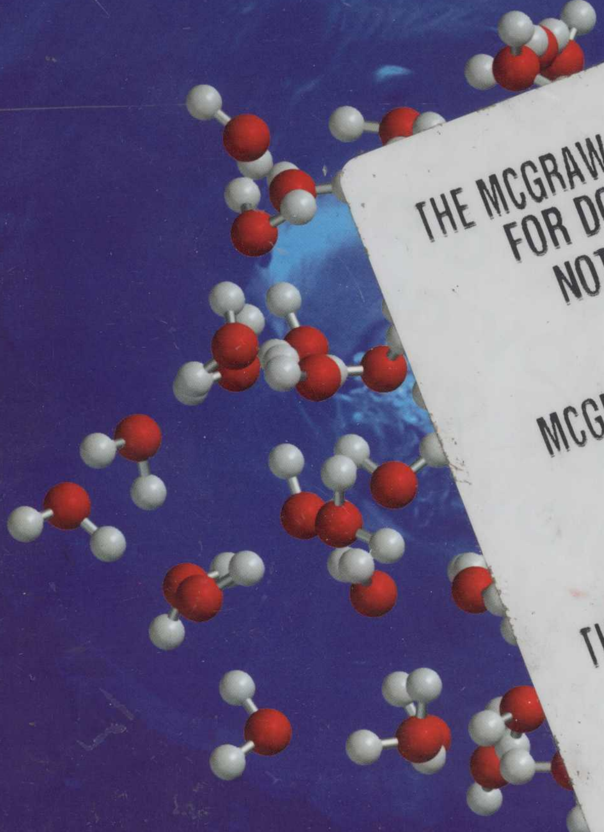
GENERAL CHEMISTRY

THE ESSENTIAL CONCEPTS

Third Edition



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Raymond Chang

General Chemistry Third Edition

The Essential Concepts

Raymond Chang

Williams College

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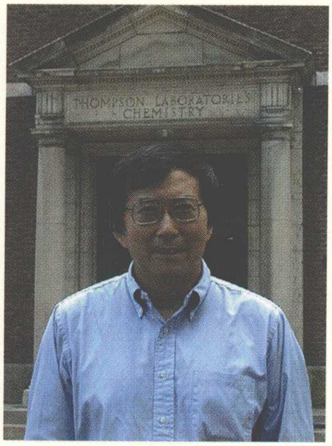
About the Author



Raymond Chang was born in Hong Kong and grew up in Shanghai and Hong Kong, China. 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 Examination (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.

List of Animations

Here is a list of animations correlated to *General Chemistry* with the section to which the animation relates given in parentheses. You can find the animations on the Online Learning Center for *General Chemistry* at www.mhhe.com/physsci/chemistry/chang. Just click on the *General Chemistry* book cover.

Chang Animations

Acid-base titrations (17.3)
Acid ionizations (16.5)
Activation energy (14.4)
Alpha-particle scattering (2.2)
Atomic and ionic radius (8.3)
Base ionizations (16.6)
Buffer solutions (17.2)
Chemical equilibrium (15.1)
Dissolution of a covalent compound (13.2)
Emission spectra (7.3)
Equilibrium vapor pressure (12.6)
Galvanic cells (19.2)
The gas laws (5.3)
Heat flow (6.4)
Hybridization (10.4)
Hydration (4.1)
Ionic versus covalent bonding (9.2)
Le Châtelier's principle (15.4)
Limiting reagent (3.9)
Making a solution (4.5)
Orientation of collision (14.4)
Packing spheres (12.4)
Polarity of molecules (10.2)Precipitation reactions (4.2)
Radioactive decay (21.3)
Sigma and pi bonds (10.5)
VSEPR (10.1)

McGraw-Hill Animations

Atomic line spectra (7.3)
Charles's law (5.3)
Cubic unit cells and their origins (12.4)
Dissociation of strong and weak acids (16.5)
Dissolving table salt (4.1)
Electronegativity (9.3)
Equilibrium (15.1)
Exothermic and endothermic reactions (6.2)
Formation of an ionic compound (9.2)
Formation of the covalent bond in H_2 (10.3)
Half-life (14.3)
Influence of shape on polarity (10.2)
Law of conservation of mass (2.1)
Molecular shape and orbital hybridization (10.4)
Nuclear medicine (21.7)
Operation of voltaic cell (19.2)
Oxidation-reduction reaction (4.4 and 19.1)
Phase diagrams and the states of matter (12.7)
Reaction rate and the nature of collisions (14.4)
Three states of matter (1.3)
Using a buffer (17.2)
VSEPR theory and the shapes of molecules (10.1)

