# Contents



# A Review of General Chemistry: Electrons, Bonds, and Molecular Properties 1

- 1.1 Introduction to Organic Chemistry 2
- 1.2 The Structural Theory of Matter 3
- 1.3 Electrons, Bonds, and Lewis Structures 4
- 1.4 Identifying Formal Charges 8
- 1.5 Induction and Polar Covalent Bonds 9
- PRACTICALLY SPEAKING Electrostatic Potential Maps 12
- 1.6 Atomic Orbitals 12
- 1.7 Valence Bond Theory 16
- 1.8 Molecular Orbital Theory 17
- 1.9 Hybridized Atomic Orbitals 18
- 1.10 VSEPR Theory: Predicting Geometry 25
- 1.11 Dipole Moments and Molecular Polarity 30
- 1.12 Intermolecular Forces and Physical Properties 34
- PRACTICALLY SPEAKING Biomimicry and Gecko Feet 36
- MEDICALLY SPEAKING Drug-Receptor Interactions 40

#### 1.13 Solubility 41

Review of Concepts & Vocabulary • Key Terminology SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems

2....

### Molecular Representations 49

- 2.1 Molecular Representations 50
- 2.2 Bond-Line Structures 52
- 2.3 Identifying Functional Groups 57
- 2.4 Carbon Atoms with Formal Charges 58

- 2.5 Identifying Lone Pairs 59
- 2.6 Three-Dimensional Bond-Line Structures 63
- MEDICALLY SPEAKING Identifying the Pharmacophore 64
- 2.7 Introduction to Resonance 66
- 2.8 Curved Arrows 68
- 2.9 Formal Charges in Resonance Structures 71
- 2.10 Drawing Resonance Structures via Pattern Recognition 73
- 2.11 Assessing Relative Importance of Resonance Structures 79
- 2.12 Delocalized and Localized Lone Pairs 83

Review of Concepts & Vocabulary • Key Terminology SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



- 3.1 An Introduction to Brønsted-Lowry Acids and Bases 95
- 3.2 Flow of Electron Density: Curved Arrow Notation 95
- MEDICALLY SPEAKING Antacids and Heartburn 98
- 3.3 Brønsted-Lowry Acidity: A Quantitative Perspective 99
- MEDICALLY SPEAKING Drug Distribution and pK<sub>a</sub> 106
- 3.4 Brønsted-Lowry Acidity: Qualitative Perspective 107
- 3.5 Position of Equilibrium and Choice of Reagents 120
- 3.6 Choice of Solvent 123
- 3.7 Solvating Effects 124
- 3.8 Counterions 125
- PRACTICALLY SPEAKING Baking Soda versus Baking Powder 126
- 3.9 Lewis Acids and Bases 127

Review of Concepts & Vocabulary • Key Terminology SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



the Reagent

8.13 Substituti

Alkanes and Cycloalkanes 136

- 4.1 Introduction to Alkanes 137
- 4.2 Nomenclature of Alkanes 137
- PRACTICALLY SPEAKING Pheromones: Chemical Messengers 142
- MEDICALLY SPEAKING Naming Drugs 150
- 4.3 Constitutional Isomers of Alkanes 151
- 4.4 Relative Stability of Isomeric Alkanes 152
- 4.5 Sources and Uses of Alkanes 153
- PRACTICALLY SPEAKING An Introduction to Polymers 155
- 4.6 Drawing Newman Projections 155
- 4.7 Conformational Analysis of Ethane and Propane 157
- 4.8 Conformational Analysis of Butane 159
- MEDICALLY SPEAKING Drugs and Their Conformations 163
- 4.9 Cycloalkanes 164
- 4.10 Conformations of Cyclohexane 166
- 4.11 Drawing Chair Conformations 167
- 4.12 Monosubstituted Cyclohexane 169
- 4.13 Disubstituted Cyclohexane 172
- 4.14 cis-trans Stereoisomerism 177
- 4.15 Polycyclic Systems 178

