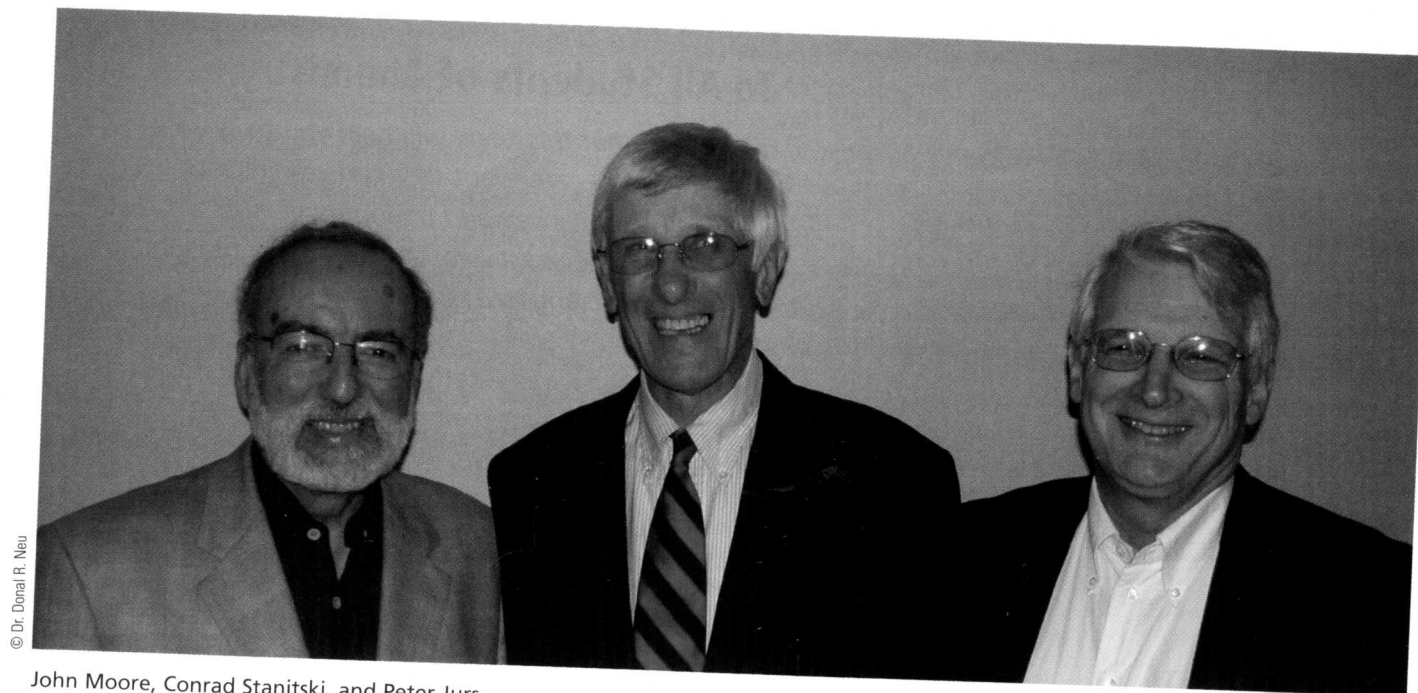


About the Authors



© Dr. Donald R. Neu

John Moore, Conrad Stanitski, and Peter Jurs

John W. Moore received an A.B. magna cum laude from Franklin and Marshall College and a Ph.D. from Northwestern University. He held a National Science Foundation (NSF) postdoctoral fellowship at the University of Copenhagen and taught at Indiana University and Eastern Michigan University before joining the faculty of the University of Wisconsin–Madison in 1989. At the University of Wisconsin, Dr. Moore is W.T. Lippincott Professor of Chemistry and Director of the Institute for Chemical Education. He was Editor of the *Journal of Chemical Education (JCE)* from 1996 to 2009. Among his many awards are the American Chemical Society (ACS) George C. Pimentel Award in Chemical Education and the James Flack Norris Award for Excellence in Teaching Chemistry. He is a Fellow of the ACS and of the American Association for the Advancement of Science (AAAS). In 2003 he won the Benjamin Smith Reynolds Award at the University of Wisconsin–Madison in recognition of his excellence in teaching chemistry to engineering students. Dr. Moore has recently received the third in a series of major grants from the NSF to support development of online chemistry learning materials for the NSF-sponsored National Science Distributed Learning (NSDL) initiative.

