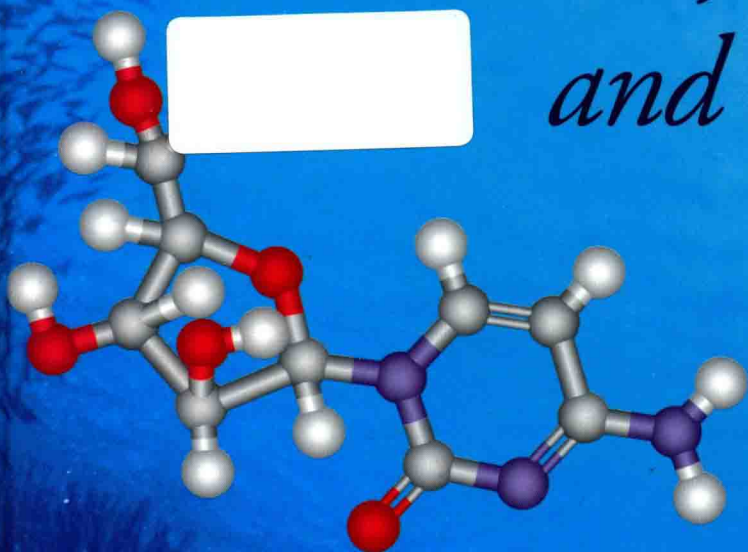


General, Organic, *and* Biochemistry

EIGHTH EDITION



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Preface

To Our Students

Just as some researchers study chemical change, others study learning. The two are related: there are measurable changes in the brain as learning occurs. While the research on brain chemistry and learning continues, the research on learning has taught us some very successful strategies for teaching and learning chemistry. For instance, we now know that building long-term memory requires “repetitions.” When you exercise to build muscle strength, you perform some number of “reps” of each exercise for each muscle that you wish to build. That is exactly what you need to do to build your long-term memory and understanding. The Center for Academic Success at the Louisiana State University has devised study tools that have allowed students to improve their performance by a full letter grade, or higher. The following is the Study Cycle with five stages that provide the “reps” needed to perform well in any course:

1. **Preview** the chapter *before* class. Either the evening before or the day of class, skim the material; pay attention to the end-of-chapter summary with boldfaced key terms, chapter map, the learning goals, and headings. Think of questions you would like the instructor to answer. Think of this 10 minutes as your “warm up.”
2. **Attend** class! Be an active participant in the class, asking and answering questions and taking thoughtful, meaningful notes. Class time is much more meaningful if you have already familiarized yourself with the organization and key concepts to be discussed.
3. **Review** your notes as soon as possible after class. Fill in any gaps that exist and note any additional questions that arise. This also takes about 10 minutes; think of it as your “cool down” period.
4. **Study.** Since repetition is the key to success, The Center for Academic Success recommends 3–5 short, but intense, study sessions each day. These intense study sessions should have a very structured organization. In the first 2–5 minutes, establish your goal for the session. Spend the next 30–50 minutes studying with focus and action. Organize the material, make flash cards to help you review, draw concept maps to define the relationship among ideas, and practice problem solving. Then reward yourself with a 5–10 minute break. Call a friend, play Angry Birds, or do anything you find enjoyable. Then take 5 minutes to review the material. Finally, about once a week, perhaps on the weekend, review all of the material that you have been studying throughout the week.
5. **Assess** your progress. Are you able to solve the questions and problems at the end of the chapter? Can you explain the concepts to others? The assessment will affirm what you know well and reveal what you need to study further.

The Center for Academic Success has many other suggestions to help students learn how to learn. You can find their online tutorials and workshops at www.cas.lsu.edu.

To the Instructor

The eighth 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 significant connections among 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.

Although our emphasis is the importance of chemistry to the health-related professions, we wanted this book to be appropriate for all students who need a one- or two-semester introduction to chemistry. Students learn best when they are engaged. One way to foster that engagement is to help them see clear relationships between the subject and real life. For these reasons, we have included perspectives and essays that focus on medicine and the function of the human body, as well as the environment, forensic science, and even culinary arts.

We begin that engagement with the book cover. Students may wonder why the cover depicts a coral reef featuring a sponge. Then they learn that one of the first drugs used to treat cancer successfully, *cytosine arabinoside*, was synthesized following the discovery of similar compounds from a Caribbean sponge. Because sponges are sessile, they produce a variety of compounds to protect them from predation. Cytosine arabinoside is now used routinely for treatment of acute myeloid leukemia (AAML), acute lymphocytic leukemia (ALL). In fact, a large number of other compounds from sponges are being tested for anticancer and antimicrobial properties.

The cover sets the theme for the book: chemistry is not an abstract study, but one that has an immediate impact on our lives. We try to spark student interest with an art program that uses relevant photography, clear and focused figures, animations that are available on our website and in the e-book, and perspectives and essays that bring life to abstract ideas. We reinforce key concepts by explaining them in a clear and concise way and encouraging students to apply the concept to solve problems. We provide guidance through the inclusion of a large number of in-chapter examples that are solved in a stepwise fashion and that provide students the opportunity to test their understanding through the practice problems that follow and the suggested end-of-chapter questions and problems that apply the same concepts.

New in This Edition

In the preparation of the eighth edition, we have been guided by the collective wisdom of reviewers who are expert chemists and excellent teachers. They represent experience in community colleges, liberal arts colleges, comprehensive institutions, and research universities. We have followed their recommendations, while remaining true to our overriding goal of writing a readable, student-centered text. The following is a summary of the additions and refinements that we have included in this edition.

