Contents

Preface xi Acknowledgments xvii List of *How To's* xix List of Applications xx



Matter and Measurement 1

- 1.1 Chemistry—The Science of Everyday Experience 2
- **1.2** States of Matter 3
- **1.3** Classification of Matter 5
- 1.4 Measurement 9
- 1.5 Significant Figures 12
- 1.6 Scientific Notation 16
- 1.7 Problem Solving Using the Factor–Label Method 19
- 1.8 FOCUS ON HEALTH & MEDICINE: Problem Solving Using Clinical Conversion Factors 22
- 1.9 Temperature 24
- 1.10 Density and Specific Gravity 26

Study Skills Part I: Calculations in Chemistry 28



2

2.1

Atoms and the Periodic Table 34

- **2.2** Structure of the Atom 40
- 2.3 Isotopes 44
- 2.4 The Periodic Table 47

Elements 35

- 2.5 Electronic Structure 52
- 2.6 Electronic Configurations 54
- 2.7 Valence Electrons 57
- 2.8 Periodic Trends 59



- **3** Ionic and Covalent Compounds 68
 - **3.1** Introduction to Bonding 69
 - 3.2 lons 70
 - 3.3 Ionic Compounds 75
 - 3.4 Naming Ionic Compounds 78
 - 3.5 Physical Properties of Ionic Compounds 82
 - 3.6 Polyatomic lons 83
 - 3.7 Covalent Bonding 86
 - 3.8 Lewis Structures 88
 - 3.9 Naming Covalent Compounds 89

- 3.10 Molecular Shape 90
- 3.11 Electronegativity and Bond Polarity 94
- 3.12 Polarity of Molecules 96



Energy and Matter 105

- 4.1 Energy 106
- 4.2 The Three States of Matter 109
- 4.3 Intermolecular Forces 110
- 4.4 Boiling Point and Melting Point 114
- 4.5 Energy and Phase Changes 115
- 4.6 Heating and Cooling Curves 119



5 Chemical Reactions 127

- 5.1 Introduction to Chemical Reactions 128
- 5.2 Balancing Chemical Equations 132
- 5.3 The Mole and Avogadro's Number 135
- 5.4 Mass to Mole Conversions 138
- 5.5 Mole Calculations in Chemical Equations 140
- 5.6 Mass Calculations in Chemical Equations 142
- 5.7 Oxidation and Reduction 148
- 5.8 Energy Changes in Reactions 152
- 5.9 Reaction Rates 155
- 5.10 FOCUS ON THE HUMAN BODY: Body Temperature 157



Gases 167

6

7

- 6.1 Gases and Pressure 168
- 6.2 Boyle's Law Relating Gas Pressure and Volume 170
- 6.3 Charles's Law Relating Gas Volume and Temperature 173
- 6.4 Gay-Lussac's Law Relating Gas Pressure and Temperature 175
- 6.5 The Combined Gas Law 177
- 6.6 Avogadro's Law Relating Gas Volume and Moles 178
- 6.7 The Ideal Gas Law 181
- 6.8 Dalton's Law and Partial Pressures 184
- 6.9 FOCUS ON THE ENVIRONMENT: Ozone and Carbon Dioxide in the Atmosphere 186



Solutions 194

- 7.1 Introduction 195
- 7.2 Solubility—General Features 197
- 7.3 Solubility—Effects of Temperature and Pressure 200
- 7.4 Concentration Units—Percent Concentration 202
- 7.5 Concentration Units—Molarity 206
- 7.6 Dilution 209
- 7.7 Osmosis and Dialysis 212



Acids and Bases 222

- 8.1 Introduction to Acids and Bases 223
- 8.2 The Reaction of a Brønsted–Lowry Acid with a Brønsted–Lowry Base 228
- 8.3 Acid and Base Strength 230
- 8.4 Dissociation of Water 234
- 8.5 The pH Scale 237
- 8.6 Common Acid–Base Reactions 241
- 8.7 Titration 244
- 8.8 Buffers 245
- 8.9 FOCUS ON THE HUMAN BODY: Buffers in the Blood 248



Nuclear Chemistry 256

- 9.1 Introduction 257
- 9.2 Nuclear Reactions 260
- 9.3 Half-Life 266
- 9.4 Detecting and Measuring Radioactivity 268
- 9.5 FOCUS ON HEALTH & MEDICINE: Medical Uses of Radioisotopes 270
- 9.6 Nuclear Fission and Nuclear Fusion 273
- 9.7 FOCUS ON HEALTH & MEDICINE: Medical Imaging Without Radioactivity 275



Introduction to Organic Molecules 283

- 10.1 Introduction to Organic Chemistry 284
- 10.2 Characteristic Features of Organic Compounds 285
- 10.3 Drawing Organic Molecules 288
- **10.4** Functional Groups 291
- 10.5 Alkanes 297
- 10.6 Alkane Nomenclature 302
- 10.7 Cycloalkanes 307
- 10.8 FOCUS ON THE ENVIRONMENT: Fossil Fuels 309
- 10.9 Physical Properties 310
- 10.10 FOCUS ON THE ENVIRONMENT: Combustion 311
- Study Skills Part II: Organic Chemistry 312



