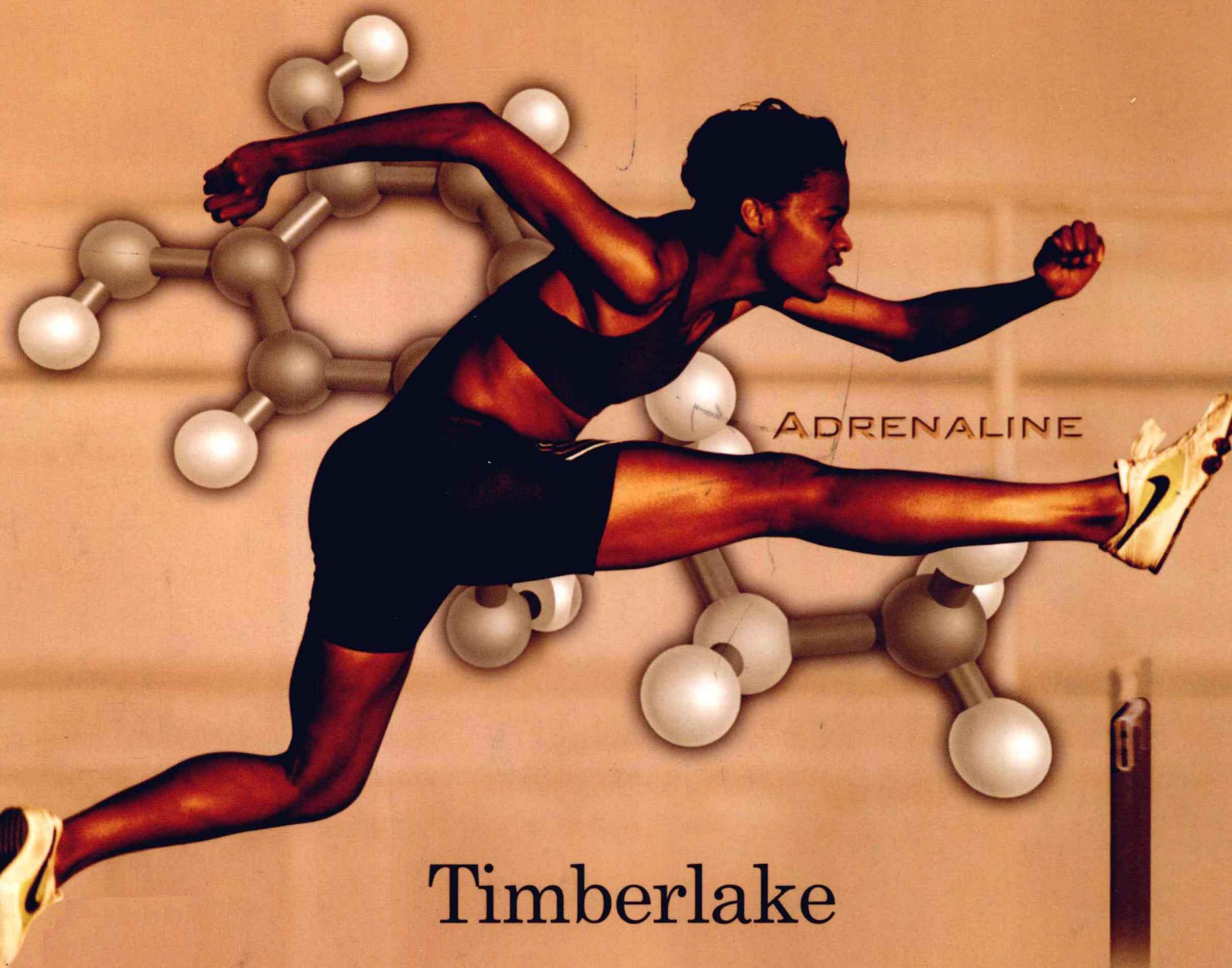
Eighth Edition

Chemistry

An Introduction to General, Organic, & Biological Chemistry



Timberlake

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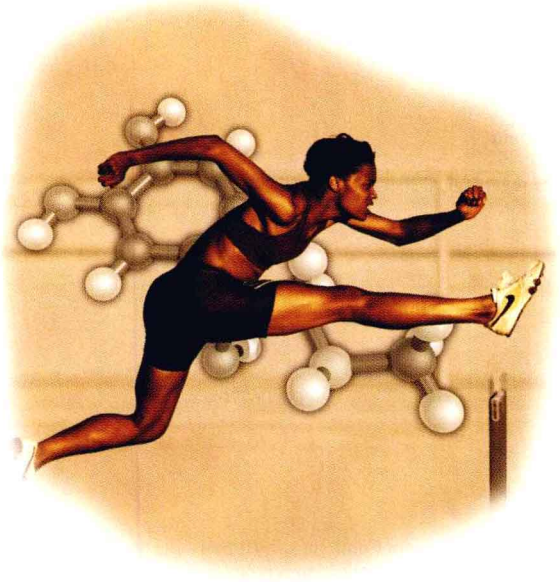
KAREN C. TIMBERLAKE



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Chemistry

An Introduction to General, Organic, and Biological Chemistry

Eighth Edition

Preface

Welcome to the eighth edition of *Chemistry: An Introduction to General, Organic, and Biological Chemistry.* This is a chemistry text specifically designed to help students prepare for careers in health-related professions, such as nursing and respiratory therapy, and a text that assumes no prior knowledge of chemistry by the student. This new edition has been completely revised with new figures and photos, updated health notes, new questions and problems, and a new pedagogical framework that provides a more effective learning environment. Two of the most exciting new features are the chapter openers that contain an interview with a health professional and the career focus snapshots within each chapter. Specific details about each of the health careers are given on the ChemistryPlace website.

Another new feature in each chapter opener is a concept map that guides the student through the concepts in the chapter. Throughout each chapter, sections of the concept map appear in the margin to reinforce the chemical connections. This eighth edition now contains a completely new art program that includes macroscopic-to-microscopic illustrations of chemical concepts. I have retained those successful learning aids from previous editions designed to support learning: clear readability, a logical presentation, plentiful sample problems with step-by-step solutions, specific learning goals, practical applications, and large numbers of questions and problems with answers. In each textbook I write, I consider it essential to relate every chemical concept to real-life issues of health and environment.

Also new to this edition is the combination of similar sections to provide stronger conceptual development and improve the flow of text. All the organic chapters now appear in sequence to serve as a bridge between the topics of general chemistry and biological chemistry. The emphasis is now on major organic families, with less time spent on nomenclature. I have also limited the number of chemical reactions to those that are related to biochemistry. This will allow the discussion of organic chemistry to be completed in two to three weeks and give time to cover the five chapters of biological chemistry. To provide a more manageable length for the one-semester course, I streamlined many sections and retained only those boxed features that I considered most important for health careers.

