dividing each number of moles by the smallest number of moles, 3.406:

$$\text{C}: \frac{3.407}{3.406} = 1.000 \qquad \text{H}: \frac{4.54}{3.406} = 1.33 \qquad \text{O}: \frac{3.406}{3.406} = 1.000$$

The ratio for H is too far from 1 to attribute the difference to experimental error; in fact, it is quite close to $1\frac{1}{3}$. This suggests that if we multiply the ratio by 3, we will obtain whole numbers:

$$\text{C:H:O} = 3(1:1.33:1) = 3:4:3$$

The whole-number mole ratio gives us the subscripts for the empirical formula:

$C_3H_4O_3$

Check: It is reassuring that the subscripts are moderately sized whole numbers. Otherwise, we have little by which to judge the reasonableness of our answer.

PRACTICE EXERCISE

A 5.325-g sample of methyl benzoate, a compound used in the manufacture of perfumes, is found to contain 3.758 g of carbon, 0.316 g of hydrogen, and 1.251 g of oxygen. What is the empirical formula of this substance?

Answer: C_4H_4O

Learning effective problem-solving skills is one of your most important goals in this course. To help you solve problems with confidence, the text integrates problem-solving pedagogy.

Worked Solutions demonstrate the strategy and thought process involved in solving each exercise.

Analyze/Plan/Solve/Check Theme provides a consistent framework for helping you to understand what you are being asked to solve, to plan how you will solve each problem, to work your way through the solution, and to check to make sure that your answer is correct.

Dual-Column Problem-Solving Strategies found in selected Sample Exercises provide an explanation of the thought process involved in each step of a mathematical calculation to give you a conceptual understanding of those calculations.

Practice Exercises include answers but not solutions, thereby giving you the opportunity to test your knowledge and get instant feedback.

Strategies in Chemistry Strategies in Chemistry boxes teach you ways to analyze information and organize thoughts, helping to improve your problem-solving and critical-thinking abilities.

STRATEGIES IN CHEMISTRY | Using Enthalpy as a Guide

If you hold a brick in the air and let it go, it will fall as the force of gravity pulls it toward Earth. A process that is thermodynamically favored to happen, such as a falling brick, is called a *spontaneous* process. A spontaneous process can be either fast or slow. Speed is not the issue in thermodynamics.

Many chemical processes are thermodynamically favored, or spontaneous, too. By "spontaneous," we don't mean that the reaction will form products without any intervention. That can be the case, but often some energy must be imparted to get the process started. The enthalpy change in a reaction gives one indication as to whether it is likely to be spontaneous. The combustion of $H_2(g)$ and $O_2(g)$, for example, is a highly exothermic process:

$$H_2(g) + \frac{1}{2} O_2(g) \longrightarrow H_2O(g) \qquad \Delta H = -242 \text{ kJ}$$

Hydrogen gas and oxygen gas can exist together in a volume indefinitely without noticeable reaction occurring, as in Figure 5.14(a). Once initiated, however, energy is rapidly transferred from the system (the reactants) to the surroundings. As the reaction proceeds, large amounts of heat are released, which greatly increases the temperature of the reactants and the products. The system then loses enthalpy by transferring the heat to the surroundings. (Recall that the first law of thermody-
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Enthalpy change is not the only consideration in the spontaneity of reactions, however, nor is it a foolproof guide. For example, the melting of ice is an endothermic process:

$$H_2O(s) \longrightarrow H_2O(l) \qquad \Delta H = +6.01 \text{ kJ}$$

Even though this process is endothermic, it is spontaneous at temperatures above the freezing point of water (0°C). The reverse process, the freezing of water to ice, is spontaneous at temperatures below 0°C. Thus, we know that ice at room temperature will melt and that water put into a freezer at −20°C will turn into ice; both of these processes are spontaneous under different conditions even though they are the reverse of one another. In Chapter 19 we will address the spontaneity of processes more fully. We will see why a process can be spontaneous at one temperature, but not at another, as is the case for the conversion of water to ice.