Chapter maps are included just before the end-of-chapter summaries to provide students with an overview of the chapter—showing connections among topics, how concepts are related, and outlining the chapter hierarchy.

End-of-chapter summaries have been changed to a bulleted list format of chapter concepts by section, with the bold-faced key terms appearing in context. This more succinct format helps students to quickly identify and review important chapter concepts and to make connections with the incorporated key terms.

Eight new Kitchen Chemistry and two new Green Chemistry applications, and six new Perspectives have been added to the eighth edition to help students see the connections between chemistry and their daily lives and future careers.

Answers to Practice Problems are now supplied at the end of each chapter so that students can quickly check their understanding of important problem-solving skills and chapter concepts.

- **Chapter 1** The chapter includes a new subsection called Problem Solving Strategies, and was also reorganized to provide a discussion of units prior to the discussion of numbers. Section 1.3 was revised to incorporate information about the English versus the metric system and unit prefixes. The material on significant figures was revised to expand and clarify the discussions of making measurements to the correct number of significant figures, of zeros and significant figures, and of scientific notation and adding numbers in scientific notation. Thirty-seven new end-of-chapter problems were added to correlate to the new and revised material within the text.
- **Chapter 2** A new subsection and example on writing shorthand electron configurations were added. Also, based on reviewer feedback, the explanations of ions and ion formation, how to use mass number or atomic number to determine the number of neutrons, how to determine the average atomic mass, and of light and the Bohr model were revised to clarify these discussions. Thirty new end-of-chapter problems were added to correlate to the new and revised material within the text.
- **Chapter 3** New worked examples were added throughout the chapter, including Example 3.3 on how to name ionic compounds using the Stock system and Example 3.16 on exceptions to the octet rule (involving electron pairs on the central atom). The text was revised to expand and clarify the discussion of how to handle molecules with more than

one central atom, and a new Example 3.10, Drawing Lewis Structures for Compounds with Multiple Central Atoms was added. Additionally, based on reviewer feedback, the symbol used for electronegativity was changed. Twenty new end-of-chapter problems were added to correlate to the new and revised material within the text.

- **Chapter 4** Several of the chapter examples were modified, with color-coding added, and otherwise enhanced for clarity. A new illustration of the conversion between numbers of moles, particles, and grams was added, and other illustrations were revised and improved.
- **Chapter 5** *A Human Perspective: Gemstones* was added, and *Green Chemistry: The Greenhouse Effect and Global Climate Change* was revised to make the article more current. Six new end-of-chapter problems were added and others revised to correlate to the new and revised material within the text.
- **Chapter 6** Several of the chapter examples were modified, with reworked solutions, and otherwise enhanced for clarity. A new Example 6.11, Calculating Freezing and Boiling Points of Aqueous Solutions of Ionic, Dissociating Solutes and a new *Kitchen Chemistry: Solubility, Surfactants, and the Dishwasher* were also added. Four new in-text and six new end-of-chapter questions and problems were added, and others revised to correlate to the new and revised material within the text.
- **Chapter 7** Based on reviewer feedback, *A Human Perspective: An Extraordinary Molecule* was revised and moved to Chapter 7 from Chapter 6 in the previous edition. Several of the chapter examples were modified and otherwise enhanced for clarity. *Green Chemistry: Twenty-First Century Energy* was revised and made more objective. Seven new end-of-chapter questions and problems were added, and others revised to correlate to the new and revised material within the text.
- **Chapter 8** Based on reviewer feedback, *A Medical Perspective: Control of Blood pH* was made part of the main text in Section 8.4. A new essay *Green Chemistry: Hydrangeas, pH, and Soil Chemistry* was also added. Several of the chapter examples were modified and otherwise enhanced for clarity. Six new in-text and six new end-of-chapter questions and problems were added, and others revised to correlate to the new and revised material within the text.
- **Chapter 9** Two new worked examples, Example 9.2, Predicting the Product of Beta Decay and Example 9.3, Predicting the Product of Positron Emission, and two new practice problems were added to the chapter. Four new in-text and two new end-of-chapter questions and problems were added, and others revised to correlate to the new and revised material within the text.
- **Chapter 10** A new *Green Chemistry: Biofuels: A Renewable Resource*, including two For Further Understanding questions, has been added to the revised Chapter 10. More explicit definitions of aliphatic hydrocarbons, alkenes, and alkynes were also added to the text. The subsections

Families of Organic Compounds Structure, Alkyl Groups, *cis-trans* Isomerism in Cycloalkanes, and Cycloalkanes were revised and expanded for clarity. A new subsection Physical Properties adds deeper understanding of properties and the relationship to structure, and includes a discussion of London dispersion forces, which has been woven into all of the organic chapters where appropriate. Several of the chapter examples were modified, with structures added and revised, to further clarify the relationship between structural and condensed formulas. Line formulas were also added throughout to help students understand relationships between line and condensed formulas, and cycloalkane structures were improved to help students visualize three-dimensional structures. Table 10.2 was revised to include a column for names of functional groups, and Table 10.6 was modified with color coding: highlighting the carbon of the alkyl group that bonds to the parent chain to assist students in identifying classification of 1°, 2°, and 3°. Five new questions and problems were added, and nineteen revised to correspond to revisions within the chapter.