Preface

The third edition of *General Chemistry: The Essential Concepts* continues the tradition of presenting only the material that is essential for a one-year general chemistry course. As before, I have included all the core topics that are necessary for a solid foundation in general chemistry without sacrificing depth, clarity, or rigor.

General Chemistry covers these core topics in the same depth and at the same level as 1100-page texts. Therefore, this book is not a condensed version of a big text. I have written it so that an instructor can cover 95 percent of the content, instead of the two-thirds or three-quarters that in my experience is typical for the big books. My hope is that this concise-but-thorough approach will appeal to efficiency-minded instructors and will please value-conscious students. Encouraging responses from users convince me that I am on the right track.

New and Improved Changes for the Third Edition

The main goal of this edition is to further improve areas that will facilitate the instructor and aid students in important areas such as organization, art program, pedagogy, readability, and media. Summarized here are the highlights of this edition.

Organization

- **New** title reflecting the content of this text is for a one-year introductory chemistry course.
- The chapter on organic chemistry (Chapter 11) has been extensively revised. Its placement enables the instructor to use organic molecules to illustrate the concepts of chemical bonding and mechanisms of reactions. For schools whose curricula involve general chemistry in the first semester and organic chemistry in the second semester, this chapter should prepare the student well for the transition.
- The chapter on coordination chemistry has been moved to near the end of the book.
- There is no general agreement on the merit of teaching molecular orbital theory in an introductory chemistry course. A recent survey by McGraw-Hill of over 200 instructors shows about a 50-50 split on this matter. For this reason, I have added a section on molecular orbital theory in Chapter 10 and have shown its application to aromatic compounds in Chapter 11. For instructors who prefer not to cover this topic, it can be omitted without disruption or loss of continuity.

Art Program

- **New** molecular art images were created using Spartan molecular modeling program. These drawings enable students to gain a better understanding of the three-dimensionality of molecules, electron distribution, and details of chemical reactions. Many other figures are new or have been revised. For example, see Figures 5.5, 9.3, 10.5, 11.12, 14.21, and 22.11.

Pedagogy

- Many "Worked Examples" have been revised to more clearly show steps in problem solving.
- A **New** periodic table icon illustrates the properties of elements according to their positions in the periodic table.
- A number of **New** end-of-chapter problems and Special Problems have been added.

- A **New** Animation Icon (▭) points to material that is further illustrated by an animation. The list of animations has been increased in this edition.

Readability

- Material is presented in a clear-cut and concise manner.
- Main points are fully developed.

Media

- **New** Essential Study Partner (ESP) interactive student tutorial.
- Improved Online Learning Center website for instructors and students.

Instructor Resources

Test Bank

Written by Gary Wolf (Spokane Falls Community College) and edited by Marcia Gillette (Indiana University–Kokomo). 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.

Computerized Test Bank

Written by Gary Wolf (Spokane Falls Community College) and edited by Marcia Gillette (Indiana University–Kokomo). 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. The Test Bank is formatted for easy integration into the following course management systems: PageOut, WebCT, and Blackboard.

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 free online study partner engages, investigates, and reinforces what the student is learning from the textbook. You will find the **Essential Study Partner** for *General Chemistry* to be a complete, interactive student study tool packed with animations and learning activities. From quizzes to interactive diagrams, you will find that this is a highly effective study partner to ensure the mastery of core concepts.

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 prep time before class. This center offers PowerPoint images, a PowerPoint lecture outline, narratives for Chang animations, 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 *General Chemistry*. This unique guide includes demonstrations that can be done in any classroom or assigned for homework, accompanied by discussion questions and tips to ensure success; information on relevant applications; chapter overviews and outlines; and annotated cross-references to other elements of the text package. In addition, this manual provides complete solutions to all end-of-chapter problems in the text.

Overhead Transparencies

Approximately 200 full-color text illustrations are reproduced on acetate for overhead projection.

