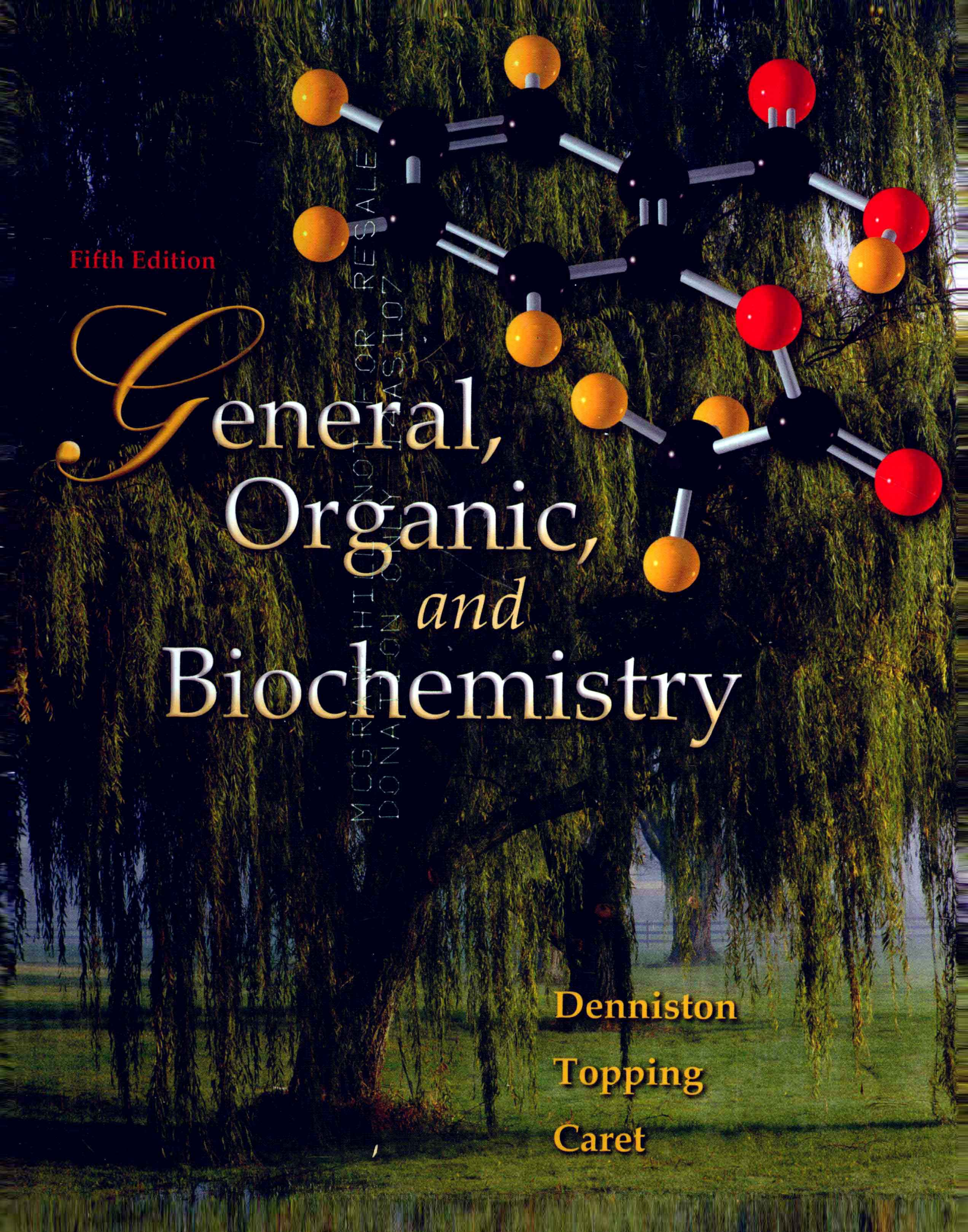

General, Organic, and Biochemistry

Fifth Edition

Katherine J. Denniston
Towson University

Joseph J. Topping
Towson University

Mc Graw Hill **Higher Education**

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Preface

The fifth edition of *General, Organic, and Biochemistry*, like our earlier editions, has been designed to help undergraduate majors in health-related fields understand key concepts and appreciate the significant connections between chemistry, health, and the treatment of disease. We have tried to strike a balance between theoretical and practical chemistry, while emphasizing material that is unique to health-related studies. We have written at a level intended for students whose professional goals do not include a mastery of chemistry, but for whom an understanding of the principles and practice of chemistry is a necessity.

While we have stressed the importance of chemistry to the health-related professions, this book was written for all students who need a one- or two-semester introduction to chemistry. Our focus on the relationship between chemistry, the environment, medicine, and the function of the human body is an approach that can engage students in a variety of majors. We have integrated the individual disciplines of inorganic, organic, and biochemistry to emphasize their interrelatedness rather than their differences. This approach provides a sound foundation in chemistry and teaches students that life is not a magical property, but rather the result of a set of chemical reactions that obey the scientific laws.

Key Features of the Fifth Edition

In preparing the fifth edition, we have been guided by the collective wisdom of over fifty reviewers who are experts in one of the three sub-disciplines covered in the book and who represent a diversity of experience, in community colleges and in four-year colleges and universities. We have retained the core approach of our successful earlier editions, updated material where necessary, and expanded or removed material consistent with retention of the original focus and mission of the book. Throughout the project, we have been careful to ensure that the final product is as student-oriented and readable as its predecessors.

