Fundamentals of Organic and Biological Chemistry 2nd Ed

Fundamentals of Organic and Biological Chemistry

Second Edition

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Periodic Table of the Elements

Main-group elements | Transition elements | Main-group elements

Metals | Metalloids | Nonmetals | Noble gases

Period	1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 **H** 1.00794																	2 **He** 4.00260
2	3 **Li** 6.941	4 **Be** 9.01218											5 **B** 10.811	6 **C** 12.011	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.9984	10 **Ne** 20.1797
3	11 **Na** 22.9898	12 **Mg** 24.3050	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 **Al** 26.9815	14 **Si** 28.0855	15 **P** 30.9738	16 **S** 32.066	17 **Cl** 35.4527	18 **Ar** 39.948
4	19 **K** 39.0983	20 **Ca** 40.078	21 **Sc** 44.9559	22 **Ti** 47.88	23 **V** 50.9415	24 **Cr** 51.9961	25 **Mn** 54.9381	26 **Fe** 55.847	27 **Co** 58.9332	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.9216	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
5	37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.9059	40 **Zr** 91.224	41 **Nb** 92.9064	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.906	46 **Pd** 106.42	47 **Ag** 107.868	48 **Cd** 112.411	49 **In** 114.818	50 **Sn** 118.710	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.904	54 **Xe** 131.29
6	55 **Cs** 132.905	56 **Ba** 137.327	57 ***La** 138.906	72 **Hf** 178.49	73 **Ta** 180.948	74 **W** 183.84	75 **Re** 186.207	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.967	80 **Hg** 200.59	81 **Tl** 204.383	82 **Pb** 207.2	83 **Bi** 208.980	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** 226.025	89 **†Ac** 227.028	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 ** (269)	111 ** (272)	112 ** (277)						

*Lanthanide series	58 **Ce** 140.115	59 **Pr** 140.908	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.965	64 **Gd** 157.25	65 **Tb** 158.925	66 **Dy** 162.50	67 **Ho** 164.930	68 **Er** 167.26	69 **Tm** 168.934	70 **Yb** 173.04	71 **Lu** 174.967
†Actinide series	90 **Th** 232.038	91 **Pa** 231.036	92 **U** 238.029	93 **Np** 237.048	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

