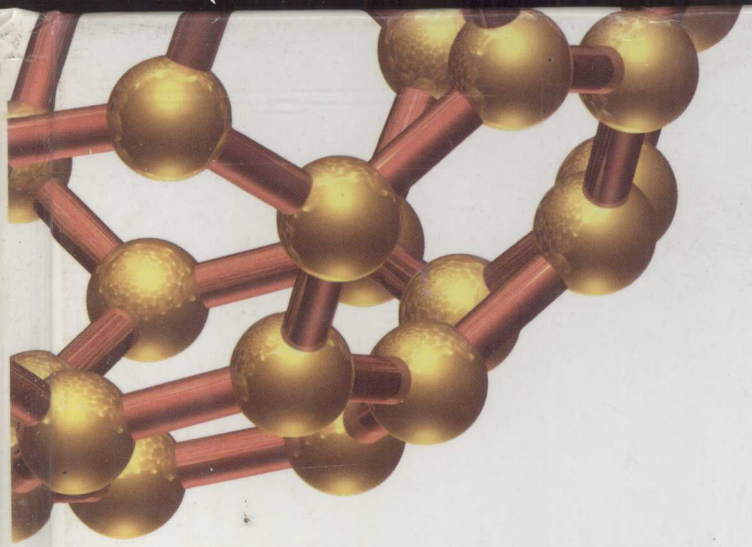


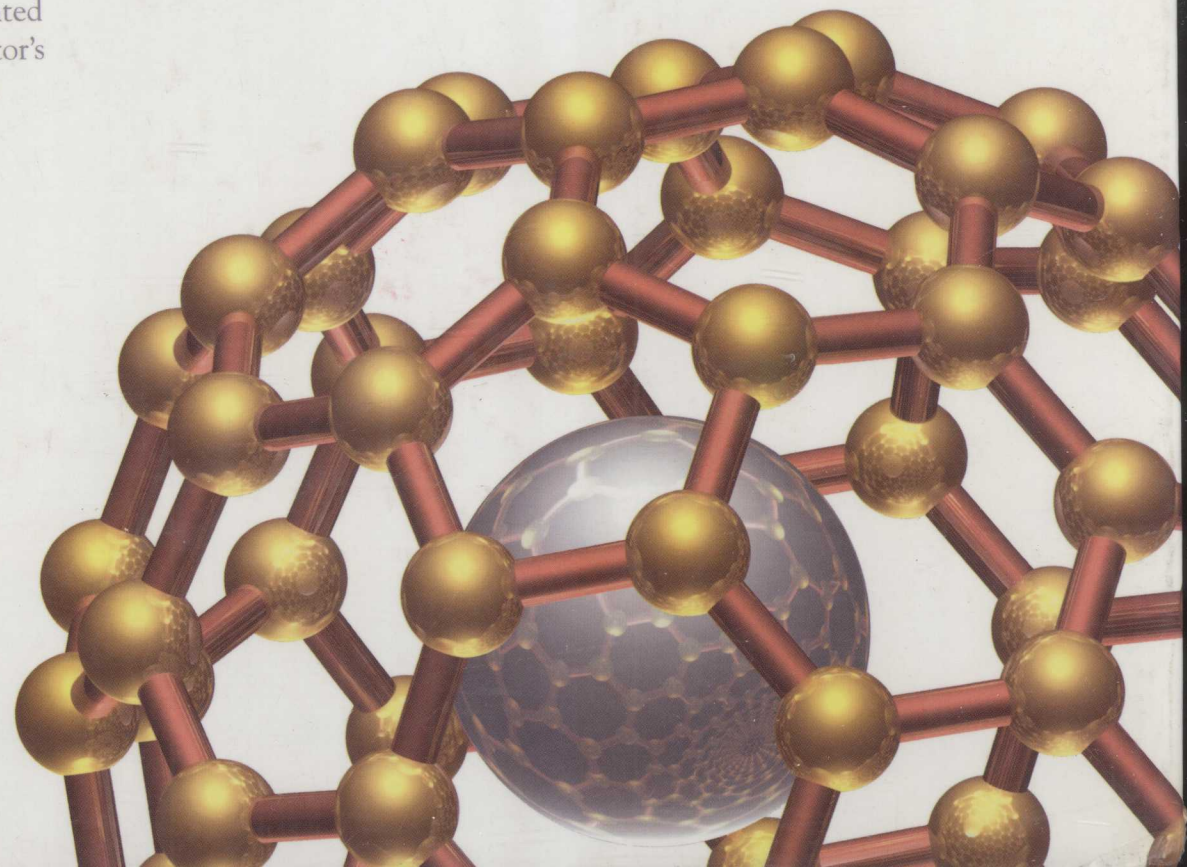
Brown LeMay Bursten

CHEMISTRY

THE CENTRAL SCIENCE

Eighth Edition

Annotated
Instructor's
Edition



Chemistry

The Central Science

Eighth Edition

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Upper Saddle River, New Jersey 07458

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

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How to Use this Annotated Instructor's Edition

This Annotated Instructor's Edition (AIE) is a specially created version of this text. In addition to the complete student edition, it references all the print and media resources available to instructors teaching the course using Brown/LeMay/Bursten, *Chemistry: The Central Science*, Eighth Edition.

This AIE is designed to reduce the amount of time you need to prepare for lectures. It also enables you to maximize the effectiveness of the many resources available to you. Prentice Hall provides an extremely comprehensive package of supplements, including several newly developed multimedia tools, which are described on page xxii.

Throughout the text, blue marginal notes indicate specific instructor resources:

This icon is found beside text or graphics that appear on the Matter 2000 CD-ROM that accompanies this text.

This icon is found beside text or graphics that appear both on the set of overhead acetates and on the Matter 2000 CD-ROM that accompany this text.