New Features

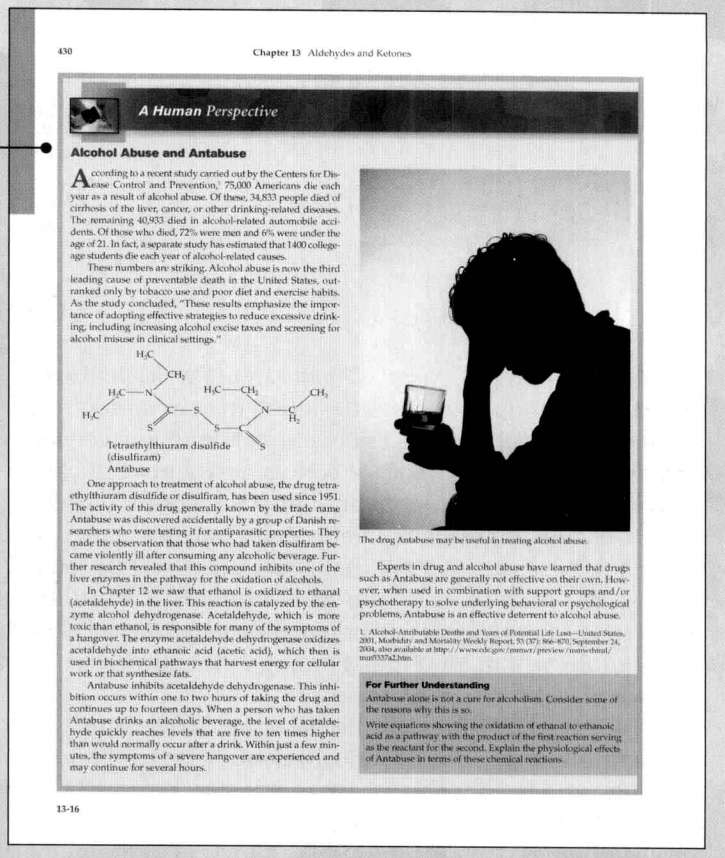
- Chapters 2 and 3 of the fourth edition have been combined in this edition to provide more integrated and concise coverage of atomic structure and periodicity.
- Each boxed topic has been enhanced by questions intended to motivate the student to go beyond what is written and/or solidify the relationship between the boxed topic and the chapter material.
- Twenty to thirty new in-chapter and end-of-chapter questions have been added to each chapter to allow instructors greater flexibility in assigning problems and to give students more opportunity to test themselves. Most chapters now include at least 100 questions and problems.
- End-of-chapter problems are now organized according to the level of understanding required of the student. *Foundations* questions provide students the opportunity to review factual information, emphasizing basic concepts, definitions, and drill. *Applications* questions are more complex or relate more directly to real-world situations. They require students to understand the information and to apply that knowledge to higher-order problems.
- The art program has undergone significant revision. New figures have been added and many others revised to create a common style and pedagogical strategy. The efforts of our Art Consultant, Dr. Ann Eakes of Northwest Vista College, have been invaluable in providing a new perspective on the art program.
- The ARIS website and other media supplements, as described later in this Preface, have been enhanced. Appendices, formerly at the end of the textbook, can now be readily accessed on the website. The instructors' Digital Content Manager CD-ROM contains electronic files of text figures and tables as well as PowerPoint lecture slides.

We designed the fifth edition to promote student learning and facilitate teaching. It is important to engage students, to appeal to visual learners, and to provide a variety of pedagogical tools to help them organize and summarize information. We have utilized a variety of strategies to accomplish our goals.

Engaging Students

Students learn better when they can see a clear relationship between the subject material they are studying and real life. We wrote the text to help students make connections between the principles of chemistry and their previous life experiences or their future professional experiences. Our strategy to accomplish this integration includes the following:

- **Boxed Readings—"Chemistry Connection":** Introductory vignettes allow students to see the significance of chemistry in their daily lives and in their future professions.
- **Boxed Perspectives:** These short stories present real-world situations that involve one or more topics that students will encounter in the chapter. The "Medical Perspectives" relate chemistry to a health concern or a diagnostic application. The "Environmental Perspectives" deal with issues, including the impact of chemistry on the ecosystem and how these environmental changes affect human health. "Human Perspectives" delve into chemistry and society and include such topics as gender issues in science and historical viewpoints. In the fifth edition, we have added a number of new boxed topics and, where needed, updated all of those perspectives retained from the fourth edition. We have included topics, such as self-tanning lotions and sugar substitutes, which are of interest to students today, as well as the most recent strategies for the treatment of HIV/AIDS. New perspectives on opioid drugs, methamphetamines, alcohol abuse, and drugs to treat chemical addiction have been added to this edition.


430 Chapter 13 Aldehydes and Ketones

A Human Perspective

Alcohol Abuse and Antabuse

According to a recent study carried out by the Centers for Disease Control and Prevention,[1] 75,000 Americans die each year as a result of alcohol abuse. Of these, 34,833 people died of cirrhosis of the liver, cancer, or other drinking-related diseases. The remaining 40,933 died in alcohol-related automobile accidents. Of those who died, 72% were men and 6% were under the age of 21. In fact, a separate study has estimated that 1400 college-age students die each year of alcohol-related causes.

These numbers are striking. Alcohol abuse is now the third leading cause of preventable death in the United States, outranked only by tobacco use and poor diet and exercise habits. As the study concluded, "These results emphasize the importance of adopting effective strategies to reduce excessive drinking, including increasing alcohol excise taxes and screening for alcohol misuse in clinical settings."

Tetraethylthiuram disulfide (disulfiram)
Antabuse

One approach to treatment of alcohol abuse, the drug tetraethylthiuram disulfide or disulfiram, has been used since 1951. The activity of this drug generally known by the trade name Antabuse was discovered accidentally by a group of Danish researchers who were testing it for antiparasitic properties. They made the observation that those who had taken disulfiram became violently ill after consuming any alcoholic beverage. Further research revealed that this compound inhibits one of the liver enzymes in the pathway for the oxidation of alcohols.

In Chapter 12 we saw that ethanol is oxidized to ethanal (acetaldehyde) in the liver. This reaction is catalyzed by the enzyme alcohol dehydrogenase. Acetaldehyde, which is more toxic than ethanol, is responsible for many of the symptoms of a hangover. The enzyme acetaldehyde dehydrogenase oxidizes acetaldehyde into ethanoic acid (acetic acid), which then is used in biochemical pathways that harvest energy for cellular work or that synthesize fats.

Antabuse inhibits acetaldehyde dehydrogenase. This inhibition occurs within one to two hours of taking the drug and continues up to fourteen days. When a person who has taken Antabuse drinks an alcoholic beverage, the level of acetaldehyde quickly reaches levels that are five to ten times higher than would normally occur after a drink. Within just a few minutes, the symptoms of a severe hangover are experienced and may continue for several hours.

The drug Antabuse may be useful in treating alcohol abuse.

Experts in drug and alcohol abuse have learned that drugs such as Antabuse are generally not effective on their own. However, when used in combination with support groups and/or psychotherapy to solve underlying behavioral or psychological problems, Antabuse is an effective deterrent to alcohol abuse.

1. Alcohol-Attributable Deaths and Years of Potential Life Lost—United States, 2001, Morbidity and Mortality Weekly Report, 53 (37): 866–870, September 24, 2004, also available at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5337a2.htm.