** Not yet named

List of the Elements with Their Atomic Symbols and Atomic Weights

Name	Symbol	Atomic Number	Atomic Weight	Name	Symbol	Atomic Number	Atomic Weight
Actinium	Ac	89	227.028	Mendelevium	Md	101	(258)
Aluminum	Al	13	26.9815	Mercury	Hg	80	200.59
Americium	Am	95	(243)	Molybdenum	Mo	42	95.94
Antimony	Sb	51	121.76	Neodymium	Nd	60	144.24
Argon	Ar	18	39.948	Neon	Ne	10	20.1797
Arsenic	As	33	74.9216	Neptunium	Np	93	237.048
Astatine	At	85	(210)	Nickel	Ni	28	58.693
Barium	Ba	56	137.327	Niobium	Nb	41	92.9064
Berkelium	Bk	97	(247)	Nitrogen	N	7	14.0067
Beryllium	Be	4	9.01218	Nobelium	No	102	(259)
Bismuth	Bi	83	208.980	Osmium	Os	76	190.23
Bohrium	Bh	107	(262)	Oxygen	O	8	15.9994
Boron	B	5	10.811	Palladium	Pd	46	106.42
Bromine	Br	35	79.904	Phosphorus	P	15	30.9738
Cadmium	Cd	48	112.411	Platinum	Pt	78	195.08
Calcium	Ca	20	40.078	Plutonium	Pu	94	(244)
Californium	Cf	98	(251)	Polonium	Po	84	(209)
Carbon	C	6	12.011	Potassium	K	19	39.0983
Cerium	Ce	58	140.115	Praseodymium	Pr	59	140.908
Cesium	Cs	55	132.905	Promethium	Pm	61	(145)
Chlorine	Cl	17	35.4527	Protactinium	Pa	91	231.036
Chromium	Cr	24	51.9961	Radium	Ra	88	226.025
Cobalt	Co	27	58.9332	Radon	Rn	86	(222)
Copper	Cu	29	63.546	Rhenium	Re	75	186.207
Curium	Cm	96	(247)	Rhodium	Rh	45	102.906
Dubnium	Db	105	(262)	Rubidium	Rb	37	85.4678
Dysprosium	Dy	66	162.50	Ruthenium	Ru	44	101.07
Einsteinium	Es	99	(252)	Rutherfordium	Rf	104	(261)
Erbium	Er	68	167.26	Samarium	Sm	62	150.36
Europium	Eu	63	151.965	Scandium	Sc	21	44.9559
Fermium	Fm	100	(257)	Seaborgium	Sg	106	(263)
Fluorine	F	9	18.9984	Selenium	Se	34	78.96
Francium	Fr	87	(223)	Silicon	Si	14	28.0855
Gadolinium	Gd	64	157.25	Silver	Ag	47	107.868
Gallium	Ga	31	69.723	Sodium	Na	11	22.9898
Germanium	Ge	32	72.61	Strontium	Sr	38	87.62
Gold	Au	79	196.967	Sulfur	S	16	32.066
Hafnium	Hf	72	178.49	Tantalum	Ta	73	180.948
Hassium	Hs	108	(265)	Technetium	Tc	43	(98)
Helium	He	2	4.00260	Tellurium	Te	52	127.60
Holmium	Ho	67	164.930	Terbium	Tb	65	158.925
Hydrogen	H	1	1.00794	Thallium	Tl	81	204.383
Indium	In	49	114.818	Thorium	Th	90	232.038
Iodine	I	53	126.904	Thulium	Tm	69	168.934
Iridium	Ir	77	192.22	Tin	Sn	50	118.710
Iron	Fe	26	55.847	Titanium	Ti	22	47.88
Krypton	Kr	36	83.80	Tungsten	W	74	183.84
Lanthanum	La	57	138.906	Uranium	U	92	238.029
Lawrencium	Lr	103	(260)	Vanadium	V	23	50.9415
Lead	Pb	82	207.2	Xenon	Xe	54	131.29
Lithium	Li	3	6.941	Ytterbium	Yb	70	173.04
Lutetium	Lu	71	174.967	Yttrium	Y	39	88.9059
Magnesium	Mg	12	24.3050	Zinc	Zn	30	65.39
Manganese	Mn	25	54.9381	Zirconium	Zr	40	91.224
Meitnerium	Mt	109	(266)				

Brief Contents

Applications and Connections

Applications

Connections

Preface

The goal of the second edition of this textbook remains the same as that of the first edition—to provide a focused introduction to the chemistry of living things. The writing style, content, and organization are directed toward students with career goals in the allied health sciences and other disciplines in which understanding the fundamentals of organic and biological chemistry is valuable.

To teach chemistry all the way from "What is an alkane?" to "How do we get energy from glucose?" is a challenge. Our experience with the first edition of this text confirms our premise that there is a wide variety of approaches to presenting this course. Thus, flexibility is of primary importance.

The material in this book is ample for a thorough, one-term introduction to organic and biological chemistry. By varying the topics covered and the time devoted to them, however, you can change the focus of the course to meet your individual needs. This edition retains our unique and well-received integrated biological chemistry sequence (described in greater detail below), which allows for the highest possible degree of flexibility.

Another matter of primary importance is student accessibility. Students in this course have their sights set well beyond academic concerns and the laboratory bench. They want to know why: Why must I study nomenclature? Why are molecular shapes important to me as a nurse, soil scientist, or nutritionist? We have therefore endeavored at every step to place chemistry in the context of applications relevant to these students' needs and interests. We have written in a clear and simple style that helps to engage students in the subject matter.

Organization

Organic Chemistry: Chapters 1–6 These chapters concisely focus on what students must know in order to get on with biochemistry. Nomenclature rules are included with the introduction to hydrocarbons (Chapters 1 and 2) and thereafter are kept to a minimum. Discussion of functional groups with single bonds to oxygen, sulfur, or a halogen (Chapter 3) is followed by a short chapter on amines (Chapter 4). After introducing aldehydes and ketones (Chapter 5), the chemistry of carboxylic acids and their derivatives (including amides) is covered with a focus on similarities among reactions of the derivatives (Chapter 6).