This icon indicates that a short movie relevant to the topic being discussed can be found on the accompanying Matter 2000 CD-ROM. The name of the movie is indicated in each case so you can locate it quickly on the CD-ROM. Some movies are animations; others are video demonstrations.

This icon references demonstrations you can perform live in class to illustrate the point being made in the text.

This icon indicates a reference to the primary literature for a point being made in the text.

This icon indicates a teaching tip. These include points to emphasize and common student misconceptions. Some experienced professors of general chemistry will find the information provided to be thoroughly familiar. But for instructors rotating into general chemistry once every 3 or 4 years, for those teaching the course for the first time, and for graduate assistants, we hope you find these helpful.

You may also find it useful to consult the Instructor's Resource Manual (IRM). The IRM includes more teaching tips, suggested lecture outlines, and a more extensive list of demonstrations that can be performed live in class.

Preface

To the Instructor

Philosophy

Throughout the evolution of this text, certain goals have guided our writing efforts. The first is that a text should show students the importance of chemistry in their major areas of study as well as in their daily lives. It has been our experience that students are more enthusiastic about learning chemistry when they are aware of its importance to their own goals and interests. With this in mind, we have attempted, as much as space permits, to bring in interesting and significant applications of chemistry. At the same time, the text provides students with the necessary background in modem chemistry for their specialized studies, including more advanced chemistry courses.

Second, we want students to see not only that chemistry provides the basis for much of what goes on in our world but also that it is a vital, continually developing science. We have kept the book up-to-date in terms of new concepts and applications and have tried to convey some of the excitement of the field.

Third, we feel that if the text is to support your role as teacher effectively, it must be addressed to the students. We have sought 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.

Organization

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.

The next four chapters (Chapters 6–9) deal with electronic structure and bonding. The focus 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 modem materials (Chapter 12), which builds on the student's understanding of chemical bonding and intermolecular interactions.

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 an optional chapter on environmental chemistry (Chapter 18), in which the concepts developed in preceding chapters are applied to a discussion of the atmosphere and hydrosphere.

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.

Flexibility: Careful writing allows coverage of gases (Chapter 10) and balancing redox equations (Sections 20.1 and 20.2) at any point in your course.

Our chapter sequence provides a fairly standard organization, but we recognize that not everyone teaches all of 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.

We have always attempted to introduce students to descriptive chemistry by integrating examples throughout the text. You will find pertinent and relevant examples of "real" chemistry woven into all of 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 chemistry in the end-of-chapter exercises.

Changes in this Edition

Our major goal in the eighth edition has been to strengthen an already strong textbook while retaining its effective and popular style. The traditional strengths of *Chemistry: The Central Science* include 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 to this edition, we have tried to be responsive to the feedback we received from the faculty and students who used the seventh edition. Students appreciate the student-friendly style of writing, and we have preserved this style in the eighth edition. Sections that have seemed most difficult to students have in many cases been rewritten and, when possible, augmented with improved artwork. In order to make the text easier for students to use, we have tried for an even more open, clean design in the layout of the book.

New: This edition features a cleaner, easier-to-read design.

Visualization: There is more molecular and compound (micro/macro) art in this edition.

The text also contains an improved art program that will better convey the beauty, excitement, and concepts of chemistry to students. The expanded use of computer-generated molecular art gives students a greater sense of molecular architecture through ball-and-stick and space-filling representations of molecules. Line art has been enhanced significantly, with a greater emphasis on three-dimensional representations. New photographs have been added throughout the book. Our goal continues to be to use color to emphasize important points, to focus the student's attention, and to make the text attractive and inviting without being distracting.

Problem-solving: New and improved *Strategies in Chemistry* essays show students how to think like a chemist.

Problem-solving: More Integrative Exercises in this edition.

Problem-solving: New Sample Integrative Exercises show students how to thread multiple concepts together to solve complicated problems.

We continue to emphasize concept-oriented learning throughout the text. *Concept links* (∞) continue to provide easy-to-see cross-references to pertinent material earlier in the text. The essays entitled *Strategies in Chemistry*, which provide advice to students on problem solving and "thinking like a chemist," have been rewritten and enhanced. The *Integrative Exercises*, introduced in the seventh edition, have been well-received, and we have increased their number. They give students the opportunity to solve problems that integrate concepts from the present chapter with those of previous chapters. To further enhance the value of these exercises, we have introduced in this edition a new feature, the *Sample Integrative Exercise: Putting Concepts Together*. These in-text Sample Exercises, which appear in all but the first few chapters, pose problems that have several

parts. Some of the parts involve concepts and methods from earlier chapters. The carefully worked-out solutions encourage students to see chemistry as an integrated whole rather than as a set of dissociated topics.

We have kept the text fresh by keeping it current. References to current events help students relate their studies of chemistry with their everyday life experiences. 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 seventh edition. We continue our focus on the positive aspects of chemistry, but 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.

Applications: New and updated *Chemistry at Work* and *Chemistry and Life* boxes.

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).
- Added and integrated more conceptual questions into the end-of-chapter material.
- Added eMedia Exercises to the end-of-chapter material. These exercises take advantage of the integrated media components and extend students' understanding, using the advantages that 3-D media presentations offer.

Problem-solving: New eMedia Exercises direct students to the simulations and animations on *Central Science Live*, the student CD that accompanies this edition.

