## **Brief Contents**

1	Structure and Bonding 1
2	Polar Covalent Bonds; Acids and Bases 34
3	Organic Compounds: Alkanes and Their Stereochemistry 74
4	Organic Compounds: Cycloalkanes and Their Stereochemistry 108
5	Stereochemistry at Tetrahedral Centers 142
6	An Overview of Organic Reactions 184
7	Alkenes: Structure and Reactivity 222
8	Alkenes: Reactions and Synthesis 262
9	Alkynes: An Introduction to Organic Synthesis 314
10	Organohalides 344
11	Reactions of Alkyl Halides: Nucleophilic Substitutions and Eliminations 372
12	Structure Determination: Mass Spectrometry and Infrared Spectroscopy 424
13	Structure Determination: Nuclear Magnetic Resonance Spectroscopy 456
14	Conjugated Compounds and Ultraviolet Spectroscopy 500
15	Benzene and Aromaticity 534
16	Chemistry of Benzene: Electrophilic Aromatic Substitution 566
17	Alcohols and Phenols 620
18	Ethers and Epoxides; Thiols and Sulfides 676
. •	Preview of Carbonyl Chemistry 712
19	Aldehydes and Ketones: Nucleophilic Addition Reactions 722
20	Carboxylic Acids and Nitriles 778
21	Carboxylic Acid Derivatives: Nucleophilic Acyl Substitution Reactions 814
22	Carbonyl Alpha-Substitution Reactions 870
23	Carbonyl Condensation Reactions 904
24	Amines and Heterocycles 944
25	Biomolecules: Carbohydrates 1000
26	Biomolecules: Amino Acids, Peptides, and Proteins 1044
27	Biomolecules: Lipids 1088
28	Biomolecules: Nucleic Acids 1128
29	The Organic Chemistry of Metabolic Pathways 1154
30	Orbitals and Organic Chemistry: Pericyclic Reactions 1214
31	Synthetic Polymers 1242
	APPENDIX A: Nomenclature of Polyfunctional Organic Compounds A-1
	APPENDIX B: Acidity Constants for Some Organic Compounds A-8
	APPENDIX C: Glossary A-10 APPENDIX D: Answers to In-Text Problems A-28
	INDEX 1-1

## Contents

Structure and Bonding 1	1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 1.10 1.11	Atomic Structure: The Nucleus 2 Atomic Structure: Orbitals 3 Atomic Structure: Electron Configurations 5 Development of Chemical Bonding Theory 6 Describing Chemical Bonds: Valence Bond Theory 9 sp³ Hybrid Orbitals and the Structure of Methane 11 sp³ Hybrid Orbitals and the Structure of Ethane 12 sp² Hybrid Orbitals and the Structure of Ethylene 13 sp Hybrid Orbitals and the Structure of Acetylene 16 Hybridization of Nitrogen, Oxygen, Phosphorus, and Sulfur 17 Describing Chemical Bonds: Molecular Orbital Theory 19 Drawing Chemical Structures 21 A DEEPER LOOK: Organic Foods: Risk versus Benefit 24 Summary 25 Key words 25 Working Problems 26 Exercises 26
Polar Covalent Bonds; Acids and Bases 34	2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 2.10 2.11 2.12	Polar Covalent Bonds: Electronegativity 34 Polar Covalent Bonds: Dipole Moments 37 Formal Charges 39 Resonance 42 Rules for Resonance Forms 43 Drawing Resonance Forms 45 Acids and Bases: The Brønsted–Lowry Definition 48 Acid and Base Strength 50 Predicting Acid–Base Reactions from pKa Values 52 Organic Acids and Organic Bases 54 Acids and Bases: The Lewis Definition 56 Noncovalent Interactions Between Molecules 60 A DEEPER LOOK: Alkaloids: From Cocaine to Dental Anesthetics 63 Summary 64 Key words 64 Exercises 65

