<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Covalent Bonding and Shapes of Molecules</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Acids and Bases</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>Alkanes and Cycloalkanes</td>
<td>61</td>
</tr>
<tr>
<td>4</td>
<td>Alkenes and Alkynes</td>
<td>103</td>
</tr>
<tr>
<td>5</td>
<td>Reactions of Alkenes and Alkynes</td>
<td>123</td>
</tr>
<tr>
<td>6</td>
<td>Chirality: The Handedness of Molecules</td>
<td>160</td>
</tr>
<tr>
<td>7</td>
<td>Haloalkanes</td>
<td>190</td>
</tr>
<tr>
<td>8</td>
<td>Alcohols, Ethers, and Thiols</td>
<td>226</td>
</tr>
<tr>
<td>9</td>
<td>Benzene and Its Derivatives</td>
<td>266</td>
</tr>
<tr>
<td>10</td>
<td>Amines</td>
<td>313</td>
</tr>
<tr>
<td>11</td>
<td>Spectroscopy</td>
<td>341</td>
</tr>
<tr>
<td>12</td>
<td>Aldehydes and Ketones</td>
<td>396</td>
</tr>
<tr>
<td>13</td>
<td>Carboxylic Acids</td>
<td>437</td>
</tr>
<tr>
<td>14</td>
<td>Functional Derivatives of Carboxylic Acids</td>
<td>468</td>
</tr>
<tr>
<td>15</td>
<td>Enolate Anions</td>
<td>504</td>
</tr>
<tr>
<td>16</td>
<td>Organic Polymer Chemistry</td>
<td>542</td>
</tr>
<tr>
<td>17</td>
<td>Carbohydrates</td>
<td>563</td>
</tr>
<tr>
<td>18</td>
<td>Amino Acids and Proteins</td>
<td>595</td>
</tr>
<tr>
<td>19</td>
<td>Lipids (Online Chapter)</td>
<td>624</td>
</tr>
<tr>
<td>20</td>
<td>Nucleic Acids (Online Chapter)</td>
<td>648</td>
</tr>
<tr>
<td>21</td>
<td>The Organic Chemistry of Metabolism (Online Chapter)</td>
<td>672</td>
</tr>
</tbody>
</table>
CONTENTS

1 Covalent Bonding and Shapes of Molecules 1

1.1 How Do We Describe the Electronic Structure of Atoms? 2
1.2 What Is the Lewis Model of Bonding? 5
1.3 How Do We Predict Bond Angles and the Shapes of Molecules? 13
1.4 How Do We Predict If a Molecule Is Polar or Nonpolar? 17
1.5 What Is Resonance? 18
1.6 What Is the Orbital Overlap Model of Covalent Bonding? 21
1.7 What Are Functional Groups? 26
Summary of Key Questions 31
Quick Quiz 32
Problems 34
Looking Ahead 38
Group Learning Activities 39

CHEMICAL CONNECTIONS
1A Buckyball: A New Form of Carbon 16

2 Acids and Bases 40

2.1 What Are Arrhenius Acids and Bases? 41
2.2 What Are Brønsted–Lowry Acids and Bases? 42
2.3 How Do We Measure the Strength of an Acid or Base? 44
2.4 How Do We Determine the Position of Equilibrium in an Acid–Base Reaction? 46
2.5 What Are the Relationships between Acidity and Molecular Structure? 48
2.6 What Are Lewis Acids and Bases? 52
Summary of Key Questions 55
Quick Quiz 56
Key Reactions 57
Problems 57
Looking Ahead 59
Group Learning Activities 60

CHEMICAL CONNECTIONS
3A The Poisonous Puffer Fish 81
3B Octane Rating: What Those Numbers at the Pump Mean 90

3 Alkanes and Cycloalkanes 61

3.1 What Are Alkanes? 62
3.2 What Is Constitutional Isomerism in Alkanes? 64
3.3 How Do We Name Alkanes? 66
3.4 What Are Cycloalkanes? 71
3.5 How Is the IUPAC System of Nomenclature Applied to Molecules that Contain Functional Groups? 72
3.6 What Are the Conformations of Alkanes and Cycloalkanes? 73
3.7 What Is Cis–Trans Isomerism in Cycloalkanes? 80
3.8 What Are the Physical Properties of Alkanes and Cycloalkanes? 84
3.9 What Are the Characteristic Reactions of Alkanes? 87
3.10 What Are the Sources of Alkanes? 88
Summary of Key Questions 91
Quick Quiz 92
Key Reactions 93
Problems 93
Looking Ahead 98
Group Learning Activities 99
Putting it Together 99

