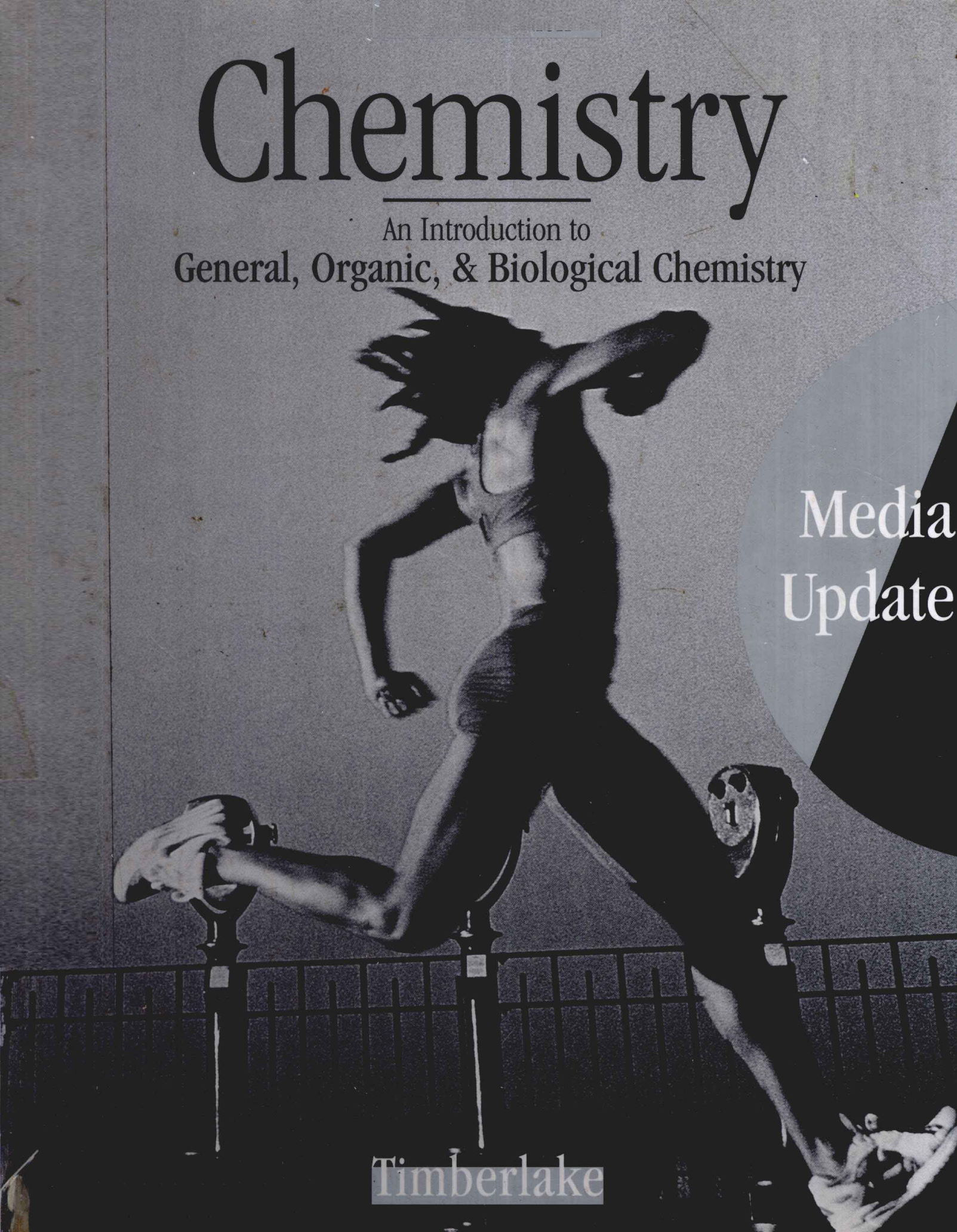
Chemistry

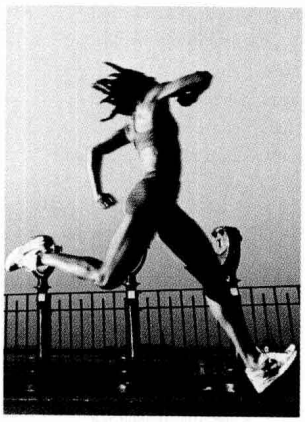
An Introduction to
General, Organic, & Biological Chemistry



Media Update

Timberlake

Chemistry



An Introduction to General, Organic, and Biological Chemistry

Seventh Edition
Media Update

Karen C. Timberlake
LOS ANGELES VALLEY COLLEGE

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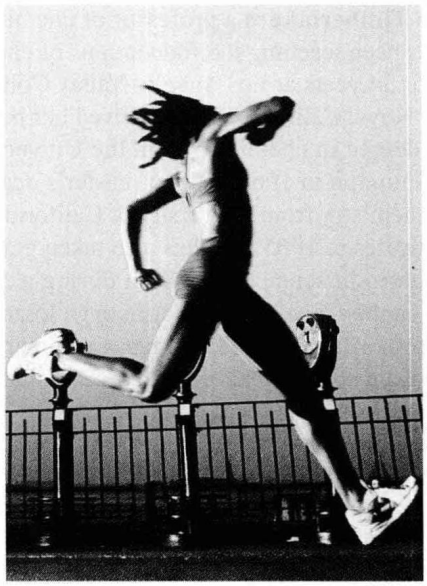
About the Cover

Running and Chemistry



You may wonder why a runner is pictured on the cover of a chemistry book. During running or any other exercise, many chemical changes occur in the body. In this course, you will discover how each of these changes involves chemistry and contributes to good health. For instance, during running or any moderate-to-strenuous exercise, you have probably experienced increases in your breathing and heart rates—this is chemistry in action. Our runner's muscles consume oxygen at a rapid rate, producing carbon dioxide that passes into the bloodstream. If her body's oxygen supply becomes too low, lactic acid forms in her muscles. An increase in lactic acid spurs several chemical changes: the blood becomes more acidic and the rate and depth of breathing increase. In fact, the breathing rate during exercise can increase by as much as 30 times more than the resting rate. As lactic acid accumulates, our runner may experience so much fatigue and pain that she eventually slows down or stops. She may also begin gasping for air, which supplies more oxygen to the blood and reduces the lactic acid in the cells.

The energy she needs to run comes from the food she has eaten. Carbohydrates provide glucose that is stored as a chemical compound called glycogen in the muscles. During exercise, glycogen is broken down to maintain a supply of glucose in the blood. In the muscle cells, glucose is oxidized to provide energy to form another chemical compound called ATP (adenosine triphosphate), the fuel required for muscle contraction. As long as ATP energy is available, the runner can continue to move the muscles that propel her during her run. A high-carbohydrate diet after running will help to restore her muscle glycogen more rapidly than a fat and protein diet.