New to this edition:

- Classification of the kinds of organic reactions has been moved forward, from Chapter 6 to Chapter 2 (Section 2.5).
- Coverage of amines (Chapter 4) has been simplified, with their role as neurotransmitters now covered in a biochemistry chapter (Chapter 9).
- Discussion of the properties and nomenclature of carboxylic acids, esters, and amides has been reorganized to provide greater clarity (Chapter 6).

Biological Chemistry: Chapters 7–17 Rather than proceed through the complexities of protein, carbohydrate, lipid, and nucleic acid structure before getting to the roles of these compounds in the body, structure and function are integrated in this text. Protein structure (Chapter 7) is followed by enzyme and coenzyme (vitamin) chemistry (Chapter 8). After that is a new chapter that deals

with hormones, neurotransmitters, and the action of drugs (Chapter 9). With enzymes introduced, the central pathways and themes of biochemical energy production can be described (Chapter 10). (If the time you have available to cover biochemistry is limited, stop with Chapter 10 and your students will have an excellent preparation in the essentials of metabolism.) The next chapters cover carbohydrate chemistry (Chapters 11 and 12), then lipids (Chapters 13 and 14). Next we discuss nucleic acids and protein synthesis (Chapter 15). The last two chapters cover protein and amino acid metabolism (Chapter 16) and the chemistry of body fluids (Chapter 17). In this text, nutrition is not treated as a separate subject, but is integrated with the discussion of each type of biomolecule.

New to this edition:

- Discussions of biochemistry have been updated wherever appropriate.
- Sections on classification of proteins and protein folding have been reorganized for greater clarity (Chapter 7).
- Chapter 8 of the previous edition has been split so that enzymes and vitamins are covered in Chapter 8 and hormones and neurotransmitters in Chapter 9. The new Chapter 9 allows for discussion of the dramatic advances in our understanding of hormones and neurotransmitters, together with the application of this understanding to drug discovery and drug design.
- Steroid hormones are now covered with other hormones (Chapter 9).
- Coverage of nucleic acids has been moved forward (Chapter 15) to follow lipid metabolism and precede protein metabolism (Chapter 16). This order will make more logical sense to students learning the central dogma of molecular biology, and it reflects the increasing importance of an understanding of DNA and RNA for these students.
- A new section on biotechnology introduces concepts fundamental to this rapidly expanding area (Chapter 15).
- Approximately three dozen new Practice Problems within the biochemistry chapters allow students to more frequently test their understanding of this material.

Focus on Relevancy

This is typically the last chemistry course for these students. Such students often benefit from increased emphasis on the relevance and application of chemistry. In this book, we carefully balance the need for solid science with the need for interesting examples and connections.

- **Applications** are both integrated into and set off from the text. They cover a wide variety of topics, and in this edition have been completely updated where appropriate. We have also added more than 20 new boxed applications. As in the first edition, each boxed application provides sufficient information for reasonable understanding; we have avoided all gratuitous discussions. As evidence of this, each boxed application ends with a cross-reference to related end-of-chapter problems that can be solved if the student has understood the boxed material. Some favorites include Chemical Information; Protein Analysis by Electrophoresis; and Acid Salts as Food Additives; Kevlar: a Life-Saving Polymer; Enzyme Inhibitors as Drugs; Life without Sunlight; and Blood Substitutes.
- **Connections** are a new feature this edition. This series of essays focuses on former OB students who are now practicing professionals. The interviewees all explain how they use chemistry in their daily

professional lives. This feature is designed to remind students that the chemistry they are learning is important, and that a solid understanding of it will benefit them down the road.

Focus on Making Connections Among General, Organic, and Biological Chemistry

This can be a difficult course to teach. Much of what students are interested in lies in the last part of the course, but the material they need to understand the biochemistry is found in the first half. Furthermore, students often get confused and lose sight of the connections between the general chemistry they've taken before and organic and biological chemistry in this course.