- **Chapter 11** Chapter 11 includes a new *Kitchen Chemistry: Amazing Chocolate* and an increased emphasis on line formulas throughout the chapter text.
- **Chapter 12** A new *A Medical Perspective: Resveratrol: Fountain of Youth?* and a new *Kitchen Chemistry: Spicy Phenols* were added. The chapter was reorganized to include alcohol classification within the section on structure. Color-coding was added to the general equations and to the examples of reactions of alcohols to help students visualize the changes occurring in the reactions. An explanation of oxidation and reduction in biochemical/organic reactions was also added to Section 12.5.
- **Chapter 13** Condensed structures were added to the introduction and line formulas to the text to help students better understand the relationships between line and condensed formulas. A new *Kitchen Chemistry: The Allure of Truffles* was added. Numerous figures were revised and color-coding added to help clarify the concepts portrayed. In addition, many areas of the text were revised to improve the clarity of explanations, based on reviewer feedback: added detail to explain polarity of carbonyl groups; improved explanations of oxidation/reduction in organic systems; revised Addition Reactions to update content; and added text art to clarify intramolecular hemiacetal formation. Two new end-of-chapter problems were added and sixteen revised to correlate to the new and revised material within the text.
- **Chapter 14** Line formulas were added where appropriate to help students see relationships with condensed formulas. A new *A Human Perspective: Detergents* and a table of common dicarboxylic acids were also added. In addition, the subsections Nomenclature and Some Important Carboxylic Acids were revised based on reviewer feedback to add detail and further clarity. Section 14.2 was reorganized to clarify the use of nomenclature, and the coverage of acid chlorides in Section 14.3 was reduced to remove unnecessary material.
- **Chapter 15** A new *Kitchen Chemistry: Browning Reactions and Flavor: The Maillard Reaction* was added. Line formulas were added where appropriate to help students see the relationship with condensed formulas. Many end-of-chapter problems were also revised to use condensed rather than expanded structures.
- **Chapter 16** Chapter 16 includes a new *Kitchen Chemistry: The Chemistry of Caramels* and updated material on intramolecular hemiacetal formation in fructose. Sections 16.2 and 16.3 were also rewritten for clarity and improved comprehension.
- **Chapter 17** Sections 17.2 and 17.3 were reorganized to place Chemical Reactions of Fatty Acids and Glycerides into Section 17.3 for greater clarity. Line formulas were added in Section 17.2 to help students understand the relationship with condensed formulas. Also Examples 17.4 and 17.5 were replaced with clearer examples of the relationship of the reaction (hydrolysis of esters) to monoglycerides. Table 17.1 was revised to add molar mass, and color-coding was added to chemical equations throughout the chapter to better portray chemical changes.
- **Chapter 18** A new *Kitchen Chemistry: Egg Foams: Meringues and Soufflés* was added as well as a new section Proteins in the Blood. Also the sections on stereoisomers, pH, and mechanical stress were revised for greater clarity. One letter codes for the amino acids were added to Table 18.1.
- **Chapter 19** A new *Kitchen Chemistry: Transglutaminase: aka Meat Glue* was added. Also Section 19.12 Uses of Enzymes in Medicine was enhanced to bring greater depth to this topic, which is extremely relevant to health professionals.
- **Chapter 20** New subsections and illustrations of Chemical Composition of DNA and RNA and Nucleosides were added. New material on nucleotide nomenclature was also added.
- **Chapter 21** Chapter 21 includes a new *A Medical Perspective: High Fructose Corn Syrup*. New subsections Biological Effects of Genetic Disorders of Glycolysis and Entry of Fructose into Glycolysis were also added. Section 21.5 The Pentose Phosphate Pathway was revised to focus on key products used in biosynthesis. Four new end-of-chapter problems were added and others revised to correlate to the new and revised material within the text.
- **Chapter 22** A new subsection Biological Effects of Disorders of the Citric Acid Cycle was added to bring medical relevance to the reactions within the chapter. New transition text introduces Summary of the Energy Yield. Five new end-of-chapter problems were added and others revised to correlate to the new and revised material within the text.
- **Chapter 23** A new *A Medical Perspective: Carnitine: The Fat Mover* was added to the revised Chapter 23. Also a new Figure 23.7 illustrates acylation of carnitine and the transport of fatty acids from the cytoplasm into the mitochondria.

Applications

Each chapter contains applications that present short stories about real-world situations involving one or more topics students will encounter within the chapter. There are over 100 applications throughout the text, so students are sure to find many topics that spark their interest. Global climate change, fingerprinting, the benefits of garlic, and gemstones are just a few examples of application topics.

- **Medical Perspectives** relate chemistry to a health concern or a diagnostic application.
- **Green Chemistry** explores environmental topics, 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.
- **Chemistry at the Crime Scene** focuses on forensic chemistry, applying the principles of chemistry to help solve crimes.
- **Kitchen Chemistry** discusses the chemistry associated with everyday foods and cooking methods.

Learning Tools

In designing the original learning system we asked ourselves: “If we were students, what would help us organize and understand the material covered in this chapter?” Based on the feedback of reviewers and users of our text, we include a variety of learning tools:

- **Chapter Overview** pages begin each chapter, listing learning goals and the chapter outline. Both students and professor can see, all in one place, the plan for the chapter.
- **Learning Goal Icons** mark the sections and examples in the chapter that focus on each learning goal.
- **Chapter Cross-References** help students locate pertinent background material. These references to previous chapters, sections, and perspectives are noted in the margins of the text. Marginal cross references also alert students to upcoming topics related to the information currently being studied.
- **End-of-Chapter Questions and Problems** are arranged according to the headings in the chapter outline, with further subdivision into Foundations (basic concepts) and Applications.
- **New Chapter Maps** are included just before the End-of-Chapter Summaries to provide students with an overview of the

Question 7.7 Using the conversion factor in Chapter 1, convert the energy released in Example 7.3 to joules (J).

