#### **Brief Contents**

**Preface** 

**Applications and Interludes** 

A Note to the Student

ΧV

xvii

390

		7474
1	Matter, Energy, and Life	1
2	Measurements in Chemistry	18
3	Atoms and the Periodic Table	48
4	Ionic Compounds	76
5	Molecular Compounds	102
6	Chemical Reactions: Classification and Mass Relationships	134
7	Chemical Reactions: Energy, Rates, and Equilibrium	168
8	Gases, Liquids, and Solids	198
9	Solutions	230
10	Acids and Bases	264
11	Nuclear Chemistry	298
12	Introduction to Organic Chemistry: Alkanes	324
13	Alkenes, Alkynes, and	358

14 Some Compounds with Oxygen, Sulfur, or a Halogen

15	Amines	418
16	Aldehydes and Ketones	444
17	Carboxylic Acids and Their Derivatives	473
18	<b>Amino Acids and Proteins</b>	512
19	Enzymes, Vitamins, and Chemical Messengers	549
20	The Generation of Biochemical Energy	590
21	Carbohydrates	620
22	Carbohydrate Metabolism	653
23	Lipids	681
24	Lipid Metabolism	712
25	Protein and Amino Acid Metabolism	734
26	Nucleic Acids and Protein Synthesis	750
27	Body Fluids	786
	Appendixes	<b>A1</b>
	Glossary	<b>A7</b>
	Selected Answers to Problems	A17
	Photo/ Illustration Credits	A28
	Index	A30

### **Contents**

App	ncations and intenudes	X
Pref	ace	xvi
A No	ote to the Student	XX
1	Matter, Energy, and Life	1
1.1	Chemistry: The Central Science 2	
1.2	•	
1.3	Classification of Matter 5	
1.4	Chemical Elements 7	
1.5	Names and Symbols for Elements	8
	Application: A Chemical Reaction	8
	Application: What's in a Name? 1	0
1.6	Energy 12	
	Interlude: Chemicals, Toxicity, and	
	Risk 13	
	Summary 14	
	Additional Problems 15	
2	Measurements in Chemistry	18
2.1	Physical Quantities 19	
2.2	Measuring Mass 21	
2.3	Measuring Length and Volume 23	į
	Application: Apothecary Units 24	
2.4	Measurement and Significant	
	Figures 25	
2.5	Scientific Notation 27	

2.10	meat and energy 30
2.11	Density 39
	Application: Measuring Body Fat 40
2.12	Specific Gravity 42
	Interlude: Powers of 10 43
	Summary 44
	Additional Problems 44
<u> </u>	Atoms and the Periodic Table 48
3.1	Atomic Theory 49
3.2	Composition of Atoms 52
3.3	Isotopes and Atomic Weight 53
3.4	Location of Electrons in Atoms 55
3.5	Electron Configurations 57
3.6	The Periodic Table 61
	Application: Chernobyl and Cesium 62
3.7	
	Elements 64
3.8	Electron Configurations and the Periodic Table 68
	Interlude: Are Atoms Real? 71
	Summary 72
	Additional Problems 73
	· · · · · · · · · · · · · · · · · · ·

Rounding Off Numbers

Problem Solving

2.9 Measuring Temperature

Calculations: Converting a Quantity from One Unit to Another 32

36

2.6

2.7

2.8

4 1	onic Compounds 76
4.1	Ions 77
4.2	Periodic Properties and Ion
	Formation 79
4.3	Ionic Bonds 80
4.4	Properties of Ionic Compounds 81
	Application: Homeostasis 82
4.5	Ions and the Octet Rule 83
4.6	Electron-Dot Symbols 85
4.7	Ions of Some Common Elements 86 Application: Biologically Important Ions 88
4.8	Naming Ions 88
	Polyatomic Ions 90
4.10	Formulas of Ionic Compounds 91
4.11	Naming Ionic Compounds 93
4.12	H <sup>+</sup> and OH <sup>-</sup> Ions: An Introduction to
	Acids and Bases 95
	Interlude: Minerals and Gems 97
	Summary 98 Additional Problems 99
5	Molecular Compounds 102
5.1	Covalent Bonds 103
5.2	Covalent Bonds, the Octet Rule, and the
	Periodic Table 106
5.3	Multiple Covalent Bonds 109
5.4	Coordinate Covalent Bonds 110
5.5	Molecular and Structural Formulas 111
	Application: Coordinate Covalent Bonds and Living Organisms 112
5.6	<b>C</b>
5.7	±
5.8	Polar Covalent Bonds and Electronegativity 122
5.9	Polar Molecules 124
5.10	Naming Binary Molecular Compounds 125
	Application: Carbon Monoxide: A Surprising Molecule 126

