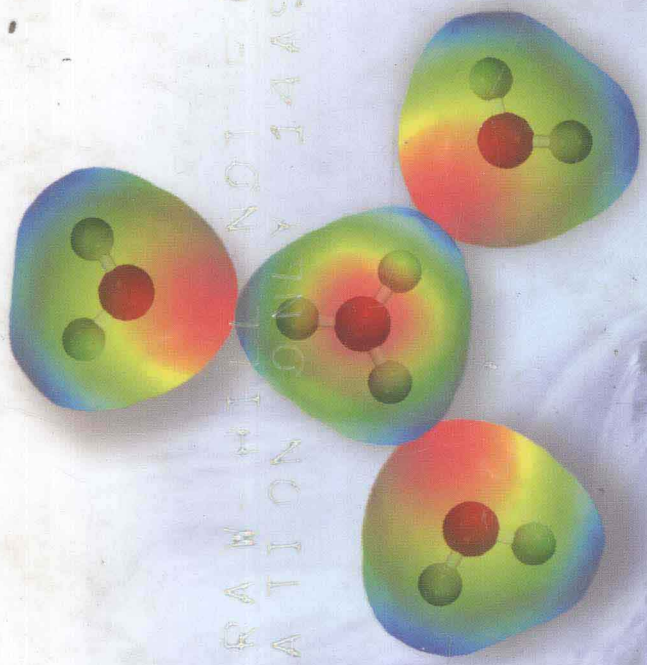
Chemistry

eighth edition



Raymond Chang

Chemistry

Eighth Edition

Raymond Chang

Williams College

With Brandon Cruickshank

Northern Arizona University

Mc Graw Hill **Higher Education**

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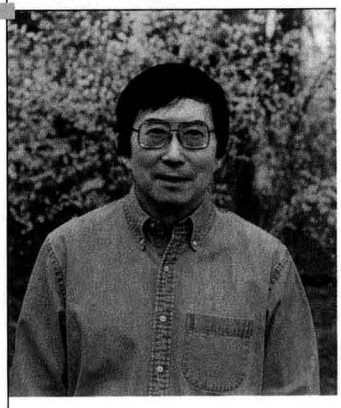


Raymond Chang was born in Hong Kong and grew up in Shanghai, China, and Hong Kong. He received his B.Sc. degree in chemistry from London University, England, and his Ph.D. in chemistry from Yale University. After doing postdoctoral research at Washington University and teaching for a year at Hunter College of the City University of New York, he joined the chemistry department at Williams College, where he has taught since 1968.

Professor Chang has served on the American Chemical Society Examination Committee, the National Chemistry Olympiad Examination Committee, and the Graduate Record Examinations (GRE) Committee. He is an editor of *The Chemical Educator.* Professor Chang has written books on physical chemistry, industrial chemistry, and physical science. He has also coauthored books on the Chinese language, children's picture books, and a novel for juvenile readers.

For relaxation, Professor Chang maintains a forest garden; plays tennis, Ping-Pong, and the harmonica; and practices the violin.

Cover Image

The H^+ ion (proton) is hydrated to varying extents in aqueous solution. The diagram shows the top view of an electrostatic potential map of a H_3O^+ ion forming hydrogen bonds with three water molecules. The formula of this hydrated species is $H_9O_4^+$.

Preface

The eighth edition of *Chemistry* continues the tradition of providing a firm foundation in chemical concepts and principles while presenting a broad range of topics in a clear, concise manner. My aims are to strike a balance between theory and application by incorporating real examples and to help students visualize the three-dimensional atomic and molecular structures that are the basis of chemical activity. An integral part of the text is to develop students' problem-solving and critical thinking skills.

Recent editions of *Chemistry* have witnessed the rapid advances in technology. While the textbook is still the best medium for students to use as they learn new concepts in chemistry, we employ many tools technology has to offer to help students visualize chemistry and explore ideas in an interactive environment. The integration of these tools in this textbook serves to inspire students in their learning process, and takes them beyond the confines of the traditional textbook.

Organization

The emphasis in this edition is on clarification. I have tried to present all processes in a step-by-step manner. You will find this style within the text of each chapter and also in the worked examples. I have reviewed and revised chapters based on the comments from reviewers and users. Some examples are shown next:

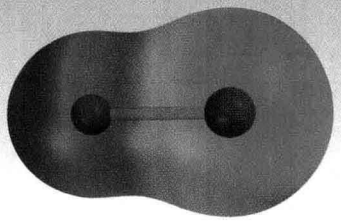
- Improved the treatment of limiting reagent (Section 3.9).
- Provided clearer explanation of atmospheric pressure (Section 5.2).
- Completely reorganized Chapter 6 so the topics flow in a more logical manner. In addition, the units for enthalpy change for chemical reactions (ΔH) are now given in kJ/mol. The same per mole unit is used for changes in entropy (ΔS) and Gibbs free energy (ΔG) in Chapter 18. As a result, the units are consistent in important thermodynamic equations such as Equation (18.14).
- Used radial probability plots to explain the shielding effect in Chapter 7.
- Clarified the influence of temperature on a reacting system at equilibrium in Chapter 14.
- Improved the treatment of acid strength, which now includes carboxylic acids in Chapter 15.
- Substantially revised the discussion of entropy and Gibbs free energy in Chapter 18.
- Added many new end-of-chapter problems and revised a number of others. As in previous editions, there is a good mix of easy, intermediate, and more challenging problems.
- Added two new Chemical Mysteries in Chapters 1 and 24.