Question 7.8 Using the conversion factor in Chapter 1, convert the energy absorbed in Example 7.4 to J.

Many chemical reactions that produce heat are combustion reactions. In our bodies many food substances (carbohydrates, proteins, and fats; Chapters 21 and 22) are oxidized to release energy. **Fuel value** is the amount of energy per g of food.

The fuel value of food is an important concept in nutrition science. The fuel value is generally reported in units of **nutritional Calories**. One **nutritional Calorie (Cal)** is equivalent to one kilocalorie (1000 cal). It is also known as the **large Calorie** (uppercase C).

Energy necessary for our daily activity and bodily function comes largely from the reaction of oxygen with carbohydrates. Chemical energy from foods that is not used to maintain normal body temperature or in muscular activity is stored in the bonds of chemical compounds known collectively as fat. Thus consumption of “high-calorie” foods is implicated in the problem of obesity.

A special type of calorimeter, a **bomb calorimeter**, is useful for the measurement of the fuel value (Cal) of foods. Such a device is illustrated in Figure 7.6. Its design is similar, in principle, to that of the “coffee cup” calorimeter discussed earlier.

Note: Refer to A Human Perspective: Food Calories, Section 1.6.

LEARNING GOAL

- 3 Describe experiments that yield thermochemical information and calculate fuel values based on experimental data.



CHEMISTRY AT THE CRIME SCENE

Adipocere and Mummies of Soap

One November evening in 1911, widower Patrick Higgins stepped into his local pub in Abgorn, Scotland. To the surprise of his drinking companions, he did not have his two young boys with him. Neighbors knew that the boys had been a great burden on Patrick since the death of his wife; so they believed Patrick's story that he left William, age 6, and John, age 4, with two women in Edinburgh who had offered to adopt the boys.

More than 18 months had passed when an object was seen floating in the Hopetoun Quarry, an unused, flooded quarry near town. When the object was fished out, it was obvious that it was the body of a young boy; the rescuers were stunned to find another small body tied to the first by a rope. How were these bodies preserved after such a long time and why did they float? The answer is that their bodies had almost completely turned into adipocere, or more simply, soap.

Forensic scientists are trying to understand the nature of the reaction that creates *adipocere*, the technical term for the yellowish-white, greasy, waxlike substance that results from the saponification of fatty tissue. Some researchers hope that this information may allow determination of the postmortem interval (length of time since death). Others simply value the process because it helps preserve the body so well that even after long periods, it can be easily recognized and any wounds or injuries can be observed.

It is known that adipocere is produced when body fat is hydrolyzed (water is needed) to release fatty acids. Because the fatty acids lower the pH in the tissues, they inhibit many of the bacteria that would begin the process of decay. Certain other bacteria, particularly *Clostridium welchii*, an organism that cannot grow in the presence of oxygen, is known to speed up the formation of adipocere in moist, warm, anaerobic (oxygenless) environments. Adipocere forms first in subcutaneous tissues, including the cheeks, breasts, and buttocks. Given appropriate warmth and damp conditions, it may be seen as early as 3 to 4 weeks after death, but more commonly it is not observed until 5 to 6 months after death.

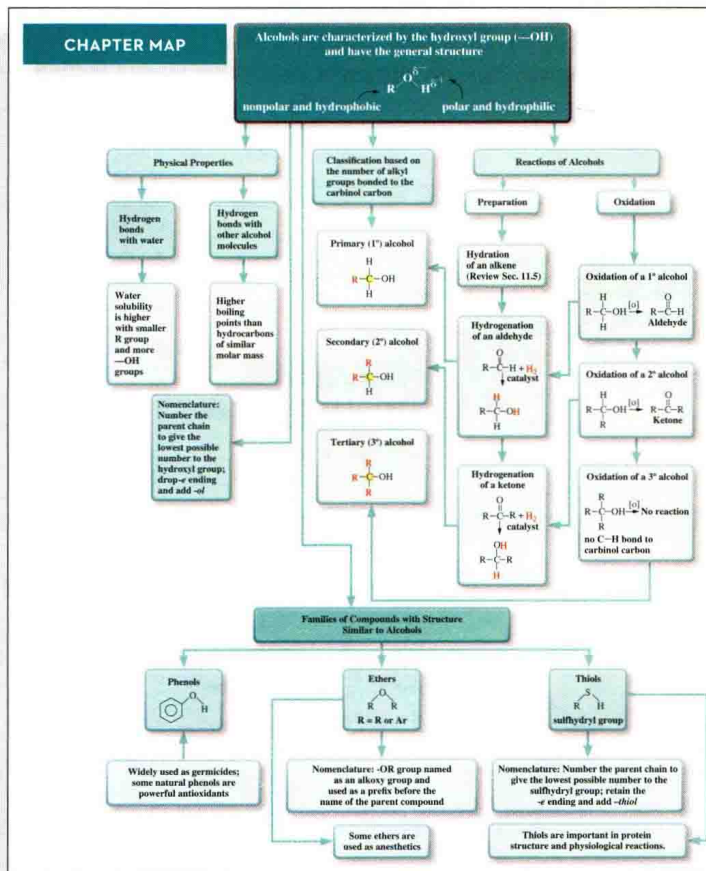
Adipocere formation in John and William Higgins was so extensive that their former neighbors had no trouble recognizing them. At the postmortem, another advantage of adipocere formation became obvious—it had preserved the stomach contents of the boys! From this, the coroner learned that the boys



had eaten Scotch broth about an hour before they died. Investigators were able to find the woman who had given the broth to the boys and, from her testimony, learned that she had fed them on the last day they were seen in the village. Clearly their father had lied about the adoption by two Edinburgh women! In under one and one-half hours, a jury convicted the father of murdering his sons and he was hanged in October 1913.

