



# CHEMISTRY Atoms First

**Burdge  
Overby**

**This  
International  
Student Edition  
is for use  
outside  
the U.S.**

McGraw-Hill International Edition



# Contents

List of Applications vi

Preface vii

## 1 CHEMISTRY: THE SCIENCE OF CHANGE 2

- 1.1 The Study of Chemistry 3**
  - Chemistry You May Already Know 3 • The Scientific Method 3
- 1.2 Classification of Matter 5**
  - States of Matter 5 • Mixtures 5
- 1.3 The Properties of Matter 7**
  - Physical Properties 7 • Chemical Properties 7 • Extensive and Intensive Properties 7
- 1.4 Scientific Measurement 8**
  - SI Base Units 9 • Mass 9 • Temperature 10 • Derived Units: Volume and Density 11
- 1.5 Uncertainty in Measurement 13**
  - Significant Figures 14 • Calculations with Measured Numbers 15 • Accuracy and Precision 17 • Thinking Outside the Box: Tips for Success in Chemistry Class 19
- 1.6 Using Units and Solving Problems 20**
  - Conversion Factors 20 • Dimensional Analysis—Tracking Units 20

## 2 ATOMS AND THE PERIODIC TABLE 32

- 2.1 Atoms First 33**
- 2.2 Subatomic Particles and Atomic Structure 34**
  - Discovery of the Electron 34 • Radioactivity 36 • The Proton and the Nuclear Model of the Atom 37 • The Neutron 38
- 2.3 Atomic Number, Mass Number, and Isotopes 39**
- 2.4 Average Atomic Mass 41**
  - Thinking Outside the Box: Measuring Atomic Mass 42
- 2.5 The Periodic Table 43**
- 2.6 The Mole and Molar Mass 44**
  - The Mole 45 • Molar Mass 45 • Interconverting Mass, Moles, and Numbers of Atoms 47

## 3 QUANTUM THEORY AND THE ELECTRONIC STRUCTURE OF ATOMS 56

- 3.1 Energy and Energy Changes 57**
  - Forms of Energy 57 • Units of Energy 58
- 3.2 The Nature of Light 60**
  - Properties of Waves 60 • The Electromagnetic Spectrum 61 • The Double-Slit Experiment 61
- 3.3 Quantum Theory 63**
  - Quantization of Energy 63 • Photons and the Photoelectric Effect 64 • Thinking Outside the Box: Everyday Occurrences of the Photoelectric Effect 65

- 3.4 Bohr's Theory of the Hydrogen Atom 67**  
• Atomic Line Spectra 67 • The Line Spectrum of Hydrogen 68
- 3.5 Wave Properties of Matter 74**  
• The de Broglie Hypothesis 74 • Diffraction of Electrons 76
- 3.6 Quantum Mechanics 76**  
• The Uncertainty Principle 77 • The Schrödinger Equation 78 • The Quantum Mechanical Description of the Hydrogen Atom 78
- 3.7 Quantum Numbers 79**  
• Principal Quantum Number ( $n$ ) 79 • Angular Momentum Quantum Number ( $\ell$ ) 79  
• Magnetic Quantum Number ( $m_\ell$ ) 79 • Electron Spin Quantum Number ( $m_s$ ) 81
- 3.8 Atomic Orbitals 82**  
•  $s$  Orbitals 82 •  $p$  Orbitals 82 •  $d$  Orbitals and Other Higher-Energy Orbitals 84  
• Energies of Orbitals 84
- 3.9 Electron Configurations 85**  
• Energies of Atomic Orbitals in Many-Electron Systems 85 • The Pauli Exclusion Principle 86 • The Aufbau Principle 87 • Hund's Rule 87 • General Rules for Writing Electron Configurations 89
- 3.10 Electron Configurations and the Periodic Table 90**

## 4 PERIODIC TRENDS OF THE ELEMENTS 106

- 4.1 Development of the Periodic Table 107**
- 4.2 The Modern Periodic Table 109**  
• Classification of Elements 109
- 4.3 Effective Nuclear Charge 112**
- 4.4 Periodic Trends in Properties of Elements 113**  
• Atomic Radius 113 • Ionization Energy 115 • Electron Affinity 118 • Metallic Character 120
- 4.5 Electron Configuration of Ions 122**  
• Ions of Main Group Elements 122 • Ions of  $d$ -Block Elements 124
- 4.6 Ionic Radius 125**  
• Comparing Ionic Radius with Atomic Radius 125 • Thinking Outside the Box: Mistaking Strontium for Calcium 126 • Isoelectronic Series 126

