

**Chemistry**  
seventh edition

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Raymond Chang

Williams College

# Chemistry

Seventh Edition



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## CHEMISTRY, SEVENTH EDITION

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# Preface

When I wrote the preface for the previous edition of this book, I considered the challenges of preparing students in a rapidly changing, technology-driven time in our history. A few years later, the challenges remain the same: How do we inspire and instruct students about the basic facts of chemistry, while taking advantage of all that technology has to offer? The answer is clear: We use many tools, and extract the best that each tool can offer. Technology can push learners to visualize chemistry and explore ideas in an interactive environment. But before that exploration, students need to build a foundation, a framework for ideas. The textbook is still the best tool for students to use as they learn new concepts in chemistry.



The strength of the seventh edition is the integration of various tools that truly are designed to inspire both students and instructors. The textbook is the foundation for the technology. The technology, most totally new for the seventh edition, takes students beyond the confines of the traditional textbook. I hope that the revisions to the seventh edition and technology answer many of your challenges as you teach general chemistry.

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## New to the Seventh Edition

Totally new technology tools, described on the following pages of this preface, include

- Essential Study Partner (ESP) interactive student tutorial
- e-Text 2.0
- OnLine Learning Center website for instructors and students
- WebCT Course created specifically for *Chemistry, Seventh Edition*, for instructor course management
- PageOut for instructor course management
- PowerPoint Lecture Presentation created specifically for *Chemistry, Seventh Edition*
- Visual Resource Library of all illustrations and photographs for *Chemistry, Seventh Edition*
- Chemistry Animations Visual Resource Library for instructor presentations
- New molecular art images were created using the Spartan molecular modeling program. These drawings enable students to gain a better understanding of the three-dimensionality of molecules and the details of chemical reactions. Much of the art program is revised or new, with emphasis on pedagogical use of color. For examples, see the art key in the back end paper, and Figures 5.6, 5.14, 10.6, 13.26, and 25.13.
- A new periodic table icon illustrates the properties of elements according to their positions in the periodic table.
- Many “Worked Examples” have been revised to more clearly show steps in problem solving.
- New “Chemistry in Action” essays have been added and many others have been updated.

- Chapter 25 features a new Chemical Mystery, “A Story That Will Curl Your Hair.”
- The text is revised to improve the clarity and readability, which are among its strengths.
- A new Animation Icon  points to material that is further illustrated by an animation.
- A Pedagogy Icon  highlights problem-solving strategies in the text.

I would greatly appreciate your comments and suggestions.

**Raymond Chang**  
**Williams College**  
**raymond.chang@williams.edu**





**Raymond Chang**

## A Note to the Student

General chemistry is commonly perceived to be more difficult than most other subjects. There is some justification for this perception. For one thing, chemistry has a very specialized vocabulary. At first, studying chemistry is like learning a new language. Furthermore, some of the concepts are abstract. Nevertheless, with diligence you can complete this course successfully, and you might even enjoy it. Here are some suggestions to help you form good study habits and master the material in this text.

- Attend classes regularly and take careful notes.
- If possible, always review the topics discussed in class the same day they are covered in class. Use this book to supplement your notes.
- Think critically. Ask yourself if you really understand the meaning of a term or the use of an equation. A good way to test your understanding is to explain a concept to a classmate or some other person.
- Do not hesitate to ask your instructor or your teaching assistant for help.

The seventh edition tools for *Chemistry* are designed to enable you to do well in your general chemistry course. The following guide explains how to take full advantage of the text, technology, and other tools.

- Before delving into the chapter, read the chapter *outline* and the chapter *introduction* to get a sense of the important topics. Use the outline to organize your notetaking in class.
- Ready Notes are another tool for notetaking. Ready Notes come as a small booklet that includes all of the text illustrations, with lines for notes. This tool enables you to take notes on existing art, instead of trying to recreate art as you take notes.
- The *Pedagogy Icon*  highlights strategies for solving mathematical problems in a logical manner. Look for this symbol when reviewing for exams.
- Use the *Animation Icon*  as a guide to review challenging concepts in motion. Most of the animations are interactive.
- At the end of each chapter you will find key equations, a summary of facts and concepts, and a list of key words, all of which will help you review for exams. Definitions of the key words can be studied in context on the pages cited in the end-of-chapter list or in the glossary at the back of the book.
- Use the *Key-Word flashcards* on the website (OnLine Learning Center, or OLC) for more practice. The flashcards include audio, so you can test your pronunciation, too. The OLC houses an extraordinary amount of resources.