For Further Understanding

- Adipocere is the technical term for “soap mummification.” It comes from the Latin words *adipis* or fat, as in adipose tissue, and *cera*, which means wax. Draw a triglyceride composed of the fatty acids myristic acid, stearic acid, and oleic acid. Write a balanced equation showing a possible reaction that would lead to the formation of adipocere.
- Forensic scientists are studying adipocere formation as a possible source of information to determine postmortem interval (length of time since death) of bodies of murder or accident victims. Among the factors being studied are the type of soil, including pH, moisture, temperature, and presence or absence of lime. How might each of these factors influence the rate of adipocere formation and hence the determination of the postmortem interval?



chapter—showing connections among topics, how concepts are related, and outlining the chapter hierarchy.

- **Chapter Summaries** are now a bulleted list format of chapter concepts by major sections, with the integrated bold-faced **Key Terms** appearing in context. This more succinct format helps students to quickly identify and review important chapter concepts and to make connections with the incorporated Key Terms. Each Key Term is defined and listed alphabetically in the **Glossary Terms** at the end of the book.
- **New Answers to Practice Problems** are supplied at the end of each chapter so that students can quickly check their understanding of important problem solving skills and chapter concepts.
- **Summary of Reactions** in the organic chemistry chapters highlight each major reaction type on a tan background. Major chemical reactions are summarized by equations at the end of the chapter, facilitating review.

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 our 2300 problems. This edition includes new problems and hundreds of example problems with step-by-step solutions.

- **In-Chapter Examples, Solutions, and Practice Problems:** Each chapter includes examples that show the student, step-by-step, how to properly reach the correct solution to model problems. Each example contains a practice problem, as well as a referral to further practice questions. These

EXAMPLE 6.4 Calculating ppt and ppm

A 1.00-g sample of stream water was found to contain 1.0×10^{-6} g lead. Calculate the concentration of lead in the stream water in units of % (m/m), ppt, and ppm. Which is the most suitable unit?

Solution
mass percent:

$$\begin{aligned}\% \left(\frac{m}{m} \right) &= \frac{\text{g solute}}{\text{g solution}} \times 100\% \\ \% \left(\frac{m}{m} \right) &= \frac{1.0 \times 10^{-6} \text{ g Pb}}{1.0 \text{ g solution}} \times 100\% \\ \% \left(\frac{m}{m} \right) &= 1.0 \times 10^{-4}\%\end{aligned}$$

parts per thousand:

$$\begin{aligned}\text{ppt} &= \frac{\text{g solute}}{\text{g solution}} \times 10^3 \text{ ppt} \\ \text{ppt} &= \frac{1.0 \times 10^{-6} \text{ g Pb}}{1.0 \text{ g solution}} \times 10^3 \text{ ppt} \\ \text{ppt} &= 1.0 \times 10^{-3} \text{ ppt}\end{aligned}$$

parts per million:

$$\begin{aligned}\text{ppm} &= \frac{\text{g solute}}{\text{g solution}} \times 10^6 \text{ ppm} \\ \text{ppm} &= \frac{1.0 \times 10^{-6} \text{ g Pb}}{1.0 \text{ g solution}} \times 10^6 \text{ ppm} \\ \text{ppm} &= 1.0 \text{ ppm}\end{aligned}$$

Parts per million is the most reasonable unit.

Practice Problem 6.4

- Calculate the ppt and ppm of oxygen gas in a mixture containing 20.0 g of oxygen gas and 80.0 g of nitrogen gas.
- Calculate the ppt and ppm of argon gas in a mixture containing 50.0 g of argon gas and 80.0 g of helium gas.

► For Further Practice: Questions 6.37 and 6.38.

LEARNING GOAL

- Calculate solute concentration in mass/volume percent, mass/mass percent, parts per thousand, and parts per million.

SUMMARY

10.3 Alkenes and Alkynes: Structure and Physical Properties

- Alkenes and alkynes are **unsaturated** hydrocarbons because they have at least one C=C double bond (alkenes) or C≡C triple bond (alkynes).
- Alkenes have the general formula C_nH_{2n} , and alkynes have the general formula C_nH_{2n-2} .
- Alkenes and alkynes have physical properties like alkanes, but very different chemical properties.

10.2 Nomenclature

- Identify the parent compound and replace the *-ane* ending with *-ene* for alkenes and *-yne* for alkynes.
- Number the parent chain to give the lowest number to the double or triple bond.

- A **phenyl group** is a benzene ring, with one hydrogen atom removed. The term may be used in the nomenclature of molecules that include the benzene as a substituent group.
- Benzene** participates in substitution reactions in which a hydrogen atom is replaced by another atom or group.
- Polynuclear aromatic hydrocarbons** consist of two or more benzene rings joined.

10.2 Heterocyclic Aromatic Compounds

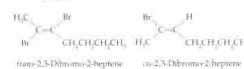
- Heterocyclic aromatic compounds** have at least one atom other than carbon in the structure of the aromatic ring.
- Many of these compounds are important components of biological molecules, including DNA, RNA, and hemoglobin.