Conrad L. Stanitski is Distinguished Emeritus Professor of Chemistry at the University of Central Arkansas and is currently Visiting Professor at Franklin and Marshall College. He received his B.S. in Science Education from Bloomsburg State College, M.A. in Chemical Education from the University of Northern Iowa, and Ph.D. in Inorganic Chemistry from the University of Connecticut. He has co-authored chemistry textbooks for science majors, allied health science students, nonscience majors, and high school chemistry students. Dr. Stanitski has won many teaching awards,

including the CMA CATALYST National Award for Excellence in Chemistry Teaching, the Gustav Ohaus–National Science Teachers Association Award for Creative Innovations in College Science Teaching, the Thomas R. Branch Award for Teaching Excellence and the Samuel Nelson Gray Distinguished Professor Award from Randolph–Macon College, and the 2002 Western Connecticut ACS Section Visiting Scientist Award. He was Chair of the American Chemical Society Division of Chemical Education (2001) and has been an elected Councilor for that division. He is a Fellow of the American Association for the Advancement of Science (AAAS). An instrumental and vocal performer, he also enjoys jogging, tennis, rowing, and reading.

Peter C. Jurs is Professor Emeritus of Chemistry at the Pennsylvania State University. Dr. Jurs earned his B.S. in Chemistry from Stanford University and his Ph.D. in Chemistry from the University of Washington. He then joined the faculty of Pennsylvania State University, where he has been Professor of Chemistry since 1978. Jurs's research interests have focused on the application of computational methods to chemical and biological problems, including the development of models linking molecular structure to chemical or biological properties (drug design). For this work he was awarded the ACS Award for Computers in Chemistry in 1990. Dr. Jurs has been Assistant Head for Undergraduate Education at Penn State, and he works with the Chemical Education Interest Group to enhance and improve the undergraduate program. In 1995 he was awarded the C. I. Noll Award for Outstanding Undergraduate Teaching. Dr. Jurs serves as an elected Councilor for the American Chemical Society Computer Division, and he was recently selected as a Fellow of the ACS.

Contents Overview

1	The Nature of Chemistry	1
2	Atoms and Elements	40
3	Chemical Compounds	75
4	Quantities of Reactants and Products	120
5	Chemical Reactions	161
6	Energy and Chemical Reactions	211
7	Electron Configurations and the Periodic Table	271
8	Covalent Bonding	327
9	Molecular Structures	375
10	Gases and the Atmosphere	424
11	Liquids, Solids, and Materials	478
12	Fuels, Organic Chemicals, and Polymers	533
13	Chemical Kinetics: Rates of Reactions	592
14	Chemical Equilibrium	655
15	The Chemistry of Solutes and Solutions	707
16	Acids and Bases	753
17	Additional Aqueous Equilibria	804
18	Thermodynamics: Directionality of Chemical Reactions	849
19	Electrochemistry and Its Applications	901
20	Nuclear Chemistry	957
21	The Chemistry of the Main Group Elements	995
22	Chemistry of Selected Transition Elements and Coordination Compounds	1037

Appendices A–J A.1

Appendix K: Answers to Problem-Solving Practice Problems A.44

Appendix L: Answers to Exercises A.62

Appendix M: Answers to Selected Questions for Review and Thought A.81

Glossary G.1

Index I.1

Detailed Contents

1 The Nature of Chemistry 1

- 1.1 Why Care About Chemistry? 2
- 1.2 Molecular Medicine 3
- 1.3 How Science Is Done 6
- 1.4 Identifying Matter: Physical Properties 7
- 1.5 Chemical Changes and Chemical Properties 11
- 1.6 Classifying Matter: Substances and Mixtures 13
- 1.7 Classifying Matter: Elements and Compounds 15
- 1.8 Nanoscale Theories and Models 17
- 1.9 The Atomic Theory 21
- 1.10 The Chemical Elements 23
- 1.11 Communicating Chemistry: Symbolism 27
- 1.12 Modern Chemical Sciences 29

