

# CONTENTS

<b>Preface</b>	<b>xxiii</b>
<b>FUNDAMENTALS</b>	<b>F1</b>
<b>INTRODUCTION AND ORIENTATION</b>	<b>F1</b>
Chemistry and Society	F1
Chemistry: A Science at Two Levels	F2
How Science Is Done	F4
The Different Branches of Chemistry	F5
Mastering Chemistry	F6
<b>A MATTER AND ENERGY</b>	<b>F7</b>
A.1 Physical Properties	F7
A.2 Energy	F8
A.3 Force	F11
<i>Exercises</i>	<b>F12</b>
<b>B ELEMENTS AND ATOMS</b>	<b>F14</b>
B.1 Atoms	F14
B.2 The Nuclear Atom	F15
B.3 Neutrons	F18
B.4 Isotopes	F20
B.5 The Organization of the Elements	F21
<i>Exercises</i>	<b>F24</b>
<b>C COMPOUNDS</b>	<b>F26</b>
C.1 What Are Compounds?	F26
C.2 Molecules and Molecular Compounds	F27
C.3 Ions and Ionic Compounds	F29
<i>Exercises</i>	<b>F33</b>
<b>D THE NOMENCLATURE OF COMPOUNDS</b>	<b>F34</b>
D.1 Names of Cations	F34
D.2 Names of Anions	F34
D.3 Names of Ionic Compounds	F36
D.4 Names of Inorganic Molecular Compounds	F37
D.5 Names of Organic Compounds	F39
<i>Exercises</i>	<b>F41</b>
<b>E MOLES AND MOLAR MASSES</b>	<b>F43</b>
E.1 The Mole	F43
E.2 Molar Mass	F45
<i>Exercises</i>	<b>F49</b>

F	DETERMINATION OF CHEMICAL FORMULAS	F51
	F.1 Mass Percentage Composition	F51
	F.2 Determining Empirical Formulas	F52
	F.3 Determining Molecular Formulas	F53
	<i>Exercises</i>	F55
G	MIXTURES AND SOLUTIONS	F56
	G.1 Classifying Mixtures	F56
	G.2 Separation Techniques	F58
	G.3 Molarity	F59
	<b>TOOLBOX G.1 HOW TO USE MOLARITY</b>	<b>F61</b>
	G.4 Dilution	F63
	<b>TOOLBOX G.2 HOW TO CALCULATE THE VOLUME OF SOLUTION TO DILUTE</b>	<b>F64</b>
	G.5 Mole Fraction	F65
	G.6 Molality	F66
	<i>Exercises</i>	F69
H	CHEMICAL EQUATIONS	F71
	H.1 Symbolizing Chemical Reactions	F71
	H.2 Balancing Chemical Equations	F73
	<i>Exercises</i>	F75
I	AQUEOUS SOLUTIONS AND PRECIPITATION	F77
	I.1 Electrolytes	F77
	I.2 Precipitation Reactions	F80
	I.3 Ionic and Net Ionic Equations	F80
	I.4 Putting Precipitation to Work	F81
	<i>Exercises</i>	F83
J	ACIDS AND BASES	F85
	J.1 Acids and Bases in Aqueous Solution	F85
	J.2 Strong and Weak Acids and Bases	F87
	J.3 Neutralization	F89
	J.4 Acidic and Basic Character in the Periodic Table	F90
	<i>Exercises</i>	F92
K	REDOX REACTIONS	F93
	K.1 Oxidation and Reduction	F93
	K.2 Oxidation Numbers: Keeping Track of Electrons	F94
	<b>TOOLBOX K.1 HOW TO ASSIGN OXIDATION NUMBERS</b>	<b>F95</b>
	K.3 Oxidizing and Reducing Agents	F96
	K.4 Balancing Simple Redox Equations	F98
	<i>Exercises</i>	F99
L	REACTION STOICHIOMETRY	F101
	L.1 Mole-to-Mole Predictions	F101
	L.2 Mass-to-Mass Predictions	F102
	L.3 Volumetric Analysis	F104
	<b>TOOLBOX L.1 HOW TO INTERPRET A TITRATION</b>	<b>F105</b>
	<i>Exercises</i>	F106



<b>M LIMITING REACTANTS</b>	<b>F109</b>
M.1 Reaction Yield	F109
M.2 The Limits of Reaction	F110
M.3 Combustion Analysis	F112
<i>Exercises</i>	<b>F115</b>