Art

A completely new design can be seen throughout the eighth edition. As always, I strive for a clean but visual design. Each chapter opens with a two-page spread containing a photo with accompanying molecular models to illustrate the chemical or physical process at the molecular level.

Many of the line art drawings have a new look while still maintaining accurate chemical information.

Molecular art, created by the Spartan drawing program, is effective in emphasizing molecular geometry. Because I have also used *electrostatic potential maps* extensively to show charge distribution in molecules, a brief explanation of the meaning of these maps is in order. Imagine the situation in which a positive charge is brought toward a molecule. The interaction between this positive charge and some point in the molecule will be attractive if the point bears a negative charge. Conversely, the interaction will be repulsive if the point bears a positive charge. In this way, we can calculate such interactions over the entire molecule and present the results as a "map" according to the colors of the rainbow (red through blue tracks regions of greater negative charge to greater positive charge). The electrostatic potential map for a given molecule can be used to represent the charge distribution within the molecule, as illustrated in Figure 9.4 for hydrogen fluoride. These maps help students better understand the polarity of molecules, intermolecular forces, acid and base properties, and reaction mechanism.



The electrostatic potential map of hydrogen fluoride (HF).

I have also added new molecular art to line drawings and photos and to a number of end-of-chapter problems. In addition, we have updated the photo program to complement the visual layout of the design.

Pedagogy

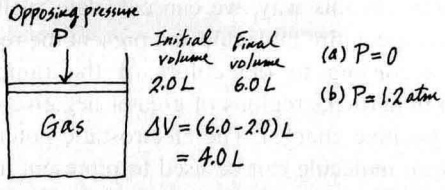
The development of problem-solving skills has always been a major objective of this text. Almost all of the Worked Examples in this new edition have been substantially revised. I have added a strategy step after stating the problem, followed by a step-by-step solution process, and, where appropriate, a check requesting the student to look at the answer to see if it makes sense. Additionally, marginal references enable students to apply new skills to other, similar problems at the end of the chapter. Each Worked Example is followed by a Practice Exercise that asks the students to solve a similar problem on their own. The answers to the Practice Exercises are provided after the end-of-chapter problems in each chapter.

As an instructor, I often tell my students that a good learning tool is to sketch out the inner workings of a problem. In some of the Worked Examples, I have included this type of drawing (for example, see Example 6.1 on p. 222). It is what a scientist would do as he or she works out a problem (sometimes called the back-of-the-envelope calculations).

Example 6.1

A certain gas expands in volume from 2.0 L to 6.0 L at constant temperature. Calculate the work done by the gas if it expands (a) against a vacuum and (b) against a constant pressure of 1.2 atm.

Strategy A simple sketch of the situation is helpful here:



The work done in gas expansion is equal to the product of the external, opposing pressure and the change in volume. What is the conversion factor between L · atm and J?

(Continued)

Inside the front cover of this text you will see a periodic table. I have added the names of the elements under their chemical symbols in this table. Students will find that having the relevant information all at the same location is a real convenience.

Index to Important Figures and Tables

The back inside cover shows a list of important figures and tables with page references. This index makes it convenient for students to quickly look up information when solving problems or studying related subjects in different chapters.

Media

The Interactive Activity Summary in the chapter opening pages enables the student and instructor to see at a glance the media that can be incorporated into the learning process. Within the text, an icon shows the student where the concept of the animation or interactive is introduced. With the icon are directions to help the student locate the animations for viewing. For the instructor, there are also directions for finding the animation or interactive in the instructor materials.

Animations

With the creation of 11 NEW animations, we have a library of animations created to specifically support *Chemistry* by Chang. The animations visually bring to life the areas in chemistry that are difficult to understand by reading alone.

Simulations

NEW simulations enable the student to manipulate several variables. The student can "see" how changes affect the topic being studied. The seven topics include stoichiometry, gas laws, kinetics, equilibrium, acid/base, nuclear reactions and radioactivity, and electrochemical cell. The other set of interactives are simple and fun learning tools that encompass a broad range of topics. All of these interactives are marked by the Interactive Activity icon.

Interactives

The interactives are simple and fun learning tools that encompass a broad range of topics. All of these interactives are marked by the Interactive icon.

Online Learning Center

The student will find the animation center and interactive center in the Online Learning Center for *Chemistry.* Also located in the Online Learning Center are self-assessment quizzes, current news articles in chemistry and supporting sciences, as well as a library of links to help with difficult concepts or to do research for chemistry.

Instructor's Resources

Annotated Instructor's Edition

By Brandon Cruickshank (Northern Arizona University) and Raymond Chang. The Annotated Instructor's Edition includes all resources available to the instructor marked by icons located in the margins and other strategic locations of the text. Information about the integration of media (animations, interactives, Online Learning Center) and where to find them is provided. The difficulty level of the end-of-chapter problems and the various chemical disciplines that the problems relate to is indicated. You'll also find information on quality demonstration videos, tips for the instructor, and icons marking the digital assets available on the Digital Content Manager.