PORTRAIT OF A SCIENTIST Susan Band Horwitz 4

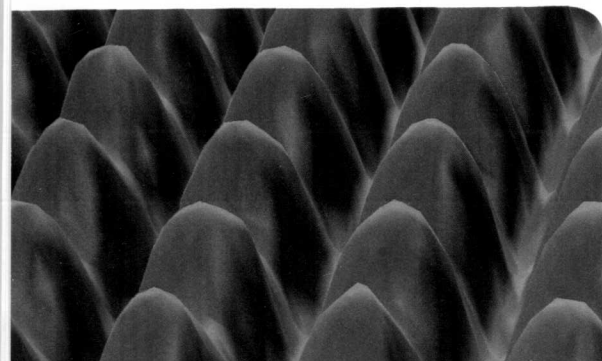
CHEMISTRY IN THE NEWS Atomic Scale Electric Switches 21

ESTIMATION How Tiny Are Atoms and Molecules? 23

PORTRAIT OF A SCIENTIST Sir Harold Kroto 26

2 Atoms and Elements 40

- 2.1 Atomic Structure and Subatomic Particles 41
- 2.2 The Nuclear Atom 43
- 2.3 The Sizes of Atoms and the Units Used to Represent Them 45
- 2.4 Uncertainty and Significant Figures 50
- 2.5 Atomic Numbers and Mass Numbers 53



IBM Almaden Labs

- 2.6 Isotopes and Atomic Weight 56
- 2.7 Amounts of Substances: The Mole 59
- 2.8 Molar Mass and Problem Solving 61
- 2.9 The Periodic Table 62

PORTRAIT OF A SCIENTIST Ernest Rutherford 45

TOOLS OF CHEMISTRY Scanning Tunneling Microscopy and Atomic Force Microscopy 46

CHEMISTRY IN THE NEWS The Kilogram Redefined 50

TOOLS OF CHEMISTRY Mass Spectrometer 56

ESTIMATION The Size of Avogadro's Number 60

PORTRAIT OF A SCIENTIST Dmitri Mendeleev 62

CHEMISTRY IN THE NEWS Periodic Table Stamp 66

CHEMISTRY YOU CAN DO Preparing a Pure Sample of an Element 67

3 Chemical Compounds 75

- 3.1 Molecular Compounds 76
- 3.2 Naming Binary Inorganic Compounds 79
- 3.3 Hydrocarbons 80
- 3.4 Alkanes and Their Isomers 83
- 3.5 Ions and Ionic Compounds 85
- 3.6 Naming Ions and Ionic Compounds 91
- 3.7 Ionic Compounds: Bonding and Properties 94
- 3.8 Moles of Compounds 98
- 3.9 Percent Composition 103
- 3.10 Determining Empirical and Molecular Formulas 104
- 3.11 The Biological Periodic Table 107

ESTIMATION Number of Alkane Isomers 85

CHEMISTRY IN THE NEWS Airport Runway Deicer Shortage 93

ESTIMATION Is Each Snowflake Unique? 99

CHEMISTRY YOU CAN DO Pumping Iron: How Strong Is Your Breakfast Cereal? 109

CHEMISTRY IN THE NEWS Removing Arsenic from Drinking Water 109

4 Quantities of Reactants and Products 120

- 4.1 Chemical Equations 121
- 4.2 Patterns of Chemical Reactions 122

- 4.3 Balancing Chemical Equations 128
- 4.4 The Mole and Chemical Reactions: The Macro-Nano Connection 131
- 4.5 Reactions with One Reactant in Limited Supply 137
- 4.6 Evaluating the Success of a Synthesis: Percent Yield 142
- 4.7 Percent Composition and Empirical Formulas 145