3.1 3.2 3.3 3.4 3.5 3.6 3.7	Functional Groups 74 Alkanes and Alkane Isomers 80 Alkyl Groups 84 Naming Alkanes 87 Properties of Alkanes 92 Conformations of Ethane 94 Conformations of Other Alkanes 96 A DEEPER LOOK: Gasoline 100 Summary 101 Key words 101 Exercises 102	Organic Compounds: Alkanes and Their Stereochemistry 74
4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9	Naming Cycloalkanes 109 Cis–Trans Isomerism in Cycloalkanes 111 Stability of Cycloalkanes: Ring Strain 114 Conformations of Cycloalkanes 116 Conformations of Cyclohexane 118 Axial and Equatorial Bonds in Cyclohexane 120 Conformations of Monosubstituted Cyclohexanes 123 Conformations of Disubstituted Cyclohexanes 126 Conformations of Polycyclic Molecules 129 A DEEPER LOOK: Molecular Mechanics 132 Summary 133 Key words 133 Exercises 134	4 Organic Compounds: Cycloalkanes and Their Stereochemistry 108
5.1 5.2 5.3 5.4 5.5 5.6 5.7 5.8 5.9 5.10 5.11 5.12	Enantiomers and the Tetrahedral Carbon 143 The Reason for Handedness in Molecules: Chirality 144 Optical Activity 147 Pasteur's Discovery of Enantiomers 150 Sequence Rules for Specifying Configuration 150 Diastereomers 156 Meso Compounds 159 Racemic Mixtures and the Resolution of Enantiomers 161 A Review of Isomerism 164 Chirality at Nitrogen, Phosphorus, and Sulfur 165 Prochirality 167 Chirality in Nature and Chiral Environments 170 A DEEPER LOOK: Chiral Drugs 172 Summary 173 Key words 173 Exercises 174	Stereochemistry at Tetrahedral Centers 142

An Overview of Organic Reactions 184	6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10 6.11	Kinds of Organic Reactions 184 How Organic Reactions Occur: Mechanisms 186 Radical Reactions 187 Polar Reactions 190 An Example of a Polar Reaction: Addition of HBr to Ethylene 194 Using Curved Arrows in Polar Reaction Mechanisms 197 Describing a Reaction: Equilibria, Rates, and Energy Changes 200 Describing a Reaction: Bond Dissociation Energies 203 Describing a Reaction: Energy Diagrams and Transition States 205 Describing a Reaction: Intermediates 208 A Comparison Between Biological Reactions and Laboratory Reactions 210 A DEEPER LOOK: Where Do Drugs Come From? 213 Summary 214 Key words 214 Exercises 215
Alkenes: Structure and Reactivity 222	7.1 7.2 7.3 7.4 7.5 7.6 7.7 7.8 7.9 7.10 7.11	Industrial Preparation and Use of Alkenes 223 Calculating Degree of Unsaturation 224 Naming Alkenes 226 Cis-Trans Isomerism in Alkenes 229 Alkene Stereochemistry and the <i>E,Z</i> Designation 231 Stability of Alkenes 234 Electrophilic Addition Reactions of Alkenes 237 Orientation of Electrophilic Additions: Markovnikov's Rule 240 Carbocation Structure and Stability 243 The Hammond Postulate 246 Evidence for the Mechanism of Electrophilic Additions: Carbocation Rearrangements 249 A DEEPER LOOK: Bioprospecting: Hunting for Natural Products 251 Summary 252 Key words 252 Exercises 253
8 Alkenes: Reactions and Synthesis 262	8.1 8.2 8.3 8.4 8.5 8.6	Preparing Alkenes: A Preview of Elimination Reactions 263 Halogenation of Alkenes: Addition of X <sub>2</sub> 264 Halohydrins from Alkenes: Addition of HOX 267 Hydration of Alkenes: Addition of H <sub>2</sub> O by Oxymercuration 269 Hydration of Alkenes: Addition of H <sub>2</sub> O by Hydroboration 272 Reduction of Alkenes: Hydrogenation 276