Instructor's Testing and Resource CD-ROM

Written by John Adams (University of Missouri). 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. The Test Bank also includes over 200 algorithmic-based questions that instructors can edit to create their own test templates. The Test Bank is formatted for easy integration into the following course management systems: PageOut, WebCT, and Blackboard. The CD also contains the electronic file or the Instructor's Resource Manual with Solutions.

Online Learning Center

This comprehensive, book-specific website (www.mhhe.com/physsci/chemistry/chang) offers excellent tools for both the instructor and the student. Instructors can create an interactive course with the integration of this site, and a secured Instructor Center stores your essential course materials to save you preparation time before class. This center offers PowerPoint images, a PowerPoint lecture outline, Instructor's Manual and Instructor's Solution Manual, Chang animations, chemistry interactives, and more.

Instructor's Resource Manual with Solutions

By Brandon J. Cruickshank (Northern Arizona University) and Raymond Chang. This complete manual for teaching a general chemistry course is based on *Chemistry* and contains a brief summary of the contents of each chapter, along with learning goals and references to background concepts discussed 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, including those that are in the Solutions Manual, are then given. Finally, this resource contains discussion questions and tips, information on relevant applications, and references to other elements of the text package. You can access the manual on the Instructor's Testing and Resource CD-ROM or by opening the Instructor Center on the Online Learning Center.

Overhead Transparencies

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

Chang Animations

By Brandon Cruickshank (Northern Arizona University). Eleven *new* animations have been added to the current 28 animations. The animations are interactive and specifically support content and concepts in *Chemistry.* The interactive summary and the icons in the text show which concepts are animated. Animations can be used by both instructor and student in the Online Learning Center and are available on the Chemistry Animations Library for use in lecture and PowerPoint presentations.

Interactives

NEW for this edition are seven simulations that will be available in the Online Learning Center, enabling manipulation of variables for specific chemical concepts including stoichiometry, gas laws, kinetics, equilibrium, and acid/base.

Chemistry Animations Library

This instructor's CD-ROM enables you to use animations and simulations in your classroom in the way that works best for you. This multi-CD set includes over 300 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.

Active Art

By Eric Johnson (Ball State University). **New** for this edition is Active Art, which presents key art pieces as a series of PowerPoint slides that illustrate difficult concepts in a step-by-step manner. Artwork is broken into small, digestible frames, enabling the instructor to bring each piece into lecture in whatever sequence or format is desired. The figures can be customized in almost any way imaginable. Because every Active Art image is completely ungroupable, any part of an Active Art slide can be used as a "chemical clipart" in any other PowerPoint presentation, or as a component in your own rendition of a figure. Active Art can be found on the Digital Content Manager under the Active Art folder for each chapter.

TextEdit Art

Also new to this edition, TextEdit Art allows an instructor to revise or delete labels on a figure as desired within PowerPoint for creating customized presentations or for use in tests. Labels can be moved, deleted, or revised; the leader lines can be moved or deleted separate from the image and labels; and images can be stretched or enlarged. TextEdit Art can be found on the Digital Content Manager.

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 a visually stunning lecture presentation. The Web-based PowerPoint lecture includes notes for the entire course, visuals from the eighth edition, and animations embedded at the appropriate points in the program. Use this complete lecture outline, or revise the lecture to fit your own course. The lecture presentation can be found on the Digital Content Manager or in the Instructor Center of the Online Learning Center.

Digital Content Library CD-ROM

This multimedia collection of visual resources enables instructors to utilize artwork from the text in multiple formats to create customized classroom presentations, visually based tests and quizzes, dynamic course website content, or attractive printed support material. The digital assets on this cross-platform CD-ROM are grouped by chapter within easy-to-use folders. Available are all figures, tables, many photographs, Active Art, TextEdit art, and the PowerPoint lecture presentation.

NetGrade

NetGrade is a robust Web-based electronic homework system that allows instructors to develop, publish, and deliver self-scoring algorithmic assignments. McGraw-Hill has provided question banks of the end-of-chapter problems, the majority of which are algorithmic, for Instructors to edit or use as is when creating assignments. You can create graded assessments (homework, quizzes, or exams), ungraded practice tests or quizzes, or tutorial assignments. Depending on the type of assessment, instant feedback and hints are provided.

Course Management Systems

The Test Bank questions and end-of-chapter problems are available in WebCT, Blackboard, and PageOut. Ask your sales representative how to receive material in the system of your choice.

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 will find integrated multimedia and a full-scale Online Learning Center. You can upload your original test questions and create your own custom designs. More than 60,000 professors have chosen PageOut to create customized course websites.

Primis LabBase

By Joseph Lagowski (University of Texas of Austin). More than 40 general chemistry experiments are available

in this database collection of general 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.

General Chemistry Laboratory Manual

By Petra A. M. van Koppen (University of California, Santa Barbara). This is the definitive lab manual for the two-semester general chemistry course. The manual contains 21 experiments that cover the most commonly assigned experiments for the introductory chemistry course.

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

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 Sharon Neal (University of Delaware). This valuable ancillary is designed to help students recognize their learning style; how to read, classify, and create a problem-solving list; and practice problem-solving skills. 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.