## CHAPTER 1 ATOMS: THE QUANTUM WORLD

<b>OBSERVING ATOMS</b>	<b>1</b>
1.1 The Characteristics of Electromagnetic Radiation	1
1.2 Quanta and Photons	4
1.3 The Wave-Particle Duality of Matter	8
1.4 The Uncertainty Principle	9
1.5 Wavefunctions and Energy Levels	11
1.6 Atomic Spectra and Energy Levels	14
<b>MODELS OF ATOMS</b>	<b>17</b>
1.7 The Principal Quantum Number	17
1.8 Atomic Orbitals	18
1.9 Electron Spin	23
<b>How Do We Know (Box 1.1) . . . That an Electron Has Spin?</b>	<b>24</b>
1.10 The Electronic Structure of Hydrogen	24
<b>THE STRUCTURES OF MANY-ELECTRON ATOMS</b>	<b>25</b>
1.11 Orbital Energies	25
1.12 The Building-Up Principle	27
1.13 Ground-State Electron Configurations	30
<b>How Do We Know (Box 1.2) . . . The Structure of the Periodic Table?</b>	<b>32</b>
1.14 Electronic Structure and the Periodic Table	33
<b>THE PERIODICITY OF ATOMIC PROPERTIES</b>	<b>34</b>
1.15 Atomic Radius	34
1.16 Ionic Radius	36
1.17 Ionization Energy	37
1.18 The Inert-Pair Effect	39
1.19 Diagonal Relationships	40
1.20 Electron Affinity	40
<b>THE IMPACT ON MATERIALS</b>	<b>42</b>
1.21 Main-Group Elements	42
1.22 The Transition Metals	44
<i>Exercises</i>	<b>45</b>

## CHAPTER 2 CHEMICAL BONDS

<b>IONIC BONDS</b>	<b>53</b>
2.1 The Formation of Ionic Bonds	53

2.2	Interactions Between Ions	55
2.3	The Electron Configurations of Ions	58
2.4	Lewis Symbols	60
<b>COVALENT BONDS</b>		60
2.5	The Nature of the Covalent Bond	61
2.6	Lewis Structures	61
2.7	Lewis Structures for Polyatomic Species	62
<b>TOOLBOX 2.1 HOW TO WRITE THE LEWIS STRUCTURE OF A POLYATOMIC SPECIES</b>		64
2.8	Resonance	65
2.9	Formal Charge	68
<b>EXCEPTIONS TO THE OCTET RULE</b>		71
2.10	Radicals and Biradicals	71
<b>What Has This to Do with (Box 2.1) . . . Staying Alive?</b>		
<b>Chemical Self-Preservation</b>		72
2.11	Expanded Valence Shells	73
<b>LEWIS ACIDS AND BASES</b>		75
2.12	The Unusual Structures of Group 13 Halides	75
2.13	Lewis Acid-Base Complexes	76
<b>IONIC VERSUS COVALENT BONDS</b>		77
2.14	Correcting the Covalent Model: Electronegativity	77
2.15	Correcting the Ionic Model: Polarizability	80
<b>THE STRENGTHS AND LENGTHS OF COVALENT BONDS</b>		81
2.16	Bonds Strengths	81
2.17	The Variation of Bond Strength	82
2.18	Bond Lengths	84
<b>How Do We Know (Box 2.2) . . . The Length of a Chemical Bond?</b>		86
<i>Exercises</i>		87
<b>MAJOR TECHNIQUE 1: Infrared Spectroscopy</b>		94

## CHAPTER 3 MOLECULAR SHAPE AND STRUCTURE

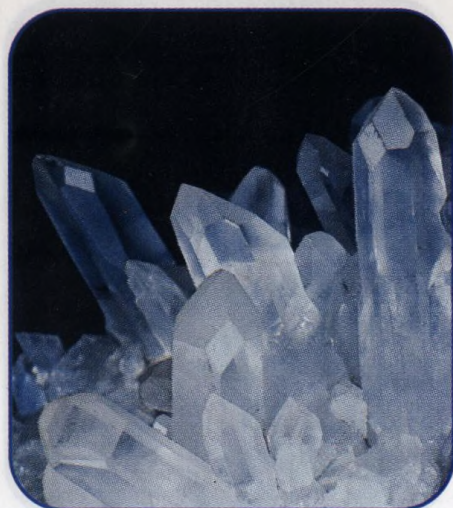
<b>THE SHAPES OF MOLECULES AND IONS</b>		97
3.1	The VSEPR Model	98
<b>Frontiers of Chemistry (Box 3.1): Drugs by Design and Discovery</b>		102
3.2	Molecules with Lone Pairs on the Central Atom	102
<b>TOOLBOX 3.1 HOW TO USE THE VSEPR MODEL</b>		106
3.3	Polar Molecules	107
<b>VALENCE-BOND THEORY</b>		110
3.4	Sigma and Pi Bonds	110



3.5	Hybridization of Orbitals	112
3.6	Hybridization in More Complex Molecules	115
3.7	Bonding in Hydrocarbons	117
3.8	Characteristics of Double Bonds	120
<b>MOLECULAR ORBITAL THEORY</b>		<b>121</b>
<b>How Do We Know (Box 3.2) . . . That Electrons Are Not Paired?</b>		<b>122</b>
3.9	Molecular Orbitals	122
3.10	The Electronic Configurations of Diatomic Molecules	123
<b>How Do We Know (Box 3.3) . . . The Energies of Molecular Orbitals?</b>		<b>128</b>
3.11	Bonding in Heteronuclear Diatomic Molecules	129
3.12	Orbitals in Polyatomic Molecules	130
3.13	The Impact on Materials: The Band Theory of Solids	133
<i>Exercises</i>		136
<b>MAJOR TECHNIQUE 2: Ultraviolet and Visible Spectroscopy</b>		<b>142</b>