Despite these complicating factors, however, you should pay attention to the enthalpy changes in reactions. As a general observation, when the enthalpy change is large, it is the dominant factor in determining spontaneity. Thus, reactions for which ΔH is *large* and *negative* tend to be spontaneous. Reactions for which ΔH is *large* and *positive* tend to be spontaneous only in the reverse direction. There are a number of ways in which the enthalpy of a reaction can be estimated; from these estimates the likelihood of the reaction being ther-

End-of-Chapter Exercises

- *Visualizing Concepts* exercises, identified by the relevant chapter section number, help to build a conceptual understanding of the chapter as a whole.
- The next section of exercises is grouped by topic. They are presented in matched pairs, giving you multiple opportunities to test each concept. *Additional Exercises* follow the paired exercises and are not categorized, because many of these exercises draw on multiple concepts from within the chapter.
- *Integrative Exercises*, which are included among the exercises at the end of Chapters 3-25, connect concepts from the current chapter with those from previous chapters. These exercises will help you gain a deeper understanding of how chemistry fits together. In addition, they serve as an overall review of key concepts.

SAMPLE INTEGRATIVE EXERCISE | Putting Concepts Together

Boron, atomic number 5, occurs naturally as two isotopes, ^{10}B and ^{11}B, with natural abundances of 19.9% and 80.1%, respectively. **(a)** In what ways do the two isotopes differ from each other? Does the electronic configuration of ^{10}B differ from that of ^{11}B? **(b)** Draw the orbital diagram for an atom of ^{11}B. Which electrons are the valence electrons? **(c)** Indicate three major ways in which the 1*s* electrons in boron differ from the 2*s* electrons in the atom. **(d)** Elemental boron reacts with fluorine to form BF_3, a gas. Write a balanced chemical equation for the reaction of solid boron with fluorine gas. **(e)** $\Delta H_f°$ for $BF_3(g)$ is $-1135.6 \text{ kJ mol}^{-1}$. Calculate the standard enthalpy change in the reaction of boron with fluorine. **(f)** When BCl_3, also a gas at room temperature, comes into contact with water, the two react to form hydrochloric acid and boric acid, H_3BO_3, a very weak acid in water. Write a balanced net ionic equation for this reaction.

Solution (a) The two nuclides of boron differ in the number of neutrons in the nucleus. (Sections 2.3 and 2.4) Each of the nuclides contains five protons, but ^{10}B contains five neutrons, whereas ^{11}B contains six neutrons. The two isotopes of boron have identical electron configurations, $1s^2 2s^2 2p^1$, because each has five electrons.

(b) The complete orbital diagram is

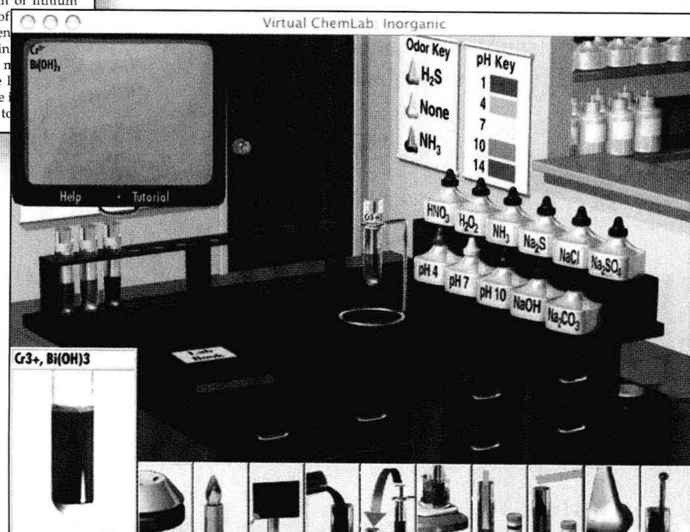
- The *Sample Integrative Exercise* at the end of the chapter shows you how to analyze and solve problems that encompass more than one concept.

eMEDIA EXERCISES

These exercises make use of the interactive objects available online in OneKey or the Companion Website, and on your Accelerator CD. Access to these resources comes in your MediaPak.

6.105 The **Electromagnetic Spectrum** activity (*6.1*) allows you to choose a color in the visible spectrum and see its wavelength, frequency, and energy per photon. **(a)** What is the wavelength range of blue light? **(b)** What are the ranges of its frequency and energy per photon? **(c)** Exercise 6.25 indicates that a type of sunburn is caused by light with wavelength ~325 nm. Would you expect any of the visible wavelengths to cause sunburn? Explain.