	Properties of Molecular
	Compounds 127 Interlude: Polymers: How Big Can a
	Molecule Be? 129
	Summary 130
	Additional Problems 130
C	Chemical Reactions:
	Classification and Mass
6 F	Relationships 134
6.1	Chemical Equations 135
6.2	Balancing Chemical Equations 137
6.3	Avogadro's Number and the Mole 139
6.4	Gram-Mole Conversions 141
6.5	Mole Relationships from Chemical Equations 143
6.6	Mass Relationships from Chemical Equations 145
6.7	
6.8	Classes of Chemical Reactions 148
6.9	Precipitation Reactions and Rules for Solubility 149
	Application: Gout and Kidney Stones: Problems in Solubility 150
6.10	Acids, Bases, and Neutralization Reactions 152
6.11	Net Ionic Equations 153
6.12	Redox Reactions 154
6.13	Recognizing Redox Reactions 156
6.14	Organic Redox Reactions 159
	Interlude: Photography: A Series of Redox Reactions 162
	Summary 163
	Additional Problems 164
Dente.	Chemical Reactions: Energy,
	Rates, and Equilibrium 16
7.1	Heat Changes During Chemical Reactions 169
7.2	Exothermic and Endothermic Reactions 170
	Application: Energy From Food 172
7.3	Why Do Chemical Reactions Occur? Free Energy 175

	Temperature 184
7.6	Reversible Reactions and Chemical
	Equilibrium 184
7.7	Equilibrium Equations and Equilibrium Constants 186
7.8	LeChâtelier's Principle: The Effect of
	Changing Conditions on
	Equilibria 189
	Interlude: Nitrogen Fixation 193
	Summary 194
	Additional Problems 195
8	Gases, Liquids, and Solids 198
8.1	States of Matter Revisited 199
8.2	Gases and the Kinetic–Molecular
	Theory 201
8.3	Pressure 201
8.4	Partial Pressure and Dalton's Law 203
8.5	Boyle's Law: The Relation Between
0.6	Pressure and Volume 205
8.6	Charles's Law: The Relation Between Volume and Temperature 207
8.7	Gay-Lussac's Law: The Relation
	Between Pressure and
	Temperature 208
8.8	The Combined Gas Law 209
	Application: Inhaled Anesthetics 210
8.9	Avogadro's Law: The Relation Between Volume and Amount 212
8.10	The Universal Gas Law 214
8.11	Intermolecular Forces: Dipole–Dipole and London Forces 215
8.12	Intermolecular Forces: Hydrogen
	Bonds 218
8.13	Liquids 219
	Application: Water 220
	Solids 223
8.15	Changes of State 224
	Interlude: Bone and Biomaterials 225

How Do Reactions Occur? Reaction

Effect of Temperature, Concentration, and Catalysts on Reaction Rates

Application: Regulation of Body

181

7.4

7.5

Rates

179

#### Summary 226 Additional Problems 227

9	Solutions 230
9.1	Mixtures and Solutions 231
9.2	The Solution Process 233
9.3	Solid Hydrates 235
9.4	Solubility 236
9.5	The Effect of Temperature on Solubility 237
9.6	The Effect of Pressure on Solubility: Henry's Law 239
	Application: Breathing and Oxygen Transport 240
9.7	Units of Concentration 242
9.8	Dilution 248
9.9	Ions in Solution: Electrolytes 250
9.10	O Body Electrolytes: Equivalents and Milliequivalents 251
9.1	1 Some Properties of Solutions 253
9.12	2 Osmosis and Osmotic Pressure 254
	Application: Dialysis 256
9.1	3 Colloids 257
	Interlude: Timed-Release Medications 259
	Summary 260
	Additional Problems 261
10	Acids and Bases 26
10.1	Acids and Bases in Aqueous Solution: A Review 265
10.2	
10.3	The Brønsted-Lowry Definition of Acids and Bases 267
10.4	Water as Both an Acid and a Base 269
10.5	Some Common Acid-Base Reactions 270
	Application: Ulcers and Antacids 272
10.6	Acid and Base Strength 274
10.7	Acid-Dissociation Constants 277
108	Discognization of Water 278