CHEMICAL CONNECTIONS

3A Buckyball: A New Form of Carbon 16

4 Alkenes and Alkynes 103

4.1 What Are the Structures and Shapes of Alkenes and Alkynes? 105
4.2 How Do We Name Alkenes and Alkynes? 107
4.3 What Are the Physical Properties of Alkenes and Alkynes? 115
4.4 Why Are 1–Alkynes (Terminal Alkynes) Weak Acids? 116
Summary of Key Questions 117
Quick Quiz 118
Problems 118
Looking Ahead 122
Group Learning Activities 122
## CHEMICAL CONNECTIONS

<table>
<thead>
<tr>
<th>4A</th>
<th>Ethylene, a Plant Growth Regulator</th>
<th>104</th>
</tr>
</thead>
<tbody>
<tr>
<td>4B</td>
<td>Cis–Trans Isomerism in Vision</td>
<td>106</td>
</tr>
<tr>
<td>4C</td>
<td>Why Plants Emit Isoprene</td>
<td>115</td>
</tr>
</tbody>
</table>

### Reactions of Alkenes and Alkynes

5.1 What Are the Characteristic Reactions of Alkenes? 123
5.2 What Is a Reaction Mechanism? 124
5.3 What Are the Mechanisms of Electrophilic Additions to Alkenes? 130
5.4 What Are Carbocation Rearrangements? 140
5.5 What Is Hydroboration–Oxidation of an Alkene? 143
5.6 How Can an Alkene Be Reduced to an Alkane? 145
5.7 How Can an Acetylide Anion Be Used to Create a New Carbon–Carbon Bond? 148
5.8 How Can Alkynes Be Reduced to Alkenes and Alkanes? 150

### CHEMICAL CONNECTIONS

5A Catalytic Cracking and the Importance of Alkenes 127

## Chirality: The Handedness of Molecules

6.1 What Are Stereoisomers? 161
6.2 What Are Enantiomers? 161
6.3 How Do We Designate the Configuration of a Stereocenter? 166
6.4 What Is the 2° Rule? 168
6.5 How Do We Describe the Chirality of Cyclic Molecules with Two Stereocenters? 172
6.6 How Do We Describe the Chirality of Molecules with Three or More Stereocenters? 174
6.7 What Are the Properties of Stereoisomers? 174
6.8 How Is Chirality Detected in the Laboratory? 175
6.9 What Is the Significance of Chirality in the Biological World? 176
6.10 How Can Enantiomers Be Resolved? 177

### CHEMICAL CONNECTIONS

6A Chiral Drugs 178

## Haloalkanes

7.1 How Are Haloalkanes Named? 191
7.2 What Are the Characteristic Reactions of Haloalkanes? 193
7.3 What Are the Products of Nucleophilic Aliphatic Substitution Reactions? 195
7.4 What Are the S_N2 and S_N1 Mechanisms for Nucleophilic Substitution? 197
7.5 What Determines Whether S_N1 or S_N2 Predominates? 201
7.6 How Can S_N1 and S_N2 Be Predicted Based on Experimental Conditions? 206
7.7 What Are the Products of β-Elimination? 208
7.8 What Are the E1 and E2 Mechanisms for β-Elimination? 211
7.9 When Do Nucleophilic Substitution and β-Elimination Compete? 214

### CHEMICAL CONNECTIONS

7A The Environmental Impact of Chlorofluorocarbons 193
7B The Effect of Chlorofluorocarbon Legislation on Asthma Sufferers 216

## Alcohols, Ethers, and Thiols

8.1 What Are Alcohols? 227
8.2 What Are the Characteristic Reactions of Alcohols? 232
8.3 What Are Ethers? 245
8.4 What Are Epoxides? 249
8.5 What Are Thiols? 253
CONTENTS

8.6 What Are the Characteristic Reactions of Thiols? 256
Summary of Key Questions 257
Quick Quiz 258
Key Reactions 259
Problems 260
Chemical Transformations 264
Looking Ahead 264
Group Learning Activities 265

CHEMICAL CONNECTIONS
8A Nitroglycerin: An Explosive and a Drug 230
8B Blood Alcohol Screening 245
8C Ethylene Oxide: A Chemical Sterilant 253