- Added a Web/CD icon to the margins to indicate where students can extend understanding of a concept or topic by looking at an activity located on the Website or the *Central Science Live* Student CD-ROM.
- Carried the step-wise problem-solving strategy — introduced in Chapter 3 of the Seventh Edition — further into the book to provide more guidance in problem solving.
- Reviewed and revised all chapters based on feedback from reviewers and users. For example, we have:
  - —Fine tuned the discussion of molarity and titration.
  - —Added a new biomaterials section.
  - —Rewritten the section on acid–base titrations.
  - —Rewritten and revised several sections on kinetics to better explain key concepts such as instantaneous rate, activation energy, and the Arrhenius equation.
  - —Improved the introduction to thermodynamic concepts.
  - —Expanded the chapter on electrochemistry, adding subsections on the molecular view of electrode processes and concentration cells and revising the section on batteries.
  - —Revised the chapter on organic chemistry to include an overview of previously covered topics of key importance and to include new sections on organic mechanisms and chirality.

Please see the next pages for more specific details about how the Eighth Edition's integrated learning program will help your students succeed.

Supplements

For the Instructor

- **Annotated Instructor's Edition (with Guide to Print and Media Resources) (0-13-084090-4)** This special instructor's edition provides marginal notes and information for instructors and TAs, including MATTER 2000 CD-ROM and transparency icons, suggested lecture demonstrations, teaching tips, and background references from the chemical education literature for key topics.
- **Solutions to Exercises (0-13-084097-1)** Full solutions to all end-of-chapter exercises in the text are provided. With an instructor's permission, this manual may be made available to students.
- **Instructor's Resource Manual (0-13-084102-1)** This useful guide describes all the different resources available to instructors and shows how to integrate them into your course. Organized by chapter, this manual offers detailed lecture outlines and complete descriptions of all available lecture demonstrations, the animated concept sequences, all video demonstrations, common student misconceptions, and much more.
- **Test Item File (0-13-084519-1)** The Test Item File has been heavily revised for this edition. It now includes integrated conceptual questions, and all questions are unique to the Test Item File. A selection of more than 3500 test questions is provided.
- **Prentice Hall Custom Test.** This computerized version of the Test Item File includes electronic versions of all 3500 test questions as well as the latest Prentice Hall Test Manager Software. Test Manager allows you to create and tailor exams to your own needs and includes tools for course management, algorithmic question generation, and offering tests over a local area network. ***Windows* (0-13-084521-3); *Macintosh* (0-13-084522-1)**
- **Transparencies (0-13-084510-8)** Two hundred fifty full-color images are included in an easy-to-use binder. For each transparency, we've made the type larger for easier viewing in large classrooms.
- ***Central Science Live* — Companion Website http://www.prenhall.com/brown** In addition to the robust content for the student found on *Central Science Live*, this Website gives *you* access to Syllabus Manager. This innovative tool allows you to quickly construct an online syllabus. There, you can list all the assignments and events for your class, as well as link to any specific online modules, including those in the *Central Science Live* Companion Website.
- **Companion Website Plus** Companion Website Plus includes all the content from the *Central Science Live* Companion Website plus a set of tools that enables you to direct, manage, analyze, and track your students' use of the site. Companion Website Plus gives you access to:
  - —**Results Reporter,** which allows you to track and analyze students' progress. There are three types of reports you can access. You can view them online or download them in spreadsheet format.
  - —**Course Roster,** which allows you to move students among multiple course sections or drop them if they leave your course.
  - —**Messaging,** which enables you to send broadcast messages or private e-mails to one student, a group of students, or even the whole class, without having to type in a single address.

- **WebCT/Prentice Hall** The WebCT Course Management System provides faculty members with easy-to-use tools to create sophisticated Web-based educational programs. Enhance a campus course or construct an entirely online course using WebCT tools and Prentice Hall's content. Instructors with little or no technical experience can use a point-and-click navigation system to design their own online course components, including setting up course calendars, quizzes, assignments, lectures, and self-paced study help.

  Prentice Hall can provide the content for a complete chemistry course tailored to Brown/LeMay/Bursten and includes the entire text online. In addition to the gallery of animations, we provide quizzing and testing material and a wide range of customizing options. For example, instructors can edit questions, modify/delete/add to the testing database, categorize material by level of difficulty, award different point values for different problems, and give partial credit.

  See *http://webct.prenhall.com* for a demonstration.

- **MATTER 2000: The Visual Presentation Resource. *Windows* (0-13-084523-X); *Macintosh* (0-13-084524-8)** This CD-ROM with Presentation Manager is specific to Brown/LeMay/Bursten and features almost all the text art (over 500 pieces), an electronic version of the course outline from the instructor's resource manual, more than 90 movies (most created by text author Ted Brown), and a complete set of lecture slides pre-built in PowerPoint using art and movies specific to Brown/LeMay/Bursten.

- **Chemistry Animation Video Series (0-13-719022-0)** Fifty short (approximately one minute) animations — the same as on MATTER 2000 — on videotape in full-screen, broadcast-quality video for those who prefer VHS format.

For the Lab

- **Laboratory Experiments *(Nelson/Kemp)* (0-13-084101-3)** This manual includes 41 finely tuned experiments chosen to introduce students to basic lab techniques and to illustrate core chemical principles. It contains pre-lab questions and detachable report sheets. This new edition has been revised to correlate more tightly with the text. Safety and disposal information has also been updated.

- **Annotated Instructor's Edition to *Laboratory Experiments* (0-13-084516-7)** This AIE combines the full student lab manual with front and back appendices covering the proper disposal of chemical waste, safety instructions for the lab, descriptions of standard lab equipment and materials, answers to questions, and more.

For the Student

- ***Central Science Live* — eMedia Chemistry** *Central Science Live* — eMedia Chemistry consists of two components, which can stand alone or work in concert: the Student CD-ROM and the Companion Website. The Student CD-ROM and the password for access to the Companion Website are both found in the Brown/Lemay/Bursten *Media Companion* (0-13-084517-5 if you are using CW; 0-13-086118-9 if you are using CW+).

  ***Central Science Live* — Student CD-ROM** This book-specific companion to *Chemistry: The Central Science, Eighth Edition* presents core chemistry content in a dynamic and interactive way. Designed specifically for students, it includes:

  —**Media-rich summaries** of each section of material in the text.