It remains my most important goal to provide a text that makes teaching and learning chemistry an engaging and positive experience. It is also my goal to help every student become a critical thinker by instilling in them the scientific concepts that will form a basis for making important decisions about issues concerning health and the environment.

Organization of the Eighth Edition

This text contains fundamental topics of general, organic, and biological chemistry. The first part, Chapters 1 through 9, discusses measurement and the need to understand the application of the metric system in the world of health care. In Chapters 2 and 3, we look at the structure of atoms, electron arrangement in atoms, and the behavior of the nucleus in radioactive atoms. Of interest to students is the application of the concepts of atomic structure to the field of nuclear medicine. I place nuclear radiation early in my texts because the discussion of radioactive atoms extends the concepts of subatomic particles, atomic number, and mass. Chapter 4 describes how the structures of atoms lead to ionic and covalent bonds as well as the shape and polarity of molecules. This introduction to the three-dimensional shape of molecules provides a basis for the shape of organic and biochemical compounds.

In the next chapters, we look at the interaction of reactants in chemical reactions. Chapter 5 describes the reactants and products in combination, decomposition, and replacement reactions as well as oxidation and reduction. Students learn patterns of chemical behavior as they organize and recognize the types of chemical reactions. With a basic understanding of equations, we can then look at some quantitative aspects of reactions including the mole and mass calculations. In Chapter 6, we discuss energy, its measurement, and its relationship to nutritional energy values. We look at the three states of matter and the energy involved in changes of state. We also discuss energy in chemical reactions, rates of reactions, and introduce the concept of reversible reactions and chemical equilibrium.

Chapter 7 describes gases in more detail and how we apply the gas laws. Chapter 8 introduces the student to important topics in health care: solutions, electrolytes,

solubility, concentrations, and osmosis and dialysis. Chapter 9 completes the general chemistry portion of the text with a discussion of acids and bases, conjugate acid–base pairs, pH, buffers, and the role of buffers in health.

The second part of the text introduces organic compounds, along with their physical and chemical properties, and gives an overview of the functional groups that form families of organic chemistry and biomolecules of living systems. In Chapter 10 through 13, we look at saturated and unsaturated hydrocarbons, alcohols, thiols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, and amides. In each chapter, physical and chemical properties are related to the functional groups in each family of organic compounds. In Chapter 12, I introduce the concept of chiral compounds and enantiomers, which I revisit in carbohydrates and amino acids to show the concept's importance in the nature of biomolecules and chiral drugs and their behavior in living systems.

The study of biomolecules begins with carbohydrates in Chapter 14, which contain some of the functional groups discussed in the previous chapters. To the student, the application of organic chemistry to biochemistry is often the most exciting part of their study of chemistry because of its relationship to health and medicine. Chapter 15, on lipids, discusses biomolecules such as triacylglycerols, glycerophospholipids, and steroids. We discuss the role of these lipids in cell membranes as well as the lipids that function as steroid hormones.

Chapters 16 and 17 continue with our study of the biomolecules of amino acids, proteins, enzymes, and nucleic acids. The importance of the structure of proteins from primary to quaternary is related to their shapes and activity. We see that proteins change shape and lose function when subjected to pH changes and high temperatures. In Chapter 18 we discuss the metabolic pathways of biomolecules from the digestion of foodstuffs to the synthesis of ATP. Chapter 18 guides the students through the stages of metabolism and the digestion of carbohydrates, our most important fuel. We then see how the metabolic pathway of glycolysis degrades the glucose molecule to pyruvate. Under aerobic conditions, we learn that pyruvate is converted to acetyl CoA. We look at the central role of the citric acid cycle in utilizing acetyl CoA to produce reduced coenzymes under aerobic conditions for the electron transport system and oxidative phosphorylation. Finally, the metabolic pathways that utilize lipids and proteins for energy are introduced, and we summarize the relationships between the catabolic and anabolic pathways in metabolism.

Changes in the Eighth Edition Compared to the Seventh Edition Media Update

Chapter 1 Measurements

This chapter has been shortened to be more manageable. Scientific notation has been reduced in emphasis and included in the section *Units of Measurements.* The sections *Measured Numbers* and *Significant Figures* and the sections *Conversion Factors* and *Problem Solving* have been combined. One table now lists all of the common equalities. Some *Sample Problem* and *Explore Your World* activities as well as the section *Percents as Conversion Factors* have been deleted. The comparison of temperature scales now completes the chapter.

Chapter 2 Atoms and Elements

This chapter has been streamlined for the one-semester course. The section *The Periodic Table* now includes a discussion of metalloids. The periodic table now lists elements up to 116 and uses the A and B notations. Atomic mass is described for a mixture of isotopes, but the calculation of average atomic mass has been deleted. The section *Electron Energy Levels* now includes a discussion of *s* and *p* orbitals. The discussions *Electromagnetic Spectrum,* and *Energy-Level Changes,* some *Sample Problems,* and some *Explore Your World* activities have been deleted.

Chapter 3 Nuclear Radiation

This chapter continues the study of the behavior of atoms, radioactive ones in this case, and their subatomic particles. The introduction to *Radioactivity* was rewritten. References to X rays, which are not nuclear, were removed. The section *Nuclear Equations* is combined with *Producing Radioactive Isotopes.* The *Medical Applications Using Radioactivity* now follows *Half-Life of a Radioisotope.* The table of half-lives has been shortened. The section *Fission and Fusion* was shortened.

Chapter 4 Compounds and Their Bonds

The discussion of bonding and naming of ionic compounds, including polyatomic ions, now precedes the discussion on covalent compounds. One table now lists ions and their names. There is less emphasis on the formation of multiple bonds and writing their electron-dot structures. *Naming of Covalent Compounds* is now combined with *Covalent Compounds. Bond Polarity*, which follows *Covalent Compounds,* is discussed conceptually without using actual electronegativity values. A new section was added, *Shapes and Polarity of Molecules,* which introduces the shapes and polarities of

common molecules with tetrahedral electron arrangement. New art gives a macroscopic-to-microscopic view of matter.