8.7	Oxidation of Alkenes: Epoxidation and Hydroxylation 281	
8.8	Oxidation of Alkenes: Cleavage to Carbonyl Compounds 284	
8.9	Addition of Carbenes to Alkenes: Cyclopropane Synthesis 287	
8.10	Radical Additions to Alkenes: Chain-Growth Polymers 289	
8.11	Biological Additions of Radicals to Alkenes 294	
8.12	Reaction Stereochemistry: Addition of H <sub>2</sub> O to an Achiral Alkene 296	
8.13	Reaction Stereochemistry: Addition of H <sub>2</sub> O to a Chiral Alkene 297  A DEEPER LOOK: Terpenes: Naturally Occurring Alkenes 299	
	Summary 300 Key words 300 Learning Reactions 301 Summary of Reactions 301 Exercises 304	
9.1	Naming Alkynes 314	9
9.2	Preparation of Alkynes: Elimination Reactions of Dihalides 316	
9.3	Reactions of Alkynes: Addition of HX and X <sub>2</sub> 316	Alkynes: An
9.4	Hydration of Alkynes 319	Introduction
9.5	Reduction of Alkynes 322	to Organic
9.6	Oxidative Cleavage of Alkynes 325	Synthesis 314
9.7	Alkyne Acidity: Formation of Acetylide Anions 325	
9.8	Alkylation of Acetylide Anions 327	
9.9	An Introduction to Organic Synthesis 329	
	A DEEPER LOOK: The Art of Organic Synthesis 333	
	Summary 334	
	Key words 334	
	Summary of Reactions 335 Exercises 337	
10.1	Names and Properties of Alkyl Halides 345	10
10.2	Preparing Alkyl Halides from Alkanes: Radical Halogenation 347	Organobalidas 244
10.3	Preparing Alkyl Halides from Alkenes: Allylic Bromination 349	Organohalides 344
10.4	Stability of the Allyl Radical: Resonance Revisited 351	
10.5	Preparing Alkyl Halides from Alcohols 354	
10.6	Reactions of Alkyl Halides: Grignard Reagents 355	
10.7	Organometallic Coupling Reactions 357	
10.8	Oxidation and Reduction in Organic Chemistry 360	
	A DEEPER LOOK: Naturally Occurring Organohalides 362	
	Summary 363 Key words 363	
	Summary of Reactions 364 Exercises 365	

Reactions of Alkyl Halides: Nucleophilic Substitutions and Eliminations 372	11.1 11.2 11.3 11.4 11.5 11.6 11.7 11.8 11.9 11.10 11.11	The Discovery of Nucleophilic Substitution Reactions 372 The S <sub>N</sub> 2 Reaction 375 Characteristics of the S <sub>N</sub> 2 Reaction 378 The S <sub>N</sub> 1 Reaction 385 Characteristics of the S <sub>N</sub> 1 Reaction 389 Biological Substitution Reactions 395 Elimination Reactions: Zaitsev's Rule 397 The E2 Reaction and the Deuterium Isotope Effect 399 The E2 Reaction and Cyclohexane Conformation 403 The E1 and E1cB Reactions 405 Biological Elimination Reactions 407 A Summary of Reactivity: S <sub>N</sub> 1, S <sub>N</sub> 2, E1, E1cB, and E2 407 A DEEPER LOOK: Green Chemistry 409 Summary 411 Key words 411 Summary of Reactions 412 Exercises 413
12 Structure Determination: Mass Spectrometry and Infrared Spectroscopy 424	12.1 12.2 12.3 12.4 12.5 12.6 12.7 12.8	Mass Spectrometry of Small Molecules: Magnetic-Sector Instruments 424 Interpreting Mass Spectra 426 Mass Spectrometry of Some Common Functional Groups 431 Mass Spectrometry in Biological Chemistry: Time-of-Flight (TOF) Instruments 433 Spectroscopy and the Electromagnetic Spectrum 434 Infrared Spectroscopy 437 Interpreting Infrared Spectra 438 Infrared Spectra of Some Common Functional Groups 442 A DEEPER LOOK: X-Ray Crystallography 447 Summary 448 Key words 448 Exercises 448
13 Structure Determination: Nuclear Magnetic Resonance Spectroscopy 456	13.1 13.2 13.3 13.4 13.5 13.6 13.7 13.8 13.9	Nuclear Magnetic Resonance Spectroscopy 456 The Nature of NMR Absorptions 458 Chemical Shifts 461  13C NMR Spectroscopy: Signal Averaging and FT–NMR 463 Characteristics of 13C NMR Spectroscopy 464 DEPT 13C NMR Spectroscopy 467 Uses of 13C NMR Spectroscopy 470  14 NMR Spectroscopy and Proton Equivalence 471 Chemical Shifts in 14 NMR Spectroscopy 474 Integration of 14 NMR Absorptions: Proton Counting 476