Visual Resource Library

More than 300 images from the text can be used for stand-alone classroom presentation or can be included in a PowerPoint presentation.

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 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.

Course-Specific PageOut

Designed specifically to help you with your individual course needs, PageOut will assist you in integrating your syllabus with *General 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 at 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.

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 is on experimental design, analysis, problem solving, and communication.

Student Resources

Problem-Solving Workbook with Solutions

By Brandon J. Cruickshank (Northern Arizona University) and Raymond Chang. This is a success guide written for use with *General Chemistry*. It aims to help students hone their analytical and problem-solving skills by presenting detailed approaches to solving chemical problems. Solutions for all of the text's even-numbered problems are included.

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-word 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 *General Chemistry*. You can also access the Essential Student Partner from the OLC. Log on with your passcode card at www.mhhe.com/physsci/chemistry/. The passcode card is available *free* with the purchase of a *new* textbook or you can purchase a card separately.

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 *General Chemistry* to be a complete, interactive student study tool packed with animations and learning activities. From quizzes to interactive diagrams, you will find that this is a highly effective study partner to ensure the mastery of core concepts.

ChemSkill Builder

New! Our **online version** of ChemSkill Builder 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.

CyberChem Multimedia 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. 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.

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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Raymond Chang

Guided Tour: Text

Art Program

Art throughout the text is enhanced with molecular art images 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.

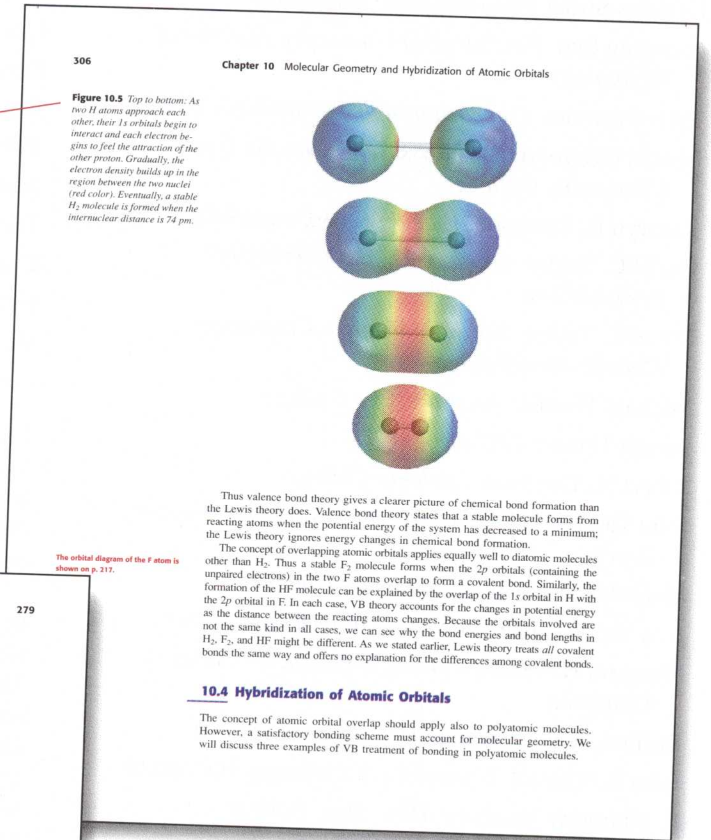

306 Chapter 10 Molecular Geometry and Hybridization of Atomic Orbitals

Figure 10.5 *Top to bottom: As two H atoms approach each other, their 1s orbitals begin to interact and each electron begins to feel the attraction of the other proton. Gradually, the electron density builds up in the region between the two nuclei (red color). Eventually, a stable H_2 molecule is formed when the internuclear distance is 74 pm.*