Chapter 5 Chemical Reactions and Quantities

This chapter begins with *Chemical Change* followed by *Chemical Equations,* which now includes methods for balancing equations. The chapter has been streamlined with the deletion of several *Sample Problems* and *Explore Your World* activities. The section *Types of Reactions* has been reduced in scope and questions requiring the prediction of products were deleted. New art was added to the material on oxidation–reduction and biological oxidation–reduction for better visual representation. The *Molar Mass* discussion was combined with *Calculations Using Molar Mass.*

Chapter 6 Energy and Matter

The section on temperature was moved to Chapter 1. The chapter now looks at the topics of energy and heat, nutritional energy values, states of matter, energy in reactions, and chemical equilibrium. The *Energy* section was combined with *Measuring Heat.* The discussion of specific forms of energy and several of the calculations using specific heat were deleted. The section *Changes of State* consolidates material from the old sections *Melting and Freezing, Boiling and Condensation,* and *Heating Curves.* Multiple energy calculations were deleted and calculations in changes of states are limited to single-step changes. The section *Chemical Equilibrium* has been rewritten and includes new art.

Chapter 7 Gases

This chapter retains most of the sequence from the seventh edition, but the discussion of variables and units for measuring pressure have been simplified. The discussions *Vapor Pressure* and *Boiling Point* have been deleted. The discussion of *Blood Gases* is now a *Health Note.*

Chapter 8 Solutions

This chapter now begins with *Types of Solutions* followed by a discussion of water as a solvent. The topic of surface tension was deleted. The sections on solvents and solutes are combined with *Formation of Solutions. Solubility* and *Saturation* are now combined with *Solution Formation* and precede the discussion of electrolytes. The topic of equivalents was simplified to a brief discussion, but contains no calculations of equivalent mass. The sections *Soluble and Insoluble Salts* and *Formation of a Solid* were deleted. The section *Molarity* now includes *Dilutions,* which has been transferred from Chapter 9, *Acids and Bases.* The terms for colloids such as aerosol, gel, and foam, as well as the Tyndall effect and osmolarity, were deleted.

Chapter 9 Acids and Bases

The discussion of Brønsted–Lowry acids and bases now looks at conjugate acid–base pairs. The section *Strengths of Acids and Bases* now follows Brønsted–Lowry theory. New art shows the differences between strong and weak acids visually. *Ionization of Water* and *The pH Scale* now follow *Strengths of Acids and Bases.* The section *Reactions of Acids and Bases* now includes reactions of acids with metals, carbonates, and hydroxides. The section on acid–base titration was deleted.

Chapter 10 Introduction to Organic Chemistry

This chapter now introduces organic compounds beginning with the alkane family. The section *Naming Alkanes* was combined with *Branched Alkanes. Properties of Alkanes* has been moved to the end of the chapter and now includes boiling point. The chapter now includes the section *Haloalkanes.* An expanded section on functional groups has been added. The environmental notes on petroleum products and chlorinated cyclic compounds as pesticides were deleted. The section *Cycloalkanes* was simplified and the section *Aromatic Hydrocarbons* was moved to Chapter 11.

Chapter 11 Unsaturated Hydrocarbons

The section *Functional Groups* has been moved to Chapter 10. This chapter now discusses unsaturated hydrocarbons including aromatic compounds, cis–trans isomers, addition reactions, polymers, and aromatic compounds. The use of common aromatic naming with prefixes *o, m,* and *p* was deleted. The reactions in *Addition Reactions* were limited to hydrogenation and hydration, which are important in biological systems. Halogenation and hydrohalogenation as well as Markovinov's rule were deleted.

Chapter 12 Organic Compounds with Oxygen and Sulfur

The section *Alcohols, Phenols, and Thiols* emphasizes the naming of alcohols, but not phenols or thiols. Alcohols are now classified early in the chapter and followed by *Reactions of Alcohols,* which now includes dehydration and oxidation, but omits the formation of ethers. The section *Ethers* uses only common names for ethers. The *Oxidation of Alcohol in the Body* is now a *Health Note.* The use of common names for aldehydes was deleted. The section *Aldehydes and Ketones* is now followed by a discussion of chiral molecules, which introduces chirality much earlier in the text.

The chapter is completed with a new section that compares the melting and boiling points and solubility of alcohols, aldehydes, ketones, and ethers. The formation of hemiacetals was deleted.

Chapter 13 Carboxylic Acids, Esters, Amines, and Amides

This chapter, which was Chapter 14 in the seventh edition Media Update, now completes the organic sequence. Throughout the chapter there is less emphasis on naming, and only reactions applicable to biochemical systems are described. New art gives the correct dimensions to the structures of carboxylic acids, esters, amines, and amides. The boiling points, solubility in water, acidic and/or basic properties are now discussed for carboxylic acids and amines. Esters and their reactions are now one section. The nomenclature section for amines and amides has been simplified. The properties of amine salts is now discussed. The discussion of alkaloids is now a *Health Note.* The sections *Amides* and *Reactions of Amides* are now combined.

Chapter 14 Carbohydrates

This chapter is now the first chapter in the biochemistry portion of the text. It has much of the same material as the seventh edition Media Update discussion of carbohydrates. The sections *Monosaccharides* and *Structures of Some Important Monosaccharides* are now combined. The section *Chiral Carbon Atoms* was moved to Chapter 12. New art was added to show the formation of maltose, lactose, and sucrose.

Chapter 15 Lipids

Some sections in Chapter 15 were rewritten to emphasize the important topics of lipids, fatty acids, and triacylglycerols with less time spent on the remaining topics. The term triglycerides is now replaced by triacylglycerols. A new table of fatty acids includes a structural representation of fatty acids. New art showing the three-dimensional structures of fatty acids was added. The *Health Note* on prostaglandins was made into a subsection of *Lipids* and now includes the effect of analgesics on the production of prostaglandins. The structure of olestra was added to the *Health Note* on olestra. A diagram of the formation of trans fatty acids was added to the *Health Note* on *Trans Fatty Acids and Hydrogenation.* Sphingolipids and glycosphingolipids were deleted from the section on glycerophospholipids. The section *Steroids* retains a discussion of cholesterol and steroid hormones, but not bile salts. New art gives a much improved diagram of lipoproteins. The material on fat-soluble vitamins has been deleted. The discussion on cell membranes was expanded with a new *Health Note* on *Transport Through Cell Membrane.*

Chapter 16 Amino Acids, Proteins, and Enzymes

All the amino acids are now discussed as chiral molecules and written in their ionized forms. The content on enzyme classification was simplified. The section *Protein Structural Levels* now includes primary, secondary, tertiary, and quaternary levels. Material on enzyme regulation has been deleted.

Chapter 17 Nucleic Acids and Protein Synthesis

The discussion on nucleic acids is similar to the seventh edition. I have added a discussion of the large and small parts of ribosomes. The material on the genetic code was combined with protein synthesis. The discussion on recombinant DNA has been deleted.