13.11 13.12 13.13	Spin–Spin Splitting in <sup>1</sup> H NMR Spectra 476 More Complex Spin–Spin Splitting Patterns 482 Uses of <sup>1</sup> H NMR Spectroscopy 484  A DEEPER LOOK: Magnetic Resonance Imaging (MRI) 486 Summary 486 Key words 486 Exercises 487	
14.1 14.2	Stability of Conjugated Dienes: Molecular Orbital Theory 501 Electrophilic Additions to Conjugated Dienes: Allylic Carbocations 505	14 Conjugated
14.3	Kinetic versus Thermodynamic Control of Reactions 508	Compounds and
14.4	The Diels–Alder Cycloaddition Reaction 510	Ultraviolet
14.5	Characteristics of the Diels–Alder Reaction 511	Spectroscopy 500
14.6	Diene Polymers: Natural and Synthetic Rubbers 516	
14.7	Structure Determination in Conjugated Systems: Ultraviolet Spectroscopy 517	
14.8	Interpreting Ultraviolet Spectra: The Effect of Conjugation 520	
14.9	Conjugation, Color, and the Chemistry of Vision 521	
	A DEEPER LOOK: Photolithography 523	
	Summary 524 Key words 524 Summary of Reactions 525 Exercises 525	
15.1	Sources and Names of Aromatic Compounds 535	15
15.2	Structure and Stability of Benzene 538	
15.3	Aromaticity and the Hückel $4n + 2$ Rule 541	Benzene and
15.4	Aromatic Ions 544	Aromaticity 534
15.5	Aromatic Heterocycles: Pyridine and Pyrrole 546	
15.6	Polycyclic Aromatic Compounds 549	
15.7	Spectroscopy of Aromatic Compounds 551	
	A DEEPER LOOK: Aspirin, NSAIDs, and COX-2 Inhibitors 554	<b>V</b>
	Summary 556 Key words 556 Exercises 557	
16.1	Electrophilic Aromatic Substitution Reactions: Bromination 567	16
16.2	Other Aromatic Substitutions 570	Chemistry of Benzene:
16.3	Alkylation and Acylation of Aromatic Rings: The Friedel–Crafts Reaction 575	Electrophilic Aromatic Substitution 566
16.4	Substituent Effects in Substituted Aromatic Rings 580	<b>30031110111 300</b>
16.5	An Explanation of Substituent Effects 582	