Review of Concepts & Vocabulary • Key Terminology SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



### Stereoisomerism 188

- 5.1 Overview of Isomerism 189
- 5.2 Introduction to Stereoisomerism 192
- PRACTICALLY SPEAKING The Sense of Smell 198
- 5.3 Designating Configuration Using the Cahn-Ingold-Prelog System 199
- MEDICALLY SPEAKING Chiral Drugs 204

5.4 Optical Activity 205

- 5.5 Stereoisomeric Relationships: Enantiomers and Diastereomers 210
- 5.6 Symmetry and Chirality 214
- 5.7 Fischer Projections 219
- 5.8 Conformationally Mobile Systems 221
- 5.9 Resolution of Enantiomers 222

Review of Concepts & Vocabulary • Key Terminology SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems

IMPRAETICALLY STREAM



# Chemical Reactivity and Mechanisms 233

- 6.1 Enthalpy 234
- 6.2 Entropy 237
- 6.3 Gibbs Free Energy 240
- PRACTICALLY SPEAKING Explosives 241
- PRACTICALLY SPEAKING Do Living Organisms Violate the Second Law of Thermodynamics? 242
- 6.4 Equilibria 243
- 6.5 Kinetics 245
- MEDICALLY SPEAKING Nitroglycerin: An Explosive with Medicinal Properties 248
- PRACTICALLY SPEAKING Beer-Making 249
- 6.6 Reading Energy Diagrams 250
- 6.7 Nucleophiles and Electrophiles 253
  - 6.8 Mechanisms and Arrow Pushing 257
  - 6.9 Combining the Patterns of Arrow Pushing 263
  - 6.10 Drawing Curved Arrows 265
  - 6.11 Carbocation Rearrangements 268

Review of Concepts & Vocabulary • Key Terminology SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems

8.6 Possible Mechanishie for Birninkarion 1946/darrageri 4.61
8.7 The E2 Mechanism 348 587 slorid to noitsrageri 3.61
8.8 Drawing the Products of an E2 Reaction 361
8.9 The E1 Mechanism 922 aiv storools to noitsrageri 0.61
8.10 Drawing the Complete Nechanism An To noitsrageri 8.61
8.11 Drawing the Complete Mechanism 362 v11A 2103M

E2 Process 372

# 7-0

# Substitution Reactions 281

- 7.1 Introduction to Substitution Reactions 282
- 7.2 Alkyl Halides 283
- 7.3 Possible Mechanisms for Substitution Reactions 287
- 7.4 The S<sub>N</sub>2 Mechanism 290
- PRACTICALLY SPEAKING S<sub>N</sub>2 Reactions in Biological Systems—Methylation 296
- 7.5 The S<sub>N</sub>1 Mechanism 297
- **7.6** Drawing the Complete Mechanism of an  $S_N$ 1 Reaction 303
- 7.7 Drawing the Complete Mechanism of an S<sub>N</sub>2 Reaction 311
- 7.8 Determining Which Mechanism Predominates 314
- 7.9 Selecting Reagents to Accomplish Functional Group Transformation 321
- MEDICALLY SPEAKING Pharmacology and Drug
   Design 324

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



# Alkenes: Structure and Preparation via Elimination Reactions 333

- 8.1 Introduction to Elimination Reactions 334
- 8.2 Alkenes in Nature and in Industry 334
- PRACTICALLY SPEAKING Pheromones to Control Insect Populations 335
- 8.3 Nomenclature of Alkenes 337
- 8.4 Stereoisomerism in Alkenes 340
- 8.5 Alkene Stability 344
- 8.6 Possible Mechanisms for Elimination 346
- 8.7 The E2 Mechanism 348
- 8.8 Drawing the Products of an E2 Reaction 361
- 8.9 The E1 Mechanism 362
- 8.10 Drawing the Complete Mechanism of an E1 Process 367
- 8.11 Drawing the Complete Mechanism of an E2 Process 372