- New **concept link icons** ( ) are used extensively throughout this book to indicate places where previously covered material is relevant to the discussion at hand. This is useful for cross-reference (as students refresh their memories), and these icons also serve to highlight important chemical themes as they are revisited. Special marginal references accompany each link to a concept students should remember from general chemistry. All this helps students see the patterns inherent in chemistry.
- Sometimes it's not enough to *say* that something is important; you have to explain why or how to help students stay motivated. New **Looking Ahead Notes** are used in this edition to highlight links to important future discussions. As students encounter these, they are given a glimpse of why what they are learning is of interest to them. They also have an opportunity to reread sections that may be unclear to them, but which are essential to future understanding.

In another effort to improve students' ability to master the key material in this course, we have rethought our chapter introductions and summaries. We begin every chapter with a list of goals, which phrased as a question. In each summary, we then return to that list, answering each question based on the content of the chapter.

Focus on Problem Solving

Chemistry is both a quantitative and a conceptual science. Throughout this text, we have provided students with tools to develop and assess their quantitative and qualitative understanding of the chemistry they are learning.

- Numerous **solved problems** give students step-by-step directions for solving all commonly encountered types of problems. Immediately following each worked problem is a practice problem, which gives students a chance to try solving a similar problem on their own.
- **Understanding Key Concepts problems** are new to this edition. They come at the end of each chapter, after the summary but before the more traditional problems. Understanding Key Concept problems are specifically designed to test students' mastery of the core principles developed in the chapter. Students thus have an opportunity to ask "Did I get it?" before they dive into the rest of the end-of-chapter problems.

One final word about students who could use help with their math skills: we'd like to recommend they read the math appendix, which has been expanded in this edition. Students will find that this Appendix affords them an excellent opportunity to review (or, if necessary, to learn for the first time) the use of scientific notation—a topic they will need to master if they are to succeed in this course. (Help with additional topics in math is available in *Allied Health Chemistry: A Companion*, described on the next page.)

Focus on Visualization

We have expanded and refined our highly praised use of color for emphasis in chemical structures and equations. We have also enhanced the pedagogical value of our art and diagrams by redrawing and improving consistency.

Understanding many aspects of chemistry—such as the specificity and selectivity of enzymes, or the action of drugs—requires understanding the three-dimensional nature of molecules. Unfortunately, being able to visualize things in three dimensions is difficult for many students. To help appreciate and understand molecular shapes and spatial relationships, we have added numerous, computer-calculated molecular models (both space-filling and ball-and-stick) throughout the book. The website that accompanies this text also features a gallery of molecules that students can manipulate in 3-D on their computers (more information on the website can be found below).

Making it Easier to Teach: Supplements for Instructors

Annotated Instructor's Edition of the text. Annotated by Daniel Sullivan of the University of Nebraska, this special version of the GOB version of this textbook includes marginal notes and indications of which illustrations are found in the transparency acetate set and Matter for GOB '99, the instructor's presentational CD-ROM, as well as teaching tips and suggested lecture demonstrations.

Instructor's Guide with Test Bank. Developed by Daniel M. Sullivan, University of Nebraska, and Barbara Mowery, Thomas Nelson Community College, this manual features lecture outlines with presentation suggestions, teaching tips, suggested in-class demonstrations, and topics for classroom discussion. Also included is a printed test bank with approximately 1250 true/false, multiple-choice, matching, and fill-in-the-blank questions keyed to chapters in the text. (0-13-918558-5)

Prentice Hall Custom Tests. These computerized versions of the Test Bank are available in both Windows (0-13-918566) and Macintosh versions (0-13-918574-7) and allow you to create and tailor exams to your specific needs.

Matter for GOB '99. This dual-platform CD features almost all the art from the textbook in Powerpoint-readable format. Special features include a link to the Prentice Hall website where new art files are posted for instructor download.

Transparencies. This set of four-color, overhead transparencies includes 120 acetates. (0-13-918541-0)

Making it Easier to Learn: Supplements for Students

Study Guide and Full Solutions Manual (0-13-010898-7) and **Study Guide and Selected Solutions Manual** (0-13-919408-8), both by Susan McMurry. The selected version provides solutions to only those problems that have a short answer in the text's Selected Answer appendix. Both versions explain in detail how the answers to in-text and end-of-chapter problems are obtained. They also contain chapter summaries, study hints, and self-tests for each chapter.