Running produces heat, which increases body temperature. In a process called homeostasis, the body reduces dangerously high temperatures by expanding the capillaries to let more blood reach the skin surface. You know that during intense exercise, a large amount of water can be lost. Sweat glands increase the production of perspiration, which then evaporates from the skin and cools the body. Even the breath exhaled by the runner contains warm water vapor. If water is not replaced, production of saliva will decrease, the water level in the blood will drop, and the body will become dehydrated. All these changes will cause the runner to feel thirsty. When she quenches her thirst, the water in the body will return to normal levels.

By now, you may begin to see how chemistry is involved in nearly everything we do—and how our runner serves to illustrate this point. This book will teach you what happens when you eat or run, when acid rain forms, when food is irradiated, or when you give a patient a saline solution. Learning about all these processes as you study chemistry will give you a better understanding of your body and the world around you.

About the Author

This book is dedicated to my family, our son John, and my husband for his loving support and late meals, and my students whose hard work and wonderful comments continue to influence my writing.

The whole art of teaching is only the art of awakening the natural curiosity of young minds.

—Anatole France

One must learn by doing the thing; though you think you know it, you have no certainty until you try.

—Sophocles

Discovery consists of seeing what everybody has seen and thinking what nobody has thought.

—Albert Szent-Gyorgi

Karen Timberlake is a professor of chemistry and has been teaching the foundations of chemistry for 34 years at Los Angeles Valley College in Van Nuys, California. She received her bachelor's degree in chemistry from the University of Washington in 1962 and her master's degree in biochemistry from University of California at Los Angeles in 1965. She has also taken graduate courses in science education during a sabbatical at the University of Northern Colorado.

Professor Timberlake belongs to numerous science and educational organizations including the American Chemical Society (ACS), National Science Teachers Association (NSTA), and International Society for Exploring Teaching Alternatives (ISETA). In 1987 she was the western regional winner of the Excellence in College Chemistry Teaching award given by the Chemical Manufacturers Association.

Professor Timberlake has been writing chemistry textbooks for 25 years with an emphasis on applying the concepts of chemistry to real-life situations concerning health and environment. In the past 5 years, she has participated in education grants for science teaching with the Los Angeles Collaborative for Teaching Excellence (LACTE) and Title III grant at her college. She often speaks at conferences and educational meetings on using student-centered teaching methods in chemistry to promote learning success. Her Lecture PLUS learning system utilizes PowerPoint slides in mini-lectures, formative assessments, and activity worksheets for group work.

Her husband, Bill, is also a chemistry instructor and contributed to the writing of *CHEMISTRY.* When Professor Timberlake is not teaching or writing, she relaxes by hiking, traveling, playing tennis, and playing the piano. The Timberlakes' son, John, is a business development manager in San Jose, California.

To the Student

I hope that this textbook helps you discover exciting new ideas and gives you a rewarding experience as you develop an understanding and appreciation of the role of chemistry in your life. If you would like to share your experience with chemistry or comments about this text, I would appreciate hearing from you.

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Preface

Welcome to the Media Update of the seventh edition of *CHEMISTRY: An Introduction to General, Organic, and Biological Chemistry.* This book is designed for an introductory course in chemistry and assumes no prior knowledge of chemistry by the student. It is geared to students preparing for careers in health-related professions, such as nursing and respiratory therapy. It can also be used as a laboratory science course for liberal arts students and future teachers.

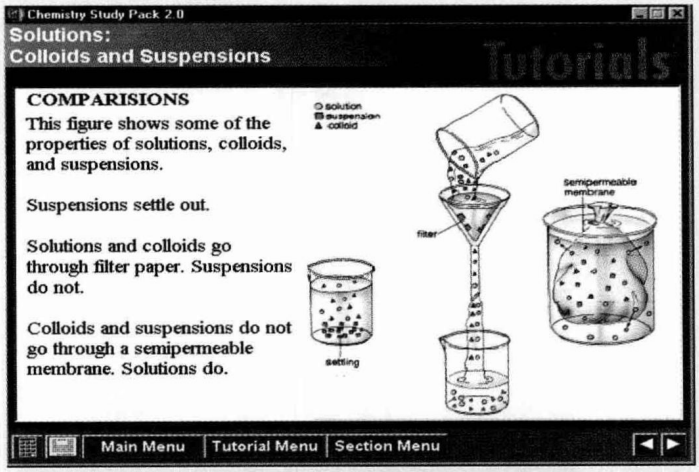
For me, this Media Update is a special edition. Its publication combines my 25th year of writing textbooks for allied health students with my desire to use technology to make new learning resources available to students and instructors.

The key features of the Media Update are shown on the following pages in *A Visual Guide to the Media Update.* Each chapter functions as a complete package, so that an instructor can easily skip some chapters or change the order of chapters. Throughout each chapter, Health Notes, Environmental Notes, and Explore Your World activities present real-life applications of chemical concepts at the point where each concept is discussed. Every section has a set of Sample Problems, Study Checks, and Questions & Problems. Students are encouraged to solve problems and apply ideas as they progress through the chapter instead of waiting until they finish. A set of Practice Problems at the end of the chapter integrates material from the entire chapter to promote critical thinking. Answers to the odd-numbered problems now appear at the end of each chapter, rather than at the end of the book.

Most important, a rich array of media resources is available. In each chapter, icons refer students to dynamic learning tools on two CD-ROMs and *The Chemistry Place, Special Edition for Timberlake* web site. *The Study Pack 2.0* CD-ROM and *The Chemistry of Life for Introductory Chemistry* CD-ROM feature tutorials, reviews, practice exams, and interactive exercises to help students visualize new concepts. On *The Chemistry Place, Special Edition for Timberlake*, students have access to tutorials, review slides, a glossary, quizzes for every chapter, a periodic table, and a calculator. The web site also offers instructors a variety of teaching tools, including an online instructor's manual, lab exercises, PowerPoint slide modules for classroom presentation, and a syllabus manager.

It is my goal that every student understands the scientific concepts that will help him or her to make informed decisions concerning health and the environment. In producing this Media Update, my hope is that the many pedagogical features of the text and all the media resources will make teaching and learning chemistry an enthusiastic and positive experience.