ANSWERS TO PRACTICE PROBLEMS

- 6-Chloro-4-methyl-2-heptene
 - 1,4-Pentadiene
 - 3-Bromo-3-heptene
 - 1,5-Heptadiene
- 1,4-Dichlorocyclopentene
 - 4,5-Dimethylcyclohexene
 - 3,4-Dibromocyclopentene
 - 3-Ethylcyclobutene
- cis*-isomer
 - trans*-isomer
 - cis*-isomer
- cis*-4,5-Dibromo-2-heptene
 - trans*-3,4-Dibromo-3-heptene
 - cis*-2,3-Dibromo-2-heptene
- 2-Pentene can exist as both *cis*- and *trans*-isomers.



- 1,2-Dibromo-1-pentene cannot exist as *cis*- and *trans*-isomers because one of the carbons involved in the double bond is also bonded to two identical atoms (Br).
- Propene cannot exist as *cis*- and *trans*-isomers because one of the carbons involved in the double bond is also bonded to two identical atoms (H).
- 2,3-Dibromo-2-heptene can exist as both *cis*- and *trans*-isomers.



questions allow students to test their mastery of information and to build self-confidence. The answers to the practice problems can be found at the end of each chapter so students can check their understanding.

- **In-Chapter and End-of-Chapter Questions and Problems:** We have created a wide variety of paired concept problems. The answers to the odd-numbered questions are found in 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.

Maple	0.70
Teak	0.98
Oak	0.85

What is the identity of the piece of wood?

- The specific gravity of a patient's urine sample was measured to be 1.008. Given that the density of water is 1.000 g/mL at 4°C, what is the density of the urine sample?
- The density of grain alcohol is 0.789 g/mL. Given that the density of water at 4°C is 1.00 g/mL, what is the specific gravity of grain alcohol?
- The density of mercury is 13.6 g/mL. If a sample of mercury weighs 272 g, what is the volume of the sample in mL?
- You are given three bars of metal. Each is labeled with its identity (lead, uranium, platinum). The lead bar has a mass of 5.0×10^1 g and a volume of 6.36 cm³. The uranium bar

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QUESTIONS AND PROBLEMS

Natural Radioactivity

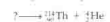
Foundations

- Describe the meaning of the term *natural radioactivity*.
- What is background radiation?
- What is the composition of an alpha particle?
- What is alpha decay?
- What is the composition of a beta particle?
- What is the composition of a positron?
- What are the major differences between alpha and beta particles?
- What are the major differences between alpha particles and gamma radiation?
- How do nuclear reactions and chemical reactions differ?
- We can control the rate of chemical reactions. Can we control the rate of natural radiation?

CRITICAL THINKING PROBLEMS

- An instrument used to detect metals in drinking water can detect as little as 1 µg of mercury in 1 L of water. Mercury is a toxic metal; it accumulates in the body and is responsible for the deterioration of brain cells. Calculate the number of mercury atoms you would consume if you drank 1 L of water that contained only 1 µg of mercury. (The mass of one mercury atom is 3.3×10^{-25} g.)
- Yesterday's temperature was 40°F. Today it is 80°F. Bill tells Sue that it is twice as hot today. Sue disagrees. Do you think Sue is correct or incorrect? Why or why not?
- Aspirin has been recommended to minimize the chance of

9.46 Complete the following nuclear equation:



Applications

- Element 107 was synthesized by bombarding bismuth-209 with chromium-54. Write the equation for this process if one product is a neutron.
- Element 109 was synthesized by bombarding bismuth-209 with iron-58. Write the equation for this process if one product is a neutron.
- Write a balanced nuclear equation for beta emission by magnesium-27.
- Write a balanced nuclear equation for alpha decay of bismuth-212.
- Write a balanced nuclear equation for positron emission by nitrogen-12.
- Write a balanced nuclear equation for positron emission by manganese-52.
- Americium-241, found in many home smoke detectors, decays by alpha emission. The alpha particle ionizes surrounding air molecules, and ions produced conduct an electric current. Smoke

Over the course of the last seven editions, hundreds of reviewers have shared their knowledge and wisdom with us, as well as the reactions 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.

The Art Program

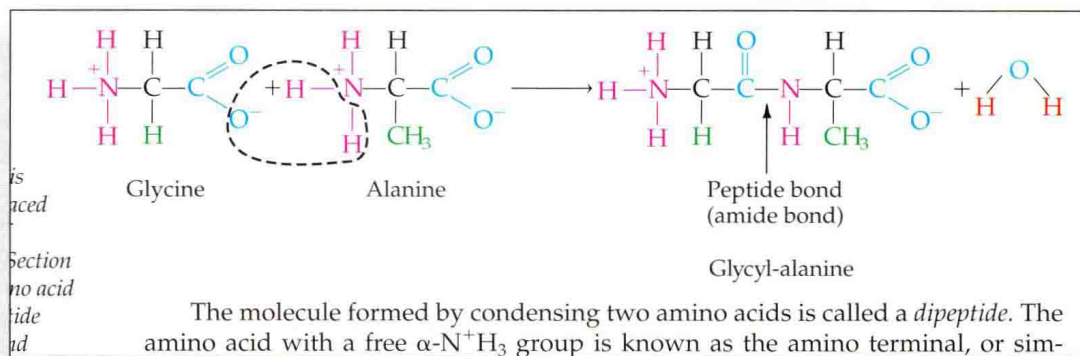
Today's students are much more visually oriented than previous generations. We have built upon this observation through the use of color, figures, and three-dimensional computer-generated models. This art program enhances the readability of the text and provides alternative pathways to learning.