Allied Health Chemistry: A Companion (0-13-470460-6) by Tim Smith and Diane Vukovich, both of the University of Akron, is a friendly and practical handbook that guides students through all the mathematics they will need to be success-

ful in any introductory chemistry course. Topics covered include using a calculator, simple algebra, unit conversions, moles, stoichiometry, logarithms, and pH. The book also includes Practice Tests and Study Skills sections, with hints on taking notes, how to best use your textbook, and preparing for tests.

Focus: the McMurry/Castellion Companion Website. Designed specifically for students using this text, the GOB Companion Website features chapter summaries, practice problems for each chapter, a gallery of molecules for students to manipulate in 3-D using their computer, and links to other websites of relevance to students in this course. Please visit the site at http://www.prenhall.com/~chem.

Chemistry Skillbuilder CD ROM (dual platform) (0-13-660143-X) by Steven D. Gammon and Sharon Hutchinson, both of the University of Idaho, offers instructions, extra practice and feedback on three key chemistry topics: nomenclature, stoichiometry, and balancing equations. This CD is available free with each new copy of the text; see your local Prentice Hall representative for details.

Prentice Hall/*The New York Times Contemporary View Program.* Through this unique program, adopters of McMurry/Castellion's ***Fundamentals of General, Organic, and Biological Chemistry*** are eligible to receive Prentice Hall's innovative *New York Times* supplement for students. This newspaper-format resource brings together current chemistry-related articles from the award-winning pages of *The New York Times*—perfect for generating in-class discussion and for additional writing assignments. Free in quantity to qualified adopters through your local representative.

For the Laboratory

Exploring Chemistry: Laboratory Experiments in General, Organic and Biological Chemistry (0-13-857426-X) by Julie R. Peller of Indiana University. Written specifically to accompany ***Fundamentals of General, Organic and Biological Chemistry,*** this manual contains 33 fresh and accessible experiments specifically for GOB students.

Annotated Instructor's Manual (0-13-863137-9) by Libbie S. Pelter to **Exploring Chemistry: Laboratory Experiments in GOB** provides the instructor with goals, special instructions, chemical and equipment lists, plus answers for each experiment.

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A Guide to Using this Text

In designing this text, we have made every effort to provide you, the student, with a set of tools that can make your study of chemistry more efficient and rewarding. As you use the textbook, keep in mind that *all* the elements on each page—text, figures, molecular structures and models, equations, and the various learning aids described below—are designed to work together. Let them work for you. As with all tools, these will work best if you first learn what each is for and how it should be used. The following four-page "user's manual" will introduce you to the special features of this book and how you can take advantage of them to get the most from the time and effort you devote to studying chemistry.

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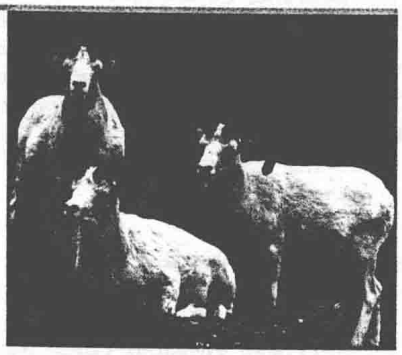
Amino Acids and Proteins

The horns, hooves, fur, and skin of these Dall rams are made largely of protein. So too are their muscles, tendons, and ligaments, as well as the hemoglobin that carries oxygen in their blood, the antibodies that protect them from disease, and the enzymes that control all their life processes.



CONTENTS

The word *protein* is a familiar one. Taken from the Greek *proteios*, meaning "primary," "protein" is an apt description for the biological molecules that are of primary importance to all living organisms. Approximately 50% of your body's dry weight is protein. Some proteins, such as the collagen in connective tissue, serve a structural purpose. Others direct responses to internal and external conditions. And still other proteins defend the body against foreign invaders. Most importantly, as enzymes, proteins catalyze almost every chemical reaction that occurs in your body. Because of their importance and the role they play in all biochemical functions, we have chosen to discuss proteins, which are polymers of amino acids, in this first chapter devoted to biochemistry.