Go to [www.mhhe.com/physsci/chemistry/chang7](http://www.mhhe.com/physsci/chemistry/chang7) to explore chapter quizzes, the e-learning sessions, opportunities, the Essential Study Partner, and more.

- Careful study of the numbered examples in the body of each chapter will improve your ability to analyze problems and correctly carry out the calculations needed to solve them. Also take the time to work through the practice exercise that follows each example to be sure you understand how to solve the type of problem illustrated in the example. The answers to the practice exercises appear at the end of the chapter, following the homework problems. For additional practice, you can turn to similar homework problems referred to in the margin next to the example.
- The questions and problems at the end of the chapter are organized by section. Generally the review questions do not require calculations. Their purpose is to help you check your understanding of new concepts introduced in the chapter. The problems enable you to test your analytical and computational skills. Even-numbered problems are similar in nature to the odd-numbered problems that precede them, except in the section titled “Additional Problems.” The additional problems require that you decide how to approach the solution, and a number of them involve concepts from more than one section of the chapter. Although your instructor will most likely not assign all the problems for homework, it is to your advantage to work as many as necessary to assure yourself that you have mastered the chapter. Refer to the back of the book for answers to all even-numbered problems; complete solutions for even-numbered problems as well as problem-solving tutorials are available in a separate Student Solutions Manual.
- For even more practice problems, use *ChemSkill Builder*. CSB is a problem-solving tutorial with hundreds of problems that include feedback.
- If you need help, use the *NetTutor* on the OLC. The NetTutor can help with any question from the end of the chapters, and will work with you either in a live session or through an email exchange.
- One of your best resources is the *Essential Study Partner*, or ESP. The ESP is a tutorial that will help you review and test your understanding of each chapter. The ESP includes animations, interactives, topic reviews with quizzes, and unit exams. [www.mhhe.com/physsci/chemistry/chang7/student/olc/esp.mhtml](http://www.mhhe.com/physsci/chemistry/chang7/student/olc/esp.mhtml)
- Two types of applications are included to help you relate chemistry to the real world. Chemistry in Action boxes in each chapter discuss applications to other sciences and to everyday activities. Chemical Mysteries focus on puzzling events that have chemical explanations and give you the opportunity to apply your knowledge of chemistry and sharpen your thinking skills. Although your instructor may not assign all of these brief essays, if you are serious about the practical side of chemistry, take a look at the list on p. xx and see which topics interest you.
- Use the e-Text to organize all of the tools for this course. The e-Text combines the text, technology, and other tools in one convenient place. You can explore the text and other tools in a nonlinear way, take notes, and link to the web immediately as you are exploring ideas in the text.

If you follow these suggestions and stay up-to-date with your assignments, you should find that chemistry is challenging, but less difficult and much more interesting than you expected.

**Raymond Chang**

## Instructor Resources

### Test Bank

This manual contains over 2000 multiple-choice and short-answer questions. The questions, which are graded in difficulty, are comparable to the problems in the text and include multistep problems that require conceptual analysis.

### MicroTest Computerized Test Bank

This test bank contains all of the questions in the print Test Bank along with algorithms and over 200 algorithm-based questions that instructors can edit to create their own test templates. This supplement is available in Windows and Macintosh versions.

### Instructor's Manual

by Brandon J. Cruickshank (Northern Arizona University), Daryl Doyle (GMI/Engineering and Management Institute), and Raymond Chang. This complete manual for teaching a general chemistry course based on *Chemistry* contains a brief summary of the contents of each chapter, along with learning goals and references to background concepts in earlier chapters. Following this material is a complete listing of the more challenging problems in the chapter and the problems that are worked out in detail in the Student Solutions Manual. The solutions to all of the end-of-chapter problems are then given, including those that are in the Solutions Manual. Some of the end-of-chapter Review Questions are also answered. Finally, this resource contains discussion questions and tips, information on relevant applications, and references to other elements of the text package.

### Overhead Transparencies

Approximately 250 full-color text illustrations are reproduced on acetate for overhead projection.