PORTRAIT OF A SCIENTIST Antoine Lavoisier 122

PORTRAIT OF A SCIENTIST Alfred Nobel 125

ESTIMATION How Much CO₂ Is Produced by Your Car? 137

CHEMISTRY IN THE NEWS Smothering Fire—Water That Isn't Wet 141

CHEMISTRY YOU CAN DO Vinegar and Baking Soda: A Stoichiometry Experiment 143

5 Chemical Reactions 161

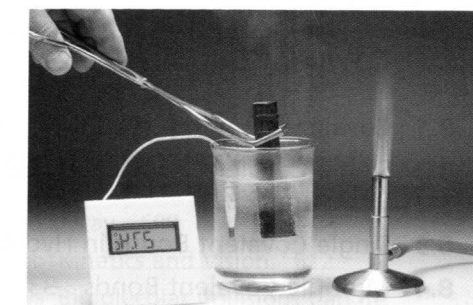
- 5.1 Exchange Reactions: Precipitation and Net Ionic Equations 162
- 5.2 Acids, Bases, and Acid-Base Exchange Reactions 168
- 5.3 Oxidation-Reduction Reactions 177
- 5.4 Oxidation Numbers and Redox Reactions 183
- 5.5 Displacement Reactions, Redox, and the Activity Series 186
- 5.6 Solution Concentration 189
- 5.7 Molarity and Reactions in Aqueous Solutions 196
- 5.8 Aqueous Solution Titrations 198

CHEMISTRY IN THE NEWS Stream Cleaning with Chemistry 177

CHEMISTRY YOU CAN DO Pennies, Redox, and the Activity Series of Metals 190

6 Energy and Chemical Reactions 211

- 6.1 The Nature of Energy 212
- 6.2 Conservation of Energy 215
- 6.3 Heat Capacity 220
- 6.4 Energy and Enthalpy 224
- 6.5 Thermochemical Expressions 230
- 6.6 Enthalpy Changes for Chemical Reactions 232
- 6.7 Where Does the Energy Come From? 236
- 6.8 Measuring Enthalpy Changes: Calorimetry 238
- 6.9 Hess's Law 242



© Cengage Learning/Charles D. Winters

- 6.10 Standard Molar Enthalpies of Formation 244
- 6.11 Chemical Fuels for Home and Industry 249
- 6.12 Foods: Fuels for Our Bodies 254

PORTRAIT OF A SCIENTIST James P. Jule 213

ESTIMATION Earth's Kinetic Energy 214

CHEMISTRY YOU CAN DO Work and Volume Change 231

CHEMISTRY YOU CAN DO Rusting and Heating 235

PORTRAIT OF A SCIENTIST Reatha Clark King 247

ESTIMATION Burning Coal 253

CHEMISTRY IN THE NEWS Charge Your iPod with a Wave of Your Hand 256

7 Electron Configurations and the Periodic Table 271

- 7.1 Electromagnetic Radiation and Matter 272
- 7.2 Planck's Quantum Theory 274
- 7.3 The Bohr Model of the Hydrogen Atom 279
- 7.4 Beyond the Bohr Model: The Quantum Mechanical Model of the Atom 285
- 7.5 Quantum Numbers, Energy Levels, and Atomic Orbitals 288
- 7.6 Shapes of Atomic Orbitals 294
- 7.7 Atom Electron Configurations 296
- 7.8 Ion Electron Configurations 302
- 7.9 Periodic Trends: Atomic Radii 306
- 7.10 Periodic Trends: Ionic Radii 309
- 7.11 Periodic Trends: Ionization Energies 311
- 7.12 Periodic Trends: Electron Affinities 314
- 7.13 Energy Considerations in Ionic Compound Formation 315

ESTIMATION Turning on the Light Bulb 279

CHEMISTRY IN THE NEWS Using an Ultra-Fast Laser to Make a More Efficient Incandescent Light Bulb 279

