

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
	1.1 Measurement, 2 1.2 Significant Figures, 3 1.3 Matter and Energy, 5	
<b>2</b>	<b>Atomic Structure</b>	<b>9</b>
	2.1 The Atom, 9 2.2 Subatomic Particles, 10 2.3 The Electron, 10 2.4 The Proton, 14 2.5 The Neutron, 15 2.6 The Nuclear Atom, 16 2.7 Atomic Symbols, 17 2.8 Isotopes and Isobars, 19 2.9 Atomic Weights, 20 2.10 Atomic Spectra, 23 2.11 The Periodic Law, 28 2.12 Dual Nature of the Electron, 31 2.13 Quantum Numbers, 36 2.14 Magnetic Moment, 39 2.15 Electronic Structures of the Elements, 42 2.16 Half-filled and Filled Subshells, 47 2.17 Types of Elements, 47 Problems, 49	
<b>3</b>	<b>Chemical Bonding</b>	<b>51</b>
	3.1 Atomic Sizes, 51 3.2 Ionization Potentials, 55 3.3 Electron Affinities, 59 3.4 The Ionic Bond, 60 3.5 Ionic Radius, 65 3.6 The Covalent Bond, 66 3.7 The Coordinate Covalent Bond, 69 3.8 Transition Between Ionic and Covalent Bonding, 70 3.9 Electronegativity, 74 3.10 Properties of Ionic and Covalent Compounds, 79 3.11 Resonance, 82 3.12 Directional Characteristics of the Covalent Bond, 84 3.13 Electron Pair Repulsions and Molecular Geometry, 90 3.14 Molecular Orbitals, 94 3.15 The Metallic Bond, 99 3.16 Nomenclature of Binary Compounds, 106 3.17 Ternary Compounds, 107 Problems, 111	
<b>4</b>	<b>Chemical Equations and Quantitative Relationships</b>	<b>113</b>
	4.1 The Gram Atom, Avogadro's Number, 113 4.2 The Mole, 114 4.3 Chemical Calculations, 116 4.4 The Law of Constant Composition, 117 4.5 Determination of Formulas, 119 4.6 Chemical Equations, 120 4.7 Problems Based on Chemical Equations, 122 4.8 Heat of Reaction, 123 4.9 Law of Hess, 125 4.10 Law of Dulong and Petit, 127 4.11 Equivalent Weights of Elements, 127 Problems, 129	
<b>5</b>	<b>Gases</b>	<b>132</b>
	5.1 The Gaseous State, 132 5.2 Pressure, 132 5.3 Boyle's Law, 135 5.4 Charles' Law, 136 5.5 Ideal Gas Law, 139 5.6 Kinetic Theory, 140	