Chapter 18 Metabolic Pathways and Energy Production

This is now the final chapter in the text. Metabolism and ATP production are discussed along with the coenzymes required in metabolic pathways. The breakdown of glucose to pyruvate is shown using the glycolytic pathway, which is followed by the decarboxylation of pyruvate to acetyl CoA. The material on fermentation has been deleted. In the preparation of compounds for energy production, we discuss the entry of acetyl CoA into the citric acid cycle and the production of reduced coenzymes for electron transport. We look at electron transport, oxidative phosphorylation, and the synthesis of ATP. The breakdown of lipids and amino acids are also discussed. Material about hibernation and the function of brown fat in babies has been added. Several drawings were reworked for clarity and understanding.

Acknowledgments

Welcome to the eighth edition of *Chemistry: An Introduction to General, Organic, and Biological Chemistry*. I am thankful for the support, encouragement, and dedication of many people who put in hours of tireless effort to produce a high-quality book that provides an outstanding learning package. Once again, the editorial team at Benjamin Cummings has done an exceptional job. I appreciate the work of my Publisher, Jim Smith, who supported my vision of a new edition with a new art program and learning package. My Project Editor, Claudia Herman, is like an angel who continually encouraged me on the development of the eighth edition while she skillfully coordinated reviews, art, website materials, and all the things it takes to make a book come together at the right time. Jean Lake, Production Editor, brilliantly coordinated all phases of the manuscript to the final pages of a beautiful book. Cathy Cobb, Copyeditor, precisely edited the manuscript to make sure the words were correct to help students learn chemistry.

I am especially proud of the new art program in this text, which lends beauty and understanding to chemistry. The photographs are the creative work of Mark Ong, Art Director, and photographers John Bagley and Richard Tauber, who took wonderfully vivid photographs that tell the story of the beauty of chemistry. Photos of chemical compounds make students feel as though they are seeing a chemical in the laboratory. The macro-to-micro features that relate real-life photos to their atomic and molecular structures are a fantastic learning tool for students. There are new three-dimensional ball-and-stick models by J.B. Woolsey and Associates that provide students with visual impressions and dimensions of organic and biochemical compounds. The entire art program is new and geared to the students' interest in allied health careers. Photos and interviews with health care professionals open each chapter and appear within chapters. I applaud Mark's creative eye as he art-directed and interviewed many professionals in the health care field. It was a big effort and is the keynote for every chapter. Thanks to the Production Coordinator, Tony Asaro, who gathered all the materials for many of the photos in the text, conducted many of the interviews, and agreed to be the "patient" in some of the photos.

It has been especially helpful to have accuracy reviewers for this new text. Without them, much would have gone unnoticed and uncorrected. Thanks to Professor Juliette Bryson, who read many galley and page proofs, for her valuable comments and corrections. Thanks to Martha Ghent for the hours of proofreading and to Professors G. Lynn Carlson and Bill Timberlake for their outstanding preparation of the Test Bank. Thanks to an enthusiastic and tireless Marketing Team: Christy Lawrence, Marketing Manager; Stacy Treco, Director of Marketing; and Chalon Bridges, Market Development Manager, whose interviews with professors provided valuable information for the direction of this eighth edition.

This eighth edition also reflects the contributions of many professors who took the time to review and edit the manuscript, as well as to provide outstanding comments, help, and suggestions. I am extremely grateful to an incredible group of peers for their careful assessment of all the new ideas for the text; for suggested additions, corrections, changes, and deletions; and for providing an incredible amount of feedback about the best direction for the text. In addition, I appreciate the time that health care professionals took to let us take photos and discuss their work with them. I admire and appreciate every one of you.

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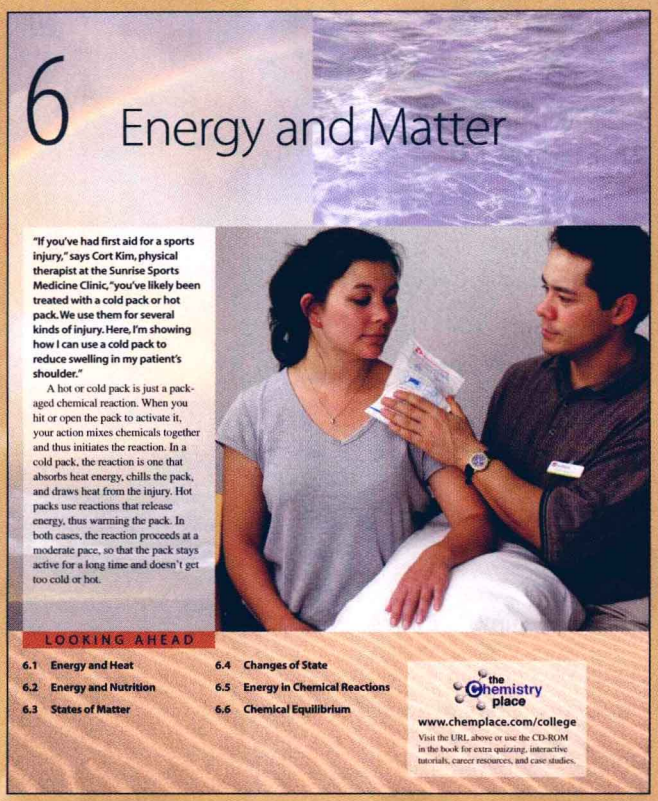
Career Focus and Real World Applications

THIS TEXT WAS DESIGNED TO HELP STUDENTS ATTAIN THEIR CAREER GOALS.



6 Energy and Matter

"If you've had first aid for a sports injury," says Cort Kim, physical therapist at the Sunrise Sports Medicine Clinic, "you've likely been treated with a cold pack or hot pack. We use them for several kinds of injury. Here, I'm showing how I can use a cold pack to reduce swelling in my patient's shoulder."

A hot or cold pack is just a packaged chemical reaction. When you hit or open the pack to activate it, your action mixes chemicals together and thus initiates the reaction. In a cold pack, the reaction is one that absorbs heat energy, chills the pack, and draws heat from the injury. Hot packs use reactions that release energy, thus warming the pack. In both cases, the reaction proceeds at a moderate pace, so that the pack stays active for a long time and doesn't get too cold or hot.

