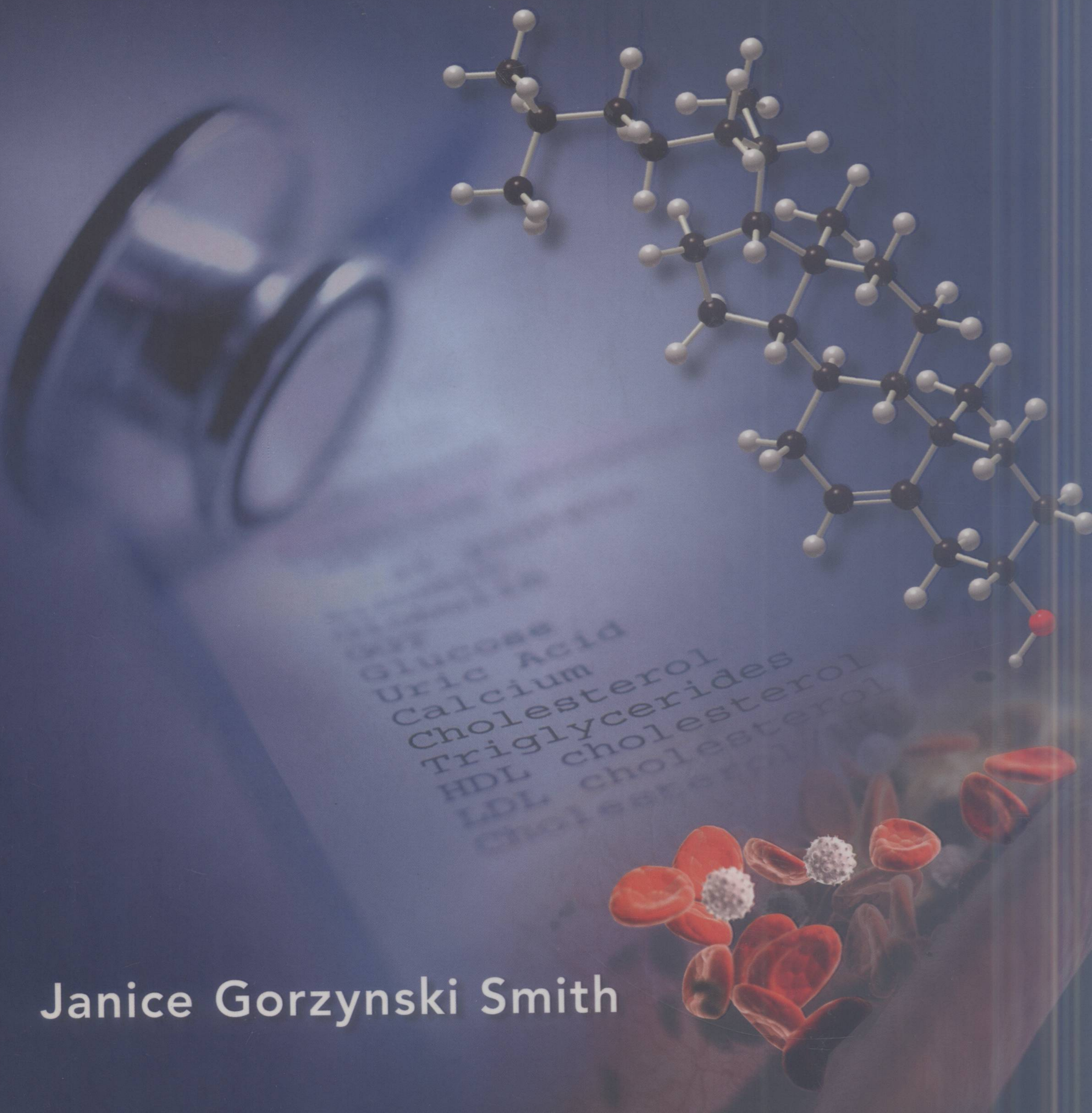
General, Organic, & Biological

CHEMISTRY



Janice Gorzynski Smith

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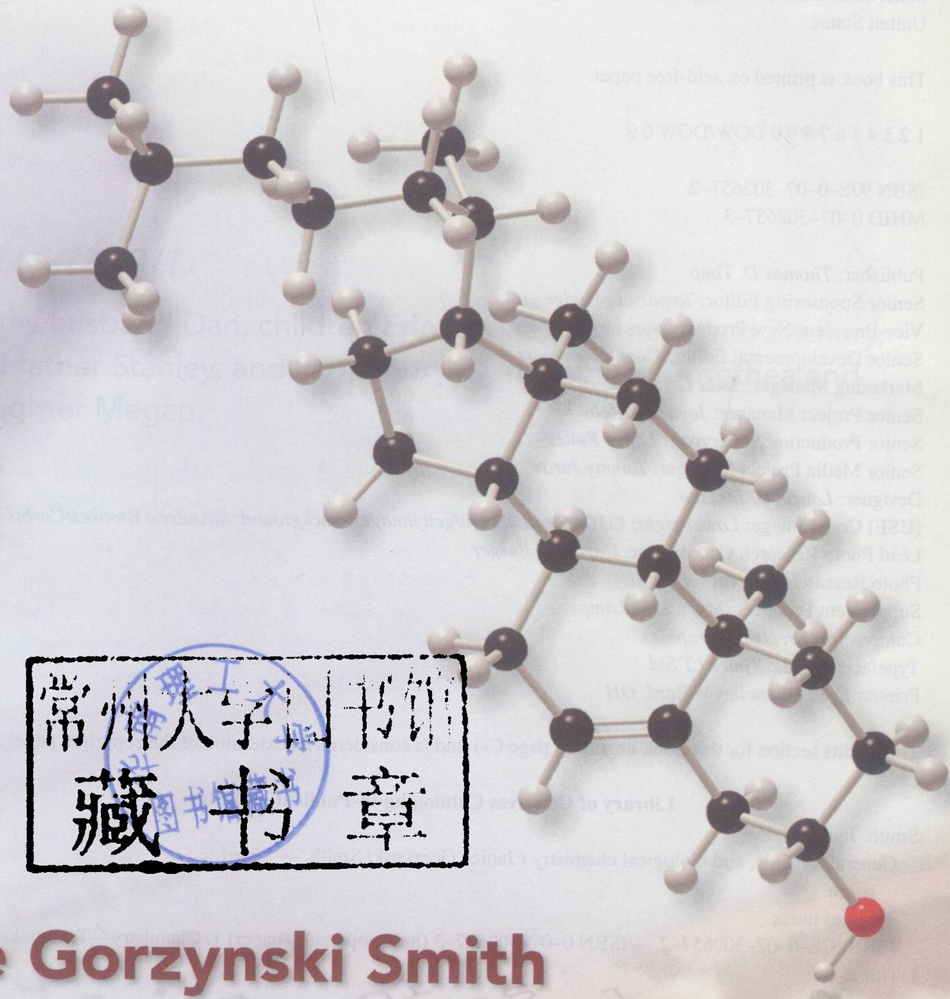

Janice Gorzynski Smith
University of Hawai'i at Mānoa

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GENERAL, ORGANIC, AND BIOLOGICAL CHEMISTRY

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THE ELEMENTS

Element	Symbol	Atomic Number	Relative Atomic Mass*	Element	Symbol	Atomic Number	Relative Atomic Mass*
Actinium	Ac	89	(227)	Mercury	Hg	80	200.59
Aluminum	Al	13	26.9815	Molybdenum	Mo	42	95.94
Americium	Am	95	(243)	Neodymium	Nd	60	144.24
Antimony	Sb	51	121.760	Neon	Ne	10	20.1797
Argon	Ar	18	39.948	Neptunium	Np	93	(237)
Arsenic	As	33	74.9216	Nickel	Ni	28	58.693
Astatine	At	85	(210)	Niobium	Nb	41	92.9064
Barium	Ba	56	137.327	Nitrogen	N	7	14.0067
Berkelium	Bk	97	(247)	Nobelium	No	102	(259)
Beryllium	Be	4	9.0122	Osmium	Os	76	190.2
Bismuth	Bi	83	208.9804	Oxygen	O	8	15.9994
Bohrium	Bh	107	(272)	Palladium	Pd	46	106.42
Boron	B	5	10.811	Phosphorus	P	15	30.9738
Bromine	Br	35	79.904	Platinum	Pt	78	195.08
Cadmium	Cd	48	112.411	Plutonium	Pu	94	(244)
Calcium	Ca	20	40.078	Polonium	Po	84	(209)
Californium	Cf	98	(251)	Potassium	K	19	39.0983
Carbon	C	6	12.011	Praseodymium	Pr	59	140.9076
Cerium	Ce	58	140.115	Promethium	Pm	61	(145)
Cesium	Cs	55	132.9054	Protactinium	Pa	91	231.03588
Chlorine	Cl	17	35.453	Radium	Ra	88	(226)
Chromium	Cr	24	51.9961	Radon	Rn	86	(222)