## 5 IONIC AND COVALENT COMPOUNDS 140

- 5.1 Compounds 141**
- 5.2 Lewis Dot Symbols 141**
- 5.3 Ionic Compounds and Bonding 143**
- 5.4 Naming Ions and Ionic Compounds 146**  
• Formulas of Ionic Compounds 147 • Naming Ionic Compounds 148
- 5.5 Covalent Bonding and Molecules 149**  
• Molecules 149 • Molecular Formulas 151 • Empirical Formulas 152
- 5.6 Naming Molecular Compounds 155**  
• Specifying Numbers of Atoms 155 • Compounds Containing Hydrogen 157 • Organic Compounds 158 • Thinking Outside the Box: Functional Groups 159
- 5.7 Covalent Bonding in Ionic Species 160**  
• Polyatomic Ions 160 • Oxoacids 162 • Hydrates 163 • Familiar Inorganic Compounds 164

- 5.8 Molecular and Formula Masses 165**
- 5.9 Percent Composition of Compounds 166**
- 5.10 Molar Mass 168**
  - Interconverting Mass, Moles, and Numbers of Particles 168 • Determination of Empirical Formula and Molecular Formula from Percent Composition 170

## **6 REPRESENTING MOLECULES 182**

- 6.1 The Octet Rule 183**
  - Lewis Structures 183 • Multiple Bonds 186
- 6.2 Electronegativity and Polarity 187**
  - Electronegativity 187 • Dipole Moment, Partial Charges, and Percent Ionic Character 189
- 6.3 Drawing Lewis Structures 193**
- 6.4 Lewis Structures and Formal Charge 194**
- 6.5 Resonance 197**
- 6.6 Exceptions to the Octet Rule 199**
  - Incomplete Octets 199 • Thinking Outside the Box: Species with Unpaired Electrons 200
  - Odd Numbers of Electrons 200 • Expanded Octets 201

## **7 MOLECULAR GEOMETRY AND BONDING THEORIES 214**

- 7.1 Molecular Geometry 215**
  - The VSEPR Model 216 • Electron-Domain Geometry and Molecular Geometry 216
  - Deviation from Ideal Bond Angles 219 • Geometry of Molecules with More than One Central Atom 221
- 7.2 Molecular Geometry and Polarity 223**
  - Thinking Outside the Box: Intermolecular Forces 226
- 7.3 Valence Bond Theory 227**
- 7.4 Hybridization of Atomic Orbitals 230**
  - Hybridization of *s* and *p* Orbitals 231 • Hybridization of *s*, *p*, and *d* Orbitals 233
- 7.5 Hybridization in Molecules Containing Multiple Bonds 238**
- 7.6 Molecular Orbital Theory 245**
  - Bonding and Antibonding Molecular Orbitals 245 •  $\sigma$  Molecular Orbitals 246 • Thinking Outside the Box: Phases 247 • Bond Order 247 •  $\pi$  Molecular Orbitals 248 • Molecular Orbital Diagrams 250 • Thinking Outside the Box: Molecular Orbitals in Heteronuclear Diatomic Species 251
- 7.7 Bonding Theories and Descriptions of Molecules with Delocalized Bonding 252**

## **8 CHEMICAL REACTIONS 266**

- 8.1 Chemical Equations 267**
  - Interpreting and Writing Chemical Equations 267 • Balancing Chemical Equations 269
  - Patterns of Chemical Reactivity 273
- 8.2 Combustion Analysis 275**
  - Determination of Empirical Formula 275
- 8.3 Calculations with Balanced Chemical Equations 277**
  - Moles of Reactants and Products 277 • Mass of Reactants and Products 279

**8.4 Limiting Reactants 280**

- Determining the Limiting Reactant 281 • Reaction Yield 285

**8.5 Periodic Trends in Reactivity of the Main Group Elements 286**

- Thinking Outside the Box: Atom Economy 287 • General Trends in Reactivity 288
- Reactions of the Active Metals 289 • Reactions of Other Main Group Elements 290
- Comparison of Group 1A and Group 1B Elements 293