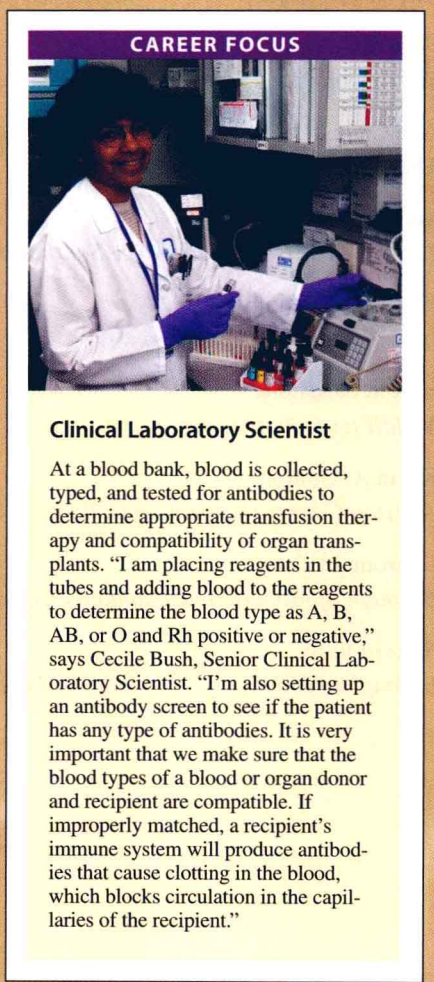
LOOKING AHEAD

6.1 Energy and Heat
6.2 Energy and Nutrition
6.3 States of Matter
6.4 Changes of State
6.5 Energy in Chemical Reactions
6.6 Chemical Equilibrium

the Chemistry place
www.chemplace.com/college
Visit the URL above or use the CD-ROM in the book for extra quizzing, interactive tutorials, career resources, and case studies.

Chapter Opener

Each chapter begins with an interview with a professional in allied health or other relevant fields. These interviews illustrate how health professionals interact with chemistry in their careers.



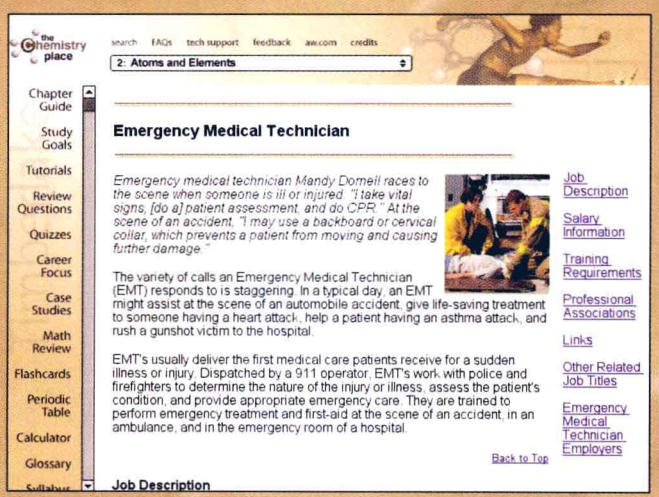
CAREER FOCUS

Clinical Laboratory Scientist

At a blood bank, blood is collected, typed, and tested for antibodies to determine appropriate transfusion therapy and compatibility of organ transplants. "I am placing reagents in the tubes and adding blood to the reagents to determine the blood type as A, B, AB, or O and Rh positive or negative," says Cecile Bush, Senior Clinical Laboratory Scientist. "I'm also setting up an antibody screen to see if the patient has any type of antibodies. It is very important that we make sure that the blood types of a blood or organ donor and recipient are compatible. If improperly matched, a recipient's immune system will produce antibodies that cause clotting in the blood, which blocks circulation in the capillaries of the recipient."

Career Focus

Within the chapters are additional examples of professionals using chemistry.



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2: Atoms and Elements

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Flashcards
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Glossary

Emergency Medical Technician

Emergency medical technician Mandy Domell races to the scene when someone is ill or injured. "I take vital signs, [do a] patient assessment, and do CPR." At the scene of an accident, "I may use a backboard or cervical collar, which prevents a patient from moving and causing further damage."

The variety of calls an Emergency Medical Technician (EMT) responds to is staggering. In a typical day, an EMT might assist at the scene of an automobile accident, give life-saving treatment to someone having a heart attack, help a patient having an asthma attack, and rush a gunshot victim to the hospital.

EMT's usually deliver the first medical care patients receive for a sudden illness or injury. Dispatched by a 911 operator, EMT's work with police and firefighters to determine the nature of the injury or illness, assess the patient's condition, and provide appropriate emergency care. They are trained to perform emergency treatment and first-aid at the scene of an accident, in an ambulance, and in the emergency room of a hospital.

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Job Description

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On the Web

The ChemistryPlace Web site features in-depth resources for each of the health professions featured in the book and takes students through interactive case studies.

STUDENTS WILL LEARN CHEMISTRY USING REAL WORLD EXAMPLES.

Health Note

A rich array of **Health Notes** in each chapter apply chemical concepts to relevant topics of health and medicine. These topics include weight loss and weight gain, artificial fats, anabolic steroids, alcohol, genetic diseases, viruses, and cancer.

HEALTH NOTE

Hot Packs and Cold Packs

In a hospital, at a first-aid station, or at an athletic event, a *cold pack* may be used to reduce swelling from an injury, remove heat from inflammation, or decrease capillary size to lessen the effect of hemorrhaging. Inside the plastic container of a cold pack, there is a compartment containing solid ammonium nitrate (NH_4NO_3) that is separated from a compartment containing water. The pack is activated when it is hit or squeezed hard enough to break the walls between the compartments and cause the ammonium nitrate to mix with the water (shown as H_2O over the reaction arrow). In an endothermic process, one mole of NH_4NO_3 that dissolves absorbs 6.3 kcal of heat from the water. The temperature drops and the pack becomes cold and ready to use:

Endothermic Reaction in a Cold Pack

$$6.3\ \text{kcal} + NH_4NO_3(s) \xrightarrow{H_2O} NH_4NO_3(aq)$$

Hot packs are used to relax muscles, lessen aches and cramps, and increase circulation by expanding capillary size. Constructed in the same way as cold packs, a hot pack may contain the salt $CaCl_2$. The dissolving of the salt in water is exothermic and releases 18 kcal per mole of salt. The temperature rises and the pack becomes hot and ready to use:

Exothermic Reaction in a Hot Pack

$$CaCl_2(s) \xrightarrow{H_2O} CaCl_2(aq) + 18\ \text{kcal}$$

Environmental Note

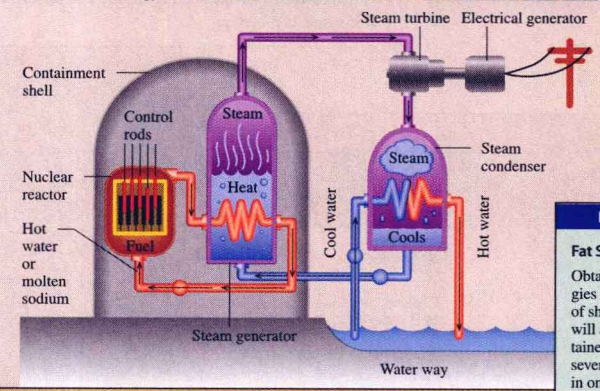
Environmental Notes delve into high interest issues such as global warming, radon, acid rain, pheromones, food irradiation, and recycling of plastics.