Cobalt	Co	27	58.9332	Rhenium	Re	75	186.207
Copper	Cu	29	63.546	Rhodium	Rh	45	102.9055
Curium	Cm	96	(247)	Roentgenium	Rg	111	(280)
Darmstadtium	Ds	110	(281)	Rubidium	Rb	37	85.4678
Dubnium	Db	105	(268)	Ruthenium	Ru	44	101.07
Dysprosium	Dy	66	162.50	Rutherfordium	Rf	104	(267)
Einsteinium	Es	99	(252)	Samarium	Sm	62	150.36
Erbium	Er	68	167.26	Scandium	Sc	21	44.9559
Europium	Eu	63	151.964	Seaborgium	Sg	106	(271)
Fermium	Fm	100	(257)	Selenium	Se	34	78.96
Fluorine	F	9	18.9984	Silicon	Si	14	28.0855
Francium	Fr	87	(223)	Silver	Ag	47	107.8682
Gadolinium	Gd	64	157.25	Sodium	Na	11	22.9898
Gallium	Ga	31	69.723	Strontium	Sr	38	87.62
Germanium	Ge	32	72.64	Sulfur	S	16	32.066
Gold	Au	79	196.9665	Tantalum	Ta	73	180.9479
Hafnium	Hf	72	178.49	Technetium	Tc	43	(98)
Hassium	Hs	108	(270)	Tellurium	Te	52	127.60
Helium	He	2	4.0026	Terbium	Tb	65	158.9253
Holmium	Ho	67	164.9303	Thallium	Tl	81	204.3833
Hydrogen	H	1	1.0079	Thorium	Th	90	232.0381
Indium	In	49	114.82	Thulium	Tm	69	168.9342
Iodine	I	53	126.9045	Tin	Sn	50	118.710
Iridium	Ir	77	192.22	Titanium	Ti	22	47.88
Iron	Fe	26	55.845	Tungsten	W	74	183.84
Krypton	Kr	36	83.80	Uranium	U	92	238.0289
Lanthanum	La	57	138.9055	Vanadium	V	23	50.9415
Lawrencium	Lr	103	(262)	Xenon	Xe	54	131.29
Lead	Pb	82	207.2	Ytterbium	Yb	70	173.04
Lithium	Li	3	6.941	Yttrium	Y	39	88.9059
Lutetium	Lu	71	174.967	Zinc	Zn	30	65.41
Magnesium	Mg	12	24.3050	Zirconium	Zr	40	91.224
Manganese	Mn	25	54.9380			112**	(285)
Meitnerium	Mt	109	(276)			114	(289)
Mendelevium	Md	101	(258)			116	(293)