A Visual Guide to the Media Update



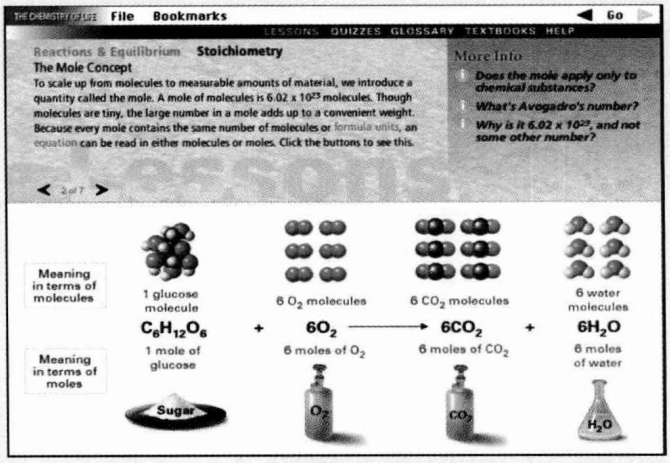
The *Chemistry Study Pack, Version 2.0* CD-ROM features **interactive tutorials** for all 18 chapters of the book, including randomized **practice tests** for each tutorial. A **quick quiz** is available for each of the 168 sections of the text and **chapter quizzes** test students' knowledge at the end of each tutorial.

Look for the Study Pack icon for cross-references to this CD.

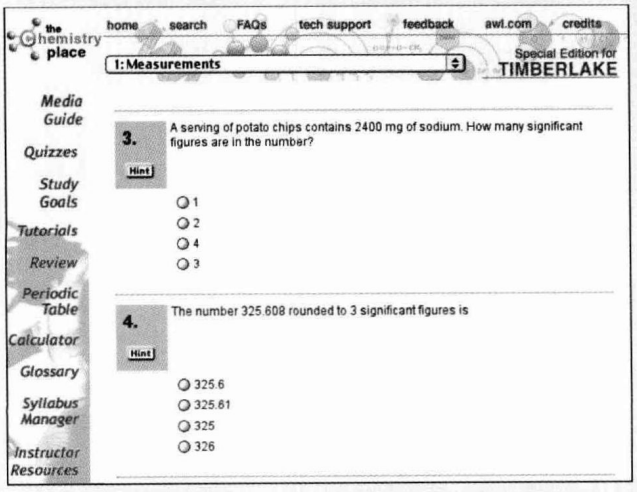
Chemistry Study Pack CD-ROM

Through more than 600 high-quality **animations** and **interactive simulations**, the *Chemistry of Life for Introductory Chemistry* CD-ROM brings the molecular world to life. Correlated to the book, this CD-ROM reinforces concepts introduced in the text. In addition, students can prepare for tests with the 250 **quiz questions** and the illustrated **glossary**.

Look for the Chem of Life icon for cross-references to this CD.



Chemistry of Life for Introductory Chemistry CD-ROM



The Chemistry Place, Special Edition for Timberlake contains many tools to help students prepare for exams. This web site includes **quiz questions** for each chapter, **review slides**, web links, **interactive tutorials**, a glossary and an interactive periodic table.

The Chemistry Place, Special Edition for Timberlake
www.chemplace.com/college/timberlake

A Visual Guide to this Book

Each chapter opens with **Looking Ahead,** an outline of the topic covered in each section of the text.

Looking Ahead

7

Gases

Looking Ahead

- **7.1** Properties of Gases
- **7.2** Gas Pressure
- **7.3** Pressure and Volume (Boyle's Law)
- **7.4** Temperature and Volume (Charles' Law)
- **7.5** Temperature and Pressure (Gay-Lussac's Law)
- **7.6** The Combined Gas Law
- **7.7** Volume and Moles (Avogadro's Law)
- **7.8** Partial Pressures (Dalton's Law)

www.chemplace.com/college/timberlake

Visit the web site above to test yourself, run simulations, and review key concepts from this chapter. For even more interactive review and quizzing, use the two CD-ROMs included with the book.

7.4 · Temperature and Volume (Charles' Law) **259**

Figure 7.6 As the air inside a hot-air balloon is heated, its volume expands and its density decreases. The hot-air balloon rises and floats in the air.

7.4

7.4 Temperature and Volume (Charles' Law)

Study Pack

Learning Goal

Use the temperature–volume relationship (Charles' law) to determine the new temperature or volume of a certain amount of gas at a constant pressure.

When preparing a hot-air balloon for a flight, the air in the balloon is heated with a small propane heater. As the air warms, its volume increases. The resulting decrease in density allows the balloon to rise. (See Figure 7.6.)

To study the effect of changing temperature on the volume of a gas, we must not change the pressure or the amount of the gas. Suppose we increase the Kelvin temperature of a gas sample. The kinetic theory shows that the activity (kinetic energy) of the gas will also increase. To keep pressure constant, the volume of the container must increase. (See Figure 7.7.) By contrast, if the temperature of the gas is lowered, the volume of the container must be reduced to maintain the same pressure.

Suppose that you are going to take a ride in a hot air balloon. The captain turns on a propane burner to heat the air inside the balloon. As the temperature rises, the air particles move faster and spread out, causing the volume of the balloon to increase. Eventually, the air in the balloon becomes less dense than the air outside, and the balloon and its passengers rise. In fact, it was in 1787 that Jacques Charles, a balloonist as well as a physicist, proposed that the volume of a gas is related to the temperature. This became **Charles' law,** which states that the volume (V) of a gas is directly related to the temperature (K) when there is no change in the pressure (P) or amount (n) of gas. A

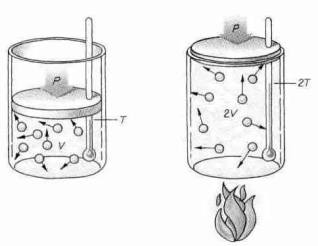


Figure 7.7 The Kelvin temperature of a gas is directly related to the volume of the gas when there is no change in pressure or amount.

Learning Goals at the beginning of each new section in a chapter give the outcome that can be expected after reading the material in the section and working the problems.

Learning Goals

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

Health Note

To determine the equivalent or rem dose, the absorbed dose (rads) is multiplied by a factor that adjusts for biological damage caused by a particular form of radiation. For beta and gamma radiation, and X rays, the factor is 1, so the biological damage in rems is the same as the absorbed radiation (rads). For high-energy protons and neutrons, the factor is about 10, and for alpha particles it is 20.

Biological damage (rem) = absorbed dose (rad) × factor

Often the measurement for an equivalent dose will be in units of **millirems (mrem)**. One rem is equal to 1000 mrem. A newer unit is the **sievert (Sv).** One sievert is equal to 100 rems. Table 3.4 summarizes the units used to measure radiation.