OLC (Online Learning Center)

This comprehensive, exclusive website provides a wealth of electronic resources for instructors and students alike. For students, the OLC features interactive quizzes, animation center, simulation center, and interactive center for each chapter of the text; key-term flashcards; NetTutor; and an interactive glossary with audio. You can also access the Essential Student Partner from the OLC. Log on with your passcode card at www.mhhe.com/physsci/chemistry/chang. The passcode card is available FREE with the purchase of a new textbook or you can purchase a card separately.

Chang Animations

By Brandon Cruickshank (Northern Arizona University). Eleven new animations have been added to the current 28 animations. The animations are interactive and specifically support content and concepts in *Chemistry*. The interactive summary and icons in the text show which concepts are animated. Animations can be used by both instructors and students in the Online Learning Center.

Simulations

NEW for this edition are seven simulations that will be available on the Online Learning Center. These simulations allow manipulation of variables for specific chemical concepts including stoichiometry, gas laws, kinetics, equilibrium, and acid/base.

Interactives

Also available are interactives that are simple and fun to help with learning many concepts.

Chang Chemistry Resource Card

Our resource card is an easy, quick source of information on general chemistry. The student will find the periodic table, basic tables, and key equations within reach without having to consult the text.

ChemSkill Builder

ChemSkill Builder is a highly regarded tutorial and electronic homework program that 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 online to an instructor for grading.

Understanding Chemistry by Lovett/Chang

This brief text is specially written in a friendly and informative manner for easy learning of the most important chemical concepts. The authors break the information down into language for a nonscientist. Cartoons were created to provide a learning tool to remember basic concepts.

Essential Study Partner

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

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.

Acknowledgments

Symposium Participants

I would like to thank the following individuals who participated in various McGraw-Hill symposia on general chemistry. Their insight into the needs of students and instructors were invaluable to me in preparing this revision.

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Alan Stolzenberg *West Virginia University*
Greg Szulczewski *University of Alabama*
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Other Contributors

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As always, I have benefited much from discussions with my colleagues at Williams College and correspondence with many instructors here and abroad.

It is a pleasure to acknowledge the support given to me by the following members of McGraw-Hill's College Division: Doug Dinardo, Tami Hodge, Kevin Kane, Jenni Lang, and Michael Lange. In particular, I would like to mention Gloria Schiesl for supervising the production, Stuart Paterson and David Hash for the book design, John Leland for photo research, and Jeffry Schmitt and Stacy Patch for the media. My publisher Kent Peterson and my editor Thomas Timp provided advice and support whenever I needed them. Finally, my special thanks go to Shirley Oberbroeckling, the developmental editor, for her care and enthusiasm for the project, and supervision at every stage of the writing of this edition. I am fortunate to work with such a dedicated and professional group of individuals.

Raymond Chang

Guided Tour

Text

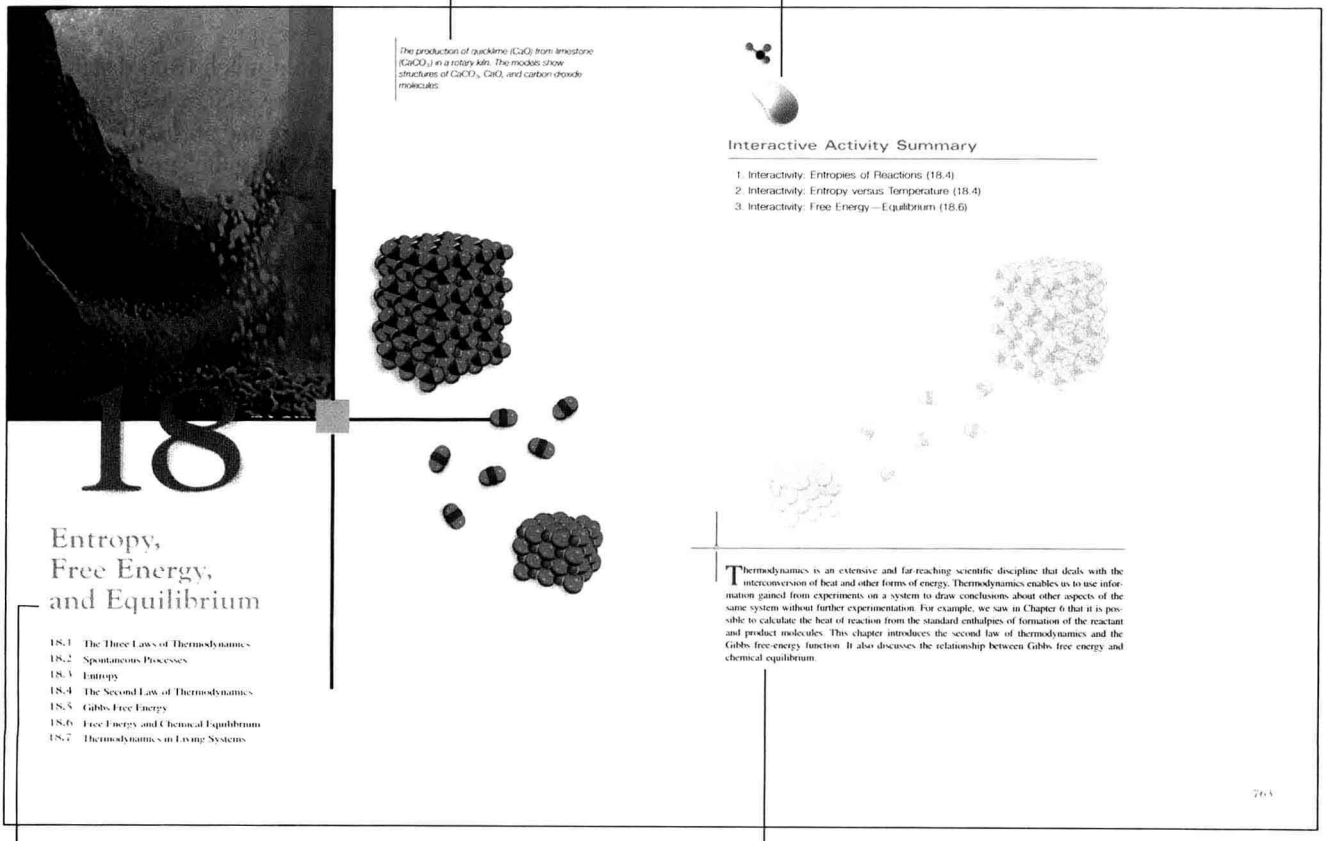
This guided tour to *Chemistry,* Eighth Edition, is designed to walk you through the features of our text and media.