*Values in parentheses represent the mass number of the most stable isotope.

**The names and symbols for elements 112, 114, and 116 have not been chosen.

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Milan Montreal New Delhi Santiago Seoul Singapore Sydney Taipei Toronto

Dedication

To my husband Dan, children Erin, Jenna, Matthew, and Zachary, and father Stanley, and in memory of my mother Dorothea and daughter Megan.

About the Author

Janice Gorzynski Smith was born in Schenectady, New York, and grew up following the Yankees, listening to the Beatles, and water skiing on Sacandaga Reservoir. She became interested in chemistry in high school, and went on to major in chemistry at Cornell University where she received an A.B. degree *summa cum laude*. Jan earned a Ph.D. in Organic Chemistry from Harvard University under the direction of Nobel Laureate E.J. Corey, and she also spent a year as a National Science Foundation National Needs Postdoctoral Fellow at Harvard. During her tenure with the Corey group, she completed the total synthesis of the plant growth hormone gibberellic acid.

Following her postdoctoral work, Jan joined the faculty of Mount Holyoke College where she was employed for 21 years. During this time she was active in teaching chemistry lecture and lab courses, conducting a research program in organic synthesis, and serving as department chair. Her organic chemistry class was named one of Mount Holyoke's "Don't-miss courses" in a survey by *Boston* magazine. After spending two sabbaticals amidst the natural beauty and diversity in Hawai'i in the 1990s, Jan and her family moved there permanently in 2000. She is currently a faculty member at the University of Hawai'i at Mānoa, where she teaches a one-semester organic and biological chemistry course for nursing students, as well as the two-semester organic chemistry lecture and lab courses. She also serves as the faculty advisor to the student affiliate chapter of the American Chemical Society. In 2003, she received the Chancellor's Citation for Meritorious Teaching.

Jan resides in Hawai'i with her husband Dan, an emergency medicine physician. She has four children: Matthew and Zachary (scuba photo on page 190); Jenna, a first-year law student at Temple University in Philadelphia; and Erin, a 2006 graduate of Brown University School of Medicine and co-author of the Student Study Guide/Solutions Manual for this text. When not teaching, writing, or enjoying her family, Jan bikes, hikes, snorkels, and scuba dives in sunny Hawai'i, and time permitting, enjoys travel and Hawai'ian quilting.

Preface

My goal in writing this text was to relate the fundamental concepts of general, organic, and biological chemistry to the world around us, and in this way illustrate how chemistry explains many aspects of everyday life. I have followed two guiding principles: use relevant and interesting applications for all basic chemical concepts, and present the material in a student-friendly fashion using bulleted lists, extensive illustrations, and step-by-step problem solving.

This text is different—by design. Since today's students rely more heavily on visual imagery to learn than ever before, this text uses less prose and more diagrams and figures to reinforce the major themes of chemistry. A key feature is the use of molecular art to illustrate and explain common phenomena we encounter every day. Each topic is broken down into small chunks of information that are more manageable and easily learned. Students are given enough detail to understand basic concepts, such as how soap cleans away dirt and why trans fats are undesirable in the diet, without being overwhelmed.

This textbook is written for students who have an interest in nursing, nutrition, environmental science, food science, and a wide variety of other health-related professions. The content of this book is designed for an introductory chemistry course with no chemistry prerequisite, and is suitable for either a two-semester sequence or a one-semester course. I have found that by introducing one new concept at a time, keeping the basic themes in focus, and breaking down complex problems into small pieces, many students in these chemistry courses acquire a new appreciation of both the human body and the larger world around them.