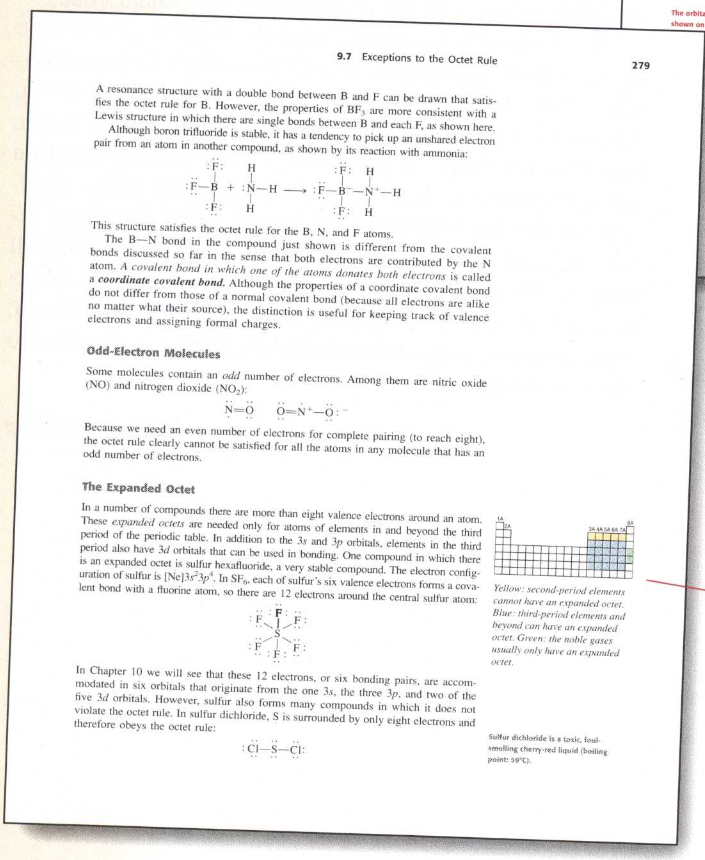
Thus valence bond theory gives a clearer picture of chemical bond formation than the Lewis theory does. Valence bond theory states that a stable molecule forms from reacting atoms when the potential energy of the system has decreased to a minimum; the Lewis theory ignores energy changes in chemical bond formation.

The concept of overlapping atomic orbitals applies equally well to diatomic molecules other than H_2. Thus a stable F_2 molecule forms when the $2p$ orbitals (containing the unpaired electrons) in the two F atoms overlap to form a covalent bond. Similarly, the formation of the HF molecule can be explained by the overlap of the $1s$ orbital in H with the $2p$ orbital in F. In each case, VB theory accounts for the changes in potential energy as the distance between the reacting atoms changes. Because the orbitals involved are not the same kind in all cases, we can see why the bond energies and bond lengths in H_2, F_2, and HF might be different. As we stated earlier, Lewis theory treats *all* covalent bonds the same way and offers no explanation for the differences among covalent bonds.

The orbital diagram of the F atom is shown on p. 217.

10.4 Hybridization of Atomic Orbitals

The concept of atomic orbital overlap should apply also to polyatomic molecules. However, a satisfactory bonding scheme must account for molecular geometry. We will discuss three examples of VB treatment of bonding in polyatomic molecules.


9.7 Exceptions to the Octet Rule 279

A resonance structure with a double bond between B and F can be drawn that satisfies the octet rule for B. However, the properties of BF_3 are more consistent with a Lewis structure in which there are single bonds between B and each F, as shown here.

Although boron trifluoride is stable, it has a tendency to pick up an unshared electron pair from an atom in another compound, as shown by its reaction with ammonia:

This structure satisfies the octet rule for the B, N, and F atoms.

The B—N bond in the compound just shown is different from the covalent bonds discussed so far in the sense that both electrons are contributed by the N atom. *A covalent bond in which one of the atoms donates both electrons* is called a ***coordinate covalent bond.*** Although the properties of a coordinate covalent bond do not differ from those of a normal covalent bond (because all electrons are alike no matter what their source), the distinction is useful for keeping track of valence electrons and assigning formal charges.

Odd-Electron Molecules

Some molecules contain an *odd* number of electrons. Among them are nitric oxide (NO) and nitrogen dioxide (NO_2):

Because we need an even number of electrons for complete pairing (to reach eight), the octet rule clearly cannot be satisfied for all the atoms in any molecule that has an odd number of electrons.