For Further Understanding

Antabuse alone is not a cure for alcoholism. Consider some of the reasons why this is so.

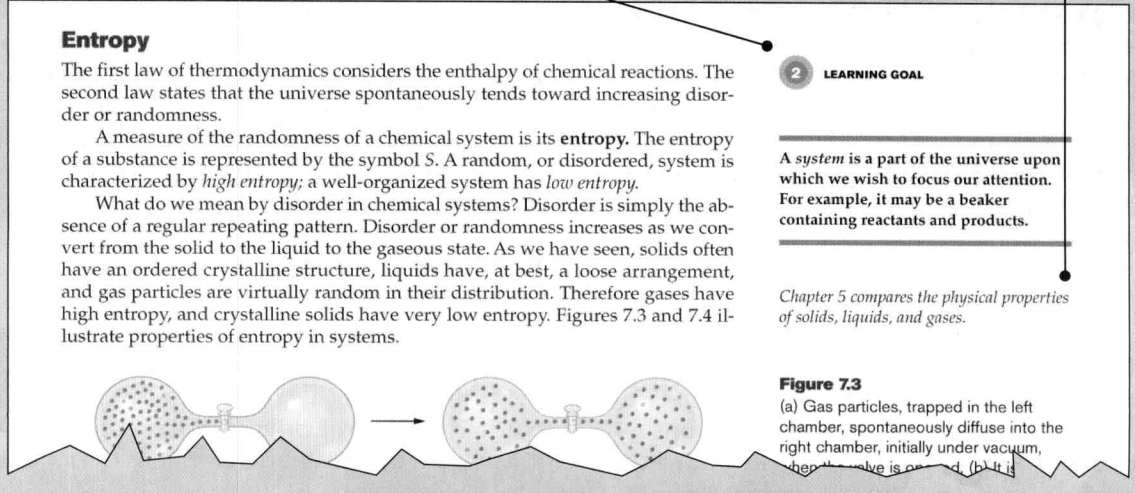
Write equations showing the oxidation of ethanal to ethanoic acid as a pathway with the product of the first reaction serving as the reactant for the second. Explain the physiological effects of Antabuse in terms of these chemical reactions.

13-16

Learning Tools

In designing the original learning system we asked ourselves the question: "If we were students, what would help us organize and understand the material covered in this chapter?" With valuable suggestions from our reviewers, we have made some modifications to improve the learning system. However, with the blessings of those reviewers, we have retained all the elements of the system that have been shown to support student learning:

- **Learning Goals:** A set of chapter objectives at the beginning of each chapter previews concepts that will be covered in the chapter. Icons ① locate text material that supports the learning goals.
- **Detailed Chapter Outline:** A listing of topic headings is provided for each chapter. Topics are arranged in outline form to help students organize the material in their own minds.
- **Chapter Cross-References:** To help students locate the pertinent background material, references to previous chapters, sections, and perspectives are noted in the margins of the text. These marginal cross-references also alert students to upcoming topics related to the information currently being studied.


Entropy

The first law of thermodynamics considers the enthalpy of chemical reactions. The second law states that the universe spontaneously tends toward increasing disorder or randomness.

A measure of the randomness of a chemical system is its **entropy.** The entropy of a substance is represented by the symbol *S*. A random, or disordered, system is characterized by *high entropy;* a well-organized system has *low entropy.*

What do we mean by disorder in chemical systems? Disorder is simply the absence of a regular repeating pattern. Disorder or randomness increases as we convert from the solid to the liquid to the gaseous state. As we have seen, solids often have an ordered crystalline structure, liquids have, at best, a loose arrangement, and gas particles are virtually random in their distribution. Therefore gases have high entropy, and crystalline solids have very low entropy. Figures 7.3 and 7.4 illustrate properties of entropy in systems.

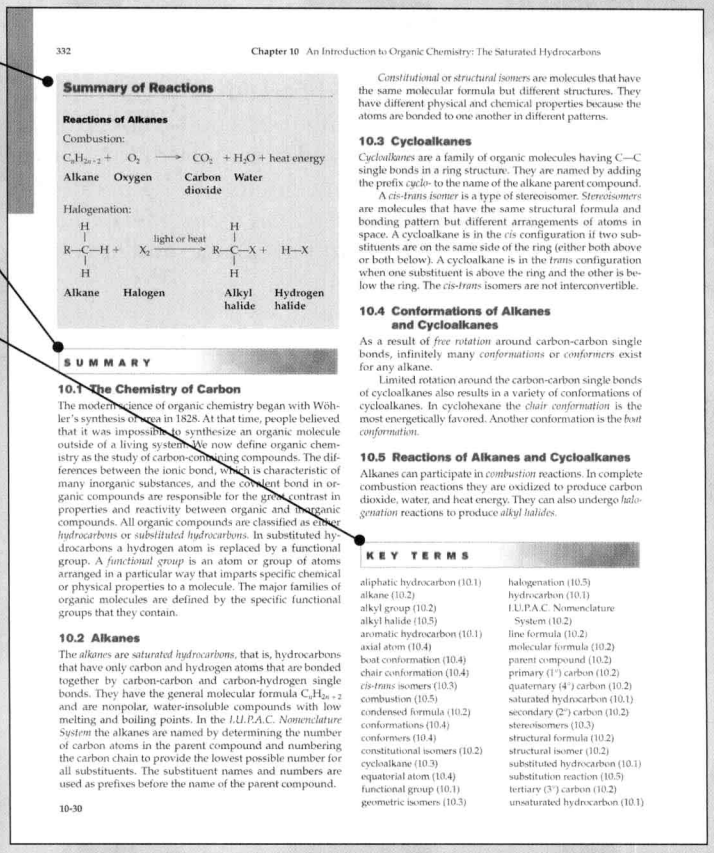
② LEARNING GOAL

A *system* is a part of the universe upon which we wish to focus our attention. For example, it may be a beaker containing reactants and products.

Chapter 5 compares the physical properties of solids, liquids, and gases.