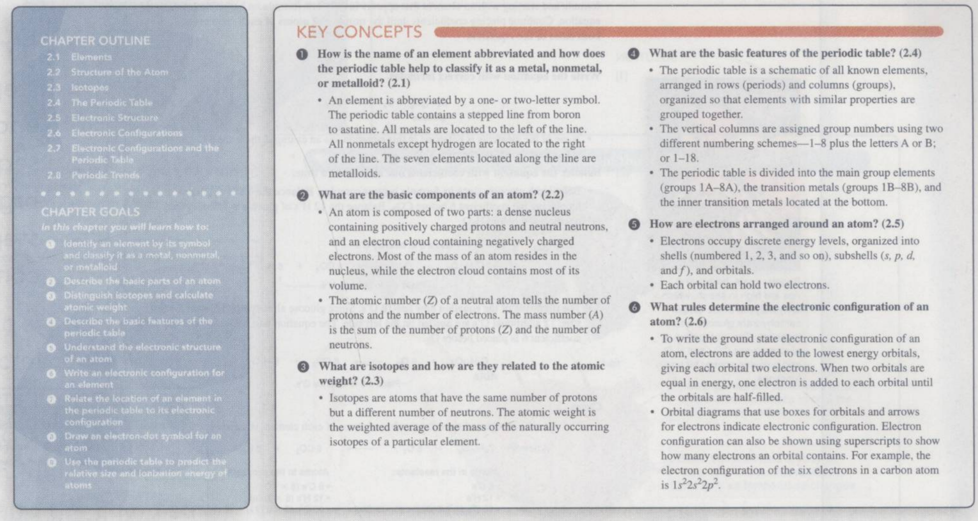
BUILDING THE TEXT

Writing a textbook is a multifaceted process. McGraw-Hill's 360° Development Process is an ongoing, never ending market-oriented approach to building accurate and innovative print and digital products. It is dedicated to continual large scale and incremental improvement, driven by multiple customer feedback loops and checkpoints. This is initiated during the early planning stages of new products and intensifies during the development and production stages, and then begins again upon publication, in anticipation of the next edition. This process is designed to provide a broad, comprehensive spectrum of feedback for refinement and innovation of learning tools, for both student and instructor. The 360° Development Process includes market research, content reviews, faculty and student focus groups, course- and product-specific symposia, accuracy checks, and art reviews, all guided by a carefully selected Board of Advisors.

THE LEARNING SYSTEM USED IN *GENERAL, ORGANIC, AND BIOLOGICAL CHEMISTRY*

- **Writing Style** A concise writing style allows students to focus on learning major concepts and themes of general, organic, and biological chemistry. Relevant materials from everyday life are used to illustrate concepts, and topics are broken into small chunks of information that are more easily learned.
- **Chapter Outline** The chapter outline lists the main headings of the chapter, to help students map out the organization of each chapter's content.

- **Chapter Goals, tied to end-of-chapter Key Concepts** The Chapter Goals at the beginning of each chapter identify what students will learn, and are tied numerically to the end-of-chapter Key Concepts, which serve as bulleted summaries of the most important concepts for study.



CHAPTER OUTLINE

2.1 Elements
2.2 Structure of the Atom
2.3 Isotopes
2.4 The Periodic Table
2.5 Electronic Structure
2.6 Electronic Configurations
2.7 Electronic Configurations and the Periodic Table
2.8 Periodic Trends

CHAPTER GOALS

In this chapter you will learn how to:

1. Identify an element by its symbol and classify it as a metal, nonmetal, or metalloid
2. Describe the basic parts of an atom
3. Distinguish isotopes and calculate atomic weight
4. Describe the basic features of the periodic table
5. Understand the electronic structure of an atom
6. Write an electronic configuration for an element
7. Relate the location of an element in the periodic table to its electronic configuration
8. Draw an electron-dot symbol for an atom
9. Use the periodic table to predict the relative size and ionization energy of atoms