## CHAPTER 4 THE PROPERTIES OF GASES

<b>THE NATURE OF GASES</b>		<b>145</b>
4.1	Observing Gases	146
4.2	Pressure	146
<b>What Has This to Do with (Box 4.1) . . . The Environment?</b>		<b>147</b>
<b>Gas Laws and the Weather</b>		<b>147</b>
4.3	Alternative Units of Pressure	150
<b>THE GAS LAWS</b>		<b>151</b>
4.4	Boyle's Law	152
4.5	Charles's Law	154
4.6	Avogadro's Principle	155
4.7	The Ideal Gas Law	156
4.8	Applications of the Ideal Gas Law	158
4.9	The Stoichiometry of Reacting Gases	161
4.10	Mixtures of Gases	163
<b>MOLECULAR MOTION</b>		<b>166</b>
4.11	Diffusion and Effusion	166
<b>THE KINETIC MODEL OF GASES</b>		<b>169</b>
4.12	The Pressure of a Gas	169
4.13	The Maxwell Distribution of Speeds	173
<b>How Do We Know (Box 4.2). . . The Distribution of Molecular Speeds?</b>		<b>174</b>



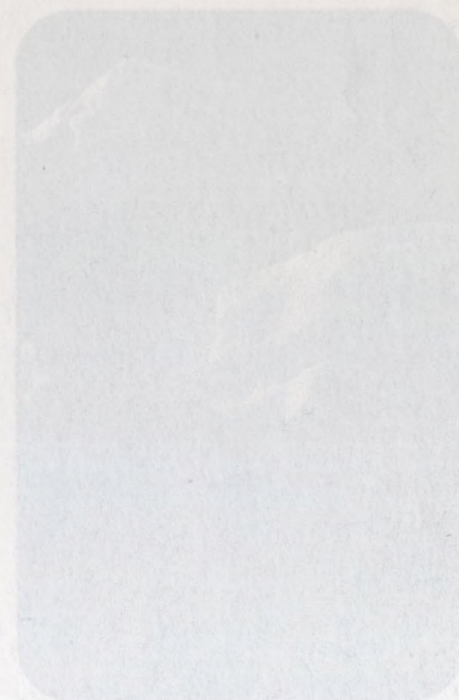
REAL GASES	175
4.14 Intermolecular Forces	175
4.15 The Liquefaction of Gases	176
4.16 Equations of State of Real Gases	177
<i>Exercises</i>	179

## CHAPTER 5 LIQUIDS AND SOLIDS

INTERMOLECULAR FORCES	187
5.1 The Formation of Condensed Phases	187
5.2 Ion-Dipole Forces	188
5.3 Dipole-Dipole Forces	190
5.4 London Forces	192
5.5 Hydrogen Bonding	196
LIQUID STRUCTURES	198
5.6 Order in Liquids	199
5.7 Viscosity and Surface Tension	199
SOLID STRUCTURES	203
5.8 Classification of Solids	203
<b>How Do We Know (Box 5.1). . . What a Surface Looks Like?</b>	<b>204</b>
5.9 Metallic Solids	206
5.10 Unit Cells	209
THE IMPACT ON MATERIALS: METALS	213
5.11 The Properties of Metals	214
5.12 Alloys	215
THE IMPACT ON MATERIALS: NONMETALLIC SOLIDS	217
5.13 Ionic Structures	217
5.14 Molecular Solids	220
5.15 Network Solids	222
<b>Frontiers of Chemistry (Box 5.2): High-Temperature Superconductors</b>	<b>224</b>
5.16 Liquid Crystals	224
<i>Exercises</i>	227
MAJOR TECHNIQUE 3: X-Ray Diffraction	234

## CHAPTER 6 THERMODYNAMICS: THE FIRST LAW

SYSTEMS, STATES, AND ENERGIES	239
6.1 Systems	239
6.2 Energy and Work	241
6.3 The Molecular Origin of Internal Energy	242
6.4 Heat	244





6.5	The First Law	245
6.6	State Functions	246
6.7	Expansion Work	247
6.8	The Measurement of Heat: Calorimetry	252
<b>ENTHALPY</b>		<b>258</b>
6.9	Heat Transfers at Constant Pressure	259
6.10	Heat Capacities of Gases	260
6.11	The Molecular Origin of the Heat Capacities of Gases	262
6.12	Enthalpies of Phase Changes	263
6.13	Heating Curves	266
<b>THE ENTHALPY OF CHEMICAL CHANGE</b>		<b>267</b>
<b>How Do We Know (Box 6.1) . . . The Shape of a Heating Curve?</b>		<b>268</b>
6.14	Reaction Enthalpies	268
6.15	The Relation Between $\Delta H$ and $\Delta U$	271
6.16	Standard Reaction Enthalpies	272
6.17	Combining Reaction Enthalpies: Hess's Law	274
<b>TOOLBOX 6.1 HOW TO USE HESS'S LAW</b>		<b>274</b>
6.18	The Heat Output of Reactions	276
<b>What Has This to Do with (Box 6.2) . . . The Environment?</b>		
<b>Alternative Fuels</b>		<b>278</b>
6.19	Standard Enthalpies of Formation	280
<b>TOOLBOX 6.2 HOW TO USE STANDARD ENTHALPIES OF FORMATION</b>		<b>281</b>
6.20	The Born-Haber Cycle	283
<b>TOOLBOX 6.3 HOW TO USE A BORN-HABER CYCLE</b>		<b>284</b>
6.21	Bond Enthalpies	285
6.22	The Variation of Reaction Enthalpy with Temperature	287
<b>Exercises</b>		<b>290</b>