Figure 7.3
(a) Gas particles, trapped in the left chamber, spontaneously diffuse into the right chamber, initially under vacuum, when the valve is opened. (b) It is

- **Summary of Reactions:** In the organic chemistry chapters, each major reaction type is highlighted on a green background. Major equations are summarized at the end of the chapter, facilitating review.
- **Chapter Summary:** Each major topic of the chapter is briefly reviewed in paragraph form in the end-of-chapter summary. These summaries serve as a mini-study guide, covering the major concepts in the chapter.
- **Key Terms:** Key terms are printed in boldface in the text, defined immediately, and listed at the end of the chapter. Each end-of-chapter key term is accompanied by a section number for rapid reference.
- **Glossary of Key Terms:** In addition to being listed at the end of the chapter, each key term from the text is also defined in the alphabetical glossary at the end of the book.



332 Chapter 10 An Introduction to Organic Chemistry: The Saturated Hydrocarbons

Summary of Reactions

Reactions of Alkanes

Combustion:

$C_nH_{2n+2} + O_2 \longrightarrow CO_2 + H_2O$ + heat energy

Alkane Oxygen Carbon dioxide Water

Halogenation:

$R{-}C{-}H + X_2 \xrightarrow{\text{light or heat}} R{-}C{-}X + H{-}X$

Alkane Halogen Alkyl halide Hydrogen halide

SUMMARY

10.1 The Chemistry of Carbon

The modern science of organic chemistry began with Wöhler's synthesis of urea in 1828. At that time, people believed that it was impossible to synthesize an organic molecule outside of a living system. We now define organic chemistry as the study of carbon-containing compounds. The differences between the ionic bond, which is characteristic of many inorganic substances, and the covalent bond in organic compounds are responsible for the great contrast in properties and reactivity between organic and inorganic compounds. All organic compounds are classified as either *hydrocarbons* or *substituted hydrocarbons*. In substituted hydrocarbons a hydrogen atom is replaced by a functional group. A *functional group* is an atom or group of atoms arranged in a particular way that imparts specific chemical or physical properties to a molecule. The major families of organic molecules are defined by the specific functional groups that they contain.

10.2 Alkanes

The *alkanes* are *saturated hydrocarbons*, that is, hydrocarbons that have only carbon and hydrogen atoms that are bonded together by carbon-carbon and carbon-hydrogen single bonds. They have the general molecular formula C_nH_{2n+2} and are nonpolar, water-insoluble compounds with low melting and boiling points. In the *I.U.P.A.C. Nomenclature System* the alkanes are named by determining the number of carbon atoms in the parent compound and numbering the carbon chain to provide the lowest possible number for all substituents. The substituent names and numbers are used as prefixes before the name of the parent compound.

10-30

Constitutional or *structural isomers* are molecules that have the same molecular formula but different structures. They have different physical and chemical properties because the atoms are bonded to one another in different patterns.

10.3 Cycloalkanes

Cycloalkanes are a family of organic molecules having C—C single bonds in a ring structure. They are named by adding the prefix *cyclo-* to the name of the alkane parent compound.

A *cis-trans isomer* is a type of stereoisomer. *Stereoisomers* are molecules that have the same structural formula and bonding pattern but different arrangements of atoms in space. A cycloalkane is in the *cis* configuration if two substituents are on the same side of the ring (either both above or both below). A cycloalkane is in the *trans* configuration when one substituent is above the ring and the other is below the ring. The *cis-trans* isomers are not interconvertible.

10.4 Conformations of Alkanes and Cycloalkanes

As a result of *free rotation* around carbon-carbon single bonds, infinitely many *conformations* or *conformers* exist for any alkane.

Limited rotation around the carbon-carbon single bonds of cycloalkanes also results in a variety of conformations of cycloalkanes. In cyclohexane the *chair conformation* is the most energetically favored. Another conformation is the *boat conformation*.

10.5 Reactions of Alkanes and Cycloalkanes

Alkanes can participate in *combustion* reactions. In complete combustion reactions they are oxidized to produce carbon dioxide, water, and heat energy. They can also undergo *halogenation* reactions to produce *alkyl halides*.

KEY TERMS

aliphatic hydrocarbon (10.1)
alkane (10.2)
alkyl group (10.2)
alkyl halide (10.5)
aromatic hydrocarbon (10.1)
axial atom (10.4)
boat conformation (10.4)
chair conformation (10.4)
cis-trans isomers (10.3)
combustion (10.5)
condensed formula (10.2)
conformations (10.4)
conformers (10.4)
constitutional isomers (10.2)
cycloalkane (10.3)
equatorial atom (10.4)
functional group (10.1)
geometric isomers (10.3)
halogenation (10.5)
hydrocarbon (10.1)
I.U.P.A.C. Nomenclature System (10.2)
line formula (10.2)
molecular formula (10.2)
parent compound (10.2)
primary (1°) carbon (10.2)
quaternary (4°) carbon (10.2)
saturated hydrocarbon (10.1)
secondary (2°) carbon (10.2)
stereoisomers (10.3)
structural formula (10.2)
structural isomer (10.2)
substituted hydrocarbon (10.1)
substitution reaction (10.5)
tertiary (3°) carbon (10.2)
unsaturated hydrocarbon (10.1)

Detailed List of Changes

Changes and updates are evident in every chapter of this fifth edition. Major changes to individual chapters include:

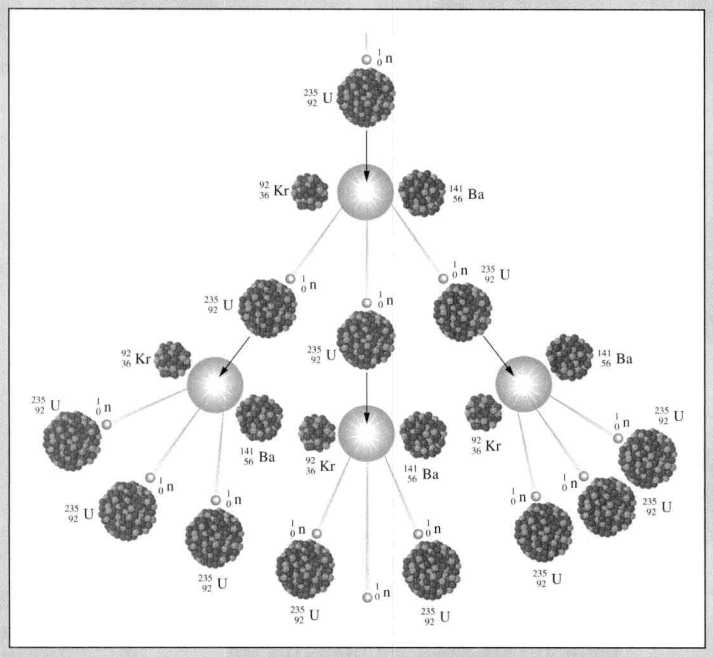
- Chapters 2 and 3 have been combined to give seamless coverage of atomic structure and periodicity, all in one unit.
- The balancing of chemical equations, previously touched on in two sections of the book, has been combined and placed in one section of the book.
- Chapter 10, "Alkanes," now includes an updated perspective on oil-eating microbes and an additional example problem.
- Chapter 11, "Alkenes and Alkynes," now has reactions of alkynes added, including example problems of each.
- Chapter 12, "Alcohols," now includes new perspectives on methanol poisoning, alcohol abuse, and the use of Antabuse.
- Chapter 14, "Carboxylic Acids," offers students an updated perspective on biodegradable plastics.
- Chapter 15, "Amines and Amides," provides new perspectives on Methamphetamine, as well as one on opiate biosynthesis and mutant poppies.
- Chapter 16, "Carbohydrates," gives an updated perspective on the sucrose/tooth decay connection. We have also removed the old food pyramid from the chapter.
- Chapter 18, "Proteins," gives students improved coverage of amino acid structure, properties, and stereoisomers, as well as properties of the peptide bond.
- Chapter 19, "Enzymes," includes a completely reworked section on enzyme nomenclature.
- Chapter 20, "Molecular Genetics," has been highly reorganized. This had been the last chapter in the fourth edition, but is now placed with the other chapters devoted to macromolecules. This chapter also includes a new, more detailed section on bacterial DNA replication.

The Art Program

Today's students are much more visually oriented than any previous generation. Television and the computer represent alternate modes of learning. We have built upon this observation through expanded use of color, figures, and three-dimensional computer-generated models. This art program enhances the readability of the text and provides alternative pathways to learning.

Dynamic Illustrations

Each chapter is amply illustrated using figures, tables, and chemical formulas. All of these illustrations are carefully annotated for clarity. Approximately 220 full-color illustrations have been revised for this edition, in addition to over 30 new illustrations and 50 new photos, to help students better understand difficult concepts. In many cases, illustrations have been redrawn to be more realistic, and have been color-enhanced.



Color-Coding Scheme

We have color-coded reactions so that chemical groups being added or removed in a reaction can be quickly recognized.

- Red print is used in chemical equations or formulas to draw the reader's eye to key elements or properties in a reaction or structure.
- Blue print is used when additional features must be highlighted.

Aldehydes and ketones can be distinguished on the basis of differences in their reactivity. The most common laboratory test for aldehydes is the **Tollens' test.** When exposed to the Tollens' reagent, a basic solution of $Ag(NH_3)_2^+$, an aldehyde undergoes oxidation. The silver ion (Ag^+) is reduced to silver metal (Ag^0) as the aldehyde is oxidized to a carboxylic acid anion.

$$\underset{\text{Aldehyde}}{R{-}\overset{O}{\overset{\|}{C}}{-}H} + \underset{\substack{\text{Silver ammonia complex—}\\ \text{Tollens' reagent}}}{Ag(NH_3)_2^+} \longrightarrow \underset{\text{Carboxylate anion}}{R{-}\overset{O}{\overset{\|}{C}}{-}O^-} + \underset{\substack{\text{Silver}\\ \text{metal}\\ \text{mirror}}}{Ag^0}$$

Silver metal precipitates from solution and coats the flask, producing a smooth silver mirror, as seen in Figure 13.4. The test is therefore often called the Tollens' silver mirror test. The commercial manufacture of silver mirrors uses a similar process. Ketones cannot be oxidized to carboxylic acids and do not react with the Tollens' reagent.

- Green background screens denote generalized chemical and mathematical equations. In the organic chemistry chapters, the Summary of Reactions at the end of these chapters is also highlighted with a green background screen for ease of recognition.

Beta Particles

The **beta particle** (β), in contrast, is a fast-moving electron traveling at approximately 90% of the speed of light as it leaves the nucleus. It is formed in the nucleus by the conversion of a neutron into a proton. The beta particle is represented as

$$^{0}_{-1}e \quad \text{or} \quad ^{0}_{-1}\beta \quad \text{or} \quad \beta$$

- Yellow background in the general and biochemistry sections of the text illustrates energy, either as energy stored in electrons or in groups of atoms. In the organic chemistry section of the text, yellow background screens also reveal the parent chain of an organic compound.

Ionization Energy

The energy required to remove an electron from an isolated atom is the **ionization energy.** The process for sodium is represented as follows:

$$\text{ionization energy} + Na \longrightarrow Na^+ + e^-$$

- There are certain situations in which it is necessary to adopt a unique color convention tailored to the material in a particular chapter. For example, in Chapter 18, the structures of amino acids require four colors to draw attention to key features of these molecules. For consistency, red is used to denote the acid portion of an amino acid, and blue is used to denote the basic portion of an amino acid. Green print is used to denote the R groups, and a yellow background screen directs the eye to the α-carbon.

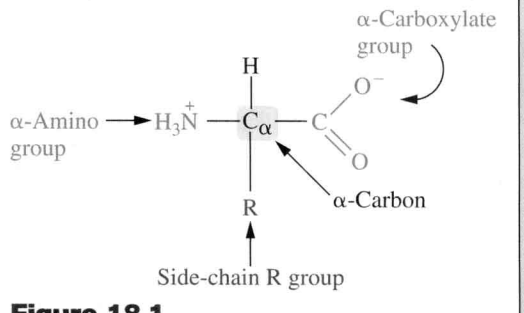


Figure 18.1
General structure of an α-amino acid. All amino acids isolated from proteins, with the exception of proline, have this general structure.