KEY CONCEPTS

1. **How is the name of an element abbreviated and how does the periodic table help to classify it as a metal, nonmetal, or metalloid? (2.1)**
   - An element is abbreviated by a one- or two-letter symbol. The periodic table contains a stepped line from boron to astatine. All metals are located to the left of the line. All nonmetals except hydrogen are located to the right of the line. The seven elements located along the line are metalloids.
2. **What are the basic components of an atom? (2.2)**
   - An atom is composed of two parts: a dense nucleus containing positively charged protons and neutral neutrons, and an electron cloud containing negatively charged electrons. Most of the mass of an atom resides in the nucleus, while the electron cloud contains most of its volume.
   - The atomic number (Z) of a neutral atom tells the number of protons and the number of electrons. The mass number (A) is the sum of the number of protons (Z) and the number of neutrons.
3. **What are isotopes and how are they related to the atomic weight? (2.3)**
   - Isotopes are atoms that have the same number of protons but a different number of neutrons. The atomic weight is the weighted average of the mass of the naturally occurring isotopes of a particular element.
4. **What are the basic features of the periodic table? (2.4)**
   - The periodic table is a schematic of all known elements, arranged in rows (periods) and columns (groups), organized so that elements with similar properties are grouped together.
   - The vertical columns are assigned group numbers using two different numbering schemes—1–8 plus the letters A or B; or 1–18.
   - The periodic table is divided into the main group elements (groups 1A–8A), the transition metals (groups 1B–8B), and the inner transition metals located at the bottom.
5. **How are electrons arranged around an atom? (2.5)**
   - Electrons occupy discrete energy levels, organized into shells (numbered 1, 2, 3, and so on), subshells (*s*, *p*, *d*, and *f*), and orbitals.
   - Each orbital can hold two electrons.
6. **What rules determine the electronic configuration of an atom? (2.6)**
   - To write the ground state electronic configuration of an atom, electrons are added to the lowest energy orbitals, giving each orbital two electrons. When two orbitals are equal in energy, one electron is added to each orbital until the orbitals are half-filled.
   - Orbital diagrams that use boxes for orbitals and arrows for electrons indicate electronic configuration. Electron configuration can also be shown using superscripts to show how many electrons an orbital contains. For example, the electron configuration of the six electrons in a carbon atom is $1s^2 2s^2 2p^2$.

- **Macro-to-Micro Illustrations** Because today's students are visual learners, and because visualizing molecular-level representations of macroscopic phenomena is critical to the understanding of any chemistry course, many illustrations in this text include photos or drawings of everyday objects, paired with their molecular representation, to help students visualize and understand the chemistry behind ordinary occurrences.
- **Problem Solving** Sample Problems lead students through the thought process tied to successful problem solving by employing Analysis and Solution parts. Sample Problems are categorized sequentially by topic to match chapter organization, and are often paired with practice problems to allow students to apply what they have just learned. Students can immediately verify their answers to the follow-up problems in the appendix at the end of the book.
- **How To's** Key processes are taught to students in a straightforward and easy-to-understand manner by using examples and multiple, detailed steps to solving problems.
- **Applications** Common applications of chemistry to everyday life are found in margin-placed Health Notes, Consumer Notes, and Environmental Notes, as well as sections entitled "Focus on Health & Medicine," "Focus on the Environment," and "Focus on the Human Body."

OUR COMMITMENT TO SERVING TEACHERS AND LEARNERS

TO THE INSTRUCTOR Writing a new chemistry textbook is a colossal task. Teaching chemistry for over 20 years at both a private, liberal arts college and a large state university has given me a unique perspective with which to write this text. I have found that students arrive with vastly different levels of preparation and widely different expectations for their college experience. As an instructor and now an author I have tried to channel my love and knowledge of chemistry into a form that allows this spectrum of students to understand chemical science more clearly, and then see everyday phenomena in a new light.

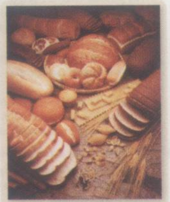
TO THE STUDENT I hope that this text and its ancillary program will help you to better understand and appreciate the world of chemistry. My interactions with thousands of students in my long teaching career have profoundly affected the way I teach and write about chemistry, so please feel free to email me with any comments or questions at jgsmith@hawaii.edu.

P.A.V.E. the Way to Student Learning

SAMPLE PROBLEM 5.2 Write a balanced equation for the reaction of glucose ($C_6H_{12}O_6$) with oxygen (O_2) to form carbon dioxide (CO_2) and water (H_2O).

ANALYSIS Balance an equation with coefficients, one element at a time, beginning with the most complex formula and starting with an element that appears in only one formula on both sides of the equation. Continue placing coefficients until the **number of atoms of each element is equal on both sides of the equation.**

SOLUTION



Bagels, pasta, bread, and rice are high in starch, which is hydrolyzed to the simple carbohydrate glucose after ingestion. The metabolism of glucose forms CO_2 and H_2O and provides energy for bodily functions.

[1] **Write the equation with correct formulas.**

$$C_6H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O$$

glucose

- None of the elements is balanced in this equation. As an example, there are 6 C's on the left side, but only 1 C on the right side.

[2] **Balance the equation with coefficients one element at a time.**

- Begin with glucose, since its formula is most complex. Balance the 6 C's of glucose by placing the coefficient 6 before CO_2. Balance the 12 H's of glucose by placing the coefficient 6 before H_2O.

Place a 6 to balance C's.

$$C_6H_{12}O_6 + O_2 \longrightarrow 6\,CO_2 + 6\,H_2O$$

Place a 6 to balance H's.

- The right side of the equation now has 18 O's. Since glucose already has 6 O's on the left side, 12 additional O's are needed on the left side. The equation will be balanced if the coefficient 6 is placed before O_2.

$$C_6H_{12}O_6 + 6\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O$$

Place a 6 to balance O's.