### Chang Animations

by Brandon Cruickshank (Northern Arizona University). These twenty-eight animations are interactive and specifically support content and concepts in *Chemistry*. Icons in the text show which concepts are animated. Animations can be used by both instructors and students on the OnLine Learning Center, Essential Study Partner, e-Source, and in the Animations Visual Resource Library.

### Chemistry Animations Visual Resource Library

organized by Eric Johnson (Ball State University). This instructor's CD-ROM enables you to use animations in your classroom in the way that works best for you. This multi-CD set includes over 150 animations that can be played directly from the CD or can be imported easily into your own lecture presentation. The animation library is fully searchable, and many animations are included at full-screen size.

### Visual Resource Library (VRL)

This instructor's CD-ROM contains electronic files of all full-color images (illustrations and photographs) from the text and is designed to help you create visually exciting presentations. The Visual Resource Library enables you to incorporate selected

images into word processing programs to use as distribution materials for students. Picture labels can be easily removed. In addition, this tool provides prearranged chapter-by-chapter PowerPoint presentations.

### **PowerPoint Lecture Presentation**

by J. David Robertson (University of Missouri). Instructors who adopt *Chemistry* will find that this presentation not only saves time but also enables them to create visually stunning lecture presentations. The web-based PowerPoint lecture includes notes for the entire course, visuals from the seventh edition, and animations embedded at appropriate points in the program. Use this complete lecture outline, or revise the lecture to fit your own course.

### **Online Learning Center Website (OLC)**

Log on at [www.mhhe.com/physsci/chemistry/chang7](http://www.mhhe.com/physsci/chemistry/chang7). This comprehensive, book-specific website offers excellent tools for both the instructor and the student. Instructors can create a more interactive course with the integration of this site, and a secured Instructor Center stores your essential course materials to save you prep time before class. This center also offers PowerPoint lecture outline, additional narratives for Chang animations, and more.

### **Media Integration Guide**

by Scott S. Perry (University of Houston). The guide explains what media is available and describes how to use media effectively during lecture and outside of the classroom.

### **WebCT**

by Renee Cole and Steve Boone (Central Missouri State University). Instructors who use WebCT will love the WebCT specific course content we offer with *Chemistry*. The WebCT course includes the complete Test Bank formatted for *easy* WebCT use; reading quizzes; online homework with detailed feedback; interactive study guide; and current topics questions.

### **Course-Specific PageOut**

Designed specifically to help you with your individual course needs, PageOut will assist you in integrating your syllabus with *Chemistry* and state-of-the-art new media tools. At the heart of PageOut you'll find integrated multimedia, a full-scale Online Learning Center, and an Integration Guide discussing technology in the classroom. More than 20,000 professors have chosen PageOut to create customized course websites. It's incredibly easy to use, and it's **FREE** to instructors who use a McGraw-Hill textbook in any of their courses.

### **Primis LabBase**

by Joseph Lagowski (the University of Texas at Austin). More than 40 general chemistry experiments are available in this database collection of general chemistry lab experiments from the *Journal of Chemical Education* and experiments used by Professor Lagowski at the University of Texas at Austin, enabling instructors to customize their lab manuals.



## Cooperative Chemistry Laboratory Manual

by Melanie Cooper (Clemson University). This innovative guide features open-ended problems designed to simulate experience in a research lab. Working in groups, students investigate one problem over a period of several weeks, so that they might complete three or four projects during the semester, rather than one preprogrammed experiment per class. The emphasis here is on experimental design, analysis problem solving, and communication.

## Student Resources

### Essential Study Partner

by David Harwell (University of Hawaii at Manoa), Laura Muller (Wheaton College), Norbert Pienta (University of Iowa), Kathleen Robins (University of Las Vegas–Nevada), and Brandon Cruickshank (Northern Arizona University). This free study partner engages, investigates, and reinforces what you are learning from your textbook. You'll find the **Essential Study Partner** for *Chemistry* to be a complete, interactive student study tool packed with hundreds of animations and learning activities. From quizzes to interactive diagrams, you'll find that there has never been a better study partner to ensure the mastery of core concepts. Best of all, it's **FREE** with your new textbook purchase.