	16.6 16.7 16.8 16.9 16.10 16.11	Trisubstituted Benzenes: Additivity of Effects 590 Nucleophilic Aromatic Substitution 591 Benzyne 594 Oxidation of Aromatic Compounds 596 Reduction of Aromatic Compounds 599 Synthesis of Polysubstituted Benzenes 600 A DEEPER LOOK: Combinatorial Chemistry 605 Summary 606 Key words 606 Summary of Reactions 607
17 Alcohols and Phenols 620	17.1 17.2 17.3 17.4	Naming Alcohols and Phenols 621 Properties of Alcohols and Phenols 623 Preparation of Alcohols: A Review 628 Alcohols from Carbonyl Compounds: Reduction 630
	17.5 17.6 17.7 17.8 17.9 17.10 17.11	Alcohols from Carbonyl Compounds: Grignard Reaction 634 Reactions of Alcohols 638 Oxidation of Alcohols 645 Protection of Alcohols 648 Phenols and Their Uses 650 Reactions of Phenols 652 Spectroscopy of Alcohols and Phenols 654 A DEEPER LOOK: Ethanol: Chemical, Drug, Poison 658 Summary 659 Key words 659 Summary of Reactions 659 Exercises 662
18 Ethers and Epoxides; Thiols and Sulfides 676	18.1 18.2 18.3 18.4 18.5 18.6 18.7 18.8 18.9	Names and Properties of Ethers 677 Synthesis of Ethers 678 Reactions of Ethers: Acidic Cleavage 681 Reactions of Ethers: Claisen Rearrangement 683 Cyclic Ethers: Epoxides 685 Reactions of Epoxides: Ring-Opening 686 Crown Ethers 690 Thiols and Sulfides 691 Spectroscopy of Ethers 695 A DEEPER LOOK: Epoxy Resins and Adhesives 697 Summary 698 Key words 698 Summary of Reactions 699 Exercises 701

I II III IV	Kinds of Carbonyl Compounds 712 Nature of the Carbonyl Group 714 General Reactions of Carbonyl Compounds 714 Summary 720	Preview of Carbonyl Chemistry 712
19.1 19.2 19.3 19.4 19.5 19.6 19.7 19.8 19.9 19.10 19.11 19.12 19.13	Naming Aldehydes and Ketones 723 Preparing Aldehydes and Ketones 725 Oxidation of Aldehydes and Ketones 727 Nucleophilic Addition Reactions of Aldehydes and Ketones 728 Nucleophilic Addition of $H_2O$ : Hydration 731 Nucleophilic Addition of HCN: Cyanohydrin Formation 733 Nucleophilic Addition of Hydride and Grignard Reagents: Alcohol Formation 734 Nucleophilic Addition of Amines: Imine and Enamine Formation 736 Nucleophilic Addition of Hydrazine: The Wolff–Kishner Reaction 741 Nucleophilic Addition of Alcohols: Acetal Formation 742 Nucleophilic Addition of Phosphorus Ylides: The Wittig Reaction 746 Biological Reductions 749 Conjugate Nucleophilic Addition to $\alpha$ , $\beta$ -Unsaturated Aldehydes	19 Aldehydes and Ketones: Nucleophilic Addition Reactions 722
19.14	and Ketones 751 Spectroscopy of Aldehydes and Ketones 756 A DEEPER LOOK: Enantioselective Synthesis 760 Summary 761 Key words 761 Summary of Reactions 762 Exercises 764	
20.1 20.2 20.3 20.4 20.5 20.6 20.7 20.8	Naming Carboxylic Acids and Nitriles 779 Structure and Properties of Carboxylic Acids 782 Biological Acids and the Henderson–Hasselbalch Equation 785 Substituent Effects on Acidity 786 Preparing Carboxylic Acids 789 Reactions of Carboxylic Acids: An Overview 791 Chemistry of Nitriles 792 Spectroscopy of Carboxylic Acids and Nitriles 797 A DEEPER LOOK: Vitamin C 799 Summary 800 Key words 800 Summary of Reactions 802 Exercises 803	20 Carboxylic Acids and Nitriles 778

