

# Contents

Preface xi

## Chapter 0

### Chemistry for a Sustainable Future 2

- 0.1 The Choices We Make Today 4
- 0.2 The Sustainable Practices We Need for Tomorrow 5
- 0.3 The Triple Bottom Line 7
- 0.4 Cradle-to-Where? 8
- 0.5 Your Ecological Footprint 10
- 0.6 Our Responsibilities as Citizens and Chemists 11
- 0.7 Back to the Blue Marble 13

## Chapter 1

### The Air We Breathe 16

- 1.1 What's in a Breath? 17
- 1.2 What Else Is in a Breath? 20
- 1.3 Air Pollutants and Risk Assessment 23
- 1.4 Air Quality and You 26
- 1.5 Where We Live: The Troposphere 29
- 1.6 Classifying Matter: Pure Substances, Elements, and Compounds 30
- 1.7 Atoms and Molecules 33
- 1.8 Names and Formulas: The Vocabulary of Chemistry 35
- 1.9 Chemical Change: The Role of Oxygen in Burning 37
- 1.10 Fire and Fuel: Air Quality and Burning Hydrocarbons 40
- 1.11 Air Pollutants: Direct Sources 42
- 1.12 Ozone: A Secondary Pollutant 47
- 1.13 The Inside Story of Air Quality 49
- 1.14 Back to the Breath— at the Molecular Level 54

**Conclusion 57**

**Chapter Summary 57**

**Questions 58**

## Chapter 2

### Protecting the Ozone Layer 64

- 2.1 Ozone: What and Where Is It? 66
- 2.2 Atomic Structure and Periodicity 68
- 2.3 Molecules and Models 71
- 2.4 Waves of Light 76
- 2.5 Radiation and Matter 78
- 2.6 The Oxygen–Ozone Screen 80
- 2.7 Biological Effects of Ultraviolet Radiation 82
- 2.8 Stratospheric Ozone Destruction: Global Observations and Causes 86
- 2.9 Chlorofluorocarbons: Properties, Uses, and Interactions with Ozone 89
- 2.10 The Antarctic Ozone Hole: A Closer Look 93
- 2.11 Responses to a Global Concern 94
- 2.12 Replacements for CFCs 97

**Conclusion 101**

**Chapter Summary 101**

**Questions 102**

## Chapter 3

### The Chemistry of Global Climate Change 106

- 3.1 In the Greenhouse: Earth's Energy Balance 108
- 3.2 Gathering Evidence: The Testimony of Time 111
- 3.3 Molecules: How They Shape Up 116
- 3.4 Vibrating Molecules and the Greenhouse Effect 120
- 3.5 The Carbon Cycle: Contributions from Nature and Humans 123
- 3.6 Quantitative Concepts: Mass 125
- 3.7 Quantitative Concepts: Molecules and Moles 127
- 3.8 Methane and Other Greenhouse Gases 130

## Contents

- 3.9 How Warm Will the Planet Get? 133
- 3.10 The Consequences of Climate Change 138
- 3.11 What Can (or Should) We Do About Climate Change 142

**Conclusion 148****Chapter Summary 148****Questions 149****Chapter 4****Energy from Combustion 154**

- 4.1 Fossil Fuels and Electricity 156
- 4.2 Efficiency of Energy Transformation 159
- 4.3 The Chemistry of Coal 161
- 4.4 Petroleum 166
- 4.5 Measuring Energy Changes 171
- 4.6 Energy Changes at the Molecular Level 175
- 4.7 The Chemistry of Gasoline 178
- 4.8 New Uses for an Old Fuel 181
- 4.9 Biofuels I—Ethanol 183
- 4.10 Biofuels II—Biodiesel, Garbage, and Biogas 187
- 4.11 The Way Forward 190

**Conclusion 193****Chapter Summary 193****Questions 194****Chapter 5****Water for Life 198**

- 5.1 The Unique Properties of Water 200
- 5.2 The Role of Hydrogen Bonding 202
- 5.3 Water Use 204
- 5.4 Water Issues 207
- 5.5 Aqueous Solutions 212
- 5.6 A Close Look at Solutes 215
- 5.7 Names and Formulas of Ionic Compounds 218
- 5.8 The Ocean—An Aqueous Solution with Many Ions 221
- 5.9 Covalent Compounds and Their Solutions 223
- 5.10 Protecting Our Drinking Water: Federal Legislation 226
- 5.11 Water Treatment 230