The Expanded Octet

In a number of compounds there are more than eight valence electrons around an atom. These *expanded octets* are needed only for atoms of elements in and beyond the third period of the periodic table. In addition to the $3s$ and $3p$ orbitals, elements in the third period also have $3d$ orbitals that can be used in bonding. One compound in which there is an expanded octet is sulfur hexafluoride, a very stable compound. The electron configuration of sulfur is $[Ne]3s^23p^4$. In SF_6, each of sulfur's six valence electrons forms a covalent bond with a fluorine atom, so there are 12 electrons around the central sulfur atom:

In Chapter 10 we will see that these 12 electrons, or six bonding pairs, are accommodated in six orbitals that originate from the one $3s$, the three $3p$, and two of the five $3d$ orbitals. However, sulfur also forms many compounds in which it does not violate the octet rule. In sulfur dichloride, S is surrounded by only eight electrons and therefore obeys the octet rule:

Yellow: second-period elements cannot have an expanded octet. Blue: third-period elements and beyond can have an expanded octet. Green: the noble gases usually only have an expanded octet.

Sulfur dichloride is a toxic, foul-smelling cherry-red liquid (boiling point: 59°C).

Icons

- Animation icon: This icon points to material that is further illustrated by an animation. Students can use the animations to review challenging concepts in motion. Animations are referenced and can be found on the Online Learning Center at **www.mhhe.com/chang**.
- Periodic Table icon: This icon illustrates the properties of elements according to their positions in the periodic table.

Worked Examples and Practice Exercises

Careful study of the solved 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 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.

140 **Chapter 5** Gases

An air bag can protect the driver in an automobile collision.

Example 5.6 Sodium azide (NaN_3) is used in some automobile air bags. The impact of a collision triggers the decomposition of NaN_3 as follows:

$$2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g)$$

The nitrogen gas produced quickly inflates the bag between the driver and the windshield. Calculate the volume of N_2 generated at 80°C and 823 mmHg by the decomposition of 60.0 g of NaN_3.

Reasoning and Solution The problem requires two steps. First, we calculate the number of moles of N_2 generated from the decomposition of 60.0 g of NaN_3. Next we calculate the volume of the N_2 gas at the given temperature and pressure.

$$\text{moles of } N_2 = 60.0 \text{ g } NaN_3 \times \frac{1 \text{ mol } NaN_3}{65.02 \text{ g } NaN_3} \times \frac{3 \text{ mol } N_2}{2 \text{ mol } NaN_3}$$
$$= 1.38 \text{ mol } N_2$$

The volume of 1.38 moles of N_2 can be obtained by using the ideal gas equation:

$$V = \frac{nRT}{P} = \frac{(1.38 \text{ mol})(0.0821 \text{ L} \cdot \text{atm/K} \cdot \text{mol})(80 + 273) \text{ K}}{(823/760) \text{ atm}}$$
$$= 36.9 \text{ L}$$

Similar problems: 5.51, 5.52.

Practice Exercise The equation for the metabolic breakdown of glucose ($C_6H_{12}O_6$) is the same as the equation for the combustion of glucose in air:

$$C_6H_{12}O_6(s) + 6O_2(g) \longrightarrow 6CO_2(g) + 6H_2O(l)$$

Calculate the volume of CO_2 produced at 37°C and 1.00 atm when 5.60 g of glucose are used up in the reaction.

5.5 Dalton's Law of Partial Pressures

Thus far we have concentrated on the behavior of pure gaseous substances, but experimental studies very often involve mixtures of gases. For example, for a study of air pollution, we may be interested in the pressure-volume-temperature relationship of a sample of air, which contains several gases. In this case, and all cases involving mixtures of gases, the total gas pressure is related to ***partial pressures,*** that is, *the pressures of individual gas components in the mixture*. In 1801 Dalton formulated a law, now known as ***Dalton's law of partial pressures,*** which states that *the total pressure of a mixture of gases is just the sum of the pressures that each gas would exert if it were present alone*. Figure 5.12 illustrates Dalton's law.

As mentioned earlier, gas pressure results from the impact of gas molecules against the walls of the container.