  —**Sixty-one short animations** presenting selected topics that are more easily conveyed in a visual fashion, and **31 laboratory demonstration**

video clips showing chemistry in live action. These are the same animations and demonstrations that instructors have on the MATTER 2000 Visual Presentation Resource.

—**Forty interactive simulations** (Java Applets) that enable students to learn by doing experiments — by changing conditions, adjusting variables, and establishing trends.

—**Interactive Quizzes** linked to each animation, demonstration, and simulation.

—**An automatic link** to the *Central Science Live* Companion Website.

—**Selected figures** from the textbook.

—**Search capabilities** for words and media elements, with links to text content.

The software that runs this CD-ROM is a standard browser — just like your students already use.

***Central Science Live* — Companion Website http://www.prenhall.com/brown** Now in its "Second Edition," this innovative online resource center is designed specifically to support and enhance Brown/LeMay/Bursten's *Chemistry: The Central Science, Eighth Edition.* It features:

—A **Problem-Solving Center** where students have access to more than 2000 additional problems — including algorithmically generated questions and non-multiple-choice questions — all organized by chapter, each with specific hints and feedback.

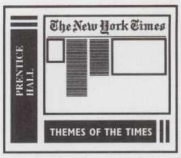
—A **Visualization Center**, with pre-built 3-D models of molecules discussed in the text that can be manipulated in real-time and displayed in different representations.

—**Constantly updated Current Topics**, linking your students to recently published articles from the lay press, and a Web Resources Center that links your students to other carefully selected, chemistry-related Websites.

—A **Communications Center** offering chatrooms, bulletin boards, and other places where students can communicate with you, teaching assistants, or classmates.

—An **eBook**, a media-rich, Web version of the textbook that enables students to link directly from Web-based activities to the appropriate sections of the text. This allows students to work through Web exercises without having the actual text in front of them.

- **Solutions to Red Exercises (0-13-084099-8)** Full solutions to all of the red-numbered exercises in the text are provided. (Short answers to red exercises are found in the appendix of the text).
- **Solutions to Black Exercises (0-13-084098-X)** Full solutions to all of the black-numbered exercises in the text are provided.
- **Student Guide (0-13-084095-5)** This book assists students through the text material with chapter overviews, learning objectives, review of key terms, cumulative reviews, and self-tests. Included are answers to all *Student Guide* exercises. Chapter summaries are correlated to those in the Instructor's Resource Manual and on the MATTER 2000 Visual Presentation Resource — the instructor's CD-ROM.
- **Math Review Toolkit (0-13-084103-X)** This free book reinforces the skills necessary to succeed in chemistry. It is keyed specifically to chapters in Brown/LeMay/Bursten and includes additional mathematics review, problem-solving tools and examples, and a section on writing for the laboratory.



- **Prentice Hall/*The New York Times* "Themes of the Times" — Chemistry** This innovative program is designed to bring current and relevant applications into the classroom. Adopters of Brown/LeMay/Bursten are eligible to receive these unique "mini-newspapers" that bring together a collection of the latest and best chemistry articles from the highly respected pages of *The New York Times.* (Updated twice annually.)
- **Prentice Hall Molecular Model Set for General and Organic Chemistry (0-13-955444-0)** This ball-and-stick model kit is designed for use in general chemistry and the student's next course in organic chemistry. It includes trigonal bipyramidal and octahedral atom centers as well as 14 carbon atoms.

To the Student

Chemistry: The Central Science, Eighth Edition, has been written to introduce you to modern chemistry. During the many years we have been practicing chemists, we have found chemistry to be an exciting intellectual challenge and an extraordinarily rich and varied part of our cultural heritage. We hope that as you advance in your study of chemistry, you will share with us some of that enthusiasm, excitement, and appreciation. We also hope that you will come to realize the importance of chemistry in your everyday life. 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 xxviii–xxxiii. You will find it helpful to examine those features.

As you proceed through your course in chemistry, it is important for you to develop good study habits to help you in the learning process. We offer the following tips for success in your study of chemistry:

Keep up with your studying day to day. In your chemistry course, new chemistry will build on material already presented. It is important not to fall behind; if you do, you will find it much harder to follow the lectures and discussions on current topics. Trying to "cram" just before an exam is generally a very ineffective way to study chemistry.

Focus your study. The amount of information you will receive in your chemistry course can sometimes seem overwhelming. It is essential to recognize those concepts and skills that are particularly important. Listen intently to the guidance and emphasis provided by your instructors. Pay attention to the skills stressed in the sample exercises and homework assignments. Notice the italicized statements in the text, and study the concepts presented in the chapter summaries.

Keep good lecture notes. Your lecture notes will provide you with a clear and concise record of the required material and will contain the insight and expertise provided by your instructors. 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 an awareness for the scope of topics. Avoid the feeling that you must learn and understand everything right away.

After lecture, carefully read the topics covered in class. You will probably need to read assigned material more than once to master it. 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. As you progress through the text you will encounter *Sample Integrative Exercises: Putting Concepts Together*. These are designed to help you see how concepts and methods learned in earlier chapters can be put together with newly learned materials.

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.

Attempt all of 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 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 from another student. Spending more than 20 minutes on a single exercise is rarely effective unless you know that it is particularly challenging.

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 it is the *central science*.