In this chapter, we'll look at the following questions about amino acids and proteins:

1. **What are the structural features of amino acids?**
   The goal: Be able to describe and recognize amino acid structures and illustrate how they are connected in proteins.
2. **What are the properties of amino acids?**
   The goal: Be able to describe how the properties of amino acids depend on their side chains and how their ionic charges vary with pH.

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OVERVIEW AND CHAPTER GOALS

Before you start a journey, it's good to know where you're going. Each chapter opens with an outline and introduction, in order to give you an overview of the chapter's contents and how this chapter is related to previous ones. Then, a set of specific goals identifies the important themes and topics of the chapter, highlighting the information that you will need to learn and helping you to structure your study of the material even before you begin.

SUMMARY: REVISITING THE CHAPTER GOALS

The chapter summary mirrors the goals that open the chapter. Each of the questions posed at the start of the chapter is answered by a summary of the essential information needed to attain the corresponding goal.

KEY WORDS

To assist you in reviewing, all of the chapter's boldface terms are listed in alphabetical order alongside the summary. Each is cross-referenced to the page where it appears in the text.

Summary: Revisiting the Chapter Goals

1. **What are the structural features of amino acids?** *Amino acids* in body fluids have an ionized carboxylic acid group ($-COO^-$), an ionized amino group ($-NH_3^+$), and a side chain R group bonded to a central carbon atom (the α carbon). Twenty different amino acids occur in *proteins* (Table 7.3), connected by *peptide bonds* (amide bonds) formed between the carboxyl group of one amino acid and the amino group of the next.
2. **What are the properties of amino acids?** Amino acid side chains have acidic or basic functional groups or neutral groups that are either polar or nonpolar. In glycine the "side chain" is a hydrogen atom. The dipolar ion in which the amino and carboxylic acid groups are both ionized is known as a *zwitterion*. For each amino acid, there is a distinctive *isoelectric point*—the pH at which the numbers of positive and negative charges in a solution are equal. At more acidic pH, some carboxylic acid groups are not ionized; at more basic pH, some amino groups are not ionized.
3. **Why do amino acids have "handedness"?** An object, including a molecule, [illegible]

Key Words

Thus, enzymes must do more than merely speed up reactions—they must also *control* them by constantly varying their activity. At a moment's notice, they must be able to turn some reactions virtually off while catalyzing others at the maximum possible rate. Clearly, then, the enzymes themselves must be regulated. How is this regulation achieved?

A variety of strategies are utilized to control the rates of enzyme-catalyzed reactions. Any process that starts or increases the action of an enzyme is an **activation** process. Any process that slows or stops the action of an enzyme is an **inhibition** process. Although we'll describe the strategies of enzyme control one by one, keep in mind that several strategies are usually operating together. Con-

Activation (of an enzyme) Any process that initiates or increases the action of an enzyme.

Inhibition (of an enzyme) Any process that slows or stops the action of an enzyme.

Feedback control Regulation of an enzyme's activity by the product of a reaction later in a pathway.

Allosteric control An interaction in which the binding of a regulator

MARGINAL DEFINITIONS

You'll be learning many new words in this course. To help you master this vocabulary quickly, every important term appears in boldface where it is first used and is accompanied by a full definition alongside it in the margin.

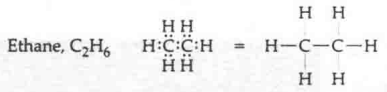
CONCEPT LINKS AND MARGINAL NOTES

Blue chain link icons show where material in the text builds on concepts from earlier chapters or important principles of general chemistry. When the needed background appears in an earlier section, a page reference helps you to find the relevant discussion for review. When it does not, a marginal note explains the concept or refers you to a fuller discussion in one of five Essential Background interchapters, which review general chemistry topics crucial to organic and biological chemistry.

- **Organic molecules have covalent bonds** ▶ . In ethane, for example, the bonds result from the sharing of two electrons, either between C and C atoms or between C and H atoms:

Covalent bonding is reviewed in Essential Background A, which follows this chapter.