- 8.12 Substitution vs. Elimination: Identifying the Reagent 373
- 8.13 Substitution vs. Elimination: Identifying the Mechanism(s) 377
- 8.14 Substitution vs. Elimination: Predicting the Products 381

Review of Synthetically Useful Elimination Reactions Review of Concepts & Vocabulary • Key Terminology SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems

Addition Reactions of Alkenes 394

- 9.1 Introduction to Addition Reactions 395
- 9.2 Addition vs. Elimination: A Thermodynamic Perspective 396
- 9.3 Hydrohalogenation 397
- PRACTICALLY SPEAKING Cationic Polymerization and Polystyrene 405
- 9.4 Acid-Catalyzed Hydration 406
- PRACTICALLY SPEAKING Industrial Production of Ethanol 410
- 9.5 Oxymercuration-Demercuration 410
- 9.6 Hydroboration-Oxidation 412
- 9.7 Catalytic Hydrogenation 418
- PRACTICALLY SPEAKING Partially Hydrogenated Fats and Oils 424
- 9.8 Halogenation and Halohydrin Formation 425
- 9.9 Anti Dihydroxylation 430
- 9.10 Syn Dihydroxylation 433
- 9.11 Oxidative Cleavage 434
- 9.12 Predicting Products of an Addition Reaction 436
- 9.13 Synthesis Strategies 438

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems

# 10 Alkynes 454

#### 10.1 Introduction to Alkynes 455

- MEDICALLY SPEAKING The Role of Molecular Rigidity 456
- PRACTICALLY SPEAKING Conducting Organic Polymers 457
- 10.2 Nomenclature of Alkynes 457
- 10.3 Acidity of Acetylene and Terminal Alkynes 460
- 10.4 Preparation of Alkynes 463
- 10.5 Reduction of Alkynes 464
- 10.6 Hydrohalogenation of Alkynes 468
- 10.7 Hydration of Alkynes 471
- 10.8 Halogenation of Alkynes 477
- 10.9 Ozonolysis of Alkynes 477
- 10.10 Alkylation of Terminal Alkynes 478
- 10.11 Synthesis Strategies 479

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



#### **Radical Reactions 490**

- 11.1 Radicals 491
- 11.2 Common Patterns in Radical Mechanisms 496
- 11.3 Chlorination of Methane 500
- 11.4 Thermodynamic Considerations for Halogenation Reactions 503
- 11.5 Regioselectivity of Halogenation 506
- 11.6 Stereochemistry of Halogenation 509
- 11.7 Allylic Bromination 512
- 11.8 Atmospheric Chemistry and the Ozone Layer 514
- PRACTICALLY SPEAKING Fighting Fires with Chemicals 516
- 11.9 Autooxidation and Antioxidants 517
- MEDICALLY SPEAKING Why is an Overdose of Acetaminophen Fatal? 520
- 11.10 Addition of HBr: Anti-Markovnikov Addition 521
- 11.11 Radical Polymerization 525

#### 11.12 Radical Processes in the Petrochemical Industry 528

#### **11.13** Halogenation as a Synthetic Technique 528

Review of Synthetically Useful Radical Reactions Review of Concepts & Vocabulary • Key Terminology SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



12.1 One-Step Syntheses 537
12.2 Functional Group Transformations 538
12.3 Reactions that Change the Carbon Skeleton 543
MEDICALLY SPEAKING Vitamins 545
12.4 How to Approach a Synthesis Problem 546
MEDICALLY SPEAKING The Total Synthesis of Vitamin B<sub>12</sub> 548
12.5 Retrosynthetic Analysis 549
PRACTICALLY SPEAKING Retrosynthetic Analysis 557
12.6 Practical Tips for Increasing Proficiency 557

Review of Concepts & Vocabulary • Key Terminology SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