- **Dynamic Illustrations:** Each chapter is amply illustrated using figures, tables, and chemical formulas. All of these illustrations are carefully annotated for clarity. To help students better understand difficult concepts, there are approximately 350 illustrations and 250 photos in the eighth edition.

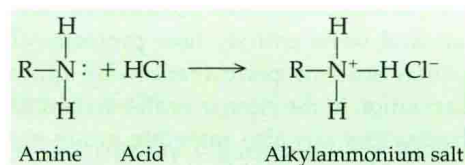
- **Color-Coding Scheme:** We have color-coded equations so that chemical groups being added or removed in a reaction can be quickly recognized.

1. **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.
2. **Blue print** is used when additional features must be highlighted.
3. **Green background** screens denote generalized chemical and mathematical equations. In the organic chemistry chapters, the Summary of Reactions at the end of the chapter is also highlighted for ease of recognition.
4. Yellow backgrounds illustrate energy, stored either in electrons or groups of atoms, in the general and biochemistry sections of the text. In the organic chemistry section of the text, yellow background screens also reveal the parent chain of an organic compound.
5. There are 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 three colors to draw attention to key features of these molecules. For consistency, blue is used to denote the acid portion of an amino acid and red 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.

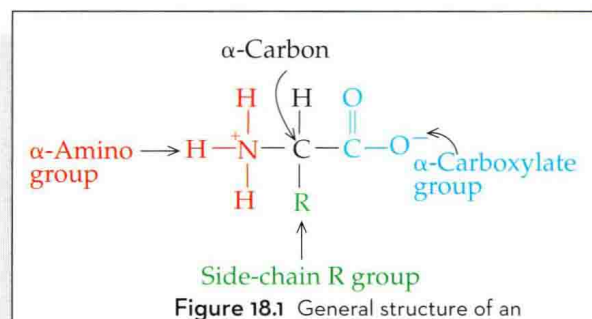
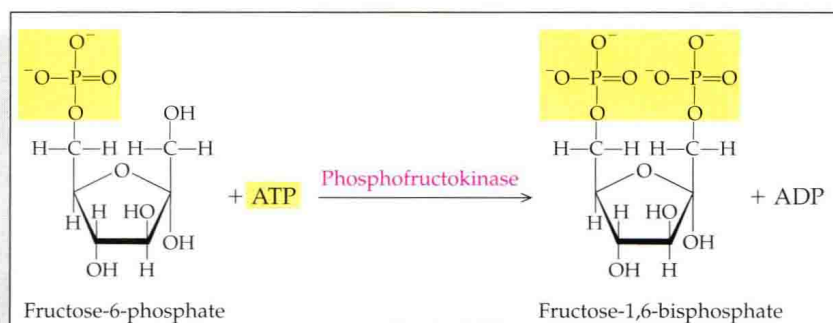
- **Computer-Generated Models:** The ability of students to understand the geometry and three-dimensional structure of molecules is essential to the understanding of organic and biochemical reactions. Computer-generated models are used throughout the text because they are both accurate and easily visualized.



Because amines are bases, they react with acids to form alkylammonium salts.



The reaction of methylamine with hydrochloric acid shown is typical of these reactions.



Learning Resources

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

For the Instructor and Student:

- **McGraw-Hill Connect Chemistry**



McGraw-Hill Connect® Chemistry is a web-based assignment and assessment platform that gives students the means to better connect with their coursework, with their instructors, and with the important concepts that they need to know for success now and in the future.

With Connect Chemistry, instructors can deliver assignments, quizzes, and tests online. Nearly all the questions from the text are presented in an auto-gradable format and tied to the text's learning objectives. Instructors can edit existing questions and write entirely new problems. They can track individual student performance—by question, assignment, or in relation to the class overall—with detailed grade reports. Instructors can also integrate grade reports easily with Learning Management Systems (LMS) such as WebCT and Blackboard, and much more.

By choosing Connect Chemistry, instructors provide their students with a powerful tool for improving academic performance and truly mastering course material. Connect Chemistry allows students to practice important skills at their own pace and on their own schedule. Importantly, students' assessment results and instructors' feedback are