21	21.1	Naming Carboxylic Acid Derivatives 815
<del></del>	21.2	Nucleophilic Acyl Substitution Reactions 818
Carboxylic Acid Derivatives:	21.3	Nucleophilic Acyl Substitution Reactions of Carboxylic Acids 823
Nucleophilic Acyl	21.4	Chemistry of Acid Halides 830
Substitution	21.5	Chemistry of Acid Anhydrides 834
Reactions 814	21.6	Chemistry of Esters 836
	21.7	Chemistry of Amides 842
	21.8	Chemistry of Thioesters and Acyl Phosphates: Biological Carboxylic Acid Derivatives 845
	21.9	Polyamides and Polyesters: Step-Growth Polymers 847
1/304	21.10	Spectroscopy of Carboxylic Acid Derivatives 851
		A DEEPER LOOK: β-Lactam Antibiotics 853
		Summary 854
		Key words 854
		Summary of Reactions 855 Exercises 858
		Excitises 556
22	22.1	Keto-Enol Tautomerism 871
Carbonyl Alpha-	22.2	Reactivity of Enols: The Mechanism of Alpha-Substitution Reactions 873
Substitution	22.3	Alpha Halogenation of Aldehydes and Ketones 874
Reactions 870	22.4	Alpha Bromination of Carboxylic Acids 876
	22.5	Acidity of Alpha Hydrogen Atoms: Enolate Ion Formation 877
	22.6	Reactivity of Enolate Ions 881
	22.7	Alkylation of Enolate Ions 882
		A DEEPER LOOK: Barbiturates 890
		Summary 892
		Key words 892 Summary of Reactions 892
		Exercises 894
	00.4	Carbonyl Condensations: The Aldol Reaction 904
23	23.1	
<b>Carbonyl Condensation</b>	23.2 23.3	Carbonyl Condensations versus Alpha Substitutions 907 Dehydration of Aldol Products: Synthesis of Enones 908
Reactions 904	23.4	Using Aldol Reactions in Synthesis 910
	23.4	Mixed Aldol Reactions 912
A Property of the second	23.5	Intramolecular Aldol Reactions 913
A TOO	23.6	The Claisen Condensation Reaction 915
	23.8	Mixed Claisen Condensations 917
STATE OF THE PARTY	20.0	WINCE CHISCH COHECHSCHOOLS ST

23.9	Intramolecular Claisen Condensations: The Dieckmann Cyclization 919	
23.10	Conjugate Carbonyl Additions: The Michael Reaction 921	
23.11	Carbonyl Condensations with Enamines: The Stork Reaction 924	
23.12	The Robinson Annulation Reaction 927	
23.13	Some Biological Carbonyl Condensation Reactions 928	
	A DEEPER LOOK: A Prologue to Metabolism 930	
	Summary 932	
	Key words 932	
	Summary of Reactions 933 Exercises 934	
	Exercises 934	
24.1	Naming Amines 944	24
24.2	Structure and Properties of Amines 947	Amines and
24.3	Basicity of Amines 948	
24.4	Basicity of Arylamines 952	Heterocycles 944
24.5	Biological Amines and the Henderson–Hasselbalch Equation 954	
24.6	Synthesis of Amines 955	
24.7	Reactions of Amines 963	
24.8	Reactions of Arylamines 966	
24.9	Heterocyclic Amines 972	
24.10	Spectroscopy of Amines 979	
	A DEEPER LOOK: Green Chemistry II: Ionic Liquids 982	
	Summary 984	
	Key words 984	
	Summary of Reactions 985 Exercises 987	
	Exercises 507	
25.1	Classification of Carbohydrates 1001	25
25.2	Depicting Carbohydrate Stereochemistry: Fischer Projections 1002	Biomolecules:
25.3	D,L Sugars 1006	Carbohydrates 1000
25.4	Configurations of Aldoses 1008	
25.5	Cyclic Structures of Monosaccharides: Anomers 1011	
25.6	Reactions of Monosaccharides 1015	-11110
25.7	The Eight Essential Monosaccharides 1023	
25.8	Disaccharides 1025	
25.9	Polysaccharides and Their Synthesis 1028	