#### Alcohols and Phenols 56

- 13.1 Structure and Properties of Alcohols 565
- MEDICALLY SPEAKING Chain Length as a Factor in Drug Design 570
- 13.2 Acidity of Alcohols and Phenols 571
- 13.3 Preparation of Alcohols via Substitution or Addition 574
- 13.4 Preparation of Alcohols via Reduction 575
- 13.5 Preparation of Diols 583
- PRACTICALLY SPEAKING Antifreeze 584
- 13.6 Preparation of Alcohols via Grignard Reagents 584
- 13.7 Protection of Alcohols 588
- 13.8 Preparation of Phenols 590
- MEDICALLY SPEAKING Phenols as Antifungal Agents 591

- 13.9 Reactions of Alcohols: Substitution and Elimination 591
- PRACTICALLY SPEAKING Drug Metabolism 595
- 13.10 Reactions of Alcohols: Oxidation 597
- PRACTICALLY SPEAKING Breath Tests to Measure Blood Alcohol Level 598
- 13.11 Biological Redox Reactions 601
- PRACTICALLY SPEAKING Biological Oxidation of Methanol and Ethanol 602
- 13.12 Oxidation of Phenol 603

#### 13.13 Synthesis Strategies 604

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



# Ethers and Epoxides; Thiols and Sulfides 622

- 14.1 Introduction to Ethers 623
- 14.2 Nomenclature of Ethers 623
- 14.3 Structure and Properties of Ethers 626
- MEDICALLY SPEAKING Ethers as Inhalation Anesthetics 627
- 14.4 Crown Ethers 628
- MEDICALLY SPEAKING Polyether Antibiotics 630
- 14.5 Preparation of Ethers 630
- 14.6 Reactions of Ethers 633
- 14.7 Nomenclature of Epoxides 636
- MEDICALLY SPEAKING Epothilones as Novel Anticancer Agents 637
- 14.8 Preparation of Epoxides 637
- MEDICALLY SPEAKING Active Metabolites and Drug Interactions 640
- 14.9 Enantioselective Epoxidation 641
- 14.10 Ring-Opening Reactions of Epoxides 643
- PRACTICALLY SPEAKING Ethylene Oxide as a Sterilizing Agent for Sensitive Medical Equipment 646
- MEDICALLY SPEAKING Cigarette Smoke and Carcinogenic Epoxides 651
- 14.11 Thiols and Sulfides 652
- 14.12 Synthesis Strategies Involving Epoxides 656

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems

# Infrared Spectroscopy and Mass Spectrometry 671

and mass opecarometry o

15.1 Introduction to Spectroscopy 671

- PRACTICALLY SPEAKING Microwave Ovens 674
- 15.2 IR Spectroscopy 674
- MEDICALLY SPEAKING IR Thermal Imaging for Cancer Detection 675
- 15.3 Signal Characteristics: Wavenumber 677
- 15.4 Signal Characteristics: Intensity 681
- PRACTICALLY SPEAKING IR Spectroscopy for Testing Blood Alcohol Levels 684
- 15.5 Signal Characteristics: Shape 684
- 15.6 Analyzing an IR Spectrum 688
- 15.7 Using IR Spectroscopy to Distinguish between Two Compounds 693
- 15.8 Introduction to Mass Spectrometry 695
- PRACTICALLY SPEAKING Mass Spectrometry for Detecting Explosives 696
- 15.9 Analyzing the (M)<sup>+•</sup> Peak 697
- 15.10 Analyzing the (M+1) +\* Peak 698
- 15.11 Analyzing the (M+2) \*\* Peak 700
- 15.12 Analyzing the Fragments 702
- 15.13 High Resolution Mass Spectrometry 705
- 15.14 Gas Chromatography—Mass Spectrometry 707
- 15.15 Mass Spectrometry of Large Biomolecules 708
- 15.16 Hydrogen Deficiency Index: Degrees of Unsaturation 708

Review of Concepts & Vocabulary • Key Terminology SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems

# Nuclear Magnetic Resonance Spectroscopy 718

- 16.1 Introduction to NMR Spectroscopy 719
- 16.2 Acquiring a <sup>1</sup>H NMR Spectrum 721
- 16.3 Characteristics of a <sup>1</sup>H NMR Spectrum 723
- 16.4 Number of Signals 723
- 16.5 Chemical Shift 730

- 16.6 Integration 736
- 16.7 Multiplicity 739
- 16.8 Drawing the Expected <sup>1</sup>H NMR Spectrum of a Compound 747
- 16.9 Using <sup>1</sup>H NMR Spectroscopy to Distinguish between Compounds 749
- MEDICALLY SPEAKING Detection of Impurities in Heparin Sodium Using <sup>1</sup>H NMR Spectroscopy 751
- 16.10 Analyzing a <sup>1</sup>H NMR Spectrum 751
- 16.11 Acquiring a <sup>13</sup>C NMR Spectrum 754
- 16.12 Chemical Shifts in <sup>13</sup>C NMR Spectroscopy 755
- 16.13 DEPT <sup>13</sup>C NMR Spectroscopy 757
- MEDICALLY SPEAKING Magnetic Resonance Imaging (MRI) 759

Review of Concepts & Vocabulary • Key Terminology SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems

Conjugated Pi Systems and Pericyclic Reactions 768

- 17.1 Classes of Dienes 769
- 17.2 Conjugated Dienes 770
- 17.3 Molecular Orbital Theory 772
- 17.4 Electrophilic Addition 776
- 17.5 Thermodynamic Control vs. Kinetic Control 779
- PRACTICALLY SPEAKING Natural and Synthetic Rubbers 782
- 17.6 An Introduction to Pericyclic Reactions 783
- 17.7 Diels-Alder Reactions 784
- 17.8 MO Description of Cycloadditions 790
- **17.9** Electrocyclic Reactions 792
- 17.10 Sigmatropic Rearrangements 798
- MEDICALLY SPEAKING The Photoinduced Biosynthesis of Vitamin D 800
- 17.11 UV-VIS Spectroscopy 800
- PRACTICALLY SPEAKING Sunscreens 805
- 17.12 Color 806
- PRACTICALLY SPEAKING Bleach 806
- 17.13 The Chemistry of Vision 807

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



# Aromatic Compounds 817

18.1 Introduction to Aromatic Compounds 818

- PRACTICALLY SPEAKING What Is Coal? 819
- 18.2 Nomenclature of Benzene Derivatives 819
- 18.3 Structure of Benzene 823
- 18.4 Stability of Benzene 823
- PRACTICALLY SPEAKING Molecular Cages 828

18.5 Aromatic Compounds Other than Benzene 830

- MEDICALLY SPEAKING The Development of Nonsedating Antihistamines 837
- 18.6 Reactions at the Benzylic Position 839
- 18.7 Reduction of the Aromatic Moiety 843
- 18.8 Spectroscopy of Aromatic Compounds 846
- PRACTICALLY SPEAKING Buckyballs and Nanotubes 849

Review of Reactions • Key Terminology

Review of Concepts & Vocabulary • SkillBuilder Review Practice Problems • Integrated Problems • Challenge Problems



# Aromatic Substitution Reactions 858

- 19.1 Introduction to Electrophilic Aromatic Substitution 859
- 19.2 Halogenation 860
- MEDICALLY SPEAKING Halogenation
   in Drug Design 863
- 19.3 Sulfonation 863
- PRACTICALLY SPEAKING What Are Those Colors in Fruity Pebbles? 865
- 19.4 Nitration 866
- 19.5 Friedel–Crafts Alkylation 867
- MEDICALLY SPEAKING The Discovery of Prodrugs 868
- 19.6 Friedel–Crafts Acylation 871
- 19.7 Activating Groups 873
- 19.8 Deactivating Groups 877
- 19.9 Halogens: The Exception 879
- 19.10 Determining the Directing Effects of a Substituent 881
- 19.11 Multiple Substituents 884