Measuring Acidity in Aqueous Solution:

10.9

pH 279

	Application: pH of Body Fluids 282
10.10	Working With pH 282
10.11	Laboratory Determination of
	Acidity 283
	Buffer Solutions 284
	Buffers in the Body 287
10.14	Equivalents of Acids and Bases: Normality 289
10.15	Titration 290
10.16	Acidity and Basicity of Salt Solutions 292
	Interlude: Acid Rain 293
	Summary 294
	Additional Problems 295
77	Nusland Chamisture
	Nuclear Chemistry 29
11.1	The Discovery and Nature of Radioactivity 299
11.2	Stable and Unstable Isotopes 301
11.3	Nuclear Decay 302
	Application: Medical Uses of Radioactivity 304
11.4	Radioactive Half-Life 306
11.5	Radioactive Decay Series 307
11.6	Ionizing Radiation 308
11.7	Detecting Radiation 310
11.8	Measuring Radiation 311
11.9	Artificial Transmutation 313
	Application: Body Imaging 314
11.10	Nuclear Fission and Nuclear Fusion 316
	Interlude: Archaeological Radiocarbon Dating 320
	Summary 321
	Additional Problems 322
	ntroduction to Organic
	Chemistry: Alkanes 32
12.1	The Nature of Organic Molecules 325
12.2	Families of Organic Molecules:
	Functional Groups 327
12.3	The Structure of Organic Molecules:
	Alkanes and Their Isomers 331
	Application: Natural Versus Synthetic 334

12.4	Drawing Organic Structures 334
12.5	The Shapes of Organic Molecules 336
	Application: Displaying Molecular
	Shapes 338
12.6	Naming Alkanes 339
12.7	Properties of Alkanes 345
12.8	
12.9	Cycloalkanes 348
12.10	Drawing and Naming
	Cycloalkanes 350
	Interlude: Petroluem 352
	Summary 353
	Summary of Reactions 353 Additional Problems 354
	Additional Problems 354
	Alkonoo Alkumoo and Aramatia
	Alkenes, Alkynes, and Aromatic Compounds 358
	zompounus 338
13.1	
13.2	8
13.3	The Structure of Alkenes: Cis-Trans
	Isomerism 363
	Application: The Chemistry of Vision 366
13.4	Properties of Alkenes and Alkynes 366
13.5	Reactions of Alkenes and Alkynes 368
13.6	How an Alkene Addition Reaction Occurs 373
13.7	Alkene Polymers 374
13.8	Aromatic Compounds and the Structure of Benzene 376
	Application: Polycyclic Aromatic
4.0.0	Hydrocarbons and Cancer 378
13.9	Naming Aromatic Compounds 378
13.10	Reactions of Aromatic Compounds 381
	Interlude: Why We See Color 383
	Summary 384
	Summary of Reactions 384
	Additional Problems 386
	Sama Camanana and a second
	Some Compounds with Oxygen, Sulfur, or a Halogen 390
14.1	Alcohols, Phenols, and Ethers 391

14.2

Some Common Alcohols

393

14.3	Naming Alcohols 394
14.4	•
14.5	Reactions of Alcohols 398
	Application: Ethyl Alcohol as a Drug and
	a Poison 402
14.6	
	Acidity of Alcohols and Phenols 404
14.8	
	Application: Antioxidants 406
14.9	
	Thiols and Disulfides 408
14.11	Halogen-Containing Compounds 409
	Interlude: Chlorofluorocarbons and the Ozone Hole 411
	Summary 412
	Summary of Reactions 413
	Additional Problems 413
	110000000000000000000000000000000000000
1 5	Amines 418
<u> </u>	Amines 418
15.1	Amines 419
15.2	Properties of Amines 421
	Application: Chemical Information 422
15.3	•
15.4	•
15.5	Amine Salts 429
	Application: Organic Compounds in
	Body Fluids and the "Solubility Switch" 430
15.6	
15.7	Amines in Plants: Alkaloids 433
15.8	Amines in Drugs 435
	Interlude: Prodrugs 438
	Summary 439
	Summary of Reactions 439
	Additional Problems 440
16	Aldehydes and Ketones 444
16.1	The Carbonyl Group 445
16.2	Naming Aldehydes and Ketones 447
16.3	Properties of Aldehydes and
	Ketones 448