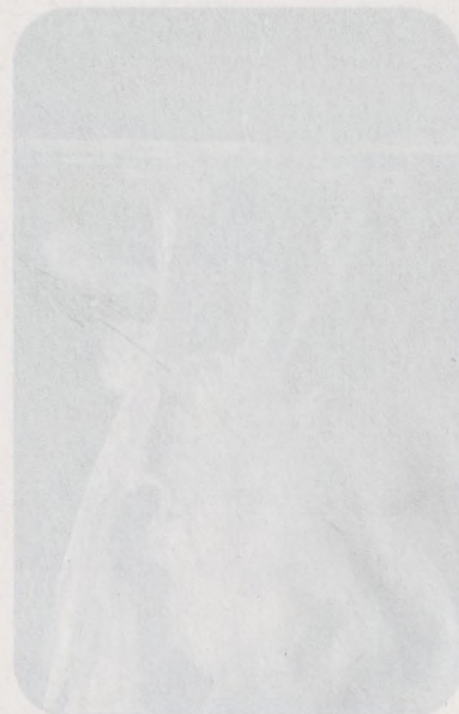
## CHAPTER 7 THERMODYNAMICS: THE SECOND AND THIRD LAWS

<b>ENTROPY</b>		<b>299</b>
7.1	Spontaneous Change	299
7.2	Entropy and Disorder	300
7.3	Changes in Entropy	302
7.4	Entropy Changes Accompanying Changes of Physical State	305
7.5	A Molecular Interpretation of Entropy	307
7.6	Standard Molar Entropies	311
7.7	Standard Reaction Entropies	314

GLOBAL CHANGES IN ENTROPY	315
7.8 The Surroundings	316
7.9 The Overall Change in Entropy	318
7.10 Equilibrium	321
FREE ENERGY	322
7.11 Focusing on the System	323
7.12 Reaction Free Energy	325
7.13 Free Energy and Nonexpansion Work	329
7.14 The Effect of Temperature	330
7.15 Free Energy Changes in Biological Systems	332
<i>Exercises</i>	334

## CHAPTER 8 PHYSICAL EQUILIBRIA

PHASES AND PHASE TRANSITIONS	343
8.1 Vapor Pressure	343
8.2 Volatility and Molecular Properties	345
8.3 The Variation of Vapor Pressure with Temperature	347
8.4 Boiling	349
8.5 Freezing and Melting	351
8.6 Phase Diagrams	351
8.7 The Phase Rule	353
8.8 Critical Properties	356
SOLUBILITY	357
8.9 The Molecular Nature of Dissolving	358
8.10 The Like-Dissolves-Like Rule	359
8.11 Pressure and Gas Solubility: Henry's Law	361
<b>Frontiers of Chemistry (Box 8.1): Smart Gels</b>	<b>362</b>
8.12 Temperature and Solubility	364
8.13 The Enthalpy of Solution	365
8.14 Individual Ion Hydration Enthalpies	367
8.15 The Free Energy of Solution	369
COLLIGATIVE PROPERTIES	371
8.16 Vapor-Pressure Lowering	371
8.17 Boiling-Point Elevation and Freezing-Point Depression	374
8.18 Osmosis	378
BINARY LIQUID MIXTURES	381
8.19 The Vapor Pressure of a Binary Mixture	381
8.20 Distillation	382
8.21 Azeotropes	384
<i>Exercises</i>	387
MAJOR TECHNIQUE 4: Chromatography	396