Consider a case in which two gases, A and B, are in a container of volume V. The pressure exerted by gas A, according to the ideal gas equation, is

$$P_A = \frac{n_A RT}{V}$$

where n_A is the number of moles of A present. Similarly, the pressure exerted by gas B is

$$P_B = \frac{n_B RT}{V}$$

10.6 Molecular Orbital Theory 325

Table 10.5 | Properties of Homonuclear Diatomic Molecules of the Second-Period Elements*

	Li_2	B_2	C_2	N_2	O_2	F_2	
$\sigma^\star_{2p_x}$	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	$\sigma^\star_{2p_x}$
$\pi^\star_{2p_y}, \pi^\star_{2p_z}$	[ ][ ]	[ ][ ]	[ ][ ]	[ ][ ]	[↑][↑]	[↑↓][↑↓]	$\pi^\star_{2p_y}, \pi^\star_{2p_z}$
σ_{2p_x}	[ ]	[ ]	[ ]	[↑↓]	[↑↓][↑↓]	[↑↓][↑↓]	π_{2p_y}, π_{2p_z}
π_{2p_y}, π_{2p_z}	[ ][ ]	[↑][↑]	[↑↓][↑↓]	[↑↓][↑↓]	[↑↓]	[↑↓]	σ_{2p_x}
$\sigma^\star_{2s}$	[ ]	[↑↓]	[↑↓]	[↑↓]	[↑↓]	[↑↓]	$\sigma^\star_{2s}$
σ_{2s}	[↑↓]	[↑↓]	[↑↓]	[↑↓]	[↑↓]	[↑↓]	σ_{2s}
Bond order	1	1	2	3	2	1	
Bond length (pm)	267	159	131	110	121	142	
Bond energy (kJ/mol)	104.6	288.7	627.6	941.4	498.7	156.9	
Magnetic properties	Diamagnetic	Paramagnetic	Diamagnetic	Diamagnetic	Paramagnetic	Diamagnetic	

*For simplicity the σ_{1s} and $\sigma^\star_{1s}$ orbitals are omitted. These two orbitals hold a total of four electrons. Remember that for O_2 and F_2, σ_{2p_x} is lower in energy than π_{2p_y} and π_{2p_z}.

The ground-state electron configuration of O is $1s^2 2s^2 2p^4$; thus there are 16 electrons in O_2. Using the order of increasing energies of the molecular orbitals from Table 10.5, we write the ground-state electron configuration of O_2 as

$$(\sigma_{1s})^2(\sigma^\star_{1s})^2(\sigma_{2s})^2(\sigma^\star_{2s})^2(\sigma_{2p_x})^2(\pi_{2p_y})^2(\pi_{2p_z})^2(\pi^\star_{2p_y})^1(\pi^\star_{2p_z})^1$$

According to Hund's rule, the last two electrons enter the $\pi^\star_{2p_y}$ and $\pi^\star_{2p_z}$ orbitals with parallel spins. Ignoring the σ_{1s} and σ_{2s} orbitals (because their net effects on bonding are zero), we calculate the bond order of O_2 using Equation (10.2):

$$\text{bond order} = \tfrac{1}{2}(6 - 2) = 2$$

Therefore, the O_2 molecule has a bond order of 2 and is paramagnetic, a prediction that corresponds to experimental observations.

Example 10.6 The N_2^+ ion can be prepared by bombarding the N_2 molecule with fast-moving electrons. Predict these properties of N_2^+: (a) electron configuration, (b) bond order, (c) magnetic character, and (d) bond length relative to the bond length of N_2 (is it longer or shorter?).

Reasoning and Solution From Table 10.5 we can deduce the properties of ions generated from the homonuclear diatomic molecules.

(a) Because N_2^+ has one fewer electron than N_2, its electron configuration is

$$(\sigma_{1s})^2(\sigma^\star_{1s})^2(\sigma_{2s})^2(\sigma^\star_{2s})^2(\pi_{2p_y})^2(\pi_{2p_z})^2(\sigma_{2p_x})^1$$