16.4	
	Some Common Aldehydes and Ketones 449
	Application: Opening the Door to the Age of Plastics 450
16.5	Oxidation of Aldehydes 453
10,0	Application: Is It Poisonous or Isn't It? 454
16.6	Reduction of Aldehydes and Ketones 456
16.7	Addition of Alcohols: Hemiacetals and Acetals 458
16.8	Aldol Reaction of Aldehydes and Ketones 464
	Interlude: Chemical Warfare Among the Insects 466
	Summary 467
	Summary of Reactions 467
	Additional Problems 469
	Carboxylic Acids and Their Derivatives 473
17.1	Properties of Carboxylic Acids and
170	Their Derivatives 474
17.2	Their Derivatives 474 Naming Carboxylic Acids and Their Derivatives 477
17.2	Naming Carboxylic Acids and Their
	Naming Carboxylic Acids and Their Derivatives 477
	Naming Carboxylic Acids and Their Derivatives 477 Application: Acids for the Skin 482
17.3 17.4	Naming Carboxylic Acids and Their Derivatives 477  Application: Acids for the Skin 482  Some Common Carboxylic Acids 484  Acidity of Carboxylic Acids 485  Application: Acid Salts as Food  Additives 486
17.3	Naming Carboxylic Acids and Their Derivatives 477  Application: Acids for the Skin 482  Some Common Carboxylic Acids 484  Acidity of Carboxylic Acids 485  Application: Acid Salts as Food
17.3 17.4 17.5 17.6	Naming Carboxylic Acids and Their Derivatives 477  Application: Acids for the Skin 482  Some Common Carboxylic Acids 484  Acidity of Carboxylic Acids 485  Application: Acid Salts as Food  Additives 486  Reactions of Carboxylic Acids: Ester and Amide Formation 488  Some Common Esters 492
17.3 17.4 17.5	Naming Carboxylic Acids and Their Derivatives 477  Application: Acids for the Skin 482  Some Common Carboxylic Acids 484  Acidity of Carboxylic Acids 485  Application: Acid Salts as Food  Additives 486  Reactions of Carboxylic Acids: Ester and Amide Formation 488  Some Common Esters 492
17.3 17.4 17.5 17.6	Naming Carboxylic Acids and Their Derivatives 477  Application: Acids for the Skin 482  Some Common Carboxylic Acids 484  Acidity of Carboxylic Acids 485  Application: Acid Salts as Food  Additives 486  Reactions of Carboxylic Acids: Ester and Amide Formation 488  Some Common Esters 492  Hydrolysis of Esters and Amides 495  Acid Anhydrides 497
17.3 17.4 17.5 17.6 17.7 17.8 17.9	Naming Carboxylic Acids and Their Derivatives 477  Application: Acids for the Skin 482  Some Common Carboxylic Acids 484  Acidity of Carboxylic Acids 485  Application: Acid Salts as Food  Additives 486  Reactions of Carboxylic Acids: Ester and Amide Formation 488  Some Common Esters 492  Hydrolysis of Esters and Amides 495  Acid Anhydrides 497  Phosphoric Acid Derivatives 498
17.3 17.4 17.5 17.6 17.7 17.8 17.9	Naming Carboxylic Acids and Their Derivatives 477  Application: Acids for the Skin 482  Some Common Carboxylic Acids 484  Acidity of Carboxylic Acids 485  Application: Acid Salts as Food  Additives 486  Reactions of Carboxylic Acids: Ester and Amide Formation 488  Some Common Esters 492  Hydrolysis of Esters and Amides 495  Acid Anhydrides 497  Phosphoric Acid Derivatives 498  Organic Reactions 501
17.3 17.4 17.5 17.6 17.7 17.8 17.9	Naming Carboxylic Acids and Their Derivatives 477  Application: Acids for the Skin 482  Some Common Carboxylic Acids 484  Acidity of Carboxylic Acids 485  Application: Acid Salts as Food  Additives 486  Reactions of Carboxylic Acids: Ester and Amide Formation 488  Some Common Esters 492  Hydrolysis of Esters and Amides 495  Acid Anhydrides 497  Phosphoric Acid Derivatives 498  Organic Reactions 501  Application: Nitrate Esters for Treating Angina 502
17.3 17.4 17.5 17.6 17.7 17.8 17.9	Naming Carboxylic Acids and Their Derivatives 477  Application: Acids for the Skin 482  Some Common Carboxylic Acids 484  Acidity of Carboxylic Acids 485  Application: Acid Salts as Food  Additives 486  Reactions of Carboxylic Acids: Ester and Amide Formation 488  Some Common Esters 492  Hydrolysis of Esters and Amides 495  Acid Anhydrides 497  Phosphoric Acid Derivatives 498  Organic Reactions 501  Application: Nitrate Esters for Treating
17.3 17.4 17.5 17.6 17.7 17.8 17.9	Naming Carboxylic Acids and Their Derivatives 477  Application: Acids for the Skin 482  Some Common Carboxylic Acids 484  Acidity of Carboxylic Acids 485  Application: Acid Salts as Food  Additives 486  Reactions of Carboxylic Acids: Ester and Amide Formation 488  Some Common Esters 492  Hydrolysis of Esters and Amides 495  Acid Anhydrides 497  Phosphoric Acid Derivatives 498  Organic Reactions 501  Application: Nitrate Esters for Treating Angina 502