3.4

HEALTH NOTE

Radiation and Food

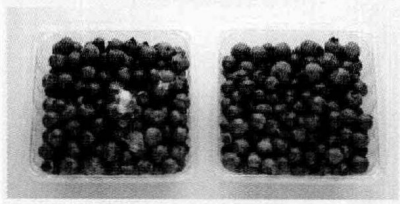
Foodborne illnesses caused by pathogenic bacteria such as *Salmonella*, *Listeria*, and *Escherichia coli* have become a major health concern in the United States. The Centers for Disease Control and Prevention estimates that each year *E. coli* in contaminated foods infects 20,000 people in the United States, and that 500 people die. A recent outbreak of *E. coli* O157:H7 resulted in more than 700 cases of illness and four deaths. This same *E. coli* has been responsible for at least nine outbreaks of illness from contaminated fruit juices, lettuce, and alfalfa sprouts.

The Food and Drug Administration (FDA) has approved the use of 0.3 kilogray (0.3 kGy) to 1 kGy of ionizing radiation produced by cobalt-60 or cesium-137 for the treatment of foods. The irradiation technology is much like that used to sterilize medical supplies. Cobalt pellets are placed in stainless steel tubes, which are arranged in racks. When food moves through the series of racks, the gamma rays pass through the food and kill the bacteria.

It is important for consumers to understand that when food is irradiated, it never comes in contact with the radioactive source. The gamma rays pass through the food to kill bacteria, but that does not make the food radioactive. The radiation kills bacteria because it stops their ability to divide and grow. We cook or heat food thoroughly for the same purpose. Radiation, as well as heat, has little effect on the food itself because its cells are no longer dividing or growing. Thus irradiated food is not harmed although a small amount of vitamin B_1 and C may be lost.

Currently, tomatoes, blueberries, and mushrooms are being irradiated to allow them to be harvested when completely ripe and extend their shelf life (see Figure 3.10). The FDA has also approved the irradiation of pork, poultry, and beef in order to decrease potential infections and to extend shelf life. Currently, irradiated vegetable and meat products are available in retail markets in South Africa. Apollo 17 astronauts ate irradiated foods on the moon, and some U.S. hospitals and nursing homes now use irradiated poultry to reduce the possibility of infections among patients. The extended shelf life of irradiated food also makes it useful for campers and military personnel. Soon consumers concerned about food safety will have a choice of irradiated meats, fruits, and vegetables at the market.

Figure 3.10 **(a)** The FDA requires this symbol to appear on irradiated retail foods. **(b)** After 2 weeks, the irradiated blueberries on the right show no spoilage. Mold is starting to grow on the nonirradiated ones on the left.



b

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

Environmental Note

ENVIRONMENTAL NOTE

Acid Rain

Rain typically has a pH of 6.2. It is slightly acidic because carbon dioxide in the air combines with water to form carbonic acid. However, in many parts of the world, rain has become considerably more acidic, with pH values as low as 3 being reported. One cause of acid rain is the sulfur dioxide (SO_2) gas produced when coal that contains sulfur is burned.

In the air, the SO_2 gas reacts with oxygen to produce SO_3, which then combines with water to form sulfuric acid, H_2SO_4, a strong acid.

$$S + O_2 \longrightarrow SO_2$$

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

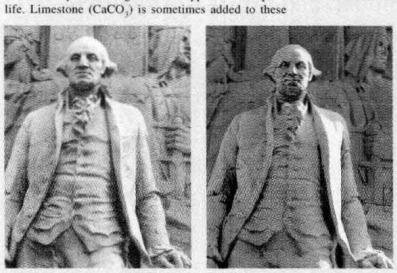
$$SO_3 + H_2O \longrightarrow H_2SO_4$$

In parts of the United States, acid rain has made lakes so acidic they are no longer able to support fish and plant life. Limestone ($CaCO_3$) is sometimes added to these lakes to neutralize the acid. In Eastern Europe, acid rain has brought about an environmental disaster. Nearly 40% of the forests in Poland have been severely damaged, and some parts of the land are so acidic that crops will not grow. Throughout Europe and the United States, monuments made of marble (a form of $CaCO_3$) are deteriorating as acid rain dissolves the marble. (See Figure 9.8.)

$$2H^+ + CaCO_3 \longrightarrow Ca^{2+} + H_2O + CO_2$$

Efforts to slow or stop the damaging effects of acid rain include the reduction of sulfur emissions. This will require installation of expensive equipment in coal-burning plants to absorb more of the SO_2 gases before they are emitted. In some outdated plants, this may be impossible, and they will need to be closed. It is a difficult problem for engineers and scientists, but one that must be solved.

9.3



a b

Figure 9.8 **(a)** Detail of the marble that is part of the Washington Square Arch in Washington Square Park, New York City, completed on July 17, 1935. **(b)** The destructive effect of acid rain on the same marble, June 1994.

QUESTIONS & PROBLEMS

The pH Scale

9.19 Why does a neutral solution have a pH of 7?

9.20 If you know the $[OH^-]$, how would you determine the pH of a solution?

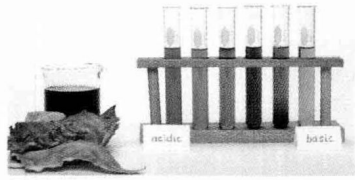
9.21 State whether each of the following solutions is acidic, basic, or neutral:
a. blood, pH 7.4 **b.** vinegar, pH 2.8 **c.** drain cleaner, pH 11.2
d. coffee, pH 5.5 **e.** milk, pH 7.0

9.22 State whether each of the following solutions is acidic, basic, or neutral:
a. soda, pH 3.2 **b.** shampoo, pH 6.0
c. hot tub water, pH 7.8 **d.** acid rain, pH 6.2
e. laundry detergent, pH 9.5

Explore Your World are 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

Figure 9.7 The dye in red cabbage juice acts as a pH indicator by turning different colors that correspond to different pH values.



9.3

EXPLORE YOUR WORLD

Using Vegetables and Flowers as pH Indicators

Many flowers and vegetables with strong color, especially reds and purples, contain compounds that change color with changes in pH. Some examples are red cabbage, cranberry juice, and cranberry drinks.