### OLC (OnLine Learning Center)

A comprehensive, exclusive website that provides a wealth of electronic resources for instructors and students alike. For students, the OLC features interactive quizzes for each chapter of the text; e-learning sessions; key-term flashcards; NetTutor; interactive glossary with audio; ChemQuest, with Internet search exercises; Visual Chemistry, with Internet exercises that require students to find and manipulate molecules that are discussed in the text; links to chemical databases; and listings of professional opportunities in *Chemistry*. Log on at [www.mhhe.com/physsci/chemistry/chang7](http://www.mhhe.com/physsci/chemistry/chang7).

### Course Ready Notes

by Eric Johnson (Ball State University). This booklet provides illustrations from the text with many labels removed. Rather than spending time copying material that is already in the book, your students can focus on the most important aspects of your lecture.

### Student Solutions Manual

by Brandon J. Cruickshank (Northern Arizona University) and Raymond Chang. This supplement contains detailed solutions and explanations for all even-numbered problems in the main text. The manual also includes a detailed discussion of different types of problems and approaches to solving chemical problems and tutorial solutions for many of the end-of-chapter problems in the text, along with strategies for solving them.

### Student Study Guide

by Kenneth W. Watkins (Colorado State University). This valuable ancillary contains material to help the student organize study time, practice problem-solving skills, and

complete self-tests. For each section of a chapter, the author provides study objectives and a summary of the corresponding text. Following the summary are sample problems with detailed solutions. Each chapter has true–false questions and a self-test, with all answers provided at the end of the chapter.

### **e-Text 2.0**

Interactive e-Text is an exciting student resource that combines McGraw-Hill print, media, study and web-based materials into one easy-to-use CD-ROM. This invaluable resource accommodates all learning styles and complements the printed text. The CD provides a nonlinear learning experience by using animations, audio, art, as well as web-based and other course materials to help students organize their studies. The following features illustrate, in depth, the benefits of e-Text:

- Full textbook and study guide PDF files are interlinked. This includes all narrative, art, and photos, plus expertly crafted animations.
- Targeted weblinks encourage focused web research.
- A Search feature enables students to improve studying by locating targeted content quickly and easily.
- This hybrid CD is compatible with both Macintosh and Windows platforms.
- Required programs, Acrobat Reader and QuickTime, are supplied on the CD-ROM.
- Bookmarks, appearing on the left side of the screen, list all of the links available on that page.
- Main menu links are at the bottom of every screen as well as in the bookmark section.
- An explanation of features is provided on the Help Page.
- Boldface terms are linked to definitions in the glossary.

### **ChemSkill Builder**

by Electronic Homework Systems. This extremely useful CD-ROM generates questions for students for every topic in the general chemistry course. The questions are presented in a randomized fashion with a constant mix of variables so that no two students will receive the same questions. The application provides feedback for students when incorrect answers are entered, and the answers can be submitted to an instructor for grading.

### **CyberChem CD-ROM**

by Maha Ashour-Abdalla (University of California, Los Angeles) and Raymond Chang. This innovative CD-ROM provides a highly interactive study and tutorial package for the one-year general chemistry course. It contains 60 animations of concepts, 25 interactive lab simulations, and 25 movies focusing on real-world applications, along with interactive step-by-step problem-solving and quizzing modules. CyberChem contains hyperlinked conceptual sections based on the chapters in *Chemistry*. In addition, no matter where students are in the program, they will have access to a unique hyperlinked Periodic Table, with photos, information about the elements, a search function, and cross-references to these elements where they are discussed elsewhere in the program. Over 59,000 copies sold!

## Schaum's Outline of College Chemistry

by Jerome Rosenberg (Michigan State University) and Lawrence Epstein (University of Pittsburgh). This helpful study aid provides students with hundreds of solved and supplementary problems for the general chemistry course.

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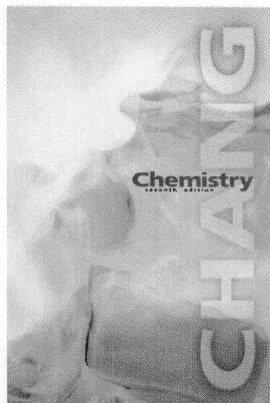
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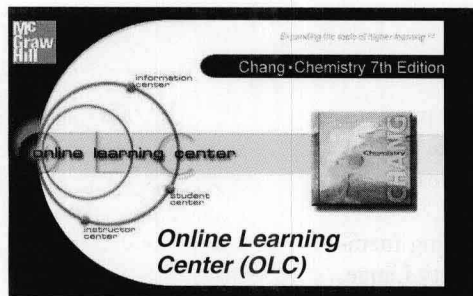
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# Media Walkthrough

This section highlights the electronic media that supports *Chemistry*, Seventh Edition, and shows how the entire package fits together. Use the pieces that work best for you, or use them all! See pages xxiv-xxviii for complete descriptions of print and media products.