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This book owes its final shape and form to the assistance and hard work of many people. Several colleagues helped us immensely by sharing their insights, reviewing our initial writing efforts, or providing suggestions for improving the text. We would especially like to thank the following:

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A Student's Guide to Using this Text

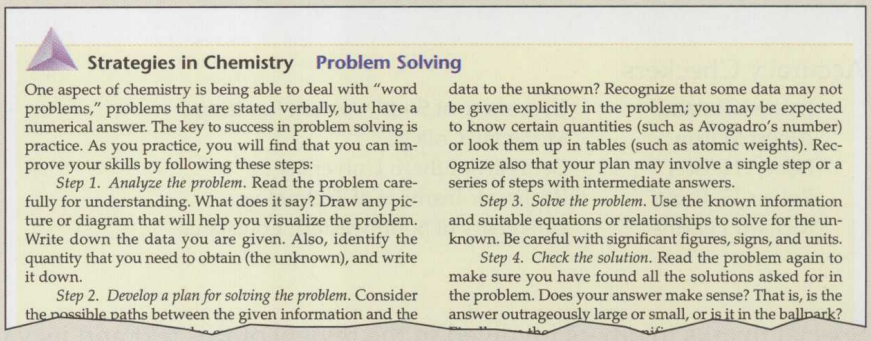
The following pages walk you through some of the main features of this text and its integrated media components. This learning system was designed with you, the student, in mind. We hope you enjoy your study of Chemistry—the *central science*.

Problem Solving

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

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 Problem Solving

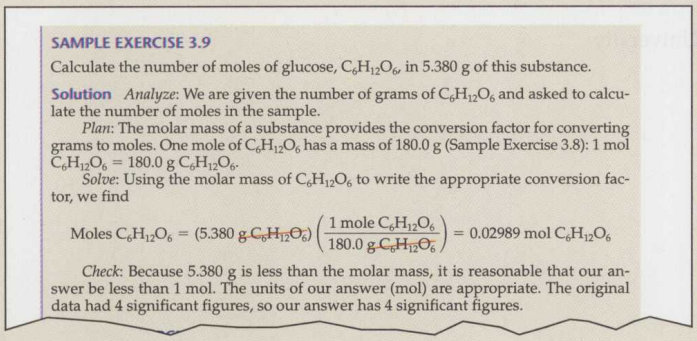
One aspect of chemistry is being able to deal with "word problems," problems that are stated verbally, but have a numerical answer. The key to success in problem solving is practice. As you practice, you will find that you can improve your skills by following these steps:

Step 1. Analyze the problem. Read the problem carefully for understanding. What does it say? Draw any picture or diagram that will help you visualize the problem. Write down the data you are given. Also, identify the quantity that you need to obtain (the unknown), and write it down.

Step 2. Develop a plan for solving the problem. Consider the possible paths between the given information and the data to the unknown? Recognize that some data may not be given explicitly in the problem; you may be expected to know certain quantities (such as Avogadro's number) or look them up in tables (such as atomic weights). Recognize also that your plan may involve a single step or a series of steps with intermediate answers.

Step 3. Solve the problem. Use the known information and suitable equations or relationships to solve for the unknown. Be careful with significant figures, signs, and units.

Step 4. Check the solution. Read the problem again to make sure you have found all the solutions asked for in the problem. Does your answer make sense? That is, is the answer outrageously large or small, or is it in the ballpark?



SAMPLE EXERCISE 3.9

Calculate the number of moles of glucose, $C_6H_{12}O_6$, in 5.380 g of this substance.

Solution *Analyze*: We are given the number of grams of $C_6H_{12}O_6$ and asked to calculate the number of moles in the sample.

Plan: The molar mass of a substance provides the conversion factor for converting grams to moles. One mole of $C_6H_{12}O_6$ has a mass of 180.0 g (Sample Exercise 3.8): 1 mol $C_6H_{12}O_6$ = 180.0 g $C_6H_{12}O_6$.

Solve: Using the molar mass of $C_6H_{12}O_6$ to write the appropriate conversion factor, we find

$$\text{Moles } C_6H_{12}O_6 = (5.380 \text{ g } \cancel{C_6H_{12}O_6}) \left(\frac{1 \text{ mole } C_6H_{12}O_6}{180.0 \text{ g } \cancel{C_6H_{12}O_6}} \right) = 0.02989 \text{ mol } C_6H_{12}O_6$$

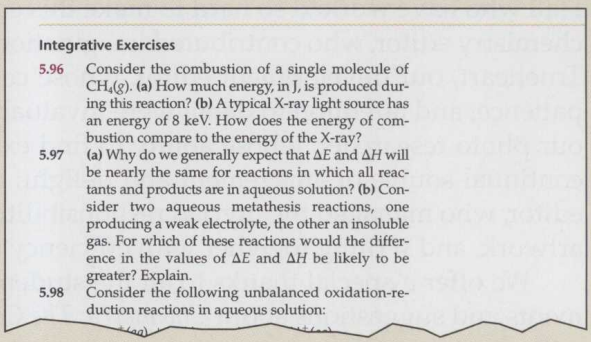
Check: Because 5.380 g is less than the molar mass, it is reasonable that our answer be less than 1 mol. The units of our answer (mol) are appropriate. The original data had 4 significant figures, so our answer has 4 significant figures.

Worked Solutions

- The solutions to *Sample Exercises* have been carefully developed to demonstrate the step-by-step strategy within the exercise solution. These help you understand and integrate the thought processes involved in solving each exercise.
- Following each *Sample Exercise* are *Practice Exercises* that provide answers, but do not provide worked solutions. These *Practice Exercises* give you instant feedback on your understanding of key concepts.

End-of-Chapter Exercises

- The first 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. Many of these exercises draw on multiple concepts from within the chapter.
- *Integrative Exercises* appear at the end of appropriate chapters and connect concepts from the current chapter with those from previous chapters. They help you gain a deeper understanding of how chemistry fits together. In addition, they serve as an overall review of key concepts. Some chapters, where appropriate, contain a *Sample Integrative Exercise* at the end of the chapter to allow you to practice solving problems that encompass more than one concept.
- Answers are provided in the back of the book for red-numbered exercises. More challenging exercises are indicated by brackets around the exercise number.