Ethane, C_2H_6



LOOKING AHEAD

It's always helpful to know *why* you're studying a particular topic or learning a particular concept. Sometimes the real significance of the material being presented doesn't become fully apparent until later, when you encounter it again in a different context. These brief forward looks provide you with a preview of how the material under discussion will prove useful in a later chapter.

pounds dissolve in water to yield solutions of ions that conduct electricity, most organic compounds are insoluble in water and do not conduct electricity. Only small polar organic molecules, such as glucose and ethyl alcohol, or large molecules with many polar groups, such as some proteins, dissolve in water. This lack of water solubility for organic compounds has important practical consequences, including the difficulty in removing greasy dirt and in cleaning up environmental oil spills.

Looking Ahead

The interior of a living cell is largely a water solution containing many hundreds of different compounds. We'll see in later chapters how cells use membranes composed of water-insoluble organic molecules to enclose their watery interiors and to regulate the flow of substances across the cell boundary.

▲ Oil spills can be a serious environmental problem because of the lack of solubility of oil in water.

1.2 Families of Organic Molecules: Functional Groups

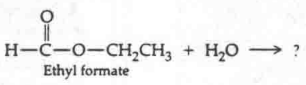
There are more than 18 *million* organic compounds described in the scientific literature. Each has unique physical properties, such as melting point and boiling point, and each has unique chemical properties. How can we ever under-

SOLVED PROBLEMS

To succeed in this course you'll have to be able to solve problems. Solved problems presented throughout the text show you how to analyze different types of problems and devise solution strategies. Then, thorough step-by-step directions show you how to work your way to the answer.

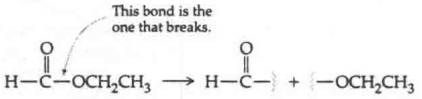
SOLVED PROBLEM 6.8

What product would you obtain from acid-catalyzed hydrolysis of ethyl formate, a flavor constituent of rum?

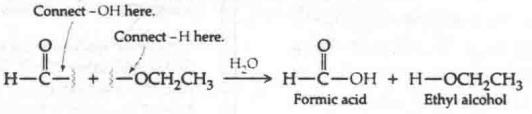


Ethyl formate

SOLUTION First, look at the name of the starting ester. Usually, the name of the ester gives a good indication of the names of the two products. Thus, ethyl formate yields ethyl alcohol and formic acid. To find the product structures in a more systematic way, write the structure of the ester and locate the bond between the carbonyl-group carbon and the –OR′ group:



Next, carry out a hydrolysis reaction on paper. First form the carboxylic acid product by connecting an –OH to the carbonyl-group carbon. Then add an –H to the $-OCH_2CH_3$ group to form the alcohol product.



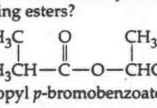
PRACTICE PROBLEMS

You can confirm your grasp of the material and hone your problem-solving skills by working the numerous practice problems that follow all important topics and solved problems in the text. (Answers to all Practice Problems can be found at the back of the book.)

PRACTICE PROBLEMS

6.20 If a bottle of aspirin tablets has the aroma of vinegar, it is time to discard those tablets. Explain why, and include a chemical equation in the explanation.

6.21 What products would you obtain from acid-catalyzed hydrolysis of the following esters?



(a) $CH_3CH(CH_3)-C(=O)-O-CH(CH_3)CH_3$ **(b)** $CH_3CH=CHCOOCH_2CH_3$

(c) Propyl *p*-bromobenzoate

Connections Sensory Evaluation Manager

Did you know you could taste a color? Teresa Pendergast does. She's in charge of sensory evaluation at a leading flavorings company, and it's her job to see that the foods that manufacturers ask them to flavor actually taste the way they're supposed to. That grape lollipop had better taste like a bunch of purple grapes—orange soda ought to be full of orange juiciness.

But tastes are funny. Make a red lollipop, but instead of flavoring it strawberry or cherry, flavor it lime. Then color another lollipop green but flavor it cherry. People will automatically say that the green one is lime and the red one is cherry, even though that's not what they're tasting at all. Terry runs sensory evaluation panels, and that interesting psychological twist makes her work a little more difficult. When she's setting up the individualized booths for each of her tasting panelists, she often must use blue, red, or yellow lights to mask subtle differences in the appearance of the foods. "If you're trying to compare two products, there might be a shade difference in color that you can't really help for some reason," she explains. "You need to camouflage that so the taster's choice is not influenced by visual cues."