Materials Needed

Red cabbage, water, and a saucepan; or cranberry juice or drinks

Several glasses or small glass containers and some tape and a pen or pencil to mark the containers

Several colorless household solutions such as vinegar, lemon juice, other fruit juices, baking soda, antacids, aspirin, window cleaners, soaps, shampoos, and detergents

Procedure

1. Obtain a bottle of cranberry juice or cranberry drink, or use a red cabbage to prepare the red cabbage pH indicator, as follows: Tear up several red cabbage leaves and place them in a saucepan and cover with water. Boil for about 5 minutes. Cool, strain, and collect the purple indicator solution.
2. Place small amounts of each household solution into separate, clear glass containers and mark what each one is. If the sample is a solid or a thick liquid, add a small amount of water. Add some cranberry juice or some red cabbage indicator until you obtain a color.
3. Observe the colors of the various samples. The colors that indicate acidic solutions are the pink and orange colors (pH 1–4) and the pink to lavender colors (5–6). A neutral solution has about the same purple color as the indicator. Bases will give blue to green color (pH 8–11) or a yellow color (pH 12–13).
4. Arrange your samples by color and pH. Classify each of the solutions as acidic (1–6), neutral (7), or basic (8–13).
5. Try to make an indicator using other colorful fruits or flowers.

Questions

1. Which products that tested acidic listed acids on their labels?
2. Which products that tested basic listed a base on their labels?
3. How many products were neutral?
4. Which flowers or vegetables behaved as indicators?

HEALTH NOTE

Stomach Acid, HCl

When a person sees, smells, thinks about, and/or tastes food, the gastric glands in the stomach begin to secrete a HCl solution that is strongly acidic. In a single day, a person may secrete as much as 2000 mL of gastric juice. The HCl in the gastric juice activates a digestive [illegible]led pepsin that breaks down proteins in food entering the stomach. The secretion of HCl continues until the stomach has a pH of about 2, which is the optimum pH for activating the digestive enzymes without ulcerating the stomach lining. Normally, large quantities of viscous mucus are secreted within the stomach to protect its lining from acid and enzyme damage.

8.5

SAMPLE 8.14 PROBLEM

Calculating Percent Concentration

A student prepared a solution by dissolving 5 g of KI with enough water to give a final volume of 250 mL. (See Figure 8.16.) What is the mass/volume percent of the KI solution?

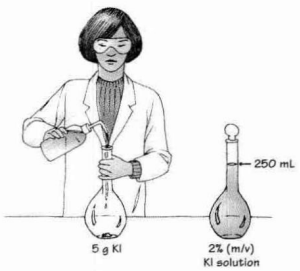


Figure 8.16 A 2% (m/v) KI solution is prepared by placing 5 g of KI in a 250-mL flask and filling the flask to the 250-mL mark.

Solution

Placing grams of solute and milliliters of solution in the expression for percent (m/v) concentration gives

$$\text{mass/volume \%} = \frac{\overset{\text{Mass of solute}}{5 \text{ g KI}}}{\underset{\text{Volume of solution}}{250 \text{ mL solution}}} \times 100 = 2\% \text{ (m/v) KI}$$

Study Check

What is the mass/volume percent, % (m/v), of Br_2 in a solution prepared by dissolving 12 g of bromine (Br_2) in enough carbon tetrachloride to make 250 mL of solution?

Percent Concentrations as Conversion Factors

In the preparation of solutions, we often need to calculate the amount of solute or solution. Then the percent concentration is useful as a conversion factor. Some examples of percent concentrations, their meanings, and possible conversion factors are given in Table 8.8.

Table 8.8 Conversion Factors from Percent Concentrations

Percent Concentration	Meaning	Conversion Factors		
10% (m/m) KCl	There are 10 g of KCl in exactly 100 g of solution.	$\frac{10 \text{ g KCl}}{100 \text{ g solution}}$	and	$\frac{100 \text{ g solution}}{10 \text{ g KCl}}$
5% (m/v) glucose	There are 5 g of glucose in exactly 100 mL of solution.	$\frac{5 \text{ g glucose}}{100 \text{ mL solution}}$	and	$\frac{100 \text{ mL solution}}{5 \text{ g glucose}}$

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.

Study Checks at the end of each Sample Problem ask the student to work a similar problem.

Sample Problems

Study Checks

Questions & Problems at the end of each section in the chapters encourage students to immediately apply concepts and begin problem solving after learning a workable chunk of information, instead of waiting until the end of the chapters to work problems.

Questions & Problems

QUESTIONS & PROBLEMS

Pressure and Volume (Boyle's Law)

7.13 Why do scuba divers need to exhale air when they ascend to the surface of the water?

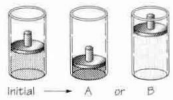
7.14 Why does a sealed bag of chips expand when you take it to a higher altitude?

7.15 What happens to the volume of your lungs during expiration when you get rid of some CO_2?

7.16 How do respirators (or CPR) help a person obtain oxygen and expel carbon dioxide?

7.17 The air in a cylinder with a piston has a volume of 220 mL and a pressure of 650 mm Hg.

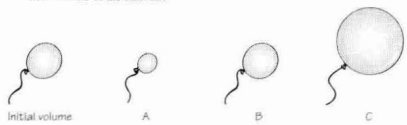
a. If a change results in a higher pressure inside the cylinder, does cylinder A or B represent the final volume? Explain your choice.



b. If the pressure inside the cylinder increases to 1.2 atm, what is the final volume of the cylinder? Complete the following data table:

Property	Initial	Final
Pressure (P)		
Volume (V)		

7.18 A balloon is filled with helium gas. When the following changes are made at constant temperature, which of these diagrams (A, B, or C) shows the new volume of the balloon?



a. The balloon floats to a higher altitude where the outside pressure is lower.

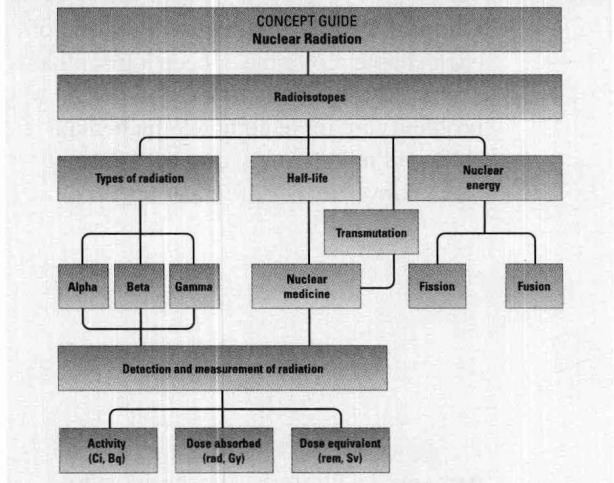
b. The balloon is taken inside the house, but the atmospheric pressure remains the same.

c. The balloon is put in a hyperbaric chamber in which the pressure is increased.

7.19 Complete the following using the pressure–volume relationship.

	Pressure	Volume
a. decreases		_____
b. increases		_____

Chapter Review



New! **Concept Guide** artwork at the end of each chapter visually links concepts and shows key relationships among the topics within a chapter.