Chapter Opening Pages

The chapter opening pages give the student and instructor the overall content that is discussed within the chapter at a quick glance.

The photo legend explains the connection between the photo and the molecules that are featured on the pages. The molecular models illustrate the chemical or physical process at the molecular level.

The Interactive Activity Summary gives a list of the media associated with the chapter. As the student moves through the chapter, the icon signals when and where to go for further understanding of the concept.



The chapter outline provides the student and instructor with the main points that will be covered while studying the content within.

Finally, the opening text draws the student into the chapter and explains what will be learned.

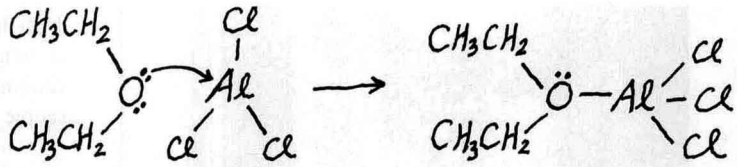
Worked Examples

A main feature of all general chemistry textbooks is the worked examples. The student will find that in a select number of examples, the author has provided hand-drawn sketches showing how to reach the solution. Each sketch demonstrates how a chemist would work out an actual problem.

The author points out problems from the end of the chapter similar to the worked example for student reference.

Strategy In Lewis acid-base reactions, the acid is usually a cation or an electron-deficient molecule, whereas the base is an anion or a molecule containing an atom with lone pairs. (a) Draw the molecular structure for $C_2H_5OC_2H_5$. What is the hybridization state of Al in $AlCl_3$? (b) Which ion is likely to be an electron acceptor? An electron donor?

Solution (a) The Al is sp^2-hybridized in $AlCl_3$ with an empty $2p_z$ orbital. It is electron-deficient, sharing only six electrons. Therefore, the Al atom has a tendency to gain two electrons to complete its octet. This property makes $AlCl_3$ a Lewis acid. On the other hand, the lone pairs on the oxygen atom in $C_2H_5OC_2H_5$ make the compound a Lewis base:



(b) Here the Hg^{2+} ion accepts four pairs of electrons from the CN^- ions. Therefore Hg^{2+} is the Lewis acid and CN^- is the Lewis base.

Similar problem: 15.92.

Practice Exercise Identify the Lewis acid and Lewis base in the reaction

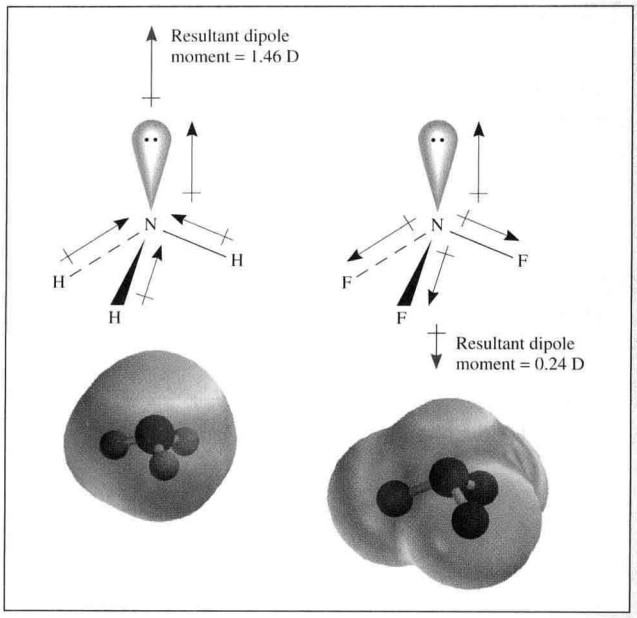
$$Co^{3+}(aq) + 6NH_3(aq) \rightleftharpoons Co(NH_3)_6^{3+}(aq)$$

The worked examples also include a strategy prior to the solution and, where appropriate, a check after the solution reminding the student to think about the reasonableness of his or her answer. Study of the worked examples helps the student develop problem-solving skills.

The Practice Problem that follows each worked example enables the student to check his or her 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.