ENVIRONMENTAL NOTE

Nuclear Power Plants

In a nuclear power plant, the quantity of uranium-235 is held below a critical mass, so it cannot sustain a chain reaction. The fission reactions are slowed by placing control rods, which absorb some of the fast-moving neutrons, among the uranium samples. In this way, less fission occurs, and there is a slower, controlled production of energy. The heat from the controlled fission is used to produce steam. The steam drives a generator, which produces electricity. Approximately 10% of the electrical energy produced in the United States is generated in nuclear power plants.

Although nuclear power plants help meet some of our energy needs, there are some problems. One of the most serious problems is the production of radioactive by-products that have very long half-lives. It is essential that these waste products be stored safely for a very long time in a place where they do not contaminate the environment. Early in 1990, the Environmental Protection Agency gave its approval for the storage of radioactive hazardous wastes in chambers 2150 ft underground. In 1998 the Waste Isolation Pilot Plant (WIPP) repository site in New Mexico was ready to receive plutonium waste from former U.S. bomb factories. Although authorities claim the caverns are safe, some people are concerned with the safe transport of the radioactive waste by trucks on the highways.



Explore Your World

Explore Your World includes hands-on activities that use everyday materials to encourage students to actively explore selected chemistry topics, either individually or in group-learning environments. Each activity is followed by questions to encourage critical thinking.

EXPLORE YOUR WORLD

Fat Storage and Blubber

Obtain two medium-sized plastic baggies and a can of Crisco or other type of shortening used for cooking. You will also need a bucket or large container with water and ice cubes. Place several tablespoons of the shortening in one of the baggies. Place the second baggie inside and tape the outside edges of the bag. With your hand inside the inner baggie, move the shortening around to cover your hand. With one hand inside the double baggie, submerge both your hands in the container of ice water. Measure the time it takes for one hand to feel uncomfortably cold. Experiment with different amounts of shortening.

Questions

1. How effective is the bag with "blubber" in protecting your hand from the cold?
2. How does "blubber" help an animal survive starvation?
3. How would twice the amount of shortening affect your results?
4. Why would animals in warm climates, such as camels and migratory birds, need to store fat?
5. If you placed 300 g of shortening in the baggie, how many moles of ATP could it provide if used for energy production (assume it produces the same ATP as myristic acid)?

Problem Solving

MANY TOOLS ENABLE STUDENTS TO SOLVE PROBLEMS.

A Step-By-Step Approach

The author understands the learning challenges facing students in this course, so she breaks down chemical concepts and calculations into manageable pieces to walk students through the problem-solving process.

Balancing a Chemical Equation

We have seen that a chemical equation must be balanced. In many cases, we can use a method of trial and error to balance an equation.

To demonstrate the process, let us balance the equation for the reaction of the gas methane, CH_4, with oxygen to produce carbon dioxide and water. This is the principal reaction that occurs in the flame of a gas burner you use in the laboratory and in the flame of a gas stove.

Step 1 **Use the correct formulas.** As a first step, we write the equation using the correct formulas for the reactants and products.

$$CH_4 + O_2 \longrightarrow CO_2 + H_2O$$

Step 2 **Determine if the equation is balanced.** When we compare the atoms on the reactant side with the atoms on the product side, we see that there are more hydrogen atoms on the left side and more oxygen atoms on the right.

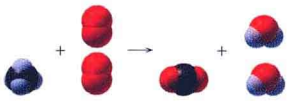
$CH_4 + O_2 \longrightarrow CO_2 + H_2O$

1 C	1 C	
4 H	2 H	Not balanced
2 O	3 O	Not balanced

Step 3 **Balance the equation one element at a time.** First we balance the hydrogen atoms by placing a coefficient of 2 in front of the formula for water. Then we balance the oxygen atoms by placing a coefficient of 2 in front of the formula for oxygen. There are now four oxygen atoms and four hydrogen atoms in both the reactants and products.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

Step 4 **Check to see if the equation is balanced.** Rechecking the balanced equation shows that the numbers of atoms of carbon, hydrogen, and oxygen are the same for both the reactants and the products.



$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ Balanced

Reactants		*Products*
1 C atom	=	1 C atom
4 H atoms	=	4 H atoms
4 O atoms	=	4 O atoms

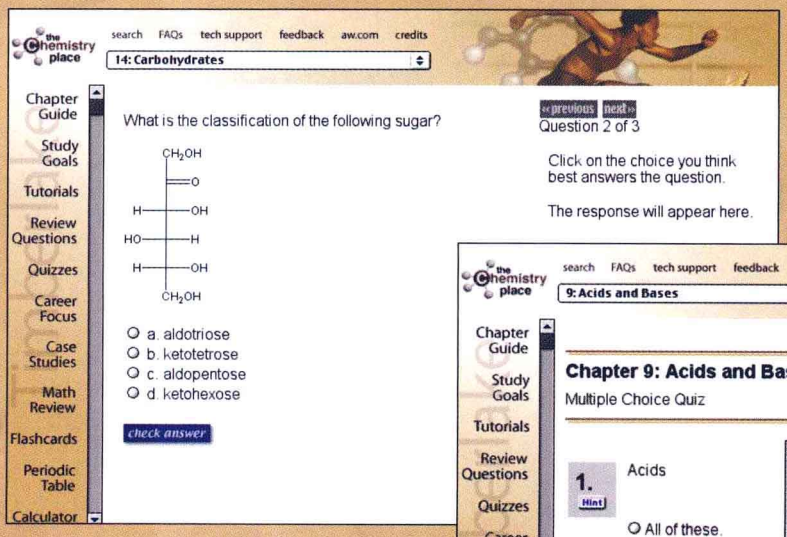
Suppose you had written the equation as follows:

$$2CH_4 + 4O_2 \longrightarrow 2CO_2 + 4H_2O$$ Incorrect

Although there are equal numbers of atoms on both sides of the equation, this is not written correctly. All the coefficients must be divided by 2 to obtain the lowest possible whole numbers.