The textbook is the foundation for all of the course tools. Use the printed text or the e-Text. The e-Text includes many of the tools that follow, or hotlinks to them.



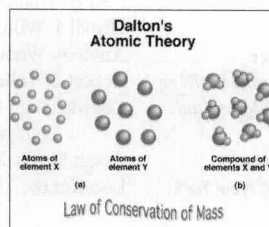
Instructor's Online Learning Center (OLC) is a secure, book-specific website. The OLC is the doorway to a library of resources for instructors.

The OLC is also the doorway for students to access almost all of the media for *Chemistry*, Seventh Edition. The OLC includes self-assessment quizzes, resources, key-term flashcards with audio pronunciation, and more. Read on!

## Instructor Media



The guide explains what is available and gives suggestions for using media effectively in the classroom.



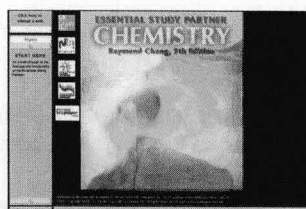
PowerPoint Presentation, organized by chapter and section, is ready for the classroom, or you can customize your lecture. This is an exciting lecture that goes beyond the presentation provided on the *Chemistry*, Seventh Edition, VRL.



Content available specifically for WebCT users includes:

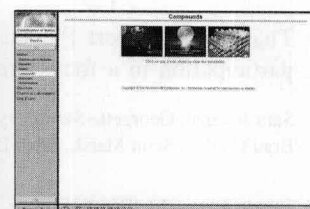
- Interactive Student Study Guide
- Reading quizzes
- Homework questions

## Student Media



### Essential Study Partner (ESP)

The Essential Study Partner (ESP) is just that—the essential tool for review, interaction, and self-assessment! Students can access the entire ESP, or the ESP by chapter for *Chemistry*, Seventh Edition, to work through a basic review of core concepts in ten units.



ESP animations allow students to really see the activity behind chemical concepts.

Also included in the e-Text.

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**Chemistry Animations  
Visual Resource Library**

**Mc  
Graw  
Hill**

All of the following tools are available on the OLC or in a cartridge for your course delivery system:

- Chemistry, Seventh Edition, Test Bank
- Instructor's Solutions Manual (odd problems from this manual)

- Instructor's Manual
- Visual Resource Library images
- Instructor narratives for select animations
- Essential Study Partner link to home page
- FAQ list for Chemistry Animations VRL

CD-ROM set includes over 300 animations that can be used directly from the CD or imported into your own lecture presentation.

**Visual  
Resource Library**

**Chemistry  
Seventh Edition**

(including Catalog of Images, PowerPoint Presentations, and Websites (Windows® only), Content List, and Optional Installations)

**Raymond Chang**

CD-ROM set includes electronic files of all full-color images in the text. Import the images into your own presentation, or use the PowerPoint presentations provided for each chapter.

ESP interactives encourage students to test comprehension, and provide a fun way to review concepts.

ESP key terms include pop-up definitions and an audio pronunciation, so students can hear the language of chemistry.

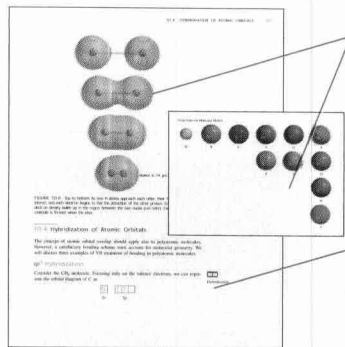
Also included in the e-Text.

e-Learning sessions are based on the Chemistry, Seventh Edition, text outline, and include animations and interactives from the ESP. This provides an easy, visual review of chapter content. Each animation in the e-Learning session includes a short quiz.