**9 CHEMICAL REACTIONS IN AQUEOUS SOLUTIONS 306****9.1 General Properties of Aqueous Solutions 307**

- Electrolytes and Nonelectrolytes 307 • Strong Electrolytes and Weak Electrolytes 308

**9.2 Precipitation Reactions 312**

- Solubility Guidelines for Ionic Compounds in Water 312 • Molecular Equations 314
- Ionic Equations 315 • Net Ionic Equations 315

**9.3 Acid-Base Reactions 317**

- Strong Acids and Bases 317 • Brønsted Acids and Bases 317 • Acid-Base Neutralization 319

**9.4 Oxidation-Reduction Reactions 321**

- Oxidation Numbers 323 • Oxidation of Metals in Aqueous Solutions 325 • Balancing Simple Redox Equations 327 • Other Types of Redox Reactions 329

**9.5 Concentration of Solutions 331**

- Molarity 331 • Dilution 333 • Serial Dilution 337 • Thinking Outside the Box: Visible Spectrophotometry 338 • Solution Stoichiometry 339

**9.6 Aqueous Reactions and Chemical Analysis 341**

- Gravimetric Analysis 341 • Acid-Base Titrations 343

**10 ENERGY CHANGES IN CHEMICAL REACTIONS 362****10.1 Energy and Energy Changes 363****10.2 Introduction to Thermodynamics 365**

- States and State Functions 365 • The First Law of Thermodynamics 366 • Work and Heat 367

**10.3 Enthalpy 368**

- Reactions Carried Out at Constant Volume or at Constant Pressure 368 • Enthalpy and Enthalpy Changes 370 • Thermochemical Equations 371

**10.4 Calorimetry 373**

- Specific Heat and Heat Capacity 374 • Constant-Pressure Calorimetry 374 • Constant-Volume Calorimetry 378 • Thinking Outside the Box: Heat Capacity of Calorimeters 379

**10.5 Hess's Law 383****10.6 Standard Enthalpies of Formation 385****10.7 Bond Enthalpy and the Stability of Covalent Molecules 388****10.8 Lattice Energy and the Stability of Ionic Solids 392**

- The Born-Haber Cycle 392 • Comparison of Ionic and Covalent Compounds 393

**11 GASES 412****11.1 Properties of Gases 413****11.2 The Kinetic Molecular Theory of Gases 415**

- Molecular Speed 416 • Diffusion and Effusion 417



**11.3 Gas Pressure 418**

• Definition and Units of Pressure 419 • Calculation of Pressure 419 • Measurement of Pressure 420

**11.4 The Gas Laws 422**

• Boyle's Law: The Pressure-Volume Relationship 422 • Charles's and Gay-Lussac's Law: The Temperature-Volume Relationship 424 • Avogadro's Law: The Amount-Volume Relationship 426 • The Gas Laws and Kinetic Molecular Theory 428 • The Combined Gas Law: The Pressure-Temperature-Amount-Volume Relationship 429

**11.5 The Ideal Gas Equation 431**

• Applications of the Ideal Gas Equation 432

**11.6 Real Gases 434**

• Factors That Cause Deviation from Ideal Behavior 435 • The van der Waals Equation 435 • van der Waals Constants 437

**11.7 Gas Mixtures 438**

• Dalton's Law of Partial Pressures 439 • Mole Fractions 440 • Thinking Outside the Box: Decompression Injury 441

**11.8 Reactions with Gaseous Reactants and Products 443**

• Calculating the Required Volume of a Gaseous Reactant 443 • Determining the Amount of Reactant Consumed Using Change in Pressure 444 • Using Partial Pressures to Solve Problems 445

## 12 INTERMOLECULAR FORCES AND THE PHYSICAL PROPERTIES OF LIQUIDS AND SOLIDS 464

**12.1 Intermolecular Forces 465**

• Dipole-Dipole Interactions 466 • Hydrogen Bonding 466 • Dispersion Forces 467  
• Ion-Dipole Interactions 469

**12.2 Properties of Liquids 470**

• Surface Tension 470 • Viscosity 470 • Vapor Pressure 471

**12.3 Crystal Structure 475**

• Unit Cells 475 • Packing Spheres 476 • Closest Packing 478 • Thinking Outside the Box: X-ray Diffraction 480

**12.4 Types of Crystals 482**

• Ionic Crystals 482 • Covalent Crystals 485 • Molecular Crystals 486 • Metallic Crystals 486