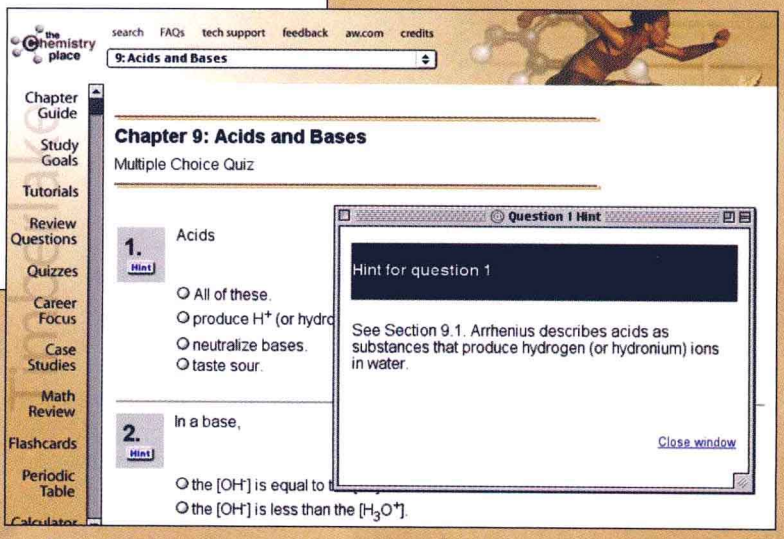
Review Questions

On the ChemistryPlace Web site, **Review Questions** give students more interactive practice for each section of the book.



Quizzes

The ChemistryPlace Web site includes two **Quizzes** per chapter, with questions unique to the site, for extra learning practice. Hints and feedback are provided, and results can be e-mailed to instructors.



SAMPLE PROBLEM 9.8

Calculating pH

Determine the pH for the following solutions:

a. $[H_3O^+] = 1.0 \times 10^{-5}$ M **b.** $[H_3O^+] = 2.5 \times 10^{-8}$ M

Solution

a. $pH = -\log [1.0 \times 10^{-5}] = 5.00$

b. Enter the 2.5×10^{-8} into your calculator and take the log. Change the sign (+/− key) to obtain the pH and round off to give two decimal places.

$pH = -\log [2.5 \times 10^{-8}] = 7.60$

Study Check

What is the pH of bleach with $[OH^-]$ of 2×10^{-3} M?

Sample Problems

Numerous **Sample Problems** appear throughout the text to immediately demonstrate the application of each new concept. The worked-out solution gives step-by-step explanations, provides a problem-solving model, and illustrates required calculations.

Questions and Problems

Questions and Problems at the end of each section encourage students to apply concepts and begin problem-solving after each section. Answers to odd-numbered problems are given at the end of the chapter.

QUESTIONS AND PROBLEMS

Naming Ionic Compounds

4.23 Write names for the following ionic compounds:
a. Al_2O_3 **b.** $CaCl_2$ **c.** Na_2O
d. Mg_3N_2 **e.** KI

4.24 Write names for the following ionic compounds:
a. $MgCl_2$ **b.** K_3P **c.** Li_2S
d. LiBr **e.** MgO

4.25 Why is a Roman numeral placed after the name of most transition metal ions?

4.26 The compound $CaCl_2$ is named calcium chloride; the compound $CuCl_2$ is named copper(II) chloride. Explain why a Roman numeral is used in one name but not the other.

4.27 Write the names of the following Group 4A and transition metal ions

Paired Problems

By pairing each even-numbered problem with a similar odd-numbered problem whose answer is at the end of the chapter, students are able to guide themselves through solving problems.

Additional Problems

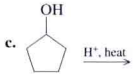
Additional Problems at the end of each chapter combine concepts from that chapter and previous chapters. These problems are more complex mathematically and require more critical thinking; some involve real-world applications.

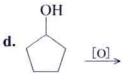
Additional Problems

12.60 Draw the condensed structural formula for the product of each of the following reactions:

a. $CH_3-CH(CH_3)-CH_2-OH \xrightarrow{H^+, \text{heat}}$

b. $CH_3-CH(CH_3)-CH(OH)-CH_3 \xrightarrow{[O]}$

c.  $\xrightarrow{H^+, \text{heat}}$

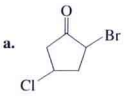
d.  $\xrightarrow{[O]}$

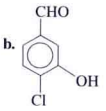
e. $CH_3-CH_2-CH_2-CH(OH)-CH_3 \xrightarrow{[O]}$

12.61 Identify the functional groups in the following molecule:

12.64 Dimethyl ether and ethyl alcohol both have the molecular formula C_2H_6O. One has a boiling point of −23°C, and the other, 79°C. Draw the condensed structural formulas of each compound. Decide which boiling point goes with which compound and explain. Check the boiling points in a chemistry handbook.

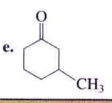
12.65 Give the IUPAC and common names (if any) for each of the following compounds:

a. 

b. 

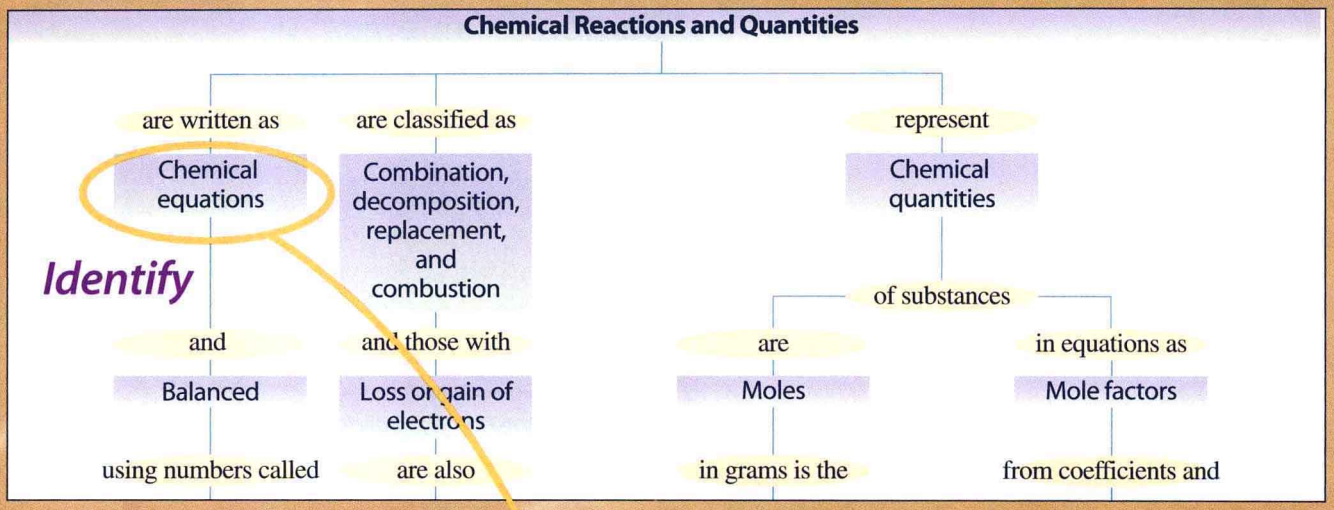
c. $Cl-CH_2-CH_2-C(=O)-H$

d. $CH_3-CH(Cl)-C(=O)-CH_2-CH_3$

e. 