Art

This edition has expanded use of the electrostatic potential maps that show the student charge distribution in molecules according to the colors of the rainbow (red through blue tracks regions of greater negative charge to greater positive charge). These maps will help the student understand the polarity of molecules, intermolecular forces, acid and base properties, and reaction mechanism.



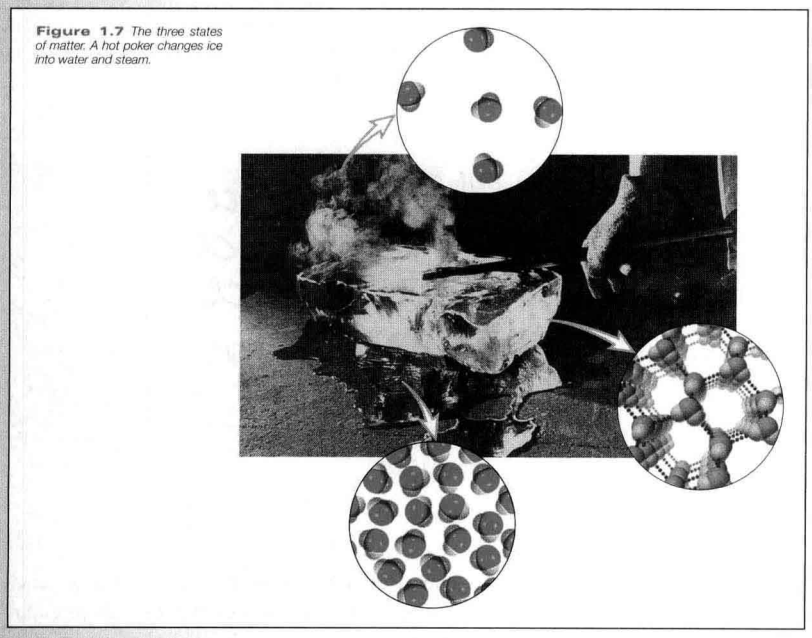
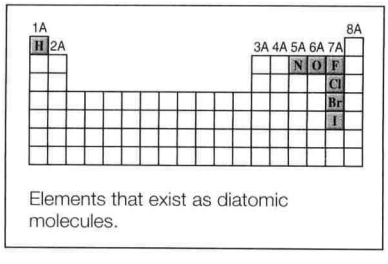


Figure 1.7 *The three states of matter. A hot poker changes ice into water and steam.*

To help the student visualize the progression of what is happening on a molecular level, certain concepts are shown from the macroscopic to the microscopic level.

A guide for the student, the periodic table icon illustrates the properties of elements according to their positions in the periodic table.



Elements that exist as diatomic molecules.