Concept Guides

Chapter Summary

3.1 Natural Radioactivity
Radioactive isotopes have unstable nuclei that break down (decay), spontaneously emitting alpha (α), beta (β), and gamma (γ) radiation. Because radiation can damage the cells in the body, proper protection must be used: shielding, limiting the time of exposure, and distance.

3.2 Nuclear Equations
A balanced equation is used to represent the changes that take place in the nuclei of the reactants and products. The new isotopes and the type of radiation emitted can be determined from the symbols that show the mass numbers and atomic numbers of the isotopes in the nuclear reaction.

3.3 Producing Radioactive Isotopes
A radioisotope is produced artificially when a nonradioactive isotope is bombarded by a small particle such as a proton, or an alpha or beta particle. Many radioactive isotopes used in nuclear medicine are produced in this way.

3.4 Radiation Detection and Measurement
In a Geiger counter, radiation ionizes gas in a metal tube, which produces an electrical current. The curie (Ci) measures the number of nuclear transformation of a radioactive sample. Activity is also measured in becquerel (Bq) units. The amount of radiation absorbed by a substance is measured in rads or the gray (Gy). The rem and the sievert (Sv) are units used to determine the biological damage from the different types of radiation.

3.5 Medical Applications Using Radioactivity
In nuclear medicine, radioisotopes are given that go to specific sites in the body. By detecting the radiation they emit, an evaluation can be made about the location and extent of

Chapter Summaries at the end of each chapter briefly review the main ideas in each section.

Chapter Summaries

Organic and biological chemistry chapters contain additional summaries such as this **Summary of Reactions.**

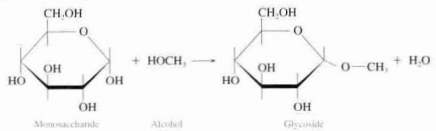
Key Terms appear in boldfaced type in a chapter and are listed as a glossary at the end of the chapter to encourage vocabulary review.

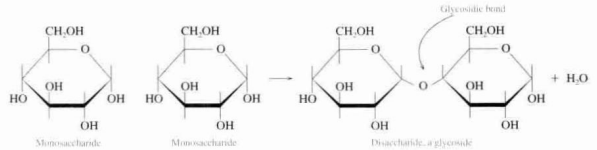
Summary of Reactions

Key Terms

Summary of Reactions

Glycoside (Acetal) Formation





Hydrolysis of Disaccharides

Sucrose + H_2O ⟶ glucose + fructose
Lactose + H_2O ⟶ glucose + galactose
Maltose + H_2O ⟶ glucose + glucose

Key Terms

aldose Monosaccharides that contain an aldehyde group.
amylopectin A branched-chain polymer of starch composed of glucose units joined by α-1,4- and α-1,6-glycosidic bonds.
amylose An unbranched polymer of starch composed of glucose units joined by α-1,4-glycosidic bonds.
anomers The isomers that occur when the formation of a hemiacetal or hemiketal of monosaccharides produces a new hydroxyl group on carbon 1 (or carbon 2). In the α anomer, the OH is drawn downward; in the β isomer the OH is up.
carbohydrate A simple or complex sugar composed of carbon, hydrogen, and oxygen.
cellulose An unbranched polysaccharide composed of glucose units linked by β-1,4-glycosidic bonds that cannot be hydrolyzed by the human digestive system.
chiral A carbon atom that is attached to four different atoms or groups of atoms; the mirror images of a chiral molecule are not superimposable.
disaccharides Carbohydrates composed of two monosaccharides joined by a glycosidic bond.
enantiomers Stereoisomers that are mirror images of each other.
fermentation A reaction of glucose, fructose, maltose, or sucrose, in which the sugar reacts with enzymes in yeast to give ethanol and carbon dioxide gas.
Fischer projection A two-dimensional straight-chain representation of a molecule.
fructose A monosaccharide found in honey and fruit juices; it is combined with glucose in sucrose. Also called levulose and fruit sugar.
galactose A monosaccharide that occurs combined with glucose in lactose.
glucose The most prevalent monosaccharide in the diet. An aldohexose that is found in fruits, vegetables, corn syrup, and honey. Also known as blood sugar and dextrose. Combines in glycosidic bonds to form most of the polysaccharides.
glycogen A polysaccharide formed in the liver and muscles for the storage of glucose as an energy reserve. It is composed of glucose in a highly branched polymer joined by α-1,4- and α-1,6-glycosidic bonds.
glycosides Acetal products of a monosaccharide reacting with an alcohol or another sugar.
glycosidic bond The acetal bond that forms when an alcohol or a hydroxyl group of a monosaccharide adds to

Chapter Practice

2.57 Why is Co the symbol for cobalt, but not CO?

2.58 Which of the following is correct? Write the correct symbol if needed.
a. copper, Co **b.** silicon, SI **c.** iron, Fe
d. fluorine, Fl **e.** potassium, P **f.** sodium, Na
g. gold, Au **h.** lead, PB

2.59 Give the symbol and name of the element found in the following group and period on the periodic table.
a. Group 2, Period 3 **b.** Group 7, Period 4
c. Group 3, Period 3 **d.** Group 6, Period 2

2.60 Give the group and period number for the following elements:
a. potassium **b.** phosphorus
c. carbon **d.** neon

2.61 The following statements are *false*. Reword the underlined word or phrase to make a *true* statement.
a. The proton is a neutral particle.
b. The electrons are found in the nucleus.
c. The nucleus is the largest part of the atom.
d. The neutron has a negative charge.
e. The mass of an atom is due

c. Which atoms have the same mass number?
d. What atoms have the same number of neutrons?

2.68 Five isotopes of zinc are zinc-64, zinc-66, zinc-67, zinc-68, and zinc-70.
a. Write the atomic symbols, including atomic number and mass number for each of these atoms.
b. Give the number of protons, electrons, and neutrons for each of the zinc isotopes.

2.69 A sample of copper has two naturally occurring isotopes. The isotope Cu-63 (mass 62.9) makes up 69.2% of all the copper atoms, and Cu-65 (mass 64.9) makes up 30.8% of the sample. What average atomic mass would you calculate for copper?

2.70 In a sample of magnesium, Mg-24 (mass 24.0) is 79.0% of the sample, Mg-25 (mass 25.0) is 10.0%, and Mg-26 (mass 26.0 ... mass would you ...

2.71 ... sodium atom is $3.14 \times 10^{-}$ ... sodium atoms would fit along a line ex- ... 1 inch long?