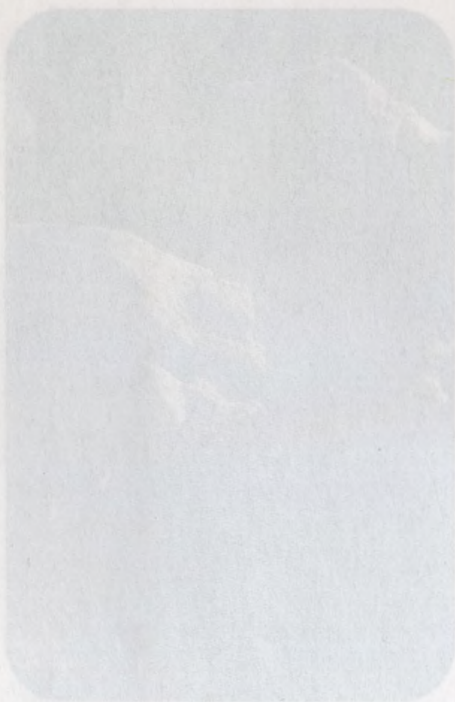


## CHAPTER 9 CHEMICAL EQUILIBRIA

REACTIONS AT EQUILIBRIUM	401
9.1 The Reversibility of Reactions	401
9.2 Thermodynamics and Chemical Equilibrium	403
9.3 Equilibrium Constants	408
9.4 Heterogeneous Equilibria	414
USING EQUILIBRIUM CONSTANTS	415
9.5 The Extent of Reaction	415
9.6 The Direction of Reaction	417
9.7 Equilibrium Tables	418
<b>TOOLBOX 9.1 HOW TO SET UP AND USE AN EQUILIBRIUM TABLE</b>	<b>420</b>
THE RESPONSE OF EQUILIBRIA TO CHANGES IN CONDITIONS	424
9.8 Adding and Removing Reagents	424
9.9 Compressing a Reaction Mixture	428
9.10 Temperature and Equilibrium	430
9.11 Catalysts and Haber's Achievements	433
<i>Exercises</i>	435

## CHAPTER 10 ACIDS AND BASES

PROPERTIES OF ACIDS AND BASES	445
10.1 Proton Transfer Equilibrium	445
10.2 Proton Exchange Between Water Molecules	449
10.3 The pH Scale	451
10.4 The pOH of Solutions	453
WEAK ACIDS AND BASES	454
10.5 Acidity and Basicity Constants	455
10.6 The Conjugate Seesaw	457
10.7 The Role of the Solvent in Acid Strength	459
10.8 Molecular Structure and Acid Strength	461
10.9 The Strength of Oxoacids	461
THE pH OF SOLUTIONS OF WEAK ACIDS AND BASES	464
10.10 Solutions of Weak Acids	464
<b>TOOLBOX 10.1 HOW TO CALCULATE THE pH OF SOLUTION OF A WEAK ACID</b>	<b>465</b>
10.11 Solutions of Weak Bases	467
10.12 The pH of Salt Solutions	468
<b>TOOLBOX 10.2 HOW TO CALCULATE THE pH OF AN ELECTROLYTE SOLUTION</b>	<b>471</b>
AUTOPROTOLYSIS AND pH	473
10.13 Very Dilute Solutions of Strong Acids and Bases	474
10.14 Very Dilute Solutions of Weak Acids	475



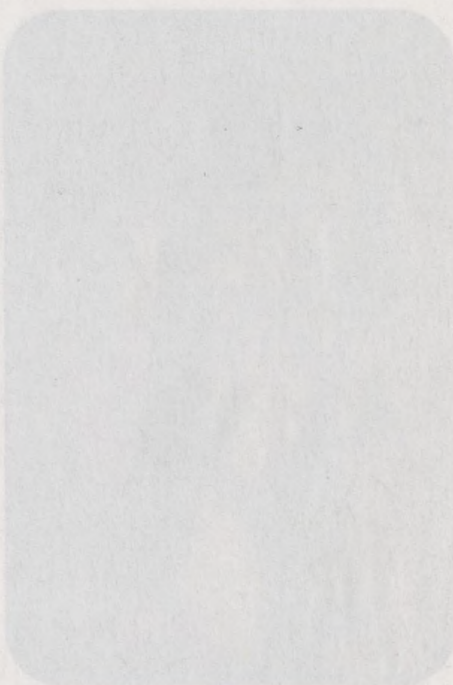
POLYPROTIC ACIDS AND BASES	478
10.15 The pH of a Polyprotic Acid Solution	479
10.16 Solutions of Salts of Polyprotic Acids	481
10.17 The Concentrations of Solute Species	483
10.18 Composition and pH	487
<b>What Has This to Do with (Box 10.1) . . . The Environment?</b>	
<b>Acid Rain and the Gene Pool</b>	<b>488</b>
<i>Exercises</i>	490

## CHAPTER 11 AQUEOUS EQUILIBRIA

MIXED SOLUTIONS AND BUFFERS	499
11.1 Mixed Solutions	499
11.2 Buffer Action	502
11.3 Designing a Buffer	502
11.4 Buffer Capacity	505
<b>What Has This to Do with (Box 11.1) . . . Staying Alive?</b>	
<b>Physiological Buffers</b>	<b>506</b>
TITRATIONS	509
11.5 Strong Acid–Base Titrations	509
11.6 Strong Acid–Weak Base and Weak Acid–Strong Base Titrations	513
11.7 Acid–Base Indicators	518
POLYPROTIC ACID TITRATIONS	521
11.8 Stoichiometry of Polyprotic Acid Titrations	522
11.9 pH Changes During Titration	523
<b>TOOLBOX 11.1 HOW TO PREDICT THE pH DURING THE TITRATION OF A POLYPROTIC ACID</b>	<b>524</b>
SOLUBILITY EQUILIBRIA	527
11.10 The Solubility Product	527
11.11 The Common-Ion Effect	530
11.12 Predicting Precipitation	532
11.13 Selective Precipitation	533
11.14 Dissolving Precipitates	534
11.15 Complex Ion Formation	535
11.16 Qualitative Analysis	537
<i>Exercises</i>	540