	25.10 25.11	Other Important Carbohydrates 1031 Cell-Surface Carbohydrates and Influenza Viruses 1031 A DEEPER LOOK: Sweetness 1033 Summary 1034 Key words 1034 Summary of Reactions 1035 Exercises 1036
26 Biomolecules: Amino Acids, Peptides, and Proteins 1044	26.1 26.2 26.3 26.4 26.5 26.6 26.7 26.8 26.9 26.10 26.11	Structures of Amino Acids 1045 Amino Acids and the Henderson–Hasselbalch Equation: Isoelectric Points 1050 Synthesis of Amino Acids 1053 Peptides and Proteins 1056 Amino Acid Analysis of Peptides 1058 Peptide Sequencing: The Edman Degradation 1059 Peptide Synthesis 1062 Automated Peptide Synthesis: The Merrifield Solid-Phase Method 1064 Protein Structure 1066 Enzymes and Coenzymes 1068 How Do Enzymes Work? Citrate Synthase 1071 A DEEPER LOOK: The Protein Data Bank 1076 Summary 1077 Key words 1077 Summary of Reactions 1078 Exercises 1079
27 Biomolecules: Lipids 1088	27.1 27.2 27.3 27.4 27.5 27.6 27.7	Waxes, Fats, and Oils 1088 Soap 1092 Phospholipids 1094 Prostaglandins and Other Eicosanoids 1095 Terpenoids 1098 Steroids 1107 Biosynthesis of Steroids 1112 A DEEPER LOOK: Saturated Fats, Cholesterol, and Heart Disease 1118 Summary 1119 Key words 1119 Exercises 1119
28 Biomolecules: Nucleic Acids 1128	28.1 28.2 28.3	Nucleotides and Nucleic Acids 1128 Base Pairing in DNA: The Watson–Crick Model 1131 Replication of DNA 1133

28.4 28.5 28.6 28.7 28.8	Transcription of DNA 1135 Translation of RNA: Protein Biosynthesis 1137 DNA Sequencing 1140 DNA Synthesis 1142 The Polymerase Chain Reaction 1145 A DEEPER LOOK: DNA Fingerprinting 1146 Summary 1147 Key words 1147 Exercises 1148	
29.1 29.2 29.3 29.4 29.5 29.6 29.7 29.8 29.9 29.10	An Overview of Metabolism and Biochemical Energy 1154 Catabolism of Triacylglycerols: The Fate of Glycerol 1158 Catabolism of Triacylglycerols: β-Oxidation 1162 Biosynthesis of Fatty Acids 1167 Catabolism of Carbohydrates: Glycolysis 1173 Conversion of Pyruvate to Acetyl CoA 1181 The Citric Acid Cycle 1185 Carbohydrate Biosynthesis: Gluconeogenesis 1191 Catabolism of Proteins: Deamination 1197 Some Conclusions about Biological Chemistry 1202 A DEEPER LOOK: Statin Drugs 1203 Summary 1204 Key words 1204 Exercises 1205	29 The Organic Chemistry of Metabolic Pathways 1154
30.1 30.2 30.3 30.4 30.5 30.6 30.7 30.8 30.9	Molecular Orbitals of Conjugated Pi Systems 1214 Electrocyclic Reactions 1217 Stereochemistry of Thermal Electrocyclic Reactions 1219 Photochemical Electrocyclic Reactions 1221 Cycloaddition Reactions 1222 Stereochemistry of Cycloadditions 1224 Sigmatropic Rearrangements 1226 Some Examples of Sigmatropic Rearrangements 1228 A Summary of Rules for Pericyclic Reactions 1231 A DEEPER LOOK: Vitamin D, the Sunshine Vitamin 1232 Summary 1233 Key words 1233 Exercises 1234	30 Orbitals and Organic Chemistry: Pericyclic Reactions 1214

31 Synthetic Polymers

1242



31.1	Chain-Growth Polymers 1242	
31.2	Stereochemistry of Polymerization: Ziegler–Natta Catalysts	
31.3	Copolymers 1246	
31.4	Step-Growth Polymers 1248	
31.5	Olefin Metathesis Polymerization 1251	
31.6	Polymer Structure and Physical Properties 1253	
	A DEEPER LOOK: Biodegradable Polymers 1256	

Summary 1258 Key words 1258 Exercises 1258

**APPENDIX A: Nomenclature of Polyfunctional Organic Compounds** A-1

**APPENDIX B: Acidity Constants for Some Organic Compounds** A-8

**APPENDIX C: Glossary** A-10

APPENDIX D: Answers to In-Text Problems A-28

INDEX I-1