- 19.12 Synthesis Strategies 891
- 19.13 Nucleophilic Aromatic Substitution 898
- 19.14 Elimination-Addition 900
- 19.15 Identifying the Mechanism of an Aromatic Substitution Reaction 902

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



## Aldehydes and Ketones 915

- 20.1 Introduction to Aldehydes and Ketones 916
- 20.2 Nomenclature 917
- 20.3 Preparing Aldehydes and Ketones: A Review 920
- 20.4 Introduction to Nucleophilic Addition Reactions 921
- 20.5 Oxygen Nucleophiles 923
- MEDICALLY SPEAKING Acetals as Prodrugs 930
- 20.6 Nitrogen Nucleophiles 931
- PRACTICALLY SPEAKING Beta-Carotene and Vision 935
- 20.7 Mechanism Strategies 940
- MEDICALLY SPEAKING Prodrugs 944
- 20.8 Sulfur Nucleophiles 945
- 20.9 Hydrogen Nucleophiles 946
- 20.10 Carbon Nucleophiles 947
- PRACTICALLY SPEAKING Cyanohydrin Derivatives in Nature 950
- 20.11 Baeyer-Villiger Oxidation of Aldehydes and Ketones 954
- 20.12 Synthesis Strategies 955
- 20.13 Spectroscopic Analysis of Aldehydes and Ketones 959

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



Carboxylic Acids and Their Derivatives 970

- **21.1** Introduction to Carboxylic Acids 971
- 21.2 Nomenclature of Carboxylic Acids 972
- 21.3 Structure and Properties of Carboxylic Acids 973
- 21.4 Preparation of Carboxylic Acids 977
- 21.5 Reactions of Carboxylic Acids 978
- 21.6 Introduction to Carboxylic Acid Derivatives 979
- MEDICALLY SPEAKING Sedatives 981
- 21.7 Reactivity of Carboxylic Acid Derivatives 983
- 21.8 Preparation and Reactions of Acid Chlorides 991
- 21.9 Preparation and Reactions of Acid Anhydrides 997
- MEDICALLY SPEAKING How does Aspirin Work? 999
- 21.10 Preparation of Esters 999
- 21.11 Reactions of Esters 1001
- PRACTICALLY SPEAKING How Soap is Made 1002
- MEDICALLY SPEAKING Esters as Prodrugs 1004
- 21.12 Preparation and Reactions of Amides 1006
- PRACTICALLY SPEAKING Polyamides and Polyesters 1007
- MEDICALLY SPEAKING Beta-Lactam Antibiotics 1010
- 21.13 Preparation and Reactions of Nitriles 1011
- 21.14 Synthesis Strategies 1013
- 21.15 Spectroscopy of Carboxylic Acids and Their Derivatives 1019

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



- 22.1 Introduction to Alpha Carbon Chemistry: Enols and Enolates 1031
- 22.2 Alpha Halogenation of Enols and Enolates 1038

#### 22.3 Aldol Reactions 1043

- PRACTICALLY SPEAKING Muscle Power 1046
- PRACTICALLY SPEAKING Why Meat from Younger Animals is Softer 1050

- 22.4 Claisen Condensations 1054
- 22.5 Alkylation of the Alpha Position 1057
- 22.6 Conjugate Addition Reactions 1065
- MEDICALLY SPEAKING Glutathione Conjugation and Biological Michael Reactions 1068

#### 22.7 Synthesis Strategies 1072

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems

23 Amines 1089

- 23.1 Introduction to Amines 1090
- MEDICALLY SPEAKING Drug Metabolism Studies 1091
- 23.2 Nomenclature of Amines 1092
- 23.3 Properties of Amines 1094
- MEDICALLY SPEAKING Fortunate Side Effects 1096
- MEDICALLY SPEAKING Amine Ionization and Drug Distribution 1101
- 23.4 Preparation of Amines: A Review 1101
- 23.5 Preparation of Amines via Substitution Reactions 1102
- 23.6 Preparation of Amines via Reductive Amination 1106
- 23.7 Synthesis Strategies 1108
- 23.8 Acylation of Amines 1111
- 23.9 The Hofmann Elimination 1112
- 23.10 Reactions of Amines with Nitrous Acid 1115
- 23.11 Reactions of Aryldiazonium lons 1118
- 23.12 Nitrogen Heterocycles 1123
- MEDICALLY SPEAKING H<sub>2</sub>-Receptor Antagonists and the Development of Cimetidine 1124
- 23.13 Spectroscopy of Amines 1126