## CHAPTER 12 ELECTROCHEMISTRY

REDOX EQUATIONS	549
12.1 Half-Reactions	549
12.2 Balancing Redox Equations	550



<b>TOOLBOX 12.1 HOW TO BALANCE COMPLICATED REDOX EQUATIONS</b>	<b>550</b>
<b>GALVANIC CELLS</b>	<b>553</b>
12.3 Examples of Galvanic Cells	553
12.4 The Notation for Cells	556
12.5 Cell Potential	557
12.6 Cell Potential and Reaction Free Energy	558
12.7 Standard Electrode Potentials	560
12.8 The Significance of Standard Potentials	565
<b>Frontiers of Chemistry (Box 12.1): Portable Energy</b>	<b>566</b>
12.9 The Electrochemical Series	568
<b>Frontiers of Chemistry (Box 12.2): Fuel Cells</b>	<b>570</b>
12.10 Standard Potentials and Equilibrium Constants	574
<b>TOOLBOX 12.2 HOW TO CALCULATE EQUILIBRIUM CONSTANTS FROM ELECTROCHEMICAL DATA</b>	<b>575</b>
12.11 The Nernst Equation	576
12.12 Ion-Selective Electrodes	577
12.13 Corrosion	578
<b>ELECTROLYSIS</b>	<b>580</b>
12.14 Electrolytic Cells	580
12.15 The Potential Needed for Electrolysis	581
12.16 The Products of Electrolysis	583
12.17 Electrolysis in Action	585
<i>Exercises</i>	<b>586</b>

## CHAPTER 13 CHEMICAL KINETICS

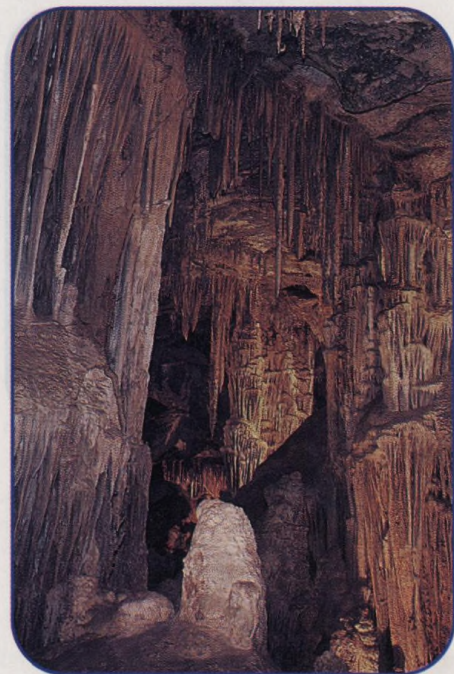
<b>REACTION RATES</b>	<b>595</b>
13.1 Concentration and Reaction Rate	595
13.2 The Instantaneous Rate of Reaction	597
<b>How Do We Know (Box 13.1) . . . What Happens to Atoms During a Reaction?</b>	<b>598</b>
13.3 Rate Laws and Reaction Order	600
<b>CONCENTRATION AND TIME</b>	<b>606</b>
13.4 First-Order Integrated Reaction Laws	606
13.5 Half-Lives for First-Order Reactions	610
13.6 Second-Order Integrated Rate Laws	611
<b>MODELS OF REACTIONS</b>	<b>612</b>
13.7 The Effect of Temperature	613
13.8 Collision Theory	616
<b>How Do We Know (Box 13.2) . . . What Happens During a Molecular Collision?</b>	<b>619</b>
13.9 Activated Complex Theory	620
<b>REACTION MECHANISMS</b>	<b>622</b>
13.10 Elementary Reactions	622
13.11 The Rate Laws of Elementary Reactions	623



13.12 Chain Reactions	628
13.13 Rates and Equilibrium	629
<b>ACCELERATING REACTIONS</b>	<b>631</b>
13.14 Catalysis	631
<b>What Has This to Do with (Box 13.3) . . . The Environment?</b>	
<b>The Ozone Layer</b>	<b>632</b>
<b>Frontiers of Chemistry (Box 13.4): Zeolite Catalysts</b>	<b>636</b>
13.15 Living Catalysts: Enzymes	637
<i>Exercises</i>	639