9 Benzene and Its Derivatives 266

9.1 What Is the Structure of Benzene? 267
9.2 What Is Aromaticity? 270
9.3 How Are Benzene Compounds Named, and What Are Their Physical Properties? 273
9.4 What Is a Benzylic Position, and How Does It Contribute to Benzene Reactivity? 276
9.5 What Is Electrophilic Aromatic Substitution? 278
9.6 What Is the Mechanism of Electrophilic Aromatic Substitution? 279
9.7 How Do Existing Substituents on Benzene Affect Electrophilic Aromatic Substitution? 288
9.8 What Are Phenols? 296
Summary of Key Questions 303
Quick Quiz 304
Key Reactions 305
Problems 305
Chemical Transformations 310
Looking Ahead 311
Group Learning Activities 312

CHEMICAL CONNECTIONS
9A Carcinogenic Polynuclear Aromatics and Cancer 277
9B Capsaicin, for Those Who Like It Hot 300

10 Amines 313

10.1 What Are Amines? 313
10.2 How Are Amines Named? 316
10.3 What Are the Characteristic Physical Properties of Amines? 319
10.4 What Are the Acid–Base Properties of Amines? 321
10.5 What Are the Reactions of Amines with Acids? 325
10.6 How Are Arylamines Synthesized? 327
10.7 How Do Amines Act as Nucleophiles? 328
Summary of Key Questions 330
Quick Quiz 331
Key Reactions 331
Problems 332
Chemical Transformations 337
Looking Ahead 337
Group Learning Activities 338
Putting it Together 338

CHEMICAL CONNECTIONS
10A Morphine as a Clue in the Design and Discovery of Drugs 314
10B The Poison Dart Frogs of South America: Lethal Amines 319

11 Spectroscopy 341

11.1 What Is Electromagnetic Radiation? 342
11.2 What Is Molecular Spectroscopy? 344
11.3 What Is Infrared Spectroscopy? 344
11.4 How Do We Interpret Infrared Spectra? 347
11.5 What Is Nuclear Magnetic Resonance? 358
11.6 What Is Shielding? 360
11.7 What Is a 1H-NMR Spectrum? 360
11.8 How Many Resonance Signals Will a Compound Yield in Its 1H-NMR Spectrum? 362
11.9 What Is Signal Integration? 365
11.10 What Is Chemical Shift? 366
11.11 What Is Signal Splitting? 368
11.12 What Is 13C-NMR Spectroscopy, and How Does It Differ from 1H-NMR Spectroscopy? 371
11.13 How Do We Solve an NMR Problem? 374
Summary of Key Questions 378
Quick Quiz 380
Problems 381
Looking Ahead 394
Group Learning Activities 395

CHEMICAL CONNECTIONS
11A Infrared Spectroscopy: A Window on Brain Activity 348
11B Infrared Spectroscopy: A Window on Climate Change 354
11C Magnetic Resonance Imaging (MRI) 371
## CONTENTS

### 20 Nucleic Acids (Online Chapter) 648

- **20.1 What Are Nucleosides and Nucleotides?** 648
- **20.2 What Is the Structure of DNA?** 652
- **20.3 What Are Ribonucleic Acids (RNA)?** 658
- **20.4 What Is the Genetic Code?** 660
- **20.5 How Is DNA Sequenced?** 662
  - Summary of Key Questions 667
  - Quick Quiz 668
  - Problems 669
  - Group Learning Activities 671

### CHEMICAL CONNECTIONS

- **20A The Search for Antiviral Drugs** 650
- **20B DNA Fingerprinting** 666

### 21 The Organic Chemistry of Metabolism (Online Chapter) 672

- **21.1 What Are the Key Participants in Glycolysis, the \( \beta \)-Oxidation of Fatty Acids, and the Citric Acid Cycle?** 673
- **21.2 What Is Glycolysis?** 678

- **21.3 What Are the Ten Reactions of Glycolysis?** 678
- **21.4 What Are the Fates of Pyruvate?** 683
- **21.5 What Are the Reactions of the \( \beta \)-Oxidation of Fatty Acids?** 685
- **21.6 What Are the Reactions of the Citric Acid Cycle?** 689
  - Summary of Key Questions 692
  - Quick Quiz 693
  - Key Reactions 693
  - Problems 694
  - Group Learning Activities 696

### Appendix 1 Acid Ionization Constants for the Major Classes of Organic Acids

- **A.1 Characteristic \( ^1H \)-NMR Chemical Shifts** A.1

### Appendix 2 Characteristic \( ^13C \)-NMR Chemical Shifts

- **A.2 Characteristic Infrared Absorption Frequencies** A.2

### Glossary

- **G.1**

### Answers Section

- **Ans.1**

### Index

- **I.1**