Tutorial Class Name	Tutor & Dates	Schedule (ST)	Actions
Tutor (encl)			
Tutor (encl)	Mon 10:00-10:00		
Tutor (encl)	Tue 10:00-10:00		
Tutor (encl)	Wed 10:00-10:00		
Tutor (encl)	Thu 10:00-10:00		
Tutor (encl)	Fri 10:00-10:00		
Tutor (encl)	Sat 10:00-10:00		
Tutor (encl)	Sun 10:00-10:00		
Tutor (encl)	Always available	24 hours a day	
Tutor (encl)	Always available	24 hours a day	

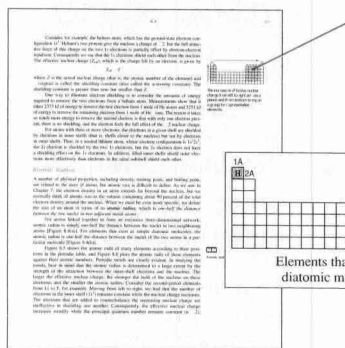
Click on NetTutor when you need extra help with an end-of-chapter problem.

# Text Walkthrough



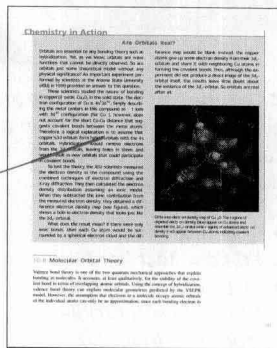
**Art Program:** Art throughout the text is enhanced with molecular art images created by Raymond Chang using the Spartan molecular modeling program. These images enable students to gain a better understanding of the three-dimensionality of molecules and the details of chemical reactions. Much of the art program is revised or new with an emphasis on pedagogical use of color.

**Animation icon:** This new icon points to material that is further illustrated by an animation. Students can use the animations to review challenging concepts in motion. Twenty-nine animations are referenced.



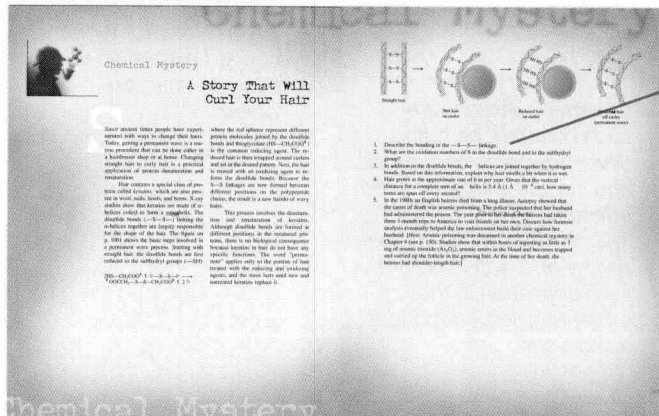
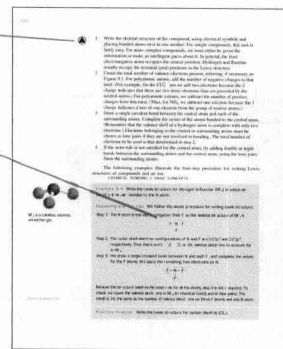
**Periodic Table icon:** This new icon illustrates the properties of elements according to their positions in the periodic table.

**Chemistry in Action: New "Chemistry in Action" essays have been added and many others have been updated.**



**Pedagogy icon:** Step-by-step explanations of problem-solving strategies are highlighted by a special icon in the margin.

**Worked Examples and Practice Exercises:** Careful study of the solved, numbered examples in the body of each chapter will help to develop students' problem-solving skills. The Practice Exercise that follows each worked example allows students to check their ability to solve the type of problem illustrated in the Worked Example. Answers to the Practice Exercises can be found at the very end of the chapter, following the Questions and Problems. The number of a Similar Problem is shown in the margin next to the Worked Example to encourage additional practice. Many Worked Examples have been revised to more clearly show steps in problem-solving.



**Chemical Mysteries:** These readings help develop and enhance students' problem-solving skills, especially with respect to non-mathematical, conceptual problems. "Chemical Clues" give students an opportunity to apply chemical principles and techniques to solve the mysteries. Some clues require the synthesis of material in more than one of the preceding chapters, and others challenge students to extend their knowledge beyond what is presented in the book. This new edition of Chemistry contains ten Chemical Mysteries.

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