6.106 In the **Flame Tests for Metals** movie (*6.3*) the characteristic color of the flame is produced by emissions at several visible wavelengths, with the most intense spectral lines dominating the color. For instance, the most intense visible lines in the spectrum of lithium occur at ~671 nm. **(a)** What color is light of length? **(b)** At what approximate wavelen you expect to find the most intense lines in spectrum of potassium? **(c)** Based on the would you expect the intensity of visible spectrum of potassium to compare to those trum of lithium? **(d)** Would it be possible to



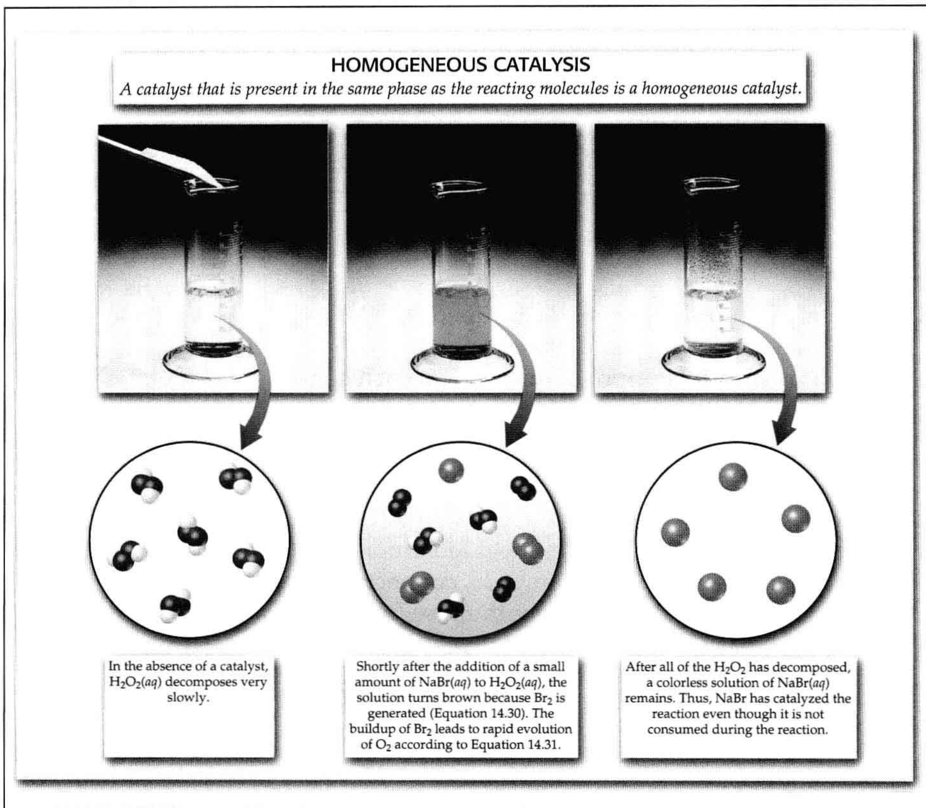
- Answers are provided in the back of the book for red-numbered exercises. More challenging exercises are indicated by brackets around the exercise number.
- *eMedia Exercises* are answered by using the movies and simulations indicated in the margins by the eMedia Activity icon and available in the student MediaPak. These questions foster your understanding through visual and interactive learning styles.
- *eLaboratory Exercises* are answered using the Virtual ChemLab software in your student MediaPak. These are chemistry questions posed in a simulated laboratory setting.

Visualization

One of the challenges facing you in general chemistry is the often abstract nature of the subject. First, chemistry relies on a symbolic language based on chemical formulas and chemical equations. Second, chemistry is based on the behavior of molecules and atoms—particles far too small to see.

This text has been designed expressly to help you better visualize the chemistry you need to learn and thus help you to succeed in your course. Spend time with the illustrations in the text— they'll help you understand the chemistry concepts being discussed.

Multi-Focus Graphics Scientists see chemical concepts from a multitude of perspectives. Concepts in the text that require a mental picture of different representations are presented through new Multi-Focus graphics. In addition to a textual statement of key information, these new graphics include a representation from a variety of perspectives, including macroscopic, microscopic, symbolic, and conceptual.



Molecular Illustrations Computer-generated renditions of molecules and materials provide visual representations of matter at the atomic level. These drawings help you visualize molecules in three dimensions and enhance your understanding of molecular architecture.