5.7	Avogadro's Principle, 143	5.8	Gay-Lussac's Law of Combining Volumes, 145	5.9	Weight-Volume Relationships in Reactions, 146	5.10	Dalton's Law of Partial Pressures, 147	5.11	Graham's Law of Effusion, 151	5.12	Molecular Velocities, 152	5.13	Deviations from the Ideal Gas Laws, 153	5.14	Liquefaction of Gases, 155	Problems, 156										
<b>6</b>	<b>Liquids and Solids</b>															<b>160</b>										
6.1	The Liquid State, 160	6.2	Evaporation, 162	6.3	Vapor Pressure, 162	6.4	Boiling Point, 164	6.5	Heat of Vaporization, 166	6.6	The Freezing Point, 167	6.7	Vapor Pressure of a Solid, 168	6.8	Phase Diagrams, 170	6.9	Crystals, 173	6.10	X-Ray Diffraction of Crystals, 175	6.11	Defect Structures, 178	6.12	Born-Haber Cycle, 180	Problems, 181		
<b>7</b>	<b>Oxygen and Hydrogen</b>																								<b>183</b>	
7.1	Occurrence and Preparation of Oxygen, 184	7.2	Properties of Oxygen, 185	7.3	Acidic and Alkaline Oxides, 188	7.4	Ozone, 189	7.5	Oxidation Numbers, 190	7.6	Oxidation-Reduction Reactions, 192	7.7	Equivalent Weights of Compounds, 197	7.8	Hydrogen Peroxide, 199	7.9	Occurrence and Preparation of Hydrogen, 200	7.10	Properties of Hydrogen, 203	7.11	The Hydrogen Bond, 205	Problems, 209				
<b>8</b>	<b>Solutions</b>																								<b>212</b>	
8.1	Types of Solutions, 212	8.2	The Solution Process, 214	8.3	Hydrates, 216	8.4	Heat of Solution, 217	8.5	Pressure and Solubility, 219	8.6	Concentration of Solutions, 220	8.7	Volumetric Analysis, 224	8.8	Vapor Pressure of Solutions, 226	8.9	Boiling Point and Freezing Point of Solutions, 230	8.10	Distillation, 234	8.11	Solutions of Electrolytes, 235	8.12	Interionic Attractions in Solution, 238	Problems, 241		
<b>9</b>	<b>Electrochemistry</b>																								<b>243</b>	
9.1	Metallic Conduction, 243	9.2	Electrolytic Conduction, 244	9.3	Electrolysis, 246	9.4	Faraday's Laws, 250	9.5	Electrolytic Conductance, 252	9.6	Voltaic Cells, 255	9.7	Electromotive Force, 257	9.8	Electrode Potentials, 260	9.9	Electrode Potentials and Concentration Changes, 265	9.10	Concentration Cells, 267	9.11	Applications of Half-Cell Potentials, 268	9.12	Some Commercial Voltaic Cells, 273	9.13	Fuel Cells, 274	Problems, 275
<b>10</b>	<b>The Nonmetals</b>																								<b>278</b>	
	THE NOBLE GASES, 278	10.1	Properties of the Noble Gases, 278																							
	THE HALOGENS, 281	10.2	Group Properties, 281	10.3	Preparation of the Halogens, 285	10.4	The Interhalogen Compounds, 287	10.5	The Hydrogen Halides, 288	10.6	The Metal Halides, 290	10.7	Iodimetry and Iodometry, 292	10.8	Oxyacids of the Halogens, 294											
	SULFUR, SELENIUM, AND TELLURIUM, 299	10.9	Group Properties, 299	10.10	The Elements, 301	10.11	Hydrogen Compounds and Derivatives, 304	10.12	The 4+ Oxidation State, 307	10.13	The 6+ Oxidation State, 309															
	THE GROUP V A ELEMENTS, 315	10.14	Group Properties, 315	10.15	The Elements, 317	10.16	Nitrides and Phosphides, 321	10.17	Hydrogen Compounds, 322	10.18	Halogen Compounds, 325	10.19	Sulfides, 328	10.20	Oxides and Oxyacids of											

Nitrogen, 329 10.21 Oxides and Oxyacids of Phosphorus, Arsenic, Antimony, and Bismuth, 334  
 CARBON AND SILICON, 339  
 10.22 Group Properties, 339 10.23 The Elements, 342 10.24 Carbides and Silicides, 345 10.25 Oxides and Oxyacides, 346 10.26 Sulfur Compounds and Halogen Compounds, 352 10.27 Carbon-Nitrogen Compounds, 353  
 BORON, 354  
 10.28 Group Properties, 354 10.29 The Element, 356  
 10.30 Compounds of Boron, 357 Problems, 362