[3] **Check.**

- The equation is balanced since the number of atoms of each element is the same

Answer: $C_6H_{12}O_6 + 6\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O$

Atoms in the reactants:	Atoms in the products:
• 6 C's	• 6 C's (6 × 1C)
• 12 H's	• 12 H's (6 × 2H's)
• 18 O's (1 × 6 O's) + (6 × 2 O's)	• 18 O's (6 × 2 O's) + (6 ×

PROBLEM 5.4 Write a balanced equation for each reaction.

a. $H_2 + O_2 \longrightarrow H_2O$
b. $NO + O_2 \longrightarrow NO_2$
c. $Fe + O_2 \longrightarrow Fe_2O_3$
d. $CH_4 + Cl_2 \longrightarrow CH_2Cl_2 + H$

PROBLEM 5.5 Write a balanced equation for the following reaction, shown with molecular art.

Practice chemistry through stepped-out practice problems and end-of-chapter problems categorized sequentially by topic to match chapter organization. **How-To boxes** offer step-by-step strategies for difficult concepts.

HOW TO Convert Moles of Reactant to Grams of Product

EXAMPLE **In the upper atmosphere, high-energy radiation from the sun converts oxygen (O_2) to ozone (O_3). Using the balanced equation, how many grams of O_3 are formed from 9.0 mol of O_2?**

$$3\,O_2(g) \xrightarrow{\text{sunlight}} 2\,O_3(g)$$

Step [1] **Convert the number of moles of reactant to the number of moles of product using a mole–mole conversion factor.**

- Use the coefficients in the balanced chemical equation to write mole–mole conversion factors.

$$\frac{3 \text{ mol } O_2}{2 \text{ mol } O_3} \quad \text{or} \quad \frac{2 \text{ mol } O_3}{3 \text{ mol } O_2}$$

Choose this conversion factor to cancel mol O_2.

- Multiply the number of moles of starting material (9.0 mol) by the conversion factor to give the number of moles of product. In this example, 6.0 mol of O_3 are formed.

Moles of reactant → Moles of product

$$9.0 \text{ mol } O_2 \times \frac{2 \text{ mol } O_3}{3 \text{ mol } O_2} = 6.0 \text{ mol } O_3$$

Moles O_2 cancel.

Step [2] **Convert the number of moles of product to the number of grams of product using the product's molar mass.**

- Use the molar mass of the product (O_3) to write a conversion factor. The molar mass of O_3 is 48.0 g/mol (3 O atoms × 16.0 g/mol for each O atom = 48.0 g/mol).

$$\frac{1 \text{ mol } O_3}{48.0 \text{ g } O_3} \quad \text{or} \quad \frac{48.0 \text{ g } O_3}{1 \text{ mol } O_3}$$

Choose this conversion factor to cancel mol.

- Multiply the number of moles of product (from step [1]) by the conversion factor to give the number of grams of product.

Moles of product → Grams of product

$$6.0 \text{ mol } O_3 \times \frac{48.0 \text{ g } O_3}{1 \text{ mol } O_3} = 288 \text{ g, rounded to } 290 \text{ g of } O_3$$

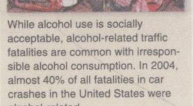
Moles cancel. **Answer**

Apply chemistry through **"Focus on Health & Medicine," "Focus on the Human Body," and "Focus on the Environment"** sections woven throughout the text. Chemistry applications are also woven into margin notes that cover topics on consumer, health, and environmental issues.

ENVIRONMENTAL NOTE

Ethanol is used as a gasoline additive. Although some of the ethanol used for this purpose comes from corn and other grains, much of it is still produced by the reaction of ethylene with water. Ethanol produced from grains is a renewable resource, whereas ethanol produced from ethylene is not, because ethylene is made from crude oil. Thus, running your car on gasohol (gasoline mixed with ethanol) reduces our reliance on fossil fuels only if the ethanol is produced from renewable sources such as grains or sugarcane.

14.6 FOCUS ON HEALTH & MEDICINE ETHANOL, THE MOST WIDELY ABUSED DRUG



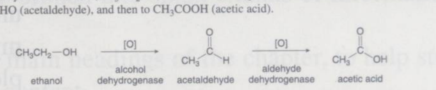
While alcohol use is socially acceptable, alcohol-related traffic fatalities are common with irresponsible alcohol consumption. In 2004, almost 40% of all fatalities in car crashes in the United States were alcohol-related.

Throughout history, humans have ingested alcoholic beverages for their pleasant taste and the feeling of euphoria they impart. Although we think of alcohol as a stimulant, largely because small amounts decrease social inhibitions, the ethanol (CH_3CH_2OH) in an alcoholic beverage actually depresses the central nervous system. The chronic and excessive consumption of alcoholic beverages has become a major health and social crisis, making ethanol the most widely abused drug in the United States. One estimate suggests that there are 40 times more alcoholics than heroin addicts.