## CHAPTER 14 THE ELEMENTS: THE FIRST FOUR MAIN GROUPS

<b>PERIODIC TRENDS</b>	<b>649</b>
14.1 Atomic Properties	649
14.2 Bonding Trends	651
14.3 Chemical Properties: Hydrides	652
14.4 Chemical Properties: Oxides	653
<b>HYDROGEN</b>	<b>654</b>
14.5 The Element	654
14.6 Compounds of Hydrogen	656
<b>GROUP 1: THE ALKALI METALS</b>	<b>657</b>
14.7 The Group 1 Elements	658
14.8 Chemical Properties of the Alkali Metals	659
14.9 Compounds of Lithium, Sodium, and Potassium	662
<b>GROUP 2: THE ALKALINE EARTH METALS</b>	<b>664</b>
14.10 The Group 2 Elements	664
14.11 Compounds of Beryllium and Magnesium	667
14.12 Compounds of Calcium	669
<b>GROUP 13: THE BORON FAMILY</b>	<b>671</b>
14.13 The Group 13 Elements	671
<b>What Has This to Do with (Box 14.1) . . . The Environment?</b>	
<b>Aluminum Recycling</b>	<b>674</b>
14.14 Group 13 Oxides	674
14.15 Carbides, Nitrides, and Halides	676
14.16 Boranes, Borohydrides, and Borides	678
<b>GROUP 14: THE CARBON FAMILY</b>	<b>679</b>
14.17 The Group 14 Elements	679
14.18 The Different Forms of Carbon	681
14.19 Silicon, Germanium, Tin, and Lead	682
<b>Frontiers of Chemistry (Box 14.2): Nanotubes, Nature's Smallest Pipes</b>	<b>684</b>
14.20 Oxides of Carbon	684
14.21 Oxides of Silicon: The Silicates	686
14.22 Other Important Group 14 Compounds	689





THE IMPACT ON MATERIALS	691
14.23 Glasses	691
14.24 Ceramics	692
<i>Exercises</i>	693

## CHAPTER 15 THE ELEMENTS: THE LAST FOUR MAIN GROUPS

GROUP 15: THE NITROGEN FAMILY	701
15.1 The Group 15 Elements	701
15.2 Compounds with Hydrogen and the Halogens	705
15.3 Nitrogen Oxides and Oxoacids	707
15.4 Phosphorus Oxides and Oxoacids	710
GROUP 16: THE OXYGEN FAMILY	712
15.5 The Group 16 Elements	712
<b>What Has This to Do with (Box 15.1) . . . The Environment?</b>	
<b>The Greenhouse Effect</b>	<b>714</b>
15.6 Compounds with Hydrogen	718
15.7 Sulfur Oxides and Oxoacids	721
15.8 Sulfur Halides	723
GROUP 17: THE HALOGENS	724
15.9 The Group 17 Elements	724
15.10 Compounds of the Halogens	727
GROUP 18: THE NOBLE GASES	731
15.11 The Group 18 Elements	731
15.12 Compounds of the Noble Gases	733
THE IMPACT ON MATERIALS	734
15.13 Colloids, Clays, and Gels	735
15.14 Phosphors and Other Luminescent Materials	736
<i>Exercises</i>	738

## CHAPTER 16 THE *d*-BLOCK: METALS IN TRANSITION

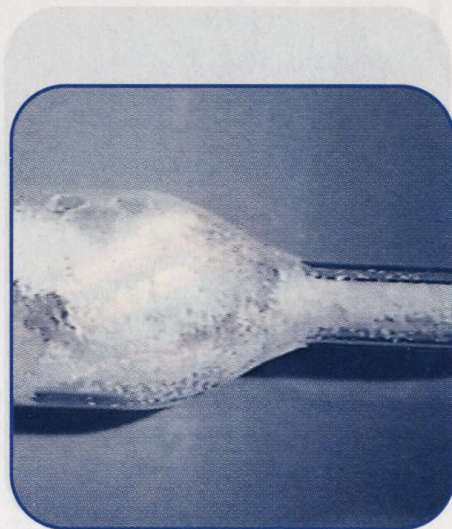
THE <i>d</i> -BLOCK ELEMENTS AND THEIR COMPOUNDS	745
<b>What Has This to Do with (Box 16.1) . . . Staying Alive?</b>	
<b>Why We Need to Eat <i>d</i>-Metals</b>	<b>746</b>
16.1 Trends in Physical Properties	747
16.2 Trends in Chemical Properties	749
SELECTED ELEMENTS: A SURVEY	752
16.3 Scandium Through Nickel	752
16.4 Groups 11 and 12	756
COORDINATION COMPOUNDS	761
16.5 The Nature of Complexes	762
<b>TOOLBOX 16.1 HOW TO NAME <i>d</i>-METAL COMPLEXES</b>	<b>764</b>

16.6 The Shapes of Complexes	765
16.7 Isomers	767
<b>How Do We Know (Box 16.2) . . . That a Complex Is Optically Active?</b>	<b>772</b>
<b>THE ELECTRONIC STRUCTURES OF COMPLEXES</b>	<b>775</b>
16.8 Crystal Field Theory	775
16.9 The Spectrochemical Series	778
16.10 High-Spin and Low-Spin Complexes	778
16.11 The Colors of Complexes	780
16.12 Magnetic Properties of Complexes	782
<b>LIGAND FIELD THEORY</b>	<b>783</b>
16.13 Sigma-Bonding in Complexes	784
16.14 Pi-Bonding in Complexes	785
<b>THE IMPACT ON MATERIALS</b>	<b>786</b>
16.15 Steel	786
16.16 Nonferrous Alloys	788
16.17 Magnetic Materials	789
<i>Exercises</i>	<b>790</b>