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



- 24.1 Introduction to Carbohydrates 1140
- 24.2 Classification of Monosaccharides 1140
- 24.3 Configuration of Aldoses 1143
- 24.4 Configuration of Ketoses 1145
- 24.5 Cyclic Structures of Monosaccharides 1146
- 24.6 Reactions of Monosaccharides 1154
- MEDICALLY SPEAKING Diseases Associated with Insufficient Glycoside Formation 1156

24.7 Disaccharides 1162

- MEDICALLY SPEAKING Lactose Intolerance 1165
- PRACTICALLY SPEAKING Artificial Sweeteners 1166
- 24.8 Polysaccharides 1167
- 24.9 Amino Sugars 1168
- 24.10 N-Glycosides 1169
- MEDICALLY SPEAKING Aminoglycoside Antibiotics 1170

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



# Amino Acids, Peptides, and Proteins 1182

- 25.1 Introduction to Amino Acids, Peptides and Proteins 1183
- 25.2 Structure and Properties of Amino Acids 1184
- PRACTICALLY SPEAKING Nutrition and Sources of Amino Acids 1186
- PRACTICALLY SPEAKING Forensic Chemistry and Fingerprint Detection 1191
- 25.3 Amino Acid Synthesis 1191
- 25.4 Structure of Peptides 1196
- MEDICALLY SPEAKING Polypeptide Antibiotics 1202
- 25.5 Sequencing a Peptide 1203

#### 25.6 Peptide Synthesis 1205

#### 25.7 Protein Structure 1214

 MEDICALLY SPEAKING Diseases Caused by Misfolded Proteins 1217

#### 25.8 Protein Function 1218

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



### Lipids 1229

- 26.1 Introduction to Lipids 1230
- 26.2 Waxes 1231
- 26.3 Triglycerides 1232
- 26.4 Reactions of Triglycerides 1235
- PRACTICALLY SPEAKING Soaps vs. Synthetic
   Detergents 1240
- 26.5 Phospholipids 1244
- MEDICALLY SPEAKING Selectivity of Antifungal Agents 1247

#### 26.6 Steroids 1248

- MEDICALLY SPEAKING Cholesterol and Heart Disease 1251
- MEDICALLY SPEAKING Anabolic Steroids and Competitive Sports 1253

#### 26.7 Prostaglandins 1254

 MEDICALLY SPEAKING NSAIDs and COX-2 Inhibitors 1256

#### 26.8 Terpenes 1257

Review of Synthetically Useful Reactions Review of Concepts & Vocabulary • Key Terminology SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems



# Synthetic Polymers 1268

- 27.1 Introduction to Synthetic Polymers 1269
- 27.2 Nomenclature of Synthetic Polymers 1269
- 27.3 Copolymers 1271
- 27.4 Polymer Classification by Reaction Type 1273
- 27.5 Polymer Classification by Mode of Assembly 1281
- 27.6 Polymer Classification by Structure 1283
- 27.7 Polymer Classification by Properties 1286
- PRACTICALLY SPEAKING Safety Glass and Car Windshields 1288

27.8 Polymer Recycling 1289

Review of Reactions • Review of Concepts & Vocabulary Key Terminology • SkillBuilder Review • Practice Problems Integrated Problems • Challenge Problems

### Glossary A-1

#### Credits A-12

Index I-1

Mainburge All Streaking Amines and and Durge an

- The sector sectors in the sector
- A PRACTICALLY LOLAR DAY Munche Prever 1046
- Animals is Sother 1050