14.6A THE METABOLISM OF ETHANOL

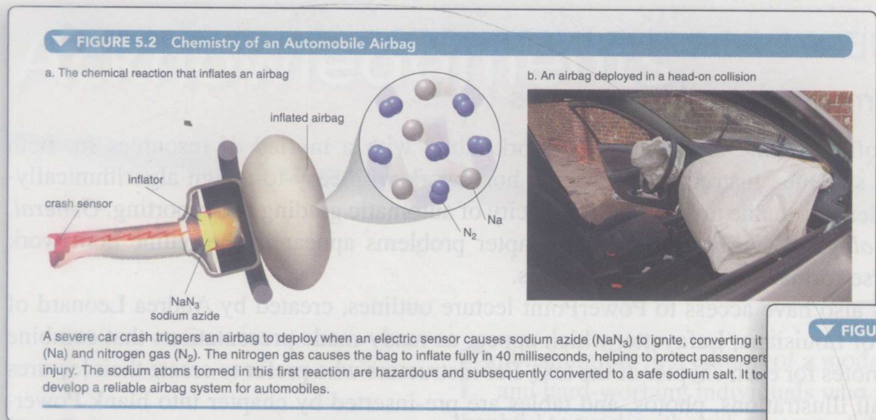
When ethanol is consumed, it is quickly absorbed in the stomach and small intestines and then rapidly transported in the bloodstream to other organs. Ethanol is metabolized in the liver, by a two-step oxidation sequence. The body does not use chromium reagents as oxidants. Instead, high molecular weight enzymes, alcohol dehydrogenase and aldehyde dehydrogenase, and a small molecule called a **coenzyme** carry out these oxidations.

The products of the biological oxidation of ethanol are the same as the products formed in the laboratory. When ethanol (CH_3CH_2OH, a 1° alcohol) is ingested, it is oxidized in the liver first to CH_3CHO (acetaldehyde), and then to CH_3COOH (acetic acid).

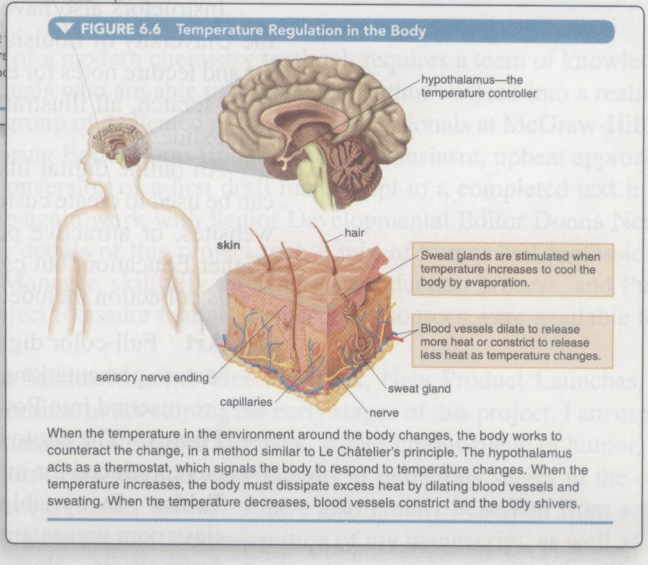


If more ethanol is ingested than can be metabolized in a given time period, the concentration of acetaldehyde accumulates. This toxic compound is responsible for the feelings associated with a hangover.

Antabuse, a drug given to alcoholics to prevent them from consuming alcoholic beverages, acts by interfering with the normal oxidation of ethanol. Antabuse inhibits the oxidation of acetaldehyde to acetic acid. Since the first step in ethanol metabolism occurs but the second does not, the concentration of acetaldehyde rises, causing an individual to become violently ill.



A severe car crash triggers an airbag to deploy when an electric sensor causes sodium azide (NaN_3) to ignite, converting it (Na) and nitrogen gas (N_2). The nitrogen gas causes the bag to inflate fully in 40 milliseconds, helping to protect passengers injury. The sodium atoms formed in this first reaction are hazardous and subsequently converted to a safe sodium salt. It too develop a reliable airbag system for automobiles.



When the temperature in the environment around the body changes, the body works to counteract the change, in a method similar to Le Châtelier's principle. The hypothalamus acts as a thermostat, which signals the body to respond to temperature changes. When the temperature increases, the body must dissipate excess heat by dilating blood vessels and sweating. When the temperature decreases, blood vessels constrict and the body shivers.