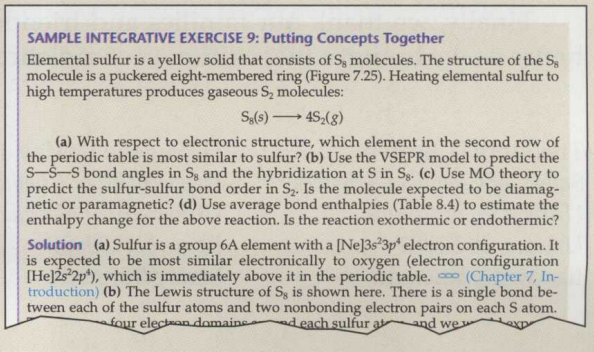


Integrative Exercises

5.96 Consider the combustion of a single molecule of $CH_4(g)$. **(a)** How much energy, in J, is produced during this reaction? **(b)** A typical X-ray light source has an energy of 8 keV. How does the energy of combustion compare to the energy of the X-ray?

5.97 **(a)** Why do we generally expect that ΔE and ΔH will be nearly the same for reactions in which all reactants and products are in aqueous solution? **(b)** Consider two aqueous metathesis reactions, one producing a weak electrolyte, the other an insoluble gas. For which of these reactions would the difference in the values of ΔE and ΔH be likely to be greater? Explain.

5.98 Consider the following unbalanced oxidation-reduction reactions in aqueous solution:



SAMPLE INTEGRATIVE EXERCISE 9: Putting Concepts Together

Elemental sulfur is a yellow solid that consists of S_8 molecules. The structure of the S_8 molecule is a puckered eight-membered ring (Figure 7.25). Heating elemental sulfur to high temperatures produces gaseous S_2 molecules:

$$S_8(s) \longrightarrow 4S_2(g)$$

(a) With respect to electronic structure, which element in the second row of the periodic table is most similar to sulfur? **(b)** Use the VSEPR model to predict the S—S—S bond angles in S_8 and the hybridization at S in S_8. **(c)** Use MO theory to predict the sulfur-sulfur bond order in S_2. Is the molecule expected to be diamagnetic or paramagnetic? **(d)** Use average bond enthalpies (Table 8.4) to estimate the enthalpy change for the above reaction. Is the reaction exothermic or endothermic?

Solution **(a)** Sulfur is a group 6A element with a $[Ne]3s^23p^4$ electron configuration. It is expected to be most similar electronically to oxygen (electron configuration $[He]2s^22p^4$), which is immediately above it in the periodic table. ∞∞ (Chapter 7, Introduction) **(b)** The Lewis structure of S_8 is shown here. There is a single bond between each of the sulfur atoms and two nonbonding electron pairs on each S atom.

End-of-Chapter Exercises (continued)

- *eMedia Exercises* are answered by using the movies and simulations available on the student CD-ROM. By answering these questions, you will increase your practical understanding of the material.

eMedia Exercises

4.100 The **Electrolytes and Non-Electrolytes** movie (*eChapter 4.1*) and the **Aqueous Acids** and **Aqueous Bases** movies (*eChapter 4.3*) illustrate the behavior of various substances in aqueous solution. For each of the seven substances mentioned in the movies, write the chemical equation that corresponds to dissolution in water. (The chemical formula of sugar is $C_{12}H_{22}O_{11}$.) Where appropriate, use the double arrow notation.

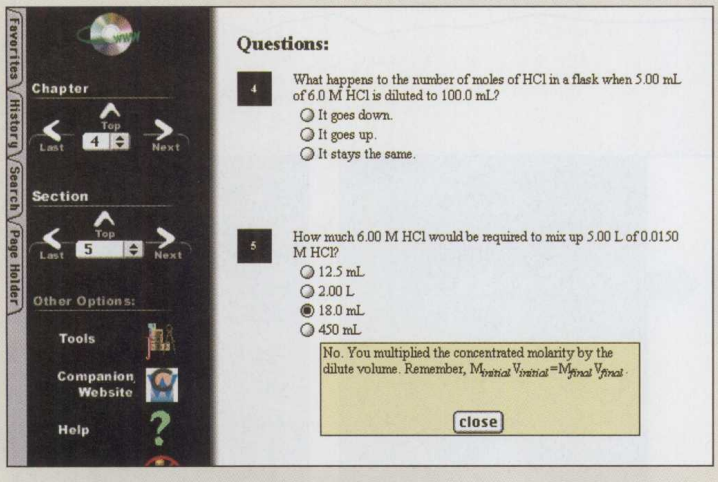
4.101 In the **Strong and Weak Electrolytes** movie (*eChapter 4.1*), the light bulb glows brightly when the beaker contains aqueous hydrochloric acid, but relatively dimly when the beaker contains aqueous acetic acid. **(a)** For each of the compounds in Exercise 4.3, would you expect an aqueous solution to cause the bulb to light? If so, how brightly? **(b)** Consider the use of aqueous solutions of each of the following compounds in the apparatus shown in the demonstration. For each compound, would you expect the light bulb to glow brightly, dimly, or not at all? H_2CO_3; C_2H_5OH; NH_4Cl; CaF_2; and HF.