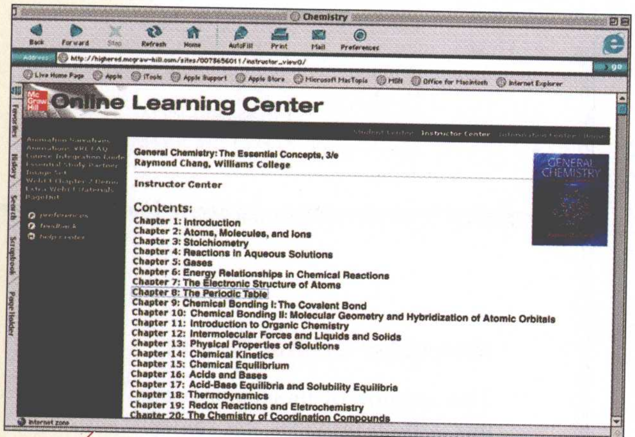
Molecular Orbital Theory

The addition of molecular orbital theory to this edition provides the students with basic skills for future courses in organic chemistry. This material is further expanded in the aromatic compounds in the organic chemistry chapter (Chapter 11). For instructors who prefer not to cover this topic, it can be omitted without disruption or loss of continuity.

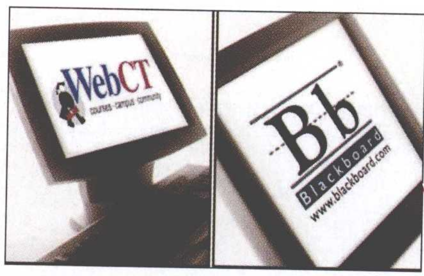
Guided Tour: Media

Instructor Media

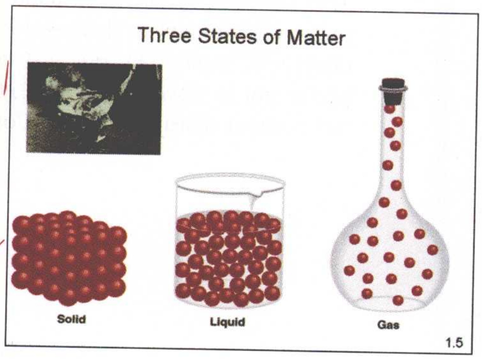
- Online Learning Center (OLC) is a secure, book-specific website. The OLC is the doorway to a library of resources for instructors.
- PowerPoint Presentation—is organized by chapters and is ready for the classroom, or instructors can customize the lecture to reflect their teaching style.
- Course Management Systems—PageOut, WebCT, and Blackboard. All of the following tools are available on the Online Learning Center or in a cartridge for your course delivery system:
  1. Computerized Test Bank
  2. Solutions Manual
  3. Images from the text
  4. Tables from the text
  5. Narratives for the animations
  6. Essential Study Partner link to home page
- Chemistry Animation Visual Resource Library—CD-ROM set includes over 300 animations that can be used directly from the CD or imported into your own lecture presentation.
- Digital Content Manager—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 presentation provided for each chapter.
- GradeSummit—is an Internet-based self-assessment service that provides students and faculty with diagnostic information about subject strengths and weaknesses. This detailed feedback and direction enables learners and teachers to focus study time on areas where they will be most effective.