Student Friendly Approach

KEEPING STUDENTS ENGAGED IS THE ULTIMATE GOAL.



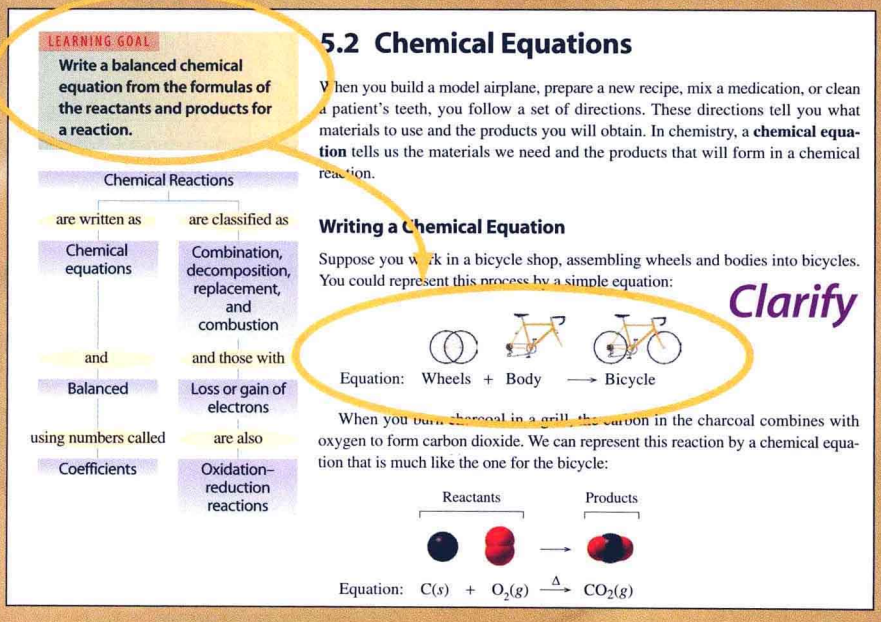
Concept Maps

Each chapter begins with a **Concept Map** that shows at a glance the key concepts of each chapter and how they fit together.

Learning Goals

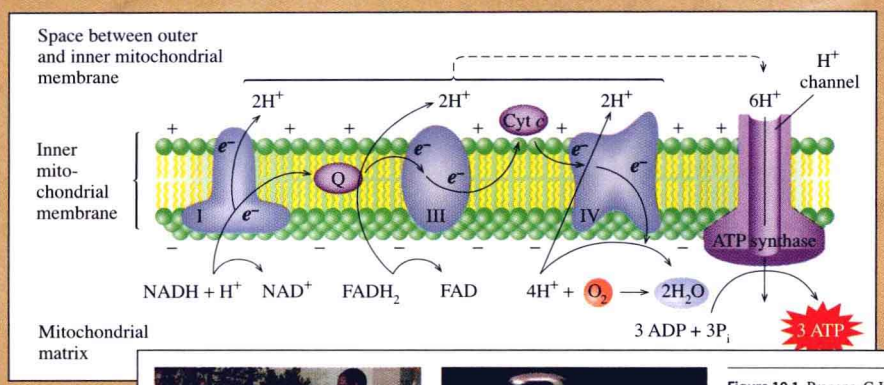
At the beginning of each section, a **Learning Goal** clearly identifies the key concept of the section, providing a roadmap for studying. All information contained in that section relates back to the Learning Goal.

Specify



Writing Style

Karen Timberlake is known for her accessible writing style, based on a carefully paced and simple development of chemical ideas, suited to the background of allied health students. She precisely defines terms and sets clear goals for each section of the text. Her clear analogies help students to visualize and understand key chemical concepts.



Art Program

The new art program is not only beautifully rendered, but pedagogically effective as well.

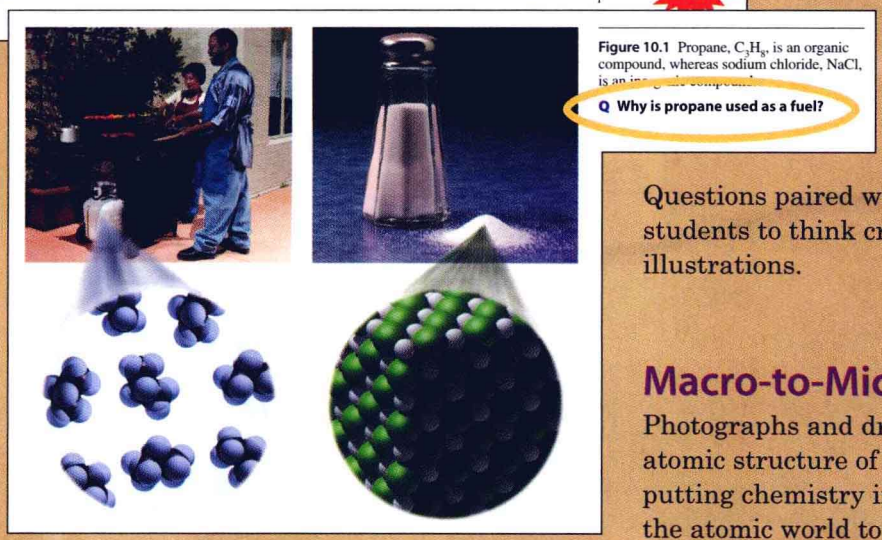


Figure 10.1 Propane, C_3H_8, is an organic compound, whereas sodium chloride, NaCl, is an

Q Why is propane used as a fuel?

Questions paired with figures challenge students to think critically about photos and illustrations.

Macro-to-Micro Art

Photographs and drawings illustrate the atomic structure of recognizable objects, putting chemistry in context and connecting the atomic world to the macroscopic world.