4.102 **(a)** For each combination listed, predict what precipitate, if any, will form. (i) $Na_2CO_3(aq)$ and $Fe(NO_3)_2(aq)$; (ii) $NH_4Cl(aq)$ and $Pb(NO_3)_2(aq)$; (iii) $AlBr_3(aq)$ and $Fe_2(SO_4)_3(aq)$; (iv) $H_2SO_4(aq)$ and $Pb(NO_3)_2(aq)$; (v) $Na_2S(aq)$ and $(NH_4)_2SO_4(aq)$. Use the **Ionic Compounds** activity (*eChapter 2.7*) to check your answers. **(b)** For each combination that produces a precipitate, write a balanced net ionic equa- When 500 mL each of 0.250 *M* NH_4

4.104 After watching the **Solution Formation from a Solid** movie (*eChapter 4.5*), answer the following questions: **(a)** If we neglect to account for the mass of the weighing paper, how would our calculated concentration differ from the actual concentration of the solution? **(b)** Describe the process of preparing an aqueous solution of known concentration, starting with a solid. **(c)** Why is it necessary to make the solution as described in the movie, rather than simply filling the flask up to the mark with water and then adding the solute? **(d)** Describe how you would prepare the solution in part (a) starting with the concentrated stock solution in the **Solution Formation by Dilution** movie (*eChapter 4.5*).

4.105 Use the **Titration** simulation (*eChapter 4.6*) to determine the concentration of an unknown acid by adding 0.40 *M* NaOH in increments of 1.0 mL. Repeat the titration adding increments of 0.10 mL of base near the endpoint. Once more, repeat the titration adding increments of 0.05 mL of base near the endpoint. If your acid is dilute enough, repeat the titration three more times using 0.10 *M* NaOH in 1.0 mL, 0.50 mL, and 0.05 mL increments. **(a)** Tabulate the acid concentrations that you calculate from your titration data. Are the values all the same? If not, why not? **(b)** Which value do you consider to be most precise and why?

4.106 **(a)** What is the maximum concentration of monoprotic acid that could be titrated in the **Titration** simulation (*eChapt* using 0.05 *M* *(a)* Wh



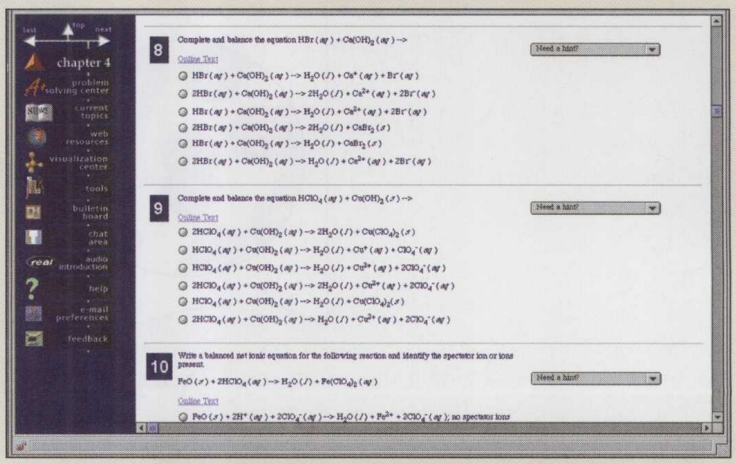
Central Science Live—Student CD-ROM

This media companion is integrated with *Chemistry: The Central Science, Eighth Edition*. It includes simulations and movies that will help you practice your problem-solving skills and master your understanding of key chemical concepts.

Central Science Live—Companion Website

http://www.prenhall.com/brown

The Brown/LeMay/Bursten Website was designed specifically to support and enhance your study of chemistry. The site provides a **Problem-Solving Center** where you have access to more than 2500 additional conceptual and quantitative exercises (including algorithmically generated, multiple-choice and essay questions). Each problem is categorized by chapter and referenced to the text, and each problem offers hints and specific feedback for incorrect answers.



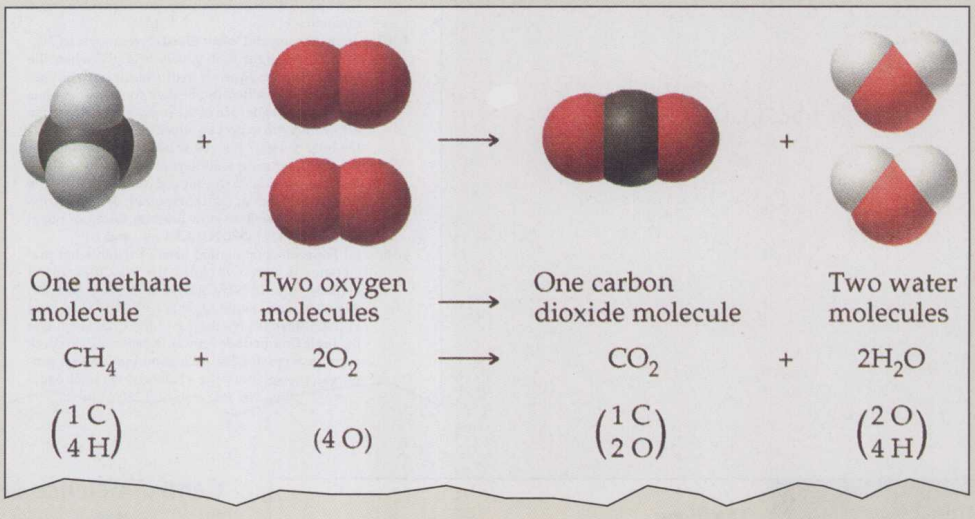
Visualization

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 succeed in your course. Spend time with the illustrations in the text; they'll help you understand the chemistry concepts being discussed.