PORTRAIT OF A SCIENTIST Niels Bohr 284

CHEMISTRY YOU CAN DO Using a Compact Disc (CD) as a Diffraction Grating 285

8 Covalent Bonding 327

- 8.1 Covalent Bonding 328
- 8.2 Single Covalent Bonds and Lewis Structures 329
- 8.3 Single Covalent Bonds in Hydrocarbons 334
- 8.4 Multiple Covalent Bonds 337
- 8.5 Multiple Covalent Bonds in Hydrocarbons 339
- 8.6 Bond Properties: Bond Length and Bond Energy 342
- 8.7 Bond Properties: Bond Polarity and Electronegativity 347
- 8.8 Formal Charge 350
- 8.9 Lewis Structures and Resonance 352
- 8.10 Exceptions to the Octet Rule 355
- 8.11 Aromatic Compounds 359
- 8.12 Molecular Orbital Theory 360
- PORTRAIT OF A SCIENTIST Gilbert Newton Lewis 329
- PORTRAIT OF A SCIENTIST Linus Pauling 347
- CHEMISTRY IN THE NEWS Self-Darkening Eyeglasses 356

9 Molecular Structures 375

- 9.1 Using Molecular Models 376
- 9.2 Predicting Molecular Shapes: VSEPR 377
- 9.3 Atomic Orbitals Consistent with Molecular Shapes: Hybridization 390
- 9.4 Hybridization in Molecules with Multiple Bonds 395
- 9.5 Molecular Polarity 398
- 9.6 Noncovalent Interactions and Forces Between Molecules 402
- 9.7 Biomolecules: DNA and the Importance of Molecular Structure 410
- TOOLS OF CHEMISTRY Infrared Spectroscopy 386
- PORTRAIT OF A SCIENTIST Peter Debye 399
- TOOLS OF CHEMISTRY Ultraviolet-Visible Spectroscopy 401
- CHEMISTRY IN THE NEWS Icy Pentagons 407
- CHEMISTRY YOU CAN DO Molecular Structure and Biological Activity 410
- PORTRAIT OF A SCIENTIST Rosalind Franklin 412
- ESTIMATION Base Pairs and DNA 413

10 Gases and the Atmosphere 424

- 10.1 The Atmosphere 425
- 10.2 Gas Pressure 427
- 10.3 Kinetic-Molecular Theory 429
- 10.4 The Behavior of Ideal Gases 433
- 10.5 Quantities of Gases in Chemical Reactions 442
- 10.6 Gas Density and Molar Mass 444
- 10.7 Gas Mixtures and Partial Pressures 446
- 10.8 The Behavior of Real Gases 451
- 10.9 Ozone and Stratospheric Ozone Depletion 454
- 10.10 Chemistry and Pollution in the Troposphere 457
- 10.11 Atmospheric Carbon Dioxide, the Greenhouse Effect, and Global Warming 463
- ESTIMATION Thickness of Earth's Atmosphere 426
- CHEMISTRY IN THE NEWS Nitrogen in Tires 431
- PORTRAIT OF A SCIENTIST Jacques Alexandre Cesar Charles 435
- ESTIMATION Helium Balloon Buoyancy 445
- CHEMISTRY YOU CAN DO Helium-Filled Balloon in Car 446
- PORTRAIT OF A SCIENTIST F. Sherwood Rowland 455
- PORTRAIT OF A SCIENTIST Susan Solomon 456
- CHEMISTRY YOU CAN DO Particle Size and Visibility 458
- CHEMISTRY IN THE NEWS Removing CO₂ from the Air 468

11 Liquids, Solids, and Materials 478

- 11.1 The Liquid State 479
- 11.2 Vapor Pressure 481
- 11.3 Phase Changes: Solids, Liquids, and Gases 485
- 11.4 Water: An Important Liquid with Unusual Properties 497
- 11.5 Types of Solids 499
- 11.6 Crystalline Solids 501



© Breitling

- 11.7 Network Solids 508
- 11.8 Materials Science 510
- 11.9 Metals, Semiconductors, and Insulators 512
- 11.10 Silicon and the Chip 517
- 11.11 Cement, Ceramics, and Glass 520
- CHEMISTRY IN THE NEWS Surface Tension and Bird Feeding 481
- CHEMISTRY IN THE NEWS Stopping Windshields from Fogging 485
- CHEMISTRY YOU CAN DO Melting Ice with Pressure 496
- CHEMISTRY YOU CAN DO Closest Packing of Spheres 507
- PORTRAIT OF A SCIENTIST Dorothy Crowfoot Hodgkin 509
- TOOLS OF CHEMISTRY X-Ray Crystallography 510
- CHEMISTRY IN THE NEWS Glassy Metals? 522