- 11 Elements of Chemical Thermodynamics 365**  
 11.1 Heat and Work, 265 11.2 First Law of Thermodynamics, 366  
 11.3 Enthalpy, 369 11.4 Heat Capacities, 371 11.5 Adiabatic and Isothermal Changes, 373 11.6 The Carnot Cycle, 374 11.7 Second Law of Thermodynamics, 378 11.8 Entropy, 379 11.9 Gibbs Free Energy, 384 11.10 Standard Free Energies, 389 11.11 Third Law of Thermodynamics, 390 Problems, 391
- 12 Chemical Kinetics and Chemical Equilibrium 394**  
 12.1 Molecular Collisions and Reaction Rates, 394 12.2 Temperature and Reaction Rate, 396 12.3 Catalysts, 400 12.4 Heterogeneous Reactions, 405 12.5 Concentrations and Reaction Rates, 405  
 12.6 Reaction Mechanisms and Rate Equations, 409 12.7 Reversible Reactions and Chemical Equilibrium, 413 12.8 Equilibrium Constants, 415 12.9 Free Energy and Chemical Equilibrium, 419  
 12.10 Le Chatelier's Principle, 422 Problems, 427
- 13 Acids and Bases 431**  
 13.1 The Arrhenius Concept, 431 13.2 The Solvent System Concept, 432  
 13.3 The Brønsted-Lowry Concept, 436 13.4 Strengths of Brønsted Acids and Bases, 437 13.5 Hydrolysis, 441 13.6 Acid and Base Strengths and Structure, 444 13.7 The Lewis Concept, 446 Problems, 450
- 14 Ionic Equilibria 452**  
 14.1 Weak Electrolytes, 452 14.2 The Ionization of Water, 458  
 14.3 pH, 460 14.4 Determination of pH, 461 14.5 Indicators, 465  
 14.6 The Common-Ion Effect, 467 14.7 Buffers, 469 14.8 The Solubility Product, 474 14.9 Precipitation and the Solubility Product, 477 14.10 Polyprotic Acids, 481 14.11 Precipitation of Sulfides, 485  
 14.12 Equilibria Involving Complex Ions, 489 14.13 Amphoterism, 497 14.14 Hydrolysis, 500 14.15 Titration of Acids and Alkalies, 509 14.16 Oxidation-Reduction Equilibria, 515 Problems, 522
- 15 Metals 526**  
 15.1 Properties of Metals, 526 15.2 Natural Occurrence of Metals, 534  
 15.3 Metallurgy: Preliminary Treatment of Ores, 535 15.4 Metallurgy: Reduction, 537 15.5 Metallurgy: Refining, 544 15.6 The Group I A Metals, 546 15.7 The Group II A Metals, 550 15.8 The Transition Metals, 556 15.9 The Lanthanides, 565 15.10 The Metals of Group III A, 568 15.11 The Metals of Group IV A, 570 Problems, 574
- 16 Complex Compounds 576**  
 16.1 Structure, 576 16.2 Nomenclature, 583 16.3 Isomerism, 584  
 16.4 The Bonding in Complexes, 588 Problems, 600

<b>17 Organic Chemistry</b>	<b>602</b>
17.1 The Alkanes, 602 17.2 The Alkenes, 607 17.3 The Alkynes, 610 17.4 Aromatic Hydrocarbons, 611 17.5 Reactions of the Hydro- carbons, 614 17.6 Alcohols and Ethers, 618 17.7 Carbonyl Compounds, 623 17.8 Carboxylic Acids and Esters, 626 17.9 Amines and Amides, 630 17.10 Amino Acids and Proteins, 632 17.11 Carbohydrates, 635 17.12 Polymers, 637 Problems, 641	
<b>18 Nuclear Chemistry</b>	<b>644</b>
18.1 The Nucleus, 644 18.2 Radioactivity, 647 18.3 Rate of Radio- active Decay, 651 18.4 Radioactive Disintegration Series, 656 18.5 Nuclear Reactions, 657 18.6 Nuclear Fission and Fusion, 661 18.7 Uses of Isotopes, 663 Problems, 665	
<b>Appendix A Values of Some Constants and Conversion Factors</b>	<b>667</b>
<b>Appendix B Solubility Products at 25°C</b>	<b>668</b>
<b>Appendix C Logarithms</b>	<b>670</b>
<b>Appendix D Instability Constants at 25°C</b>	<b>672</b>
<b>Answers to Selected Numerical Problems</b>	<b>673</b>
<b>Index</b>	<b>675</b>