Computer-Generated Models

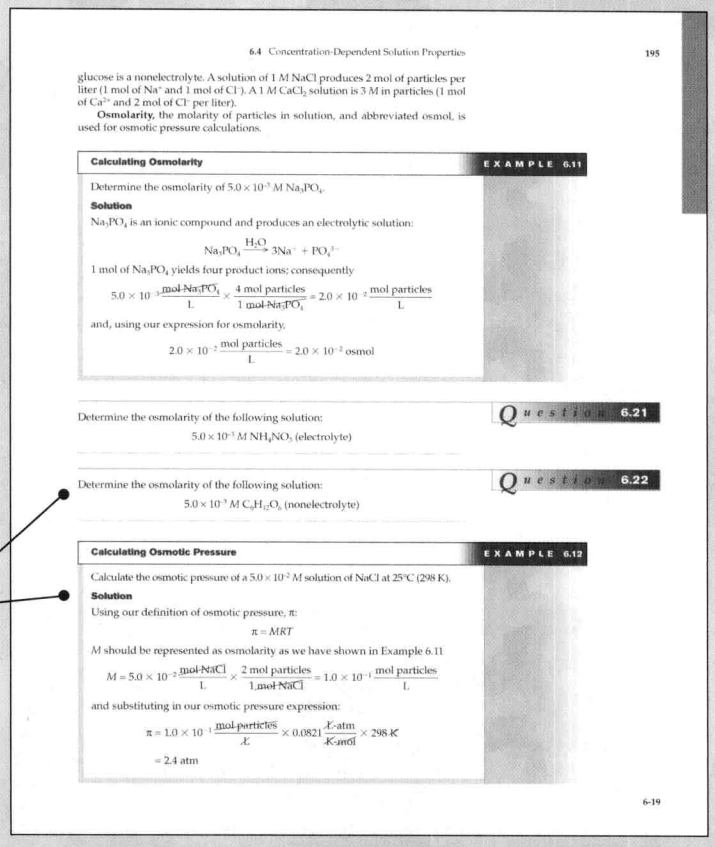
The students' ability to understand the geometry and three-dimensional structure of molecules is essential to the understanding of organic and biochemical reactions. Computer generated models are used throughout the text because they are both accurate and easily visualized.

Problem Solving and Critical Thinking

Perhaps the best preparation for a successful and productive career is the development of problem-solving and critical thinking skills. To this end, we created a variety of problems that require recall, fundamental calculations, and complex reasoning. In this edition, we have used suggestions from our reviewers, as well as from our own experience, to enhance the problem sets to include more practice problems for difficult concepts and further integration of the subject areas.

In-Chapter Examples, Solutions, and Questions

Each chapter includes a number of examples that show the student, step-by-step, how to properly reach the correct solution to model problems. Whenever possible, the examples are followed by in-text questions that allow students to test their mastery of information and to build self-confidence.



6.4 Concentration-Dependent Solution Properties 195

glucose is a nonelectrolyte. A solution of 1 *M* NaCl produces 2 mol of particles per liter (1 mol of Na^+ and 1 mol of Cl^-). A 1 *M* $CaCl_2$ solution is 3 *M* in particles (1 mol of Ca^{2+} and 2 mol of Cl^- per liter).

Osmolarity, the molarity of particles in solution, and abbreviated osmol, is used for osmotic pressure calculations.

Calculating Osmolarity EXAMPLE 6.11

Determine the osmolarity of 5.0×10^{-3} *M* Na_3PO_4.

Solution

Na_3PO_4 is an ionic compound and produces an electrolytic solution:

$$Na_3PO_4 \xrightarrow{H_2O} 3Na^+ + PO_4^{3-}$$

1 mol of Na_3PO_4 yields four product ions; consequently

$$5.0 \times 10^{-3} \frac{\text{mol } Na_3PO_4}{\text{L}} \times \frac{4 \text{ mol particles}}{1 \text{ mol } Na_3PO_4} = 2.0 \times 10^{-2} \frac{\text{mol particles}}{\text{L}}$$

and, using our expression for osmolarity,

$$2.0 \times 10^{-2} \frac{\text{mol particles}}{\text{L}} = 2.0 \times 10^{-2} \text{ osmol}$$

Determine the osmolarity of the following solution: **Question 6.21**

5.0×10^{-3} *M* NH_4NO_3 (electrolyte)

Determine the osmolarity of the following solution: **Question 6.22**

5.0×10^{-3} *M* $C_6H_{12}O_6$ (nonelectrolyte)

Calculating Osmotic Pressure EXAMPLE 6.12

Calculate the osmotic pressure of a 5.0×10^{-2} *M* solution of NaCl at 25°C (298 K).

Solution

Using our definition of osmotic pressure, π:

$$\pi = MRT$$

M should be represented as osmolarity as we have shown in Example 6.11

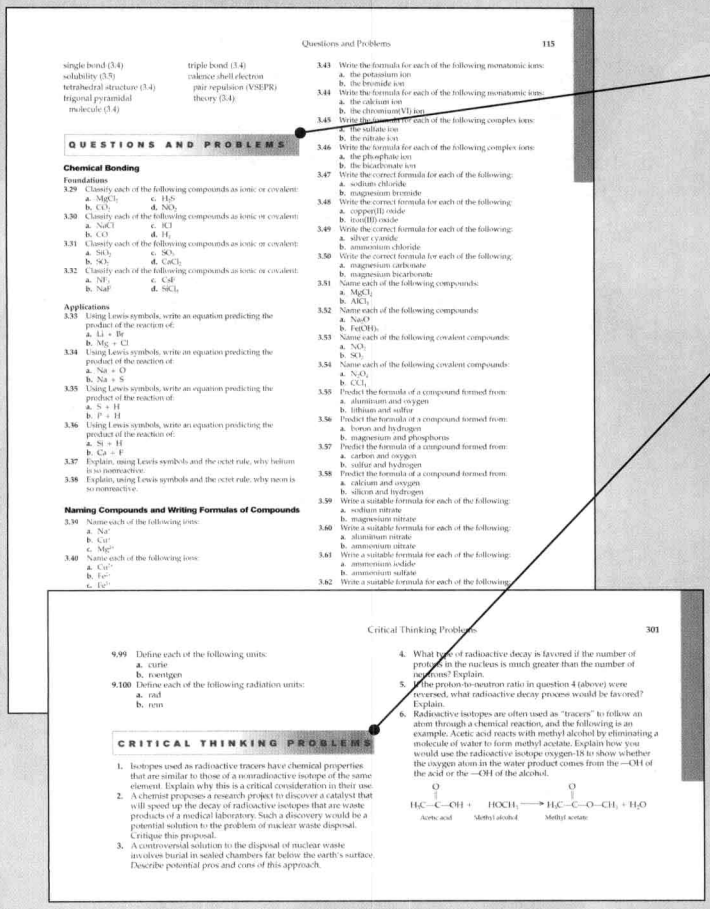
$$M = 5.0 \times 10^{-2} \frac{\text{mol NaCl}}{\text{L}} \times \frac{2 \text{ mol particles}}{1 \text{ mol NaCl}} = 1.0 \times 10^{-1} \frac{\text{mol particles}}{\text{L}}$$

and substituting in our osmotic pressure expression:

$$\pi = 1.0 \times 10^{-1} \frac{\text{mol particles}}{\text{L}} \times 0.0821 \frac{\text{L-atm}}{\text{K-mol}} \times 298 \text{ K}$$

$$= 2.4 \text{ atm}$$

6-19



Questions and Problems 115

single bond (3.4)
solubility (3.5)
tetrahedral structure (3.4)
trigonal pyramidal molecule (3.4)
triple bond (3.4)
valence shell electron pair repulsion (VSEPR) theory (3.4)