## CHAPTER 17 NUCLEAR CHEMISTRY

<b>NUCLEAR STABILITY</b>	<b>797</b>
17.1 The Evidence for Spontaneous Nuclear Decay	797
17.2 Nuclear Reactions	799
<b>TOOLBOX 17.1 HOW TO IDENTIFY THE PRODUCTS OF A NUCLEAR REACTION</b>	<b>800</b>
17.3 The Pattern of Nuclear Stability	802
17.4 Predicting the Type of Nuclear Decay	804
17.5 Nucleosynthesis	805
<b>Frontiers of Chemistry (Box 17.1): Spallation</b>	<b>806</b>
<b>What Has This to Do with (Box 17.2) . . . Staying Alive?</b>	
<b>Nuclear Medicine</b>	<b>809</b>
<b>NUCLEAR RADIATION</b>	<b>810</b>
17.6 The Biological Effects of Radiation	810
17.7 Measuring the Rate of Radioactive Decay	812
<b>How Do We Know (Box 17.3) . . . How Radioactive a Material Is?</b>	<b>813</b>
17.8 Uses of Radioisotopes	817
<b>NUCLEAR ENERGY</b>	<b>818</b>
17.9 Mass-Energy Conversion	818
17.10 Nuclear Fission	820
17.11 Nuclear Fusion	825
17.12 The Chemistry of Nuclear Power	826
<i>Exercises</i>	<b>828</b>

KNIHOVNA KATEDRY BOTANIKY  
přirodovědecké fakulty  
UNIVERZITY PALACKÉHO V OLOMOUCI



## CHAPTER 18 ORGANIC CHEMISTRY I: THE HYDROCARBONS

<b>ALIPHATIC HYDROCARBONS</b>	<b>835</b>
18.1 Types of Hydrocarbons	835
18.2 Nomenclature of Hydrocarbons	837
<b>TOOLBOX 18.1 HOW TO NAME ALIPHATIC HYDROCARBONS</b>	<b>839</b>
18.3 Isomers	841
18.4 Properties of Alkanes	845
<b>What Has This to Do with (Box 18.1) . . . The Environment? Fossil Fuels</b>	<b>846</b>
18.5 Mechanism: Alkane Substitution	848
18.6 Properties of Alkenes	849
18.7 Mechanism: Electrophilic Addition to Alkenes	850
<b>AROMATIC COMPOUNDS</b>	<b>853</b>
18.8 Reactions of Arenes	855
18.9 Mechanisms: Electrophilic Substitution	855
<i>Exercises</i>	859
 <b>MAJOR TECHNIQUE 5: Mass Spectrometry</b>	 <b>864</b>

## CHAPTER 19 ORGANIC CHEMISTRY II: FUNCTIONAL GROUPS

<b>FUNCTIONAL GROUPS</b>	<b>867</b>
19.1 Haloalkanes	867
19.2 Mechanisms: Nucleophilic Substitutions	868
19.3 Alcohols	870
<b>How Do We Know (Box 19.1) . . . The Pathway of a Reaction?</b>	<b>870</b>
19.4 Ethers	872
19.5 Phenols	873
19.6 Aldehydes and Ketones	873
19.7 Carboxylic Acids	874
19.8 Amines, Amino Acids, and Amides	876
<b>TOOLBOX 19.1 HOW TO NAME COMPOUNDS WITH FUNCTIONAL GROUPS</b>	<b>878</b>
<b>THE IMPACT ON MATERIALS</b>	<b>879</b>
19.9 Addition Polymerization	879
<b>Frontiers of Chemistry (Box 19.2): Conducting Polymers</b>	<b>882</b>
19.10 Condensation Polymerization	883
19.11 Copolymers and Composites	888
19.12 Physical Properties of Polymers	889



<b>THE IMPACT ON BIOLOGY</b>	<b>890</b>
19.13 Proteins	890
19.14 Carbohydrates	894
19.15 DNA and RNA	895
Exercises	899
<b>MAJOR TECHNIQUE 6: Nuclear Magnetic Resonance</b>	<b>906</b>
<b>APPENDIX 1 Symbols, Units, and Mathematical Techniques</b>	<b>A1</b>
A Symbols	A1
B Units and Unit Conversions	A3
C Scientific Notation	A6
D Exponents and Logarithms	A7
E Equations and Graphs	A9
F Calculus	A10
<b>APPENDIX 2 Experimental Data</b>	<b>A13</b>
A Thermodynamic Data at 25°C	A13
Inorganic Substances	A13
Organic Compounds	A18
B Standard Potentials at 25°C	A20
Potentials in Electrochemical Order	A20
Potentials in Alphabetical Order	A21
C Ground-State Electron Configurations	A22
D The Elements	A24
E The Top 25 Chemicals by Industrial Production in the United States in 1997	A36
<b>APPENDIX 3 Nomenclature</b>	<b>A37</b>
A The Nomenclature of Polyatomic Ions	A37
B Common Names of Chemicals	A38
C Names of Cations with Variable Charge Numbers	A38
<b>Glossary</b>	<b>B1</b>
<b>Answers</b>	<b>C1</b>
Odd-Numbered Exercises	C1
Self-Tests B	C42
<b>Illustration Credits</b>	<b>D1</b>
<b>Index</b>	<b>E1</b>