**12.5 Amorphous Solids 487****12.6 Phase Changes 488**

• Liquid-Vapor Phase Transition 488 • Solid-Liquid Phase Transition 490 • Solid-Vapor Phase Transition 491

**12.7 Phase Diagrams 494**

## 13 PHYSICAL PROPERTIES OF SOLUTIONS 510

**13.1 Types of Solutions 511****13.2 A Molecular View of the Solution Process 512**

• The Importance of Intermolecular Forces 512 • Energy and Entropy in Solution Formation 513

**13.3 Concentration Units 516**

• Molality 516 • Percent by Mass 516 • Comparison of Concentration Units 517

**13.4 Factors That Affect Solubility 519**

• Temperature 519 • Pressure 520

**13.5 Colligative Properties 521**

• Vapor-Pressure Lowering 522 • Boiling-Point Elevation 524 • Freezing-Point Depression 525 • Osmotic Pressure 527 • Electrolyte Solutions 527 • Thinking Outside the Box: Intravenous Fluids 530 • Thinking Outside the Box: Fluoride Poisoning 531

**13.6 Calculations Using Colligative Properties 532****13.7 Colloids 534****14 CHEMICAL KINETICS 550****14.1 Reaction Rates 551****14.2 Collision Theory of Chemical Reactions 551****14.3 Measuring Reaction Progress and Expressing Reaction Rate 553**

• Average Reaction Rate 553 • Instantaneous Rate 557 • Stoichiometry and Reaction Rate 560

**14.4 Dependence of Reaction Rate on Reactant Concentration 562**

• The Rate Law 563 • Experimental Determination of the Rate Law 563

**14.5 Dependence of Reactant Concentration on Time 568**

• First-Order Reactions 568 • Second-Order Reactions 573

**14.6 Dependence of Reaction Rate on Temperature 576**

• The Arrhenius Equation 576 • Thinking Outside the Box: Surface Area 580

**14.7 Reaction Mechanisms 581**

• Elementary Reactions 581 • Rate-Determining Step 582 • Mechanisms with a Fast First Step 586 • Experimental Support for Reaction Mechanisms 587

**14.8 Catalysis 589**

• Heterogeneous Catalysis 590 • Homogeneous Catalysis 590 • Enzymes: Biological Catalysts 591

**15 CHEMICAL EQUILIBRIUM 608****15.1 The Concept of Equilibrium 609****15.2 The Equilibrium Constant 611**

• Calculating Equilibrium Constants 612 • Magnitude of the Equilibrium Constant 615

**15.3 Equilibrium Expressions 616**

• Heterogeneous Equilibria 616 • Manipulating Equilibrium Expressions 617 • Gaseous Equilibria 621

**15.4 Using Equilibrium Expressions to Solve Problems 623**

• Predicting the Direction of a Reaction 624 • Calculating Equilibrium Concentrations 625

**15.5 Factors That Affect Chemical Equilibrium 630**

• Addition or Removal of a Substance 630 • Changes in Volume and Pressure 633 • Changes in Temperature 634 • Catalysis 635 • Thinking Outside the Box: Biological Equilibria 640

**16 ACIDS AND BASES 656****16.1 Brønsted Acids and Bases 657****16.2 Molecular Structure and Acid Strength 659**

• Hydrohalic Acids 659 • Oxoacids 659 • Carboxylic Acids 661

**16.3 The Acid-Base Properties of Water 661****16.4 The pH Scale 663**

- 16.5 Strong Acids and Bases 668**  
 • Strong Acids 668 • Strong Bases 669
- 16.6 Weak Acids and Acid Ionization Constants 672**  
 • The Ionization Constant,  $K_a$  672 • Calculating pH from  $K_a$  673 • Thinking Outside the Box: Acid Rain 678 • Percent Ionization 678 • Using pH to Determine  $K_a$  680
- 16.7 Weak Bases and Base Ionization Constants 681**  
 • The Ionization Constant  $K_b$  682 • Calculating pH from  $K_b$  682 • Using pH to Determine  $K_b$  683
- 16.8 Conjugate Acid-Base Pairs 684**  
 • The Strength of a Conjugate Acid or Base 684  
 • The Relationship Between  $K_a$  and  $K_b$  of a Conjugate Acid-Base Pair 685
- 16.9 Diprotic and Polyprotic Acids 688**
- 16.10 Acid-Base Properties of Salt Solutions 690**  
 • Basic Salt Solutions 691 • Acidic Salt Solutions 692 • Neutral Salt Solutions 694  
 • Salts in Which Both the Cation and the Anion Hydrolyze 695
- 16.11 Acid-Base Properties of Oxides and Hydroxides 696**  
 • Oxides of Metals and of Nonmetals 696 • Basic and Amphoteric Hydroxides 697
- 16.12 Lewis Acids and Bases 697**