QUESTIONS AND PROBLEMS

Chemical Bonding

Foundations

3.29 Classify each of the following compounds as ionic or covalent:
a. $MgCl_2$ c. H_2S
b. CO_2 d. NO_2

3.30 Classify each of the following compounds as ionic or covalent:
a. NaCl c. ICl
b. CO d. H_2

3.31 Classify each of the following compounds as ionic or covalent:
a. SiO_2 c. SO_2
b. SCl_2 d. $CaCl_2$

3.32 Classify each of the following compounds as ionic or covalent:
a. NF_3 c. CsF
b. NaF d. $SiCl_4$

Applications

3.33 Using Lewis symbols, write an equation predicting the product of the reaction of:
a. Li + Br
b. Mg + Cl

3.34 Using Lewis symbols, write an equation predicting the product of the reaction of:
a. Na + O
b. Na + S

3.35 Using Lewis symbols, write an equation predicting the product of the reaction of:
a. S + H
b. P + H

3.36 Using Lewis symbols, write an equation predicting the product of the reaction of:
a. Si + H
b. Ca + F

3.37 Explain, using Lewis symbols and the octet rule, why helium is so nonreactive.

3.38 Explain, using Lewis symbols and the octet rule, why neon is so nonreactive.

Naming Compounds and Writing Formulas of Compounds

3.39 Name each of the following ions:
a. Na^+
b. Cu^+
c. Mg^{2+}

3.40 Name each of the following ions:
a. Cu^{2+}
b. Fe^{3+}
c. Fe^{2+}

3.43 Write the formula for each of the following monatomic ions:
a. the potassium ion
b. the bromide ion

3.44 Write the formula for each of the following monatomic ions:
a. the calcium ion
b. the chromium(VI) ion

3.45 Write the name for each of the following complex ions:
a. the sulfate ion
b. the nitrate ion

3.46 Write the formula for each of the following complex ions:
a. the phosphate ion
b. the bicarbonate ion

3.47 Write the correct formula for each of the following:
a. sodium chloride
b. magnesium bromide

3.48 Write the correct formula for each of the following:
a. copper(II) oxide
b. iron(III) oxide

3.49 Write the correct formula for each of the following:
a. silver cyanide
b. ammonium chloride

3.50 Write the correct formula for each of the following:
a. magnesium carbonate
b. magnesium bicarbonate

3.51 Name each of the following compounds:
a. $MgCl_2$
b. $AlCl_3$

3.52 Name each of the following compounds:
a. Na_2O
b. $Fe(OH)_3$

3.53 Name each of the following covalent compounds:
a. NO_2
b. SO_3

3.54 Name each of the following covalent compounds:
a. N_2O_4
b. CCl_4

3.55 Predict the formula of a compound formed from:
a. aluminum and oxygen
b. lithium and sulfur

3.56 Predict the formula of a compound formed from:
a. boron and hydrogen
b. magnesium and phosphorus

3.57 Predict the formula of a compound formed from:
a. carbon and oxygen
b. sulfur and hydrogen

3.58 Predict the formula of a compound formed from:
a. calcium and oxygen
b. silicon and hydrogen

3.59 Write a suitable formula for each of the following:
a. sodium nitrate
b. magnesium nitrate

3.60 Write a suitable formula for each of the following:
a. aluminum nitrate
b. ammonium nitrate

3.61 Write a suitable formula for each of the following:
a. ammonium iodide
b. ammonium sulfate

3.62 Write a suitable formula for each of the following:

Critical Thinking Problems 301

9.99 Define each of the following units:
a. curie
b. roentgen

9.100 Define each of the following radiation units:
a. rad
b. rem

CRITICAL THINKING PROBLEMS

1. Isotopes used as radioactive tracers have chemical properties that are similar to those of a nonradioactive isotope of the same element. Explain why this is a critical consideration in their use.
2. A chemist proposes a research project to discover a catalyst that will speed up the decay of radioactive isotopes that are waste products of a medical laboratory. Such a discovery would be a potential solution to the problem of nuclear waste disposal. Critique this proposal.
3. A controversial solution to the disposal of nuclear waste involves burial in sealed chambers far below the earth's surface. Describe potential pros and cons of this approach.
4. What type of radioactive decay is favored if the number of protons in the nucleus is much greater than the number of neutrons? Explain.
5. If the proton-to-neutron ratio in question 4 (above) were reversed, what radioactive decay process would be favored? Explain.
6. Radioactive isotopes are often used as "tracers" to follow an atom through a chemical reaction, and the following is an example. Acetic acid reacts with methyl alcohol by eliminating a molecule of water to form methyl acetate. Explain how you would use the radioactive isotope oxygen-18 to show whether the oxygen atom in the water product comes from the —OH of the acid or the —OH of the alcohol.

Acetic acid Methyl alcohol Methyl acetate

In-Chapter and End-of-Chapter Problems

We have created a wide variety of paired concept problems. The answers to the odd-numbered questions are found at the back of the book as reinforcement for students as they develop problem-solving skills. However, students must then be able to apply the same principles to the related even-numbered problems.

Critical Thinking Problems

Each chapter includes a set of critical thinking problems. These problems are intended to challenge students to integrate concepts to solve more complex problems. They make a perfect complement to the classroom lecture because they provide an opportunity for in-class discussion of complex problems dealing with daily life and the health care sciences.