12 Fuels, Organic Chemicals, and Polymers 533

- 12.1 Petroleum 534
- 12.2 U.S. Energy Sources and Consumption 541
- 12.3 Organic Chemicals 545
- 12.4 Alcohols and Their Oxidation Products 546
- 12.5 Carboxylic Acids and Esters 554
- 12.6 Synthetic Organic Polymers 561
- 12.7 Biopolymers: Polysaccharides and Proteins 575
- ESTIMATION Burning Oil 543
- TOOLS OF CHEMISTRY Gas Chromatography 544
- CHEMISTRY IN THE NEWS Small Molecules, Big Results: Molecular Possibilities for Drug Development 545
- PORTRAIT OF A SCIENTIST Percy Lavon Julian 551
- TOOLS OF CHEMISTRY Nuclear Magnetic Resonance and Its Applications 552
- CHEMISTRY YOU CAN DO Making "Gluep" 568
- PORTRAIT OF A SCIENTIST Stephanie Louise Kwolek 573

13 Chemical Kinetics: Rates of Reactions 592

- 13.1 Reaction Rate 593
- 13.2 Effect of Concentration on Reaction Rate 598
- 13.3 Rate Law and Order of Reaction 602
- 13.4 A Nanoscale View: Elementary Reactions 608
- 13.5 Temperature and Reaction Rate: The Arrhenius Equation 615
- 13.6 Rate Laws for Elementary Reactions 619
- 13.7 Reaction Mechanisms 621

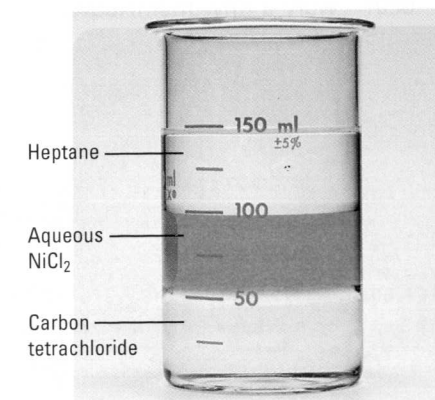
- 13.8 Catalysts and Reaction Rate 625
- 13.9 Enzymes: Biological Catalysts 629
- 13.10 Catalysis in Industry 634
- CHEMISTRY YOU CAN DO Simulating First-Order and Zeroth-Order Reactions 606
- ESTIMATION Pesticide Decay 609
- CHEMISTRY YOU CAN DO Kinetics and Vision 612
- CHEMISTRY IN THE NEWS Bimolecular Collisions Can Be Complicated 615
- PORTRAIT OF A SCIENTIST Ahmed H. Zewail 617
- CHEMISTRY YOU CAN DO Enzymes: Biological Catalysts 630
- CHEMISTRY IN THE NEWS Catalysis and Hydrogen Fuel 636

14 Chemical Equilibrium 655

- 14.1 Characteristics of Chemical Equilibrium 656
- 14.2 The Equilibrium Constant 659
- 14.3 Determining Equilibrium Constants 666
- 14.4 The Meaning of the Equilibrium Constant 669
- 14.5 Using Equilibrium Constants 672
- 14.6 Shifting a Chemical Equilibrium: Le Chatelier's Principle 678
- 14.7 Equilibrium at the Nanoscale 687
- 14.8 Controlling Chemical Reactions: The Haber-Bosch Process 689
- CHEMISTRY IN THE NEWS Bacteria Communicate Chemically 680
- ESTIMATION Generating Gaseous Fuel 686
- PORTRAIT OF A SCIENTIST Fritz Haber 690

15 The Chemistry of Solutes and Solutions 707

- 15.1 Solubility and Intermolecular Forces 708
- 15.2 Enthalpy, Entropy, and Dissolving Solutes 712