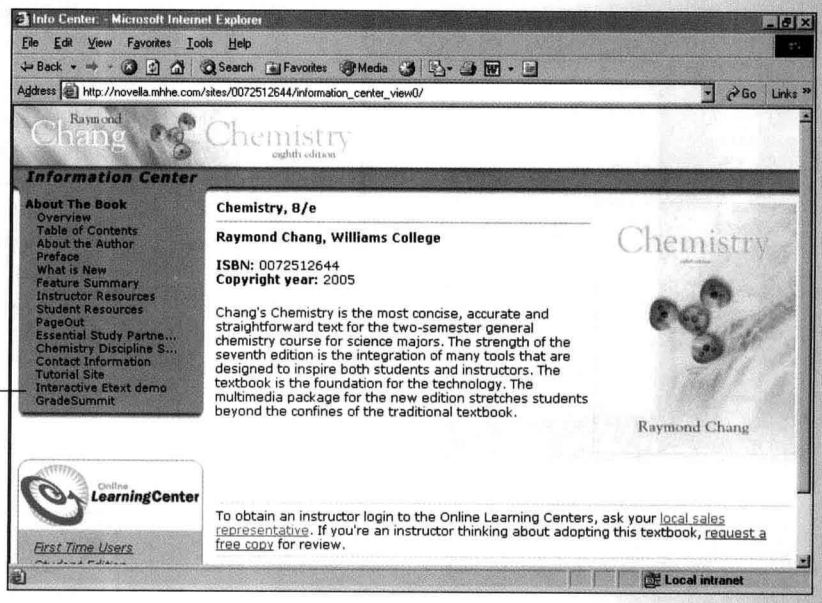
Media

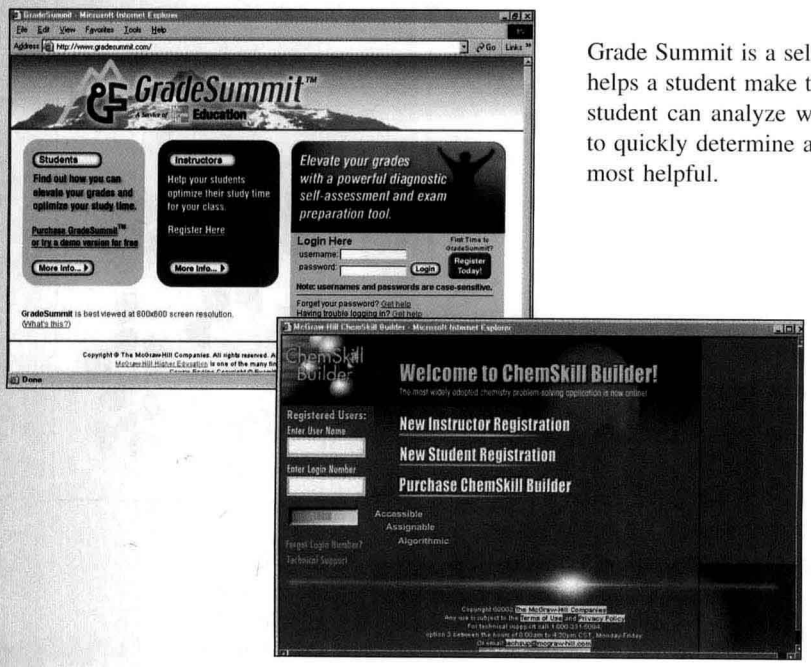
Students

The Online Learning Center at www.mhhe.com/physsci/chemistry/chang is the doorway for the student to access the media for *Chemistry,* Eighth Edition, that is featured in the Interactive Activity Summary and pointed out in the text by the icon. The Online Learning Center also contains the self-assessment quizzes and various other study tools for the student.

The Interactive Center in the Online Learning Center hosts two different styles of interactives. One interactive is a simulation in which a student can control one or more variables that show different reactions. Another interactive is a simple manipulation of data that the student will use to learn specific concepts.

The Animation Center in the Online Learning Center hosts the animations created to help the student visualize difficult concepts in chemistry.



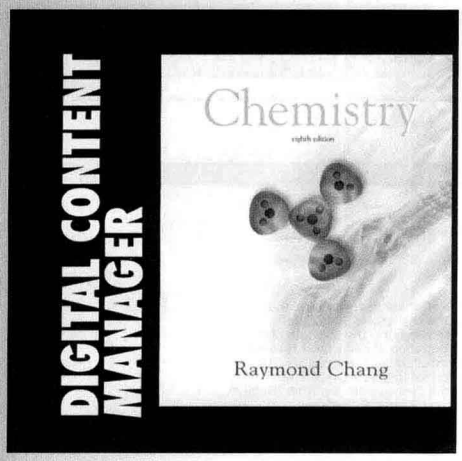


Grade Summit is a self-assessment and diagnostic service that helps a student make the most efficient use of study time. The student can analyze what he or she knows and doesn't know to quickly determine areas where spending study time will be most helpful.

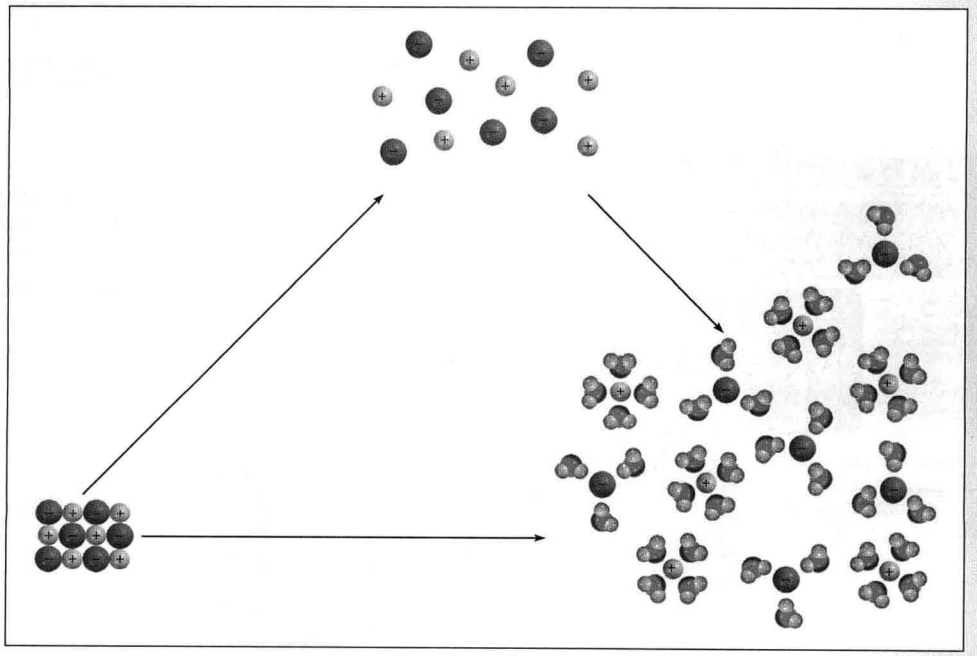
ChemSkill Builder is an electronic homework system that helps a student master general chemistry concepts with tutorial feedback on questions. There is direct correlation between time investment in this program and increased problem-solving ability.

Instructor

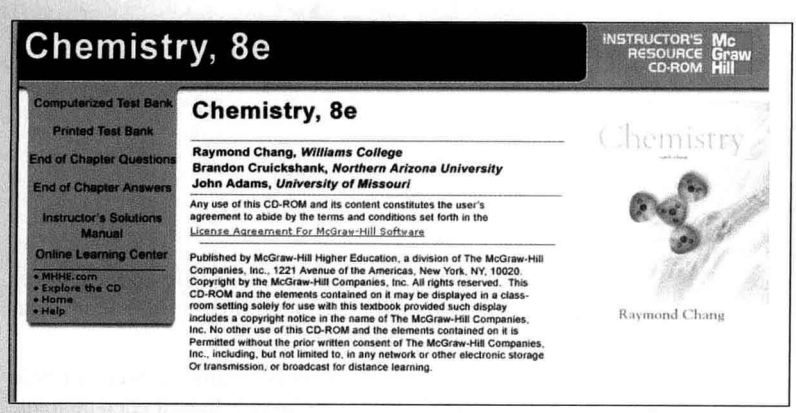
The Animations Library is an instructor's CD-ROM enabling the instructor to use animations in the classroom in the way that works best for her or him. This multi-CD set includes over 300 animations and interactives that can be played directly from the CD or can be imported easily into the lecture presentation. The animation library is fully searchable, and many animations are included at full-screen size.