Perhaps the manufacturer of a particular ranch style salad dressing would like to make a fat-free version of that dressing. It's not as easy as it sounds, because when the fat is removed from a substance both the taste and the texture change. Terry says, "When they've taken out all the fats and substituted gums or other starches, our job is to use flavors to compensate—to make it taste like their

Buttermilk might be used as a reference for the taste of sour. For other components the chemists actually make up solutions. For sweetness they use a 7% sucrose solution; for salt, a 0.1% solution in water. The panelists taste these and use them as benchmarks.

Ta[illegible] chemist[illegible] is [illegible]

CONNECTIONS INTERVIEWS
In these interviews with former chemistry students who are now practicing professionals in a variety of fields, you'll see how the chemistry that you study in this course can lay the groundwork for many diverse and interesting career paths.

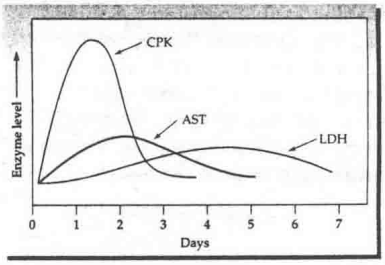
APPLICATION BOXES
These boxed discussions show how what you learn in this text provides insight into a variety of interesting subjects. Some of the topics discussed are drawn from everyday life, while others focus on aspects of clinical practice, health and nutrition, ecology, biotechnology, and chemical research.

Application Enzymes in Medical Diagnosis

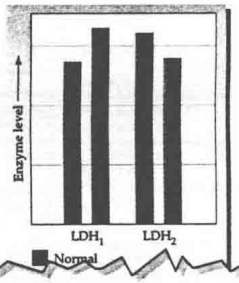
In a healthy person, certain enzymes, such as those responsible for the formation and dissolving of blood clots, are normally present in high concentration in blood serum. Other enzymes function mainly within cells and are normally in low concentration in blood serum, which they enter only during normal degeneration of healthy cells. When tissue is injured, however, large quantities of enzymes are released into the blood from dying cells, with the distribution of enzymes dependent on the identity of the injured cells. Measurement of blood levels of enzymes is therefore a valuable diagnostic tool. For example, higher than normal levels of the enzymes included in a routine blood analysis would result in the following conditions:

Aspartate transaminase (AST)	Damage to heart or liver
Alanine transaminase (ALT)	Damage to heart or liver
Lactate dehydrogenase (LH)	Damage to heart, liver, or red blood cells
Alkaline posphatase (ALP)	Damage to bone and liver cells
γ-Glutamyl transferase (GGT)	Damage to liver cells; alcoholism

Enzyme analysis relies on measuring the activity of an enzyme rather than its concentration. Because activity is influenced by pH, temperature, and substrate concentration, it is measured in international units at standard conditions: 1 unit (U) is defined as the amount [illegible]



▲ Blood levels of creatine phosphokinase (CPK), aspartate transaminase (AST), and lactate dehydrogenase (LDH) in the days following a heart attack.



CADUCEUS ICON
If you are particularly interested in topics related to medicine, health, or human biology, you will find text discussions that bear on these topics highlighted by this icon.

Water-Soluble Vitamins

Vitamins are grouped by solubility into two classes: water-soluble and fat-soluble. The water-soluble vitamins, listed in Table 8.3, are found in the aqueous environment inside cells, where most of them are needed as components of coenzymes. Over time, an assortment of names, letters, and numbers for designating the vitamins have accumulated. (One reason is that what was originally known as vitamin B turned out to be several different vitamins.) Among the water-soluble vitamins, three remain best known by letters rather than names—vitamins C, B_6, and B_{12}. Structurally, the water-soluble vitamins have in common the presence of –OH, –COOH, or other polar groups that impart their water solubility, but otherwise they range from simple molecules like vitamin C to quite large and complex structures like vitamin B_{12}.

Vitamin C is biologically active without any change in structure from the

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