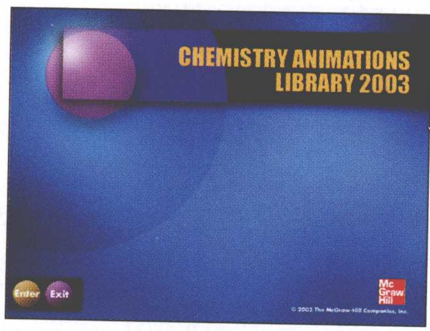
Online Learning Center



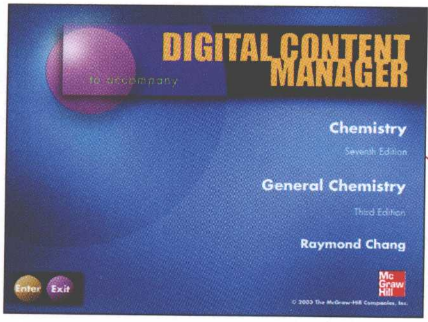
Course Management Systems



PowerPoint



Chemistry Animation Visual Resource Library



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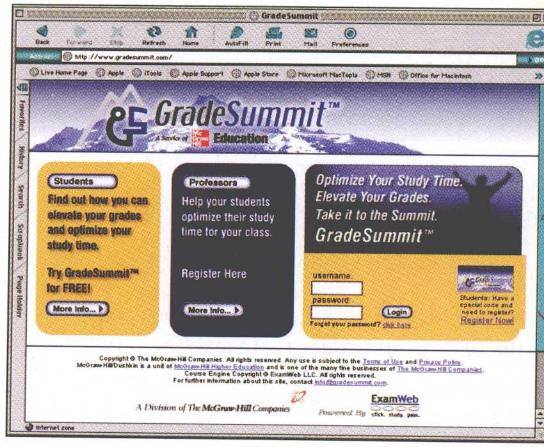
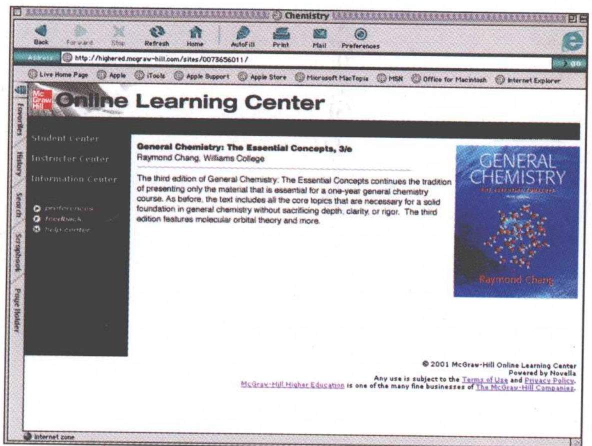


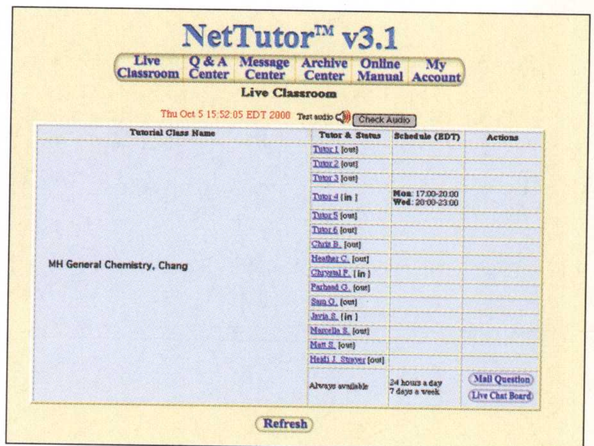
GradeSummit

Student Media

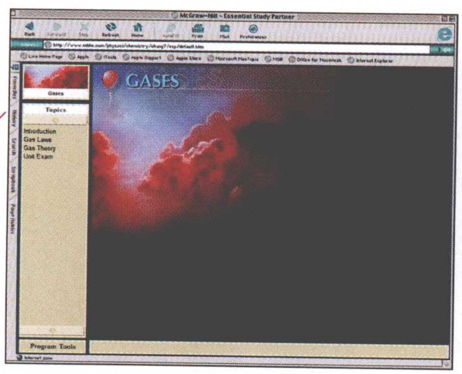
- Online Learning Center—is the doorway to access almost all of the media for *General Chemistry,* Third Edition. The OLC includes self-assessment quizzes, resources, key-term flashcards with audio pronunciation, and more.
- Essential Study Partner—is the essential tool for review, interaction, and self-assessment. Students can work through a basic review of core concepts in the ten units.
- NetTutor—is a tool for students when they need extra help with an end-of-chapter problem. Live sessions are scheduled or you can e-mail a tutor at any time.
- Online ChemSkill Builder—provides questions for all general chemistry topics. Students can practice problem types until they master the skill and concept. Feedback is provided for each question.



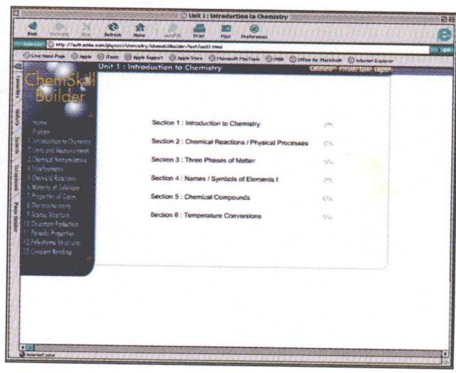
Online Learning Center



NetTutor



Essential Study Partner



Online ChemSkill Builder

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 third edition tools for *General 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 note-taking in class.
- 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 a summary of facts and concepts and a list of key words, both 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/chang and click on the appropriate cover 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 calculation. 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