- 5.12 Water Solutions for Global Challenges 233

**Conclusion 237****Chapter Summary 238****Questions 238****Chapter 6****Neutralizing the Threat of Acid Rain 242**

- 6.1 What Is an Acid? 244
- 6.2 What Is a Base? 245
- 6.3 Neutralization: Bases Are Antacids 247
- 6.4 Introducing pH 249
- 6.5 Ocean Acidification 250
- 6.6 The Challenges of Measuring the pH of Rain 252
- 6.7 Sulfur Dioxide and the Combustion of Coal 257
- 6.8 Nitrogen Oxides and the Combustion of Gasoline 259
- 6.9 The Nitrogen Cycle 260
- 6.10 SO<sub>2</sub> and NO<sub>x</sub>—How Do They Stack Up? 264
- 6.11 Acid Deposition and Its Effects on Materials 266
- 6.12 Acid Deposition, Haze, and Human Health 270
- 6.13 Damage to Lakes and Streams 274

**Conclusion 276****Chapter Summary 276****Questions 277****Chapter 7****The Fires of Nuclear Fission 282**

- 7.1 Nuclear Power Worldwide 283
- 7.2 How Fission Produces Energy 286
- 7.3 How Nuclear Reactors Produce Electricity 292
- 7.4 What Is Radioactivity? 295
- 7.5 Looking Backward to Go Forward 298
- 7.6 Radioactivity and You 302
- 7.7 The Weapons Connection 308
- 7.8 Nuclear Time: The Half-Life 311
- 7.9 Nuclear Waste: Here Today, Here Tomorrow 315
- 7.10 Risks and Benefits of Nuclear Power 319
- 7.11 A Future for Nuclear Power 321

**Conclusion 324****Chapter Summary 324****Questions 325****Chapter 8****Energy from Electron Transfer 330**

- 8.1 Batteries, Galvanic Cells, and Electrons 332
- 8.2 Other Common Galvanic Cells 335
- 8.3 Battery Ingredients: Cradle-to-Cradle 338
- 8.4 Hybrid Vehicles 341
- 8.5 Fuel Cells: The Basics 344
- 8.6 Hydrogen for Fuel Cell Vehicles 348
- 8.7 Photovoltaic Cells: The Basics 352
- 8.8 Electricity from Renewable (Sustainable) Sources 360

**Conclusion 363****Chapter Summary 363****Questions 364****Chapter 9****The World of Polymers and Plastics 368**

- 9.1 Polymers: Long, Long Chains 370
- 9.2 Adding up the Monomers 371
- 9.3 Polyethylene: A Closer Look 374
- 9.4 The "Big Six": Theme and Variations 377
- 9.5 Condensing the Monomers 382
- 9.6 Polyamides: Natural and Nylon 385
- 9.7 Recycling: The Big Picture 388
- 9.8 Recycling Plastics: The Details 391

**Conclusion 398****Chapter Summary 398****Questions 398****Chapter 10****Manipulating Molecules and Designing Drugs 404**

- 10.1 A Classic Wonder Drug 405
- 10.2 The Study of Carbon-Containing Molecules 407
- 10.3 Functional Groups 411
- 10.4 How Aspirin Works: Function Follows Form 416
- 10.5 Modern Drug Design 418

10.6 Give These Molecules a Hand! 423

10.7 Steroids 427

10.8 Prescription, Generic, and Over-the-Counter Medicines 429

10.9 Herbal Medicine 432

10.10 Drugs of Abuse 435

**Conclusion 439****Chapter Summary 440****Questions 440****Chapter 11****Nutrition: Food for Thought 446**

- 11.1 Food and the Planet 448
- 11.2 You Are What You Eat 450
- 11.3 Fats and Oils 452
- 11.4 Fats, Oils, and Your Diet 457
- 11.5 Carbohydrates: Sweet and Starchy 461
- 11.6 How Sweet It Is: Sugars and Sugar Substitutes 464
- 11.7 Proteins: First Among Equals 467
- 11.8 Vitamins and Minerals: The Other Essentials 470
- 11.9 Energy from Food 474
- 11.10 Quality Versus Quantity: Dietary Advice 478
- 11.11 Eat Local? Eat Veggies? 480
- 11.12 Feeding a Hungry World 483

**Conclusion 485****Chapter Summary 485****Questions 486****Chapter 12****Genetic Engineering and the Molecules of Life 490**

- 12.1 Stronger and Better Corn Plants? 491
- 12.2 A Chemical That Codes Life 493
- 12.3 The Double Helix of DNA 497
- 12.4 Cracking the Chemical Code 502
- 12.5 Proteins: Form to Function 503
- 12.6 The Process of Genetic Engineering 507
- 12.7 Making Chemical Synthesis Green from Genetic Modification 511
- 12.8 The New Frankenstein 513

**Conclusion 515****Chapter Summary 516****Questions 516**

**Appendix 1**

Measure for Measure:  
Conversion Factors  
and Constants A1

**Appendix 2**

The Power of Exponents A2

**Appendix 3**

Clearing the Logjam A3

**Appendix 4**

Answers to Your Turn Questions  
Not Answered in Text A4

**Appendix 5**

Answers to Selected  
End-of-Chapter Questions  
Indicated in Color in the Text A16

**Glossary G1**

**Credits C1**

**Index I1**