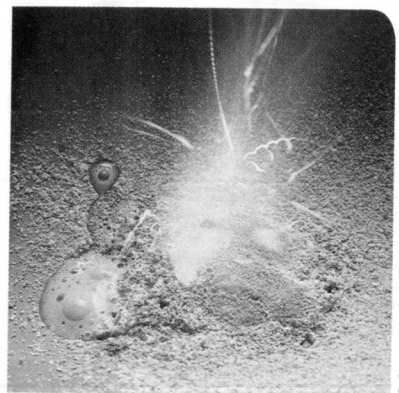


© Cengage Learning/Charles D. Winters

- 15.3** Solubility and Equilibrium 714
15.4 Temperature and Solubility 717
15.5 Pressure and Dissolving Gases in Liquids: Henry's Law 718
15.6 Solution Concentration: Keeping Track of Units 721
15.7 Vapor Pressures, Boiling Points, Freezing Points, and Osmotic Pressures of Solutions 727
15.8 Colloids 738
15.9 Surfactants 740
15.10 Water: Natural, Clean, and Otherwise 741
CHEMISTRY IN THE NEWS Bubbling Away: Catching a Draught 720
PORTRAIT OF A SCIENTIST Jacobus Henricus van't Hoff 733
CHEMISTRY IN THE NEWS Thirsty Southern California to Test Desalination 738
CHEMISTRY YOU CAN DO Curdled Colloids 739

16 Acids and Bases 753

- 16.1** The Brønsted-Lowry Concept of Acids and Bases 754
16.2 Carboxylic Acids and Amines 760
16.3 The Autoionization of Water 762
16.4 The pH Scale 764
16.5 Ionization Constants of Acids and Bases 767
16.6 Molecular Structure and Acid Strength 772
16.7 Problem Solving Using K_a and K_b 776
16.8 Acid-Base Reactions of Salts 781
16.9 Lewis Acids and Bases 786
16.10 Additional Applied Acid-Base Chemistry 790
CHEMISTRY IN THE NEWS HCl Dissociation at the Smallest Scale 755
PORTRAIT OF A SCIENTIST Arnold Beckman 766
ESTIMATION Using an Antacid 791
CHEMISTRY YOU CAN DO Aspirin and Digestion 795



© Cengage Learning/Charles D. Winters

17 Additional Aqueous Equilibria 804

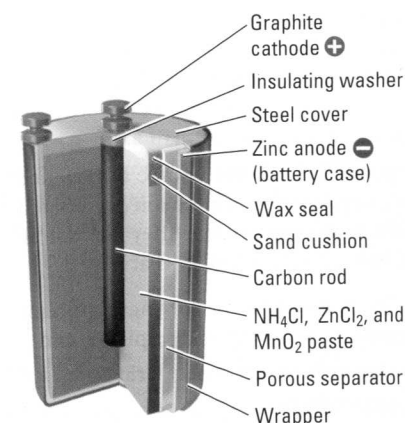
- 17.1** Buffer Solutions 805
17.2 Acid-Base Titrations 817
17.3 Acid Rain 825
17.4 Solubility Equilibria and the Solubility Product Constant, K_{sp} 827
17.5 Factors Affecting Solubility 830
17.6 Precipitation: Will It Occur? 838
CHEMISTRY IN THE NEWS Ocean Acidification, a Global pH Change Concern 831

18 Thermodynamics: Directionality of Chemical Reactions 849

- 18.1** Reactant-Favored and Product-Favored Processes 850
18.2 Chemical Reactions and Dispersal of Energy 851
18.3 Measuring Dispersal of Energy: Entropy 853
18.4 Calculating Entropy Changes 860
18.5 Entropy and the Second Law of Thermodynamics 860
18.6 Gibbs Free Energy 864
18.7 Gibbs Free Energy Changes and Equilibrium Constants 868
18.8 Gibbs Free Energy, Maximum Work, and Energy Resources 874
18.9 Gibbs Free Energy and Biological Systems 876
18.10 Conservation of Gibbs Free Energy 883
18.11 Thermodynamic and Kinetic Stability 886
CHEMISTRY YOU CAN DO Energy Distributions 854
PORTRAIT OF A SCIENTIST Ludwig Boltzmann 856
PORTRAIT OF A SCIENTIST Josiah Willard Gibbs 865
CHEMISTRY IN THE NEWS Ethanol Fuel and Energy 884
ESTIMATION Gibbs Free Energy and Automobile Travel 886