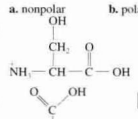
Answers

Answers to Study Checks

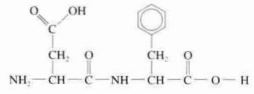
16.1 hormones

16.2 **a.** nonpolar **b.** polar

16.3



16.4



16.5 threonylleucylphenylalanine

16.6 a triple helix

16.7 Both are nonpolar and would be found on the inside of the tertiary structure.

16.8 quaternary

16.9 The heavy metal Ag^+ denatures the protein in bacteria that cause gonorrhea.

16.10 hydrolase

16.11 The active site has a rigid shape in the lock-and-key model but is flexible in the induced-fit model and adapts to the shape of the substrate.

16.12 The vitamin B_6 in part c.

16.13 Urease will lose enzymatic activity as denaturation of its protein occurs.

16.14 noncompetitive inhibitor

Answers to Selected Questions and Problems

16.1 **a.** transport **b.** structural
c. structural **d.** enzyme

16.3 All amino acids contain a carboxylic acid group and an amino group on the α carbon.

Chapter Practice 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; several involve real-life relationships.

Answers to all Study Checks and odd-numbered problems are given at the end of each chapter.

Chapter Practice Answers

Key Content Changes

Chapter 1: Measurements contains features from the old appendices on scientific notation and working with a calculator. A new discussion on accuracy and precision is now included with the topic of significant figures. Temperature equations have been moved to Chapter 6, where temperature is needed for heat calculations.

Chapter 2: Atoms and Elements appears earlier in the sequence with heat and energy moved to a later chapter. The new IUPAC names for elements 104–109 are included in *CHEMISTRY* along with spaces for elements 110–118. The section on the structure of the atom has been rewritten and now includes Rutherford's gold foil experiment. The term "atomic mass" replaces "atomic weight." In agreement with reviewer comments, the section in the sixth edition on subshells and orbitals has been deleted.

Chapter 3: Nuclear Radiation has been moved to follow the chapter on atoms because a discussion of radioactivity relates to subatomic particles, particularly the nucleus. The definitions of terms such as "mass numbers" and "isotopes" in Chapter 2 are applied immediately to radioisotopes. It is a continuation of a study of the behavior of atoms, in this case radioactive ones, and their subatomic particles. A new health note discusses the controversy of food irradiation, and the SI units for measurement of radiation have been added.

Chapter 4: Compounds and Their Bonds has a revised order. The discussion of bonding and naming of binary ionic and covalent compounds now precedes the topics of polarity and polyatomic ions in ternary compounds.

Chapter 5: Chemical Reactions and Quantities now begins with chemical change, equations, and balancing equations. A new section on types of reactions has been added along with a section on oxidation–reduction and combustion reactions. Some problems now include biochemistry examples. The mole concept is then introduced with a final, optional section on using the mole to calculate the mass of reactants and products in a reaction. The discussion of molar mass has been rewritten and the term "formula mass" deleted.

Chapter 6: Energy and States of Matter presents energy, temperature equations, heat and nutrition calculations, and states of matter later in the sequence so they can be combined with energy in reactions and chemical equilibrium. A section on melting and freezing with the heat of fusion is followed by a separate section on boiling and condensation with the heat of vaporization. Calculations for energy in changes of states have been simplified and several steps omitted. The new section on chemical equilibrium ties together rates of reactions and reversible reactions and discusses the effects of adding or removing a reactant or product, and changing temperature on equilibrium. The concept of equilibrium is applied to biological systems with the examples of hemoglobin and oxygen and carbon monoxide.

Chapter 7: Gases retains the sequence from the sixth edition except that the equation and calculations using the ideal gas law have been deleted as suggested by several reviewers. More conceptual problems have been added and some of the mathematical discussion omitted.

Chapter 8: Solutions now combines the section on solutes and solvents with polar and nonpolar solutes and solvents. A discussion on electrolytes and nonelectrolytes now follows the discussion on forming solutions with ionic substances. The topics of colloids, suspensions, osmosis, and dialysis are combined with percent concentration and precede the introduction of molarity. The discussion of molarity at the end of the chapter is in preparation for the use of molarity in acids and bases and pH calculation in the next chapter.

Chapter 9: Acids and Bases now uses the properties and theories of acids and bases to introduce the chapter. The dissociation of water and the topic of pH and the pH scale precede reactions of acids and bases. Students are encouraged to make pH indicators from fruits, vegetables, and flowers with intense colors.

Chapter 10: Alkanes and Aromatic Hydrocarbons introducing organic chemistry, now includes aromatic hydrocarbons. The haloalkane discussion has been moved to the next chapter so that Chapter 10 now deals only with compounds of carbon and hydrogen. Naming of compounds has been de-emphasized and the discussion of branched-chain alkanes has been rewritten. The reactions of alkanes is now limited to combustion. The writing of structural formulas of isomers was placed later in the chapter due to its complexity. The section on aromatic hydrocarbons has been shortened and complex-naming systems deleted.

Chapter 11: Haloalkanes, Alkenes, and Alkynes opens by describing functional groups and giving a list of the groups that will be discussed in *CHEMISTRY.* This addition is in response to reviewers who want to move faster through the organic material, concentrate more on functional groups, and limit the amount of time spent on naming compounds. Information about alkenes and alkynes and their naming is now combined into one section. A new environmental note describes the effect of ethene on the ripening process of fruits. The section on geometric isomers has been shortened and simplified. A new Explore Your World activity asks students to make models of cis–trans isomers using their hands or gumdrops and toothpicks. All the addition reactions are now in one section. A new section on addition polymers has been written in preparation for the idea of polymers in biomolecules. Recycling information is included here.

Chapter 12: Alcohols, Phenols, Ethers, Aldehydes, and Ketones combines the classification of alcohols with the oxidation of alcohols. IUPAC rules have been simplified. The

oxidation of alcohol in the body is now part of the section on oxidation of alcohols. A discussion of aldehydes and ketones, including a new note on vanilla, now precedes the oxidation of alcohols. A new section on hemiacetals and hemiketals along with acetals and ketals completes the chapter. This is in preparation for the cyclic structures of monosaccharides in the following chapter on carbohydrates.

Chapter 13: Carbohydrates now immediately follows the organic chapter that describes the same functional groups found in carbohydrates. The discussion on optical activity has been deleted. Mutarotation is now discussed as an equilibrium system between the open chain and its anomers. Explore Your World activities include photosynthesis, sugars, sweetness of sugars, and the iodine test for polysaccharides.

Chapter 14: Carboxylic Acids, Esters, Amines, and Amides places carboxylic acids and their solubility into one section and simplifies naming. An Explore Your World activity asks students to list names and write structures of some carboxylic acids and esters that they identify in foods and cosmetics.