## 17 ACID-BASE EQUILIBRIA AND SOLUBILITY EQUILIBRIA 712

- 17.1 The Common Ion Effect 713**
- 17.2 Buffer Solutions 715**  
 • Calculating the pH of a Buffer 715 • Preparing a Buffer Solution with a Specific pH 720
- 17.3 Acid-Base Titrations 721**  
 • Strong Acid–Strong Base Titrations 721 • Weak Acid–Strong Base Titrations 723 • Strong Acid–Weak Base Titrations 727 • Acid-Base Indicators 729
- 17.4 Solubility Equilibria 731**  
 • Solubility Product Expression and  $K_{sp}$  732 • Calculations Involving  $K_{sp}$  and Solubility 732  
 • Predicting Precipitation Reactions 735
- 17.5 Factors Affecting Solubility 737**  
 • The Common Ion Effect 737 • pH 740 • Complex Ion Formation 742 • Thinking Outside the Box: Equilibrium and Tooth Decay 743
- 17.6 Separation of Ions Using Differences in Solubility 747**  
 • Fractional Precipitation 747 • Qualitative Analysis of Metal Ions in Solution 748

## 18 ENTROPY, FREE ENERGY, AND EQUILIBRIUM 762

- 18.1 Spontaneous Processes 763**
- 18.2 Entropy 764**  
 • A Qualitative Description of Entropy 764 • A Quantitative Definition of Entropy 764
- 18.3 Entropy Changes in a System 766**  
 • Calculating  $\Delta S_{\text{sys}}$  766 • Standard Entropy,  $S^\circ$  767 • Qualitatively Predicting the Sign of  $\Delta S_{\text{sys}}^\circ$  770
- 18.4 Entropy Changes in the Universe 774**  
 • Calculating  $\Delta S_{\text{surr}}$  775 • The Second Law of Thermodynamics 775 • Thinking Outside the Box: Thermodynamics and Living Systems 778 • The Third Law of Thermodynamics 778



**18.5 Predicting Spontaneity 780**

• Gibbs Free-Energy Change,  $\Delta G$  780 • Standard Free-Energy Changes,  $\Delta G^\circ$  782 • Using  $\Delta G$  and  $\Delta G^\circ$  to Solve Problems 783

**18.6 Free Energy and Chemical Equilibrium 786**

• Relationship Between  $\Delta G$  and  $\Delta G^\circ$  786 • Relationship Between  $\Delta G^\circ$  and  $K$  787

**18.7 Thermodynamics in Living Systems 790****19 ELECTROCHEMISTRY 804****19.1 Balancing Redox Reactions 805****19.2 Galvanic Cells 809****19.3 Standard Reduction Potentials 812****19.4 Spontaneity of Redox Reactions Under Standard-State Conditions 819**

• Thinking Outside the Box: Amalgam Fillings and Dental Pain 822

**19.5 Spontaneity of Redox Reactions Under Conditions Other Than Standard State 822**

• The Nernst Equation 823 • Concentration Cells 824

**19.6 Batteries 827**

• Dry Cells and Alkaline Batteries 827 • Lead Storage Batteries 828 • Lithium-Ion Batteries 828 • Fuel Cells 829

**19.7 Electrolysis 830**

• Electrolysis of Molten Sodium Chloride 830 • Electrolysis of Water 831 • Electrolysis of an Aqueous Sodium Chloride Solution 832 • Quantitative Applications of Electrolysis 833

**19.8 Corrosion 835****20 NUCLEAR CHEMISTRY 850****20.1 Nuclei and Nuclear Reactions 851****20.2 Nuclear Stability 853**

• Patterns of Nuclear Stability 853 • Nuclear Binding Energy 855

**20.3 Natural Radioactivity 858**

• Kinetics of Radioactive Decay 858 • Dating Based on Radioactive Decay 859

**20.4 Nuclear Transmutation 862****20.5 Nuclear Fission 865****20.6 Nuclear Fusion 871****20.7 Uses of Isotopes 873**

• Chemical Analysis 873 • Isotopes in Medicine 873 • Thinking Outside the Box: Nuclear Medicine 874