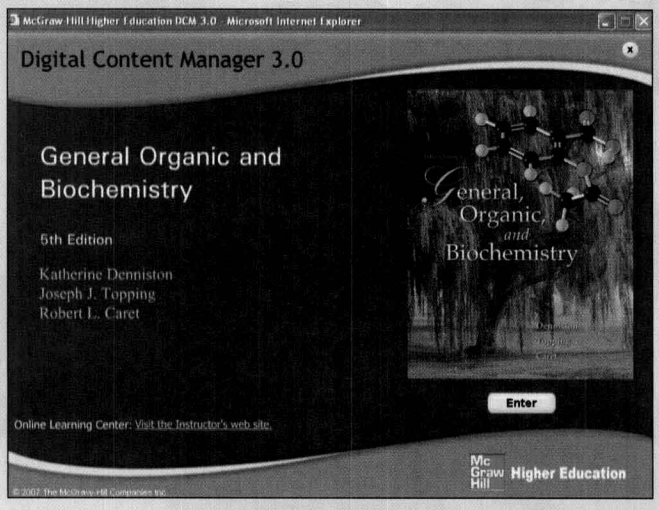
Over the course of the last four editions, hundreds of reviewers have shared their knowledge and wisdom with us, as well as the reaction of their students to elements of this book. Their contributions, as well as our own continuing experience in the area of teaching and learning science, have resulted in a text that we are confident will provide a strong foundation in chemistry, while enhancing the learning experience of students.

Supplementary Materials

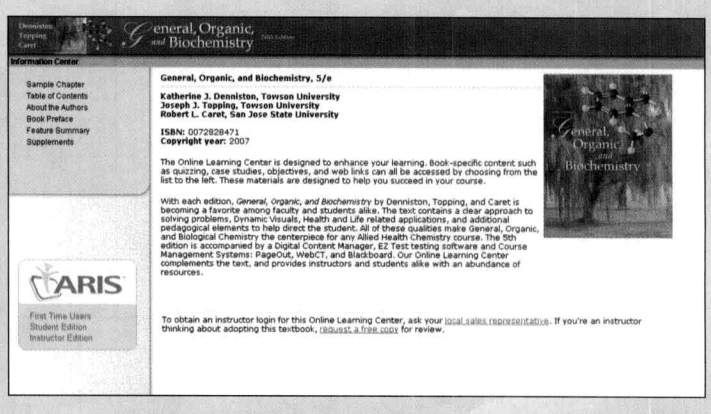
This text is supported by a complete package for instructors and students. Several print and media supplements have been prepared to accompany the text and make learning as meaningful and up-to-date as possible.

For the Instructor

- **Digital Content Manager CD/DVD:** This primary instructor supplement offers over 800 visual images, including illustrations, photos, examples, boxed readings, and tables from the text. These images are in full color and can be readily incorporated into lecture presentations, exams, or classroom materials. Also on the Digital Content Manager are PowerPoint Lecture Outline slides, prepared by Dr. Ann Eakes of Northwest Vista College, that cover all 23 chapters and can be modified according to instructor preference.



- **Instructor's Manual:** Written by the authors and also Dr. Timothy Dwyer of Towson University, this ancillary contains suggestions for organizing lectures, instructional objectives, perspectives on boxed readings from the text, a list of each chapter's key problems and concepts, and more. The Instructor's Manual is a part of the Instructor's Testing and Resource CD, and is also available through the ARIS website for this text.
- **Transparencies:** A set of 100 transparencies is available to help the instructor coordinate the lecture with key illustrations from the text.
- **Computerized Classroom Management System:** This Instructor's Testing and Resource CD includes a database of test questions, reproducible student self-quizzes, and a grade-recording program. Also found on this CD is the Instructor's Manual to accompany this text.
- *A Laboratory Manual for General, Organic, and Biochemistry,* Fifth Edition, by Charles H. Henrickson, Larry C. Byrd, and Norman W. Hunter of Western Kentucky University, offers clear and concise laboratory experiments that reinforce students' understanding of concepts. Prelaboratory exercises, questions, and report sheets are coordinated with each experiment to ensure active student involvement and comprehension. A new student tutorial on graphing with Excel has been added to this edition.
- **Laboratory Resource Guide:** Written by Charles H. Henrickson, Larry C. Byrd, and Norman W. Hunter of Western Kentucky University, this helpful prep guide contains the hints that the authors have learned over the years to ensure students' success in the laboratory. This Resource Guide is available through the ARIS course website for this text.
- **ARIS** (McGraw-Hill's Assessment, Review and Instruction System) for *General, Organic, and Biochemistry*—a complete electronic homework and course management system—is designed for greater ease of use than any other system available. ARIS enables instructors to create and share course materials and assignments with colleagues with a few clicks of the mouse. Instructors can edit questions, import their own content, and create announcements and due dates for assignments. ARIS has automatic grading and reporting of easy-to-assign homework, quizzing, and testing. Once a student is registered in the course, all student activity within McGraw-Hill's ARIS is automatically recorded and available to the instructor through a fully integrated grade book that can be downloaded to Excel. This book-specific website is found at www.mhhe.com/denniston5e.



- **Course Management Systems—PageOut, WebCT, and Blackboard:** The course cartridge that accompanies *General, Organic, and Biochemistry,* Fifth Edition, includes all ARIS website content, and the entire test bank that accompanies this new edition.

For the Student

- **Student Study Guide/Solutions Manual:** A separate Student Study Guide/Solutions Manual, prepared by Dr. Timothy Dwyer and the authors of this text, is available. It contains the answers and complete solutions for the odd-numbered problems. It also offers students a variety of exercises and keys for testing their comprehension of basic, as well as difficult, concepts.
- **Schaum's Outline of General, Organic, and Biological Chemistry:** Written by George Odian and Ira Blei, this supplement provides students with over 1400 solved problems with complete solutions. It also teaches effective problem-solving techniques.
- **ARIS:** McGraw-Hill's Assessment, Review, and Instruction System for *General, Organic, and Biochemistry* is available to students and instructors using this text. The website offers quizzes, key definitions, a review of mathematics applied to problem solving, important tables, definitions, and more. This book-specific website can be found at www.mhhe.com/denniston5e.

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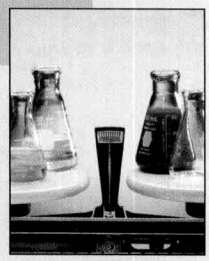

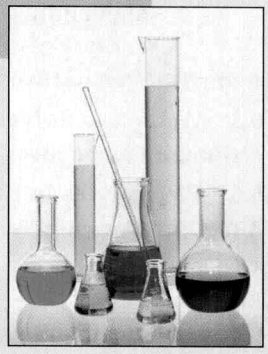

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