The Digital Content Manager is a multimedia collection of visual resources enabling instructors to utilize artwork from the text in multiple formats to create customized classroom presentations, visually based tests and quizzes, dynamic course website content, or attractive printed support material. The digital assets on this cross-platform CD-ROM are grouped by chapter within easy-to-use folders. Available are all figures, tables, many photographs, Active Art, and the PowerPoint lecture presentation.



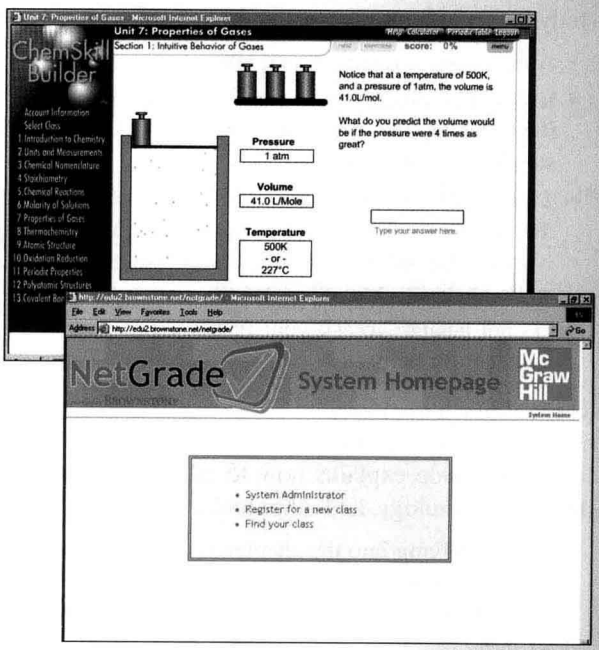
Active Art is a folder within the Digital Content Manager presenting key art pieces as a series of PowerPoint slides that illustrate difficult concepts in a step-by-step manner. Artwork is broken into small, digestible frames, enabling the instructor to bring each piece into lecture in whatever sequence or format is desired. The figures can be customized in almost any way imaginable.

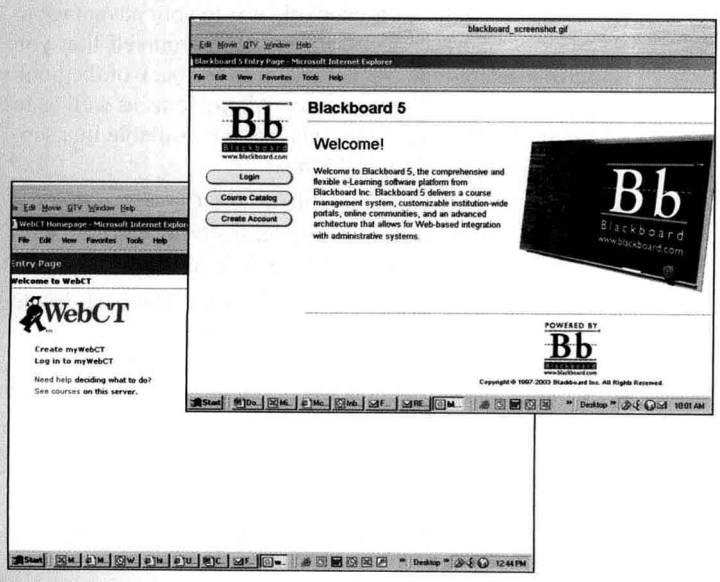


The Instructor's Testing and Resource CD is a cross-platform CD-ROM providing a wealth of resources. It includes a test bank utilizing Brownstone Diploma® testing software, which contains over 2000 multiple-choice, short-answer questions, and algorithmically based questions that instructors can edit to create their own test templates. Comparable to the problems in the text, the questions include multistep problems that require conceptual analysis. The CD also contains the electronic file of the Instructor's Resource Manual with Solutions.

Electronic Homework is available in a variety of programs and course management systems.

- ChemSkill Builder is an electronic homework program containing more than 1500 algorithmically generated questions, each with tutorial feedback. A record of student work is maintained in an online gradebook so that homework can be done at home, in a dorm room, or in a university lab.
- NetGrade is a robust Web-based electronic homework system that allows instructors to develop, publish, and deliver self-scoring algorithmic assignments. You can create graded assessments (homework, quizzes, or exams), ungraded practice tests or quizzes, or tutorial assignments.





McGraw-Hill supports WebCT and Blackboard course management systems. The end-of-chapter problems from *Chemistry,* Eighth Edition, are available for import into these systems. Also available is the content from the Online Learning Center and test bank questions. We also support several other course management systems. Contact your sales representative for more details.