**20.8 Biological Effects of Radiation 875****21 METALLURGY AND THE CHEMISTRY OF METALS 884****21.1 Occurrence of Metals 885****21.2 Metallurgical Processes 886**

• Preparation of the Ore 886 • Production of Metals 886 • The Metallurgy of Iron 887 • Steelmaking 888 • Purification of Metals 890 • Thinking Outside the Box: Copper 891

**21.3 Band Theory of Conductivity 892**

• Conductors 892 • Semiconductors 892

- 21.4 Periodic Trends in Metallic Properties 894**
- 21.5 The Alkali Metals 894**
- 21.6 The Alkaline Earth Metals 897**
  - Magnesium 897 • Calcium 898
- 21.7 Aluminum 898**

## **22 COORDINATION CHEMISTRY 906**

- 22.1 Coordination Compounds 907**
  - Properties of Transition Metals 907 • Ligands 909 • Nomenclature of Coordination Compounds 911 • Thinking Outside the Box: Chelation Therapy 913
- 22.2 Structure of Coordination Compounds 914**
- 22.3 Bonding in Coordination Compounds: Crystal Field Theory 916**
  - Crystal Field Splitting in Octahedral Complexes 917 • Color 918 • Magnetic Properties 919 • Tetrahedral and Square-Planar Complexes 921
- 22.4 Reactions of Coordination Compounds 922**
- 22.5 Applications of Coordination Compounds 922**

## **23 NONMETALLIC ELEMENTS AND THEIR COMPOUNDS 930**

- 23.1 General Properties of Nonmetals 931**
- 23.2 Hydrogen 932**
  - Binary Hydrides 933 • Isotopes of Hydrogen 934 • Hydrogenation 934
  - The Hydrogen Economy 935
- 23.3 Carbon 935**
- 23.4 Nitrogen and Phosphorus 937**
  - Nitrogen 937 • Phosphorus 939
- 23.5 Oxygen and Sulfur 942**
  - Oxygen 942 • Sulfur 944 • Thinking Outside the Box: Arsenic 948
- 23.6 The Halogens 948**
  - Preparation and General Properties of the Halogens 949 • Compounds of the Halogens 951 • Uses of the Halogens 953

## **24 ORGANIC CHEMISTRY 960**

- 24.1 Why Carbon Is Different 961**
- 24.2 Classes of Organic Compounds 963**
  - Basic Nomenclature 967 • Molecules with Multiple Substituents 970 • Molecules with Specific Functional Groups 970
- 24.3 Representing Organic Molecules 973**
  - Condensed Structural Formulas 974 • Kekulé Structures 974 • Skeletal Structures 974
  - Resonance 976
- 24.4 Isomerism 980**
  - Constitutional Isomerism 980 • Stereoisomerism 980 • Thinking Outside the Box: Thalidomide 984

**24.5 Organic Reactions 984**

• Addition Reactions 985 • Substitution Reactions 987 • Other Types of Organic Reactions 993

**24.6 Organic Polymers 994**

• Addition Polymers 995 • Condensation Polymers 995 • Biological Polymers 997

**25 MODERN MATERIALS 1012****25.1 Polymers 1013**

• Addition Polymers 1013 • Condensation Polymers 1018 • Thinking Outside the Box: Electrically Conducting Polymers 1021

**25.2 Ceramics and Composite Materials 1021**

• Ceramics 1021 • Composite Materials 1023

**25.3 Liquid Crystals 1023****25.4 Biomedical Materials 1026**

• Dental Implants 1026 • Soft Tissue Materials 1027 • Artificial Joints 1028

**25.5 Nanotechnology 1028**

• Graphite, Buckyballs, and Nanotubes 1029

**25.6 Semiconductors 1030****25.7 Superconductors 1033****Appendixes**

- 1 Mathematical Operations A-1
- 2 Thermodynamic Data at 1 ATM and 25°C A-6
- 3 Ionization Constants of Weak Acids and Bases at 25°C A-13
- 4 Solubility Product Constants at 25°C A-15

**Glossary G-1****Answers to Odd-Numbered Problems AP-1****Credits C-1****Index I-1**