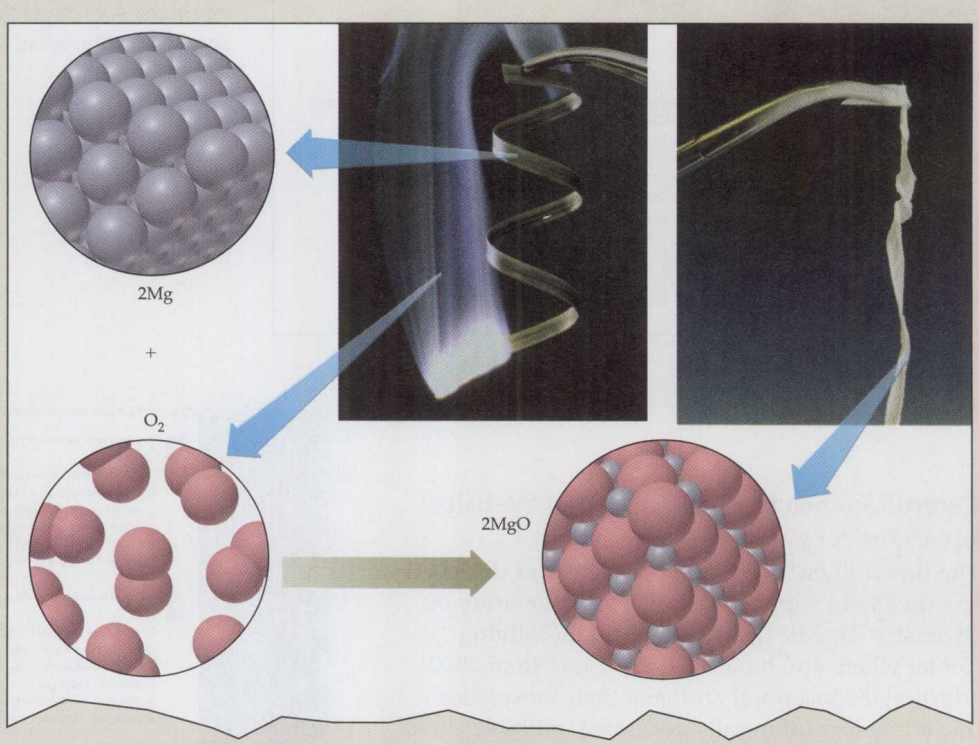
Symbolic and Molecular Representations

The careful inclusion of molecular art with chemical formulas helps you see the connection between the symbols you write and the molecules to which they refer.



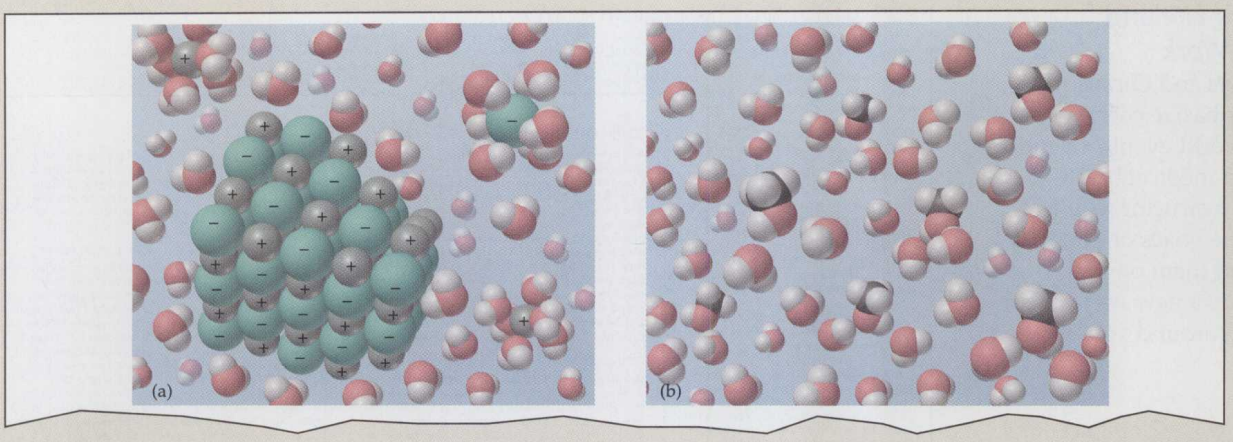
Compound Illustrations

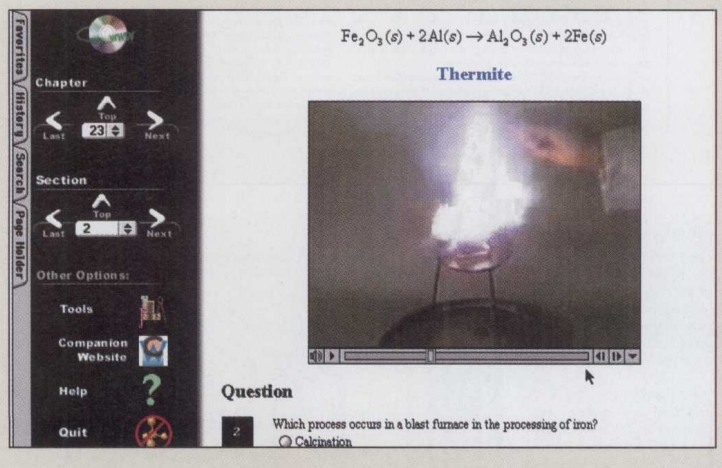
Compound illustrations combine photographs with molecular art. They give you a better sense of the relationships between the macroscopic properties of matter and its underlying structure at the atomic and molecular levels.



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.





Central Science Live—Student CD-ROM

The media companion to *Chemistry: The Central Science, Eighth Edition* brings the molecular world to life for you with **more than 90 movies** (including animations written and developed by Ted Brown) as well as numerous **3-D Chime models.** The CD-ROM also features **more than 40 simulations,** where you are guided through virtual experiments to discover and enhance your understanding of chemical concepts. You know to look on the CD-ROM when you see this icon:

Central Science Live—Companion Website and Companion Website Plus

http://www.prenhall.com/brown

The Brown/LeMay/Bursten site provides a **3-D Visualization Center** where you can look at a gallery of over 250 molecules in 3-D and work through visualization tutorials (for example, there's one on VSEPR theory) to gain a deeper understanding of the three-dimensional nature of molecules.