Chapter 15: Lipids presents a rewritten section on the physical properties of fatty acids. New Health Notes on omega-3 fatty acids, fat substitutes, and trans-fatty acids have been added. The discussion of plasma membranes expands on the role of phospholipids in the lipid bilayer of cell membranes. The structures of steroid compounds have been improved. Several Explore Your World activities on fats and oils and their solubility have been added.

Chapter 16: Amino Acids, Proteins, and Enzymes includes a rewritten section of the ionization of amino acids. The terms N- and C-terminus were deleted from the peptide discussion. Secondary structures now include alpha helix, beta-pleated sheet, and triple helix. Tertiary structures now include fibrous and globular proteins. A new discussion of specificity of enzymes has been added. The section on enzyme action is completely rewritten to clarify active site, lock-and-key model, and induced fit model, and uses redesigned illustrations.

Chapter 17: Metabolic Pathways and Energy (formerly Chapter 18) describes the metabolic relationship among the biomolecules discussed in the preceding chapters and their role in producing energy. A new section on coenzymes precedes the discussion of metabolic pathways. The sections on glycolysis and citric acid cycle have been rewritten and new figures drawn to give a better set of structures and pathway steps. Complex equations have been simplified. The section on the electron transport chain has been completely rewritten with electron carriers described first, followed by the electron transfer sequence using enzyme clusters and the concept of proton pumps. The detailed discussion of fatty acid synthesis has been deleted. The amino acids in transamination and oxidation deamination have been written as their anions to make their structures consistent with the anions in the citric acid cycle. Several drawings have been reworked to promote better understanding.

Chapter 18: Nucleic Acids (formerly Chapter 17) describes how DNA controls the metabolic processes in the cells. The discussion on recombinant DNA has been rewritten and expanded as a complete section with a new photograph of DNA fingerprinting.

Instructional Package

The Media Update of the seventh edition of *CHEMISTRY: An Introduction to General, Organic, and Biological Chemistry* is the nucleus of an integrated teaching and learning package of support materials for both professors and students.

For Students

Laboratory Manual, seventh edition by Karen Timberlake. Coordinates the topics and the sequence in *CHEMISTRY* to use new terms during the lab and to explore chemical concepts. Early experiments introduce students to basic laboratory skills, safety, and use of standard equipment. Laboratory investigations develop skills of manipulating laboratory equipment, gathering and reporting data, solving problems, making calculations, and drawing conclusions. Some questions at the end of labs require essay-type answers to promote writing skills in science. (0-321-03603-X). To inquire about adopting a customized version of the ***Laboratory Manual,*** please contact Addison Wesley customer service at (800) 282-0683 or visit us on the World Wide Web at www.aw.com/bc.

Essential Laboratory Manual by Karen Timberlake. Offering 21 experiments from the successful main edition of the ***Laboratory Manual,*** this slimmer version maintains the same quality and emphasis on critical thinking. Features safety procedures in the lab, pre-lab questions and report pages. (0-8053-2982-X)

Study Guide with Selected Solutions, seventh edition, by Karen Timberlake. Uses step-by-step learning exercises to review all the basic concepts for each chapter. Each *Study Guide* section is keyed to the learning goals in *CHEMISTRY* to provide a cross-reference with the working tools. The *Study Guide* is designed to promote active learning with a variety of exercises, all with answers, and a mastery test. After checking answers, students can determine if they have mastered the material or if they need further study. In this way, areas of difficulty can be identified and the material reviewed again. For the first time, complete solutions to the odd-numbered problems from *CHEMISTRY* are included for additional understanding of the solution process in problem solving. (0-321-03691-3)

Chemistry Study Pack, Version 2.0 **CD-ROM** by Tom Hall (Windows only). This CD-ROM contains 18 interactive, multimedia tutorials and Practice Tests, which are based on the 18 chapters in this textbook. The tutorials

guide the student through the main concepts of the book, making use of video clips from *The World of Chemistry* (by The Annenberg/CPB Project) and color graphics from the book. The students practice what they learn by taking a 5-question Quick Quiz for each of the 145 sections of the book, and a 10-question Chapter Quiz at the end of each tutorial. To check their knowledge, students can take a Practice Test of up to 40 questions. The tests are scored, so the student knows how he or she is progressing. The CD can be used alone or with the *Study Guide.* The CD is included with the Media Update, but you can also order it as a stand-alone. (0-321-02977-1)

The Chemistry of Life for Introductory Chemistry CD-ROM by Robert M. Thornton of University of California, Davis. (For Mac and Windows) This lively tutorial teaches the essential concepts of chemistry through simulated lessons and interactive quizzes. With correlations to *CHEMISTRY,* this CD will help students picture atomic structure, reactions and equilibrium, properties of water, acids and bases, and the structure and function of macromolecules in a whole new light. The CD is included with the Media Update, but you can also order it as a stand-alone. (0-8053-3109-3)

For Instructors

The following items are available only to qualified adopters. To access online instructor resources, contact your Benjamin/Cummings sales representative. Visit www.aw.com and click "Find your rep." For further information or to order any of our products, please visit us at www.aw.com/bc on the World Wide Web, visit your campus bookstore, or contact our customer service department at (800) 282-0683.

Online Instructor Resources by Karen Timberlake. The Chemistry Place, Special Edition for Timberlake includes many online resources for instructors. The Instructor's Manual highlights chapter topics, provides suggestions for laboratory and lecture demonstration, and includes answers and solutions to problems in *CHEMISTRY.* Lab Exercises for both versions of the Laboratory Manual provide solutions to lab exercises. PowerPoint slides can be downloaded for classroom presentations. Visit www.chemplace.com/college/timberlake.

Benjamin Cummings Science Digital Library. This easy-to-search CD-ROM includes every figure and table from the book. The images can be exported into PowerPoint presentations, other presentation tools, and web sites. (0-8053-2981-1)

Test Bank by Karen Timberlake and Karen Wiechelman (Southeastern Louisiana University). Enhanced to include 35% more multiple-choice, true-false, and matching questions and their answers for a total of 850 test items. Available in a printed version (0-321-03694-8) as well as on TestGen-EQ software for Windows (0-321-03755-3) and Macintosh (0-321-03756-1) that lets instructors scramble questions, add new questions, and select questions based on the level of difficulty.

Transparency Acetates A set of 140 full-color transparency acetates contains key figures, tables, and illustrations from *CHEMISTRY.* (0-321-03692-1)

Videotape

Promoting Student Success in Chemistry by Karen Timberlake, developed with the University of California, Los Angeles. Shows actual student-centered classroom activities, including problem solving using collaborative learning in a large lecture setting, peer presentations, and study teams in discussion hours. (0-321-03759-6)

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