19 Electrochemistry and Its Applications 901

- 19.1** Redox Reactions 902
19.2 Using Half-Reactions to Understand Redox Reactions 904
19.3 Electrochemical Cells 910



- 19.4** Electrochemical Cells and Voltage 914
19.5 Using Standard Reduction Potentials 919
19.6 E° and Gibbs Free Energy 923
19.7 Effect of Concentration on Cell Potential 926
19.8 Neuron Cells 930
19.9 Common Batteries 933
19.10 Fuel Cells 937
19.11 Electrolysis—Causing Reactant-Favored Redox Reactions to Occur 939
19.12 Counting Electrons 942
19.13 Corrosion—Product-Favored Redox Reactions 946
CHEMISTRY YOU CAN DO Remove Tarnish the Easy Way 921
PORTRAIT OF A SCIENTIST Michael Faraday 924
CHEMISTRY IN THE NEWS Plug-in Hybrid Cars 937
PORTRAIT OF A SCIENTIST Wilson Greatbatch 937
ESTIMATION The Cost of Aluminum in a Beverage Can 945

20 Nuclear Chemistry 957

- 20.1** The Nature of Radioactivity 958
20.2 Nuclear Reactions 959
20.3 Stability of Atomic Nuclei 963
20.4 Rates of Disintegration Reactions 968
20.5 Artificial Transmutations 974
20.6 Nuclear Fission 975
20.7 Nuclear Fusion 980
20.8 Nuclear Radiation: Effects and Units 981
20.9 Applications of Radioactivity 985
PORTRAIT OF A SCIENTIST Glenn Seaborg 974
PORTRAIT OF A SCIENTIST Darleane C. Hoffman 976
ESTIMATION Counting Millirems: Your Radiation Exposure 983
CHEMISTRY IN THE NEWS Another Reason Not to Smoke 984
ESTIMATION Radioactivity of Common Foods 985

21 The Chemistry of the Main Group Elements 995

- 21.1** Formation of the Elements 996
21.2 Terrestrial Elements 998
21.3 Some Main Group Elements Extracted by Physical Methods: Nitrogen, Oxygen, and Sulfur 1002
21.4 Some Main Group Elements Extracted by Electrolysis: Sodium, Chlorine, Magnesium, and Aluminum 1003
21.5 Some Main Group Elements Extracted by Chemical Oxidation-Reduction: Phosphorus, Bromine, and Iodine 1009
21.6 A Periodic Perspective: The Main Group Elements 1012
PORTRAIT OF A SCIENTIST Charles Martin Hall 1008
PORTRAIT OF A SCIENTIST Paul Louis-Toussaint Héroult 1009
PORTRAIT OF A SCIENTIST Herbert H. Dow 1011
CHEMISTRY IN THE NEWS Air-Stable White Phosphorus 1024

22 Chemistry of Selected Transition Elements and Coordination Compounds 1037

- 22.1** Properties of the Transition (d -Block) Elements 1038
22.2 Iron and Steel: The Use of Pyrometallurgy 1042
22.3 Copper: A Coinage Metal 1047
22.4 Silver and Gold: The Other Coinage Metals 1051
22.5 Chromium 1052
22.6 Coordinate Covalent Bonds: Complex Ions and Coordination Compounds 1055
22.7 Crystal-Field Theory: Color and Magnetism in Coordination Compounds 1065
ESTIMATION Stealing Automobiles 1046
CHEMISTRY IN THE NEWS An Apartment with a View 1050
CHEMISTRY YOU CAN DO A Penny for Your Thoughts 1061
PORTRAIT OF A SCIENTIST Alfred Werner 1063

Appendices A–J A.1

Appendix K: Answers to Problem-Solving Practice Problems A.44

Appendix L: Answers to Exercises A.62

Appendix M: Answers to Selected Questions for Review and Thought A.81

Glossary G.1

Index I.1