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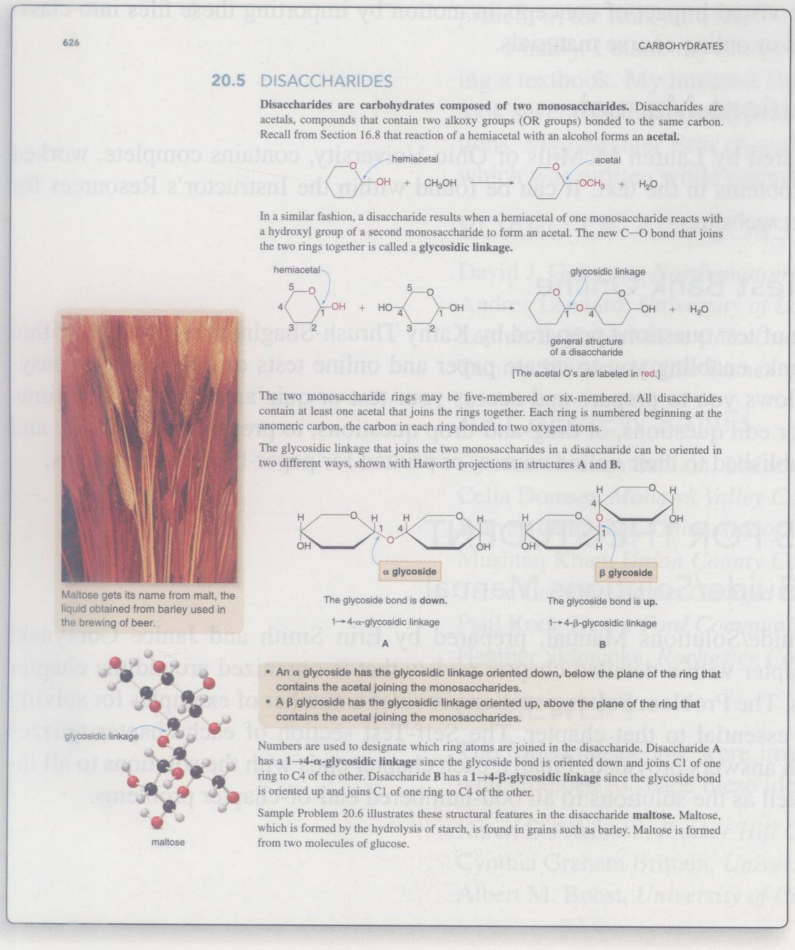

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20.5 DISACCHARIDES

Disaccharides are carbohydrates composed of two monosaccharides. Disaccharides are acetals, compounds that contain two alkoxy groups (OR groups) bonded to the same carbon. Recall from Section 16.8 that reaction of a hemiacetal with an alcohol forms an **acetal.**

In a similar fashion, a disaccharide results when a hemiacetal of one monosaccharide reacts with a hydroxyl group of a second monosaccharide to form an acetal. The new C—O bond that joins the two rings together is called a **glycosidic linkage.**

[The acetal O's are labeled in red.]

The two monosaccharide rings may be five-membered or six-membered. All disaccharides contain at least one acetal that joins the rings together. Each ring is numbered beginning at the anomeric carbon, the carbon in each ring bonded to two oxygen atoms.

The glycosidic linkage that joins the two monosaccharides in a disaccharide can be oriented in two different ways, shown with Haworth projections in structures A and B.

α glycoside — The glycoside bond is down. 1→4-α-glycosidic linkage — A

β glycoside — The glycoside bond is up. 1→4-β-glycosidic linkage — B

Maltose gets its name from malt, the liquid obtained from barley used in the brewing of beer.

- An α glycoside has the glycosidic linkage oriented down, below the plane of the ring that contains the acetal joining the monosaccharides.
- A β glycoside has the glycosidic linkage oriented up, above the plane of the ring that contains the acetal joining the monosaccharides.

Numbers are used to designate which ring atoms are joined in the disaccharide. Disaccharide A has a **1→4-α-glycosidic linkage** since the glycoside bond is oriented down and joins C1 of one ring to C4 of the other. Disaccharide B has a **1→4-β-glycosidic linkage** since the glycoside bond is oriented up and joins C1 of one ring to C4 of the other.

Sample Problem 20.6 illustrates these structural features in the disaccharide **maltose.** Maltose, which is formed by the hydrolysis of starch, is found in grains such as barley. Maltose is formed from two molecules of glucose.

glycosidic linkage

maltose

Engage students with a unique writing style that matches the method in which students learn. Key points of general, organic, and biological chemistry, along with attention-grabbing applications to consumer, environmental, and health-related fields, are woven together in a succinct style for today's to-the-point readers.

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The Student Study Guide/Solutions Manual, prepared by Erin Smith and Janice Gorzynski Smith, begins each chapter with a detailed chapter review that is organized around the chapter goals and key concepts. The Problem Solving section provides a number of examples for solving each type of problem essential to that chapter. The Self-Test section of each chapter quizzes chapter highlights, with answers provided. Finally, each chapter ends with the solutions to all in-chapter problems, as well as the solutions to all odd-numbered end-of-chapter problems.

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Publishing the first edition of a modern chemistry textbook requires a team of knowledgeable and hard-working individuals who are able to translate an author's vision into a reality. I am thankful to work with such a group of dedicated publishing professionals at McGraw-Hill. Much thanks goes to Senior Sponsoring Editor Tami Hodge, whose enthusiasm, upbeat approach, and unflinching support led the conversion of a first draft manuscript to a completed text in record time. I was privileged to once again work with Senior Developmental Editor Donna Nemmers, who managed the day-to-day details of this project with a mix of humor and professionalism. Jayne Klein, Senior Project Manager, skillfully directed the production process, and Publisher Thomas Timp guided the project to assure that all the needed resources were available to see it to completion.

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