- Unsaturated Hydrocarbons 322
 - 11.1 Alkenes and Alkynes 323
 - 11.2 Nomenclature of Alkenes and Alkynes 325
 - 11.3 Cis–Trans Isomers 327
 - 11.4 FOCUS ON HEALTH & MEDICINE: Oral Contraceptives 331
 - 11.5 Reactions of Alkenes 332
 - 11.6 FOCUS ON HEALTH & MEDICINE: Margarine or Butter? 334
 - 11.7 Polymers—The Fabric of Modern Society 336
 - 11.8 Aromatic Compounds 340
 - 11.9 Nomenclature of Benzene Derivatives 340
 - 11.10 FOCUS ON HEALTH & MEDICINE: Sunscreens and Antioxidants 343



12 Organic Compounds That Contain Oxygen or Sulfur 353

- 12.1 Introduction 354
- 12.2 Structure and Properties of Alcohols 355
- 12.3 Structure and Properties of Ethers 358
- 12.4 Interesting Alcohols and Ethers 360
- 12.5 Reactions of Alcohols 361
- 12.6 Thiols 366
- 12.7 Structure and Properties of Aldehydes and Ketones 367
- 12.8 FOCUS ON HEALTH & MEDICINE: Interesting Aldehydes and Ketones 370
- 12.9 Oxidation of Aldehydes 371
- 12.10 Looking Glass Chemistry—Molecules and Their Mirror Images 373
- 12.11 FOCUS ON HEALTH & MEDICINE: Chiral Drugs 378



- 3 Carboxylic Acids, Esters, Amines, and Amides 391
 - 13.1 Introduction 392
 - 13.2 Nomenclature of Carboxylic Acids and Esters 393
 - 13.3 Physical Properties of Carboxylic Acids and Esters 395
 - 13.4 Interesting Carboxylic Acids in Consumer Products and Medicines 396
 - 13.5 The Acidity of Carboxylic Acids 398
 - 13.6 Reactions Involving Carboxylic Acids and Esters 401
 - 13.7 Amines 404
 - 13.8 Amines as Bases 409
 - 13.9 Amides 412
 - 13.10 Interesting Amines and Amides 415



Carbohydrates 427

- 14.1 Introduction 428
- 14.2 Monosaccharides 429
- 14.3 The Cyclic Forms of Monosaccharides 435
- 14.4 Reactions of Monosaccharides 438
- 14.5 Disaccharides 441
- 14.6 Polysaccharides 445
- 14.7 FOCUS ON THE HUMAN BODY: Blood Type 448

Study Skills Part III: Biomolecules 450



Lipids 459

- 15.1 Introduction to Lipids 460
- 15.2 Fatty Acids 461
- 15.3 Waxes 463
- 15.4 Triacylglycerols—Fats and Oils 465
- **15.5** Hydrolysis of Triacylglycerols 469
- 15.6 Phospholipids 472
- 15.7 Cell Membranes 474
- 15.8 FOCUS ON HEALTH & MEDICINE: Cholesterol, the Most Prominent Steroid 476

- 15.9 Steroid Hormones 479
- 15.10 FOCUS ON HEALTH & MEDICINE: Fat-Soluble Vitamins 481



Amino Acids, Proteins, and Enzymes 492

- 16.1 Introduction 493
- 16.2 Amino Acids 494
- 16.3 Acid-Base Behavior of Amino Acids 497
- 16.4 Peptides 499
- 16.5 FOCUS ON THE HUMAN BODY: Biologically Active Peptides 502
- 16.6 Proteins 504
- 16.7 FOCUS ON THE HUMAN BODY: Common Proteins 508
- 16.8 Protein Hydrolysis and Denaturation 511
- 16.9 Enzymes 514
- 16.10 FOCUS ON HEALTH & MEDICINE: Using Enzymes to Diagnose and Treat Diseases 518



Nucleic Acids and Protein Synthesis 527

- 17.1 Nucleosides and Nucleotides 528
- 17.2 Nucleic Acids 533
- 17.3 The DNA Double Helix 535
- 17.4 Replication 538
- 17.5 RNA 540
- **17.6** Transcription 541
- 17.7 The Genetic Code 542
- 17.8 Translation and Protein Synthesis 544
- 17.9 Mutations and Genetic Diseases 547
- 17.10 FOCUS ON THE HUMAN BODY: DNA Fingerprinting 549
- 17.11 FOCUS ON HEALTH & MEDICINE: Viruses 549



Energy and Metabolism 560

- 18.1 An Overview of Metabolism 561
- 18.2 ATP and Energy Production 564
- 18.3 Coenzymes in Metabolism 566
- 18.4 Glycolysis 569
- 18.5 The Fate of Pyruvate 573
- 18.6 The Citric Acid Cycle 576
- 18.7 The Electron Transport Chain and Oxidative Phosphorylation 579
- 18.8 The ATP Yield from Glucose 582
- 18.9 The Catabolism of Triacylglycerols 584
- 18.10 Ketone Bodies 587
- 18.11 Amino Acid Metabolism 588

Appendix Useful Mathematical Concepts A-1

Glossary G-1 Credits C-1 Index I-1