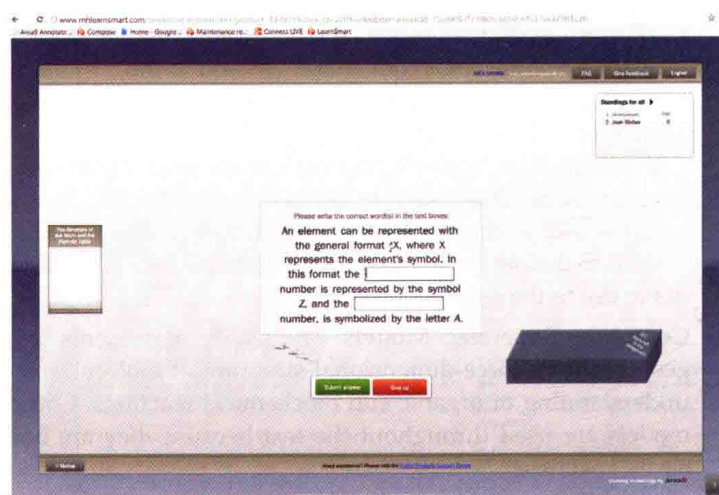
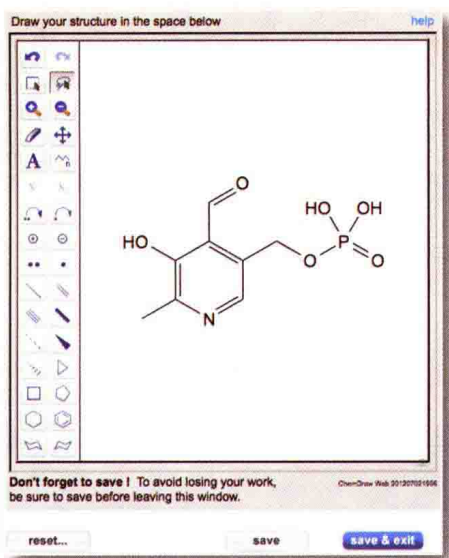
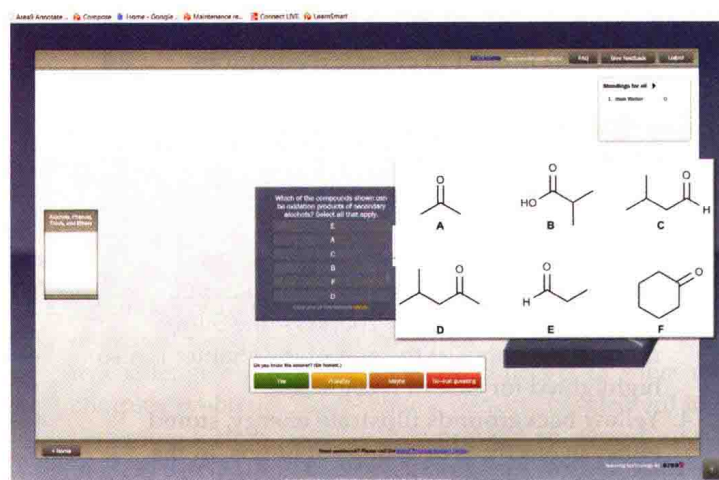
all saved online—so students can continually review their progress and plot their course to success.

- **McGraw-Hill ConnectPlus® Chemistry**


Like Connect Chemistry, ConnectPlus Chemistry provides students with online assignments and assessments, plus 24/7 online access to an eBook—an online edition of the text—to aid them in successfully completing their work, wherever and whenever they choose.

- **McGraw-Hill LearnSmart™**

McGraw-Hill LearnSmart is available as a stand-alone product as well as an integrated feature of McGraw-Hill Connect Chemistry. It is an adaptive learning system designed to help students learn faster, study more efficiently, and retain more knowledge for greater success. LearnSmart assesses a student's knowledge of course content through a series of probes, pinpointing concepts the student does not understand. This innovative study tool also has features that allow instructors to see exactly what students have accomplished and a built-in assessment tool for graded assignments. Visit the following site for a demonstration. www.mhlearnsmart.com



For the Instructor

- **Instructor's Manual:** Written by the authors and developed for the eighth edition by Cheryl Vaughn and Danae Quirk Dorr, this ancillary contains suggestions for organizing lectures, instructional objectives, perspectives on readings from the text, answers to the even-numbered problems from the text, a list of each chapter's key problems and concepts, and more. The Instructor's Manual is available through the Connect website for this text.
- **Test Bank:** The electronic test bank offers questions that can be used for homework assignments or the preparation of exams. The test bank can be utilized to quickly create customized exams. It allows instructors to sort questions by format or level of difficulty, edit existing questions or add new ones, and scramble questions and answer keys for multiple versions of the same test.
- **Laboratory Manual for General, Organic, and Biochemistry:** The seventh edition, by Charles H. Henrickson, Larry C. Byrd, and Norman W. Hunter of Western Kentucky University, offers clear and concise laboratory experiments to reinforce students' understanding of concepts. Pre-laboratory exercises, questions, and report sheets are coordinated with each experiment to ensure active student involvement and comprehension. An updated student tutorial on graphing with Excel has been added to this edition.
- **Laboratory Instructor's Manual:** Written by Charles H. Henrickson, Larry C. Byrd, and Norman W. Hunter of Western Kentucky University, this helpful guide contains hints that the authors have learned over the years to ensure students' success in the laboratory. This Resource Guide is available through the Connect Chemistry website for this text.
- **McGraw-Hill Presentation Center:** Build instructional material wherever, whenever, and however you want! McGraw-Hill Presentation Center is an online digital library containing assets such as photos, artwork, and other media that can be used to create customized lectures, visually enhanced tests and quizzes, compelling course websites, or attractive printed support materials. The McGraw-Hill Presentation Center Library includes thousands of assets from many McGraw-Hill titles. This ever-growing resource gives instructors the power to use assets specific to an adopted textbook as well as content from all other books in the library. The Presentation Center can be accessed from the instructor side of your textbook's Connect website, and the Presentation Center's dynamic search engine allows you to explore by discipline, course, textbook chapter, asset type, or key word. Simply browse, select, and download the files you need to build engaging course materials. All assets are copyrighted by McGraw-Hill Higher Education but can be used by instructors for classroom purposes.
- **More than 300 animations available through the Connect website:** Many animations are linked to appropriate sections of the textbook using the . They supplement the textbook material in much the same way as instructor demonstrations. However, for students, they are only a few mouse-clicks away, any time, day or night. Because many students are visual learners and quite computer-literate, the

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For the Student

- **Student Study Guide/Solutions Manual:** A separate Student Study Guide/Solutions Manual, prepared by Cheryl Vaughn and Danae Quirk Dorr, 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 more than 1400 solved problems with complete solutions. It also teaches effective problem-solving techniques.

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