Additional Problems 507

18	Amino Acids and Proteins	51
18.1	An Introduction to Biochemistry	513
18.2		
18.3	Amino Acids 516	
18.4	Acid-Base Properties of Amino Acids 518	
18.5	Handedness 520	
18.6	Molecular Handedness and Amin Acids 521	0
18.7	Primary Protein Structure 523	
	Application: Protein Analysis by Electrophoresis 526	
18.8	Shape-Determining Interactions in Proteins 529	
	Application: Protein Structure—In Has Led the Way 530	
18.9	Secondary Structure of Proteins	533
	Application: Determining Protein Structure 534	
	Tertiary and Quaternary Structure Proteins 536	es of
	Classification of Proteins 539	
18.12		541
	Interlude: The Food Pyramid and Proteins in the Diet 542	
	Summary 545	
	Additional Problems 546	
	Enzymes, Vitamins, and Chemi	cal
T6	Messengers	549
19.1	Enzymes 550	
19.2	Enzyme Structure 552	
19.3	Enzyme Classification 553	
19.4	Enzyme Specificity 556	
19.5	How Enzymes Work 557	
19.6	Effect of Temperature and pH on Enzymes 559	
19.7	Effect of Enzyme and Substrate Concentration on Enzyme Activity	z 561
	Application: Enzymes in Medical Diagnosis 562	
19.8	Enzyme Inhibition 564	
19.9	Enzyme Regulation: Feedback and Allosteric Control 567	

19.11 19.12 19.13	Enzyme Regulation: Zymogens and Genetic Control 568 Vitamins 569 Chemical Messengers 574 Hormones and the Endocrine System 575 Application: Vitamins, Minerals, and Food Labels 576 How Chemical Messengers Work: Epinephrine and Fight-or-Flight 580 Neurotransmitters 581 Interlude: A Drug Family 584 Summary 586 Additional Problems 587
400 400	The Generation of Biochemical Energy 590
*	
20.1	Energy and Life 591
20.2	Free Energy and Biochemical Reactions 592
20.3	Cells and Their Structure 594
20.4	An Overview of Metabolism and Energy
<b>.</b>	Production 597
20.5	Strategies of Metabolism: ATP and Energy Transfer 599
	Application: Basal Metabolism 600 Strategies of Metabolism: Metabolic
	Pathways and Coupled Reactions 601
20.7	Strategies of Metabolism: Oxidized and Reduced Coenzymes 604
	The Citric Acid Cycle 607
	The Electron Transport Chain and ATP Production 610
20.10	Superoxide Ion and Other Oxygen By- Products 614
	Application: Diets, Babies, and Hibernating Bears 614
,	Interlude: Plants and Photosynthesis 616
	Summary 617
	Additional Problems 617
A CONTRACTOR OF THE PARTY OF TH	arbohydrates 620
	Classification of Carbohydrates 621
21.2	Handedness of Carbohydrates 622

21.3	The D and L Families of Sugars: Drawing Sugar Molecules 625
21.4	Structure of Glucose and Other
	Monosaccharides 627
	Application: Carbohydrates in the Diet 630
21.5	Some Important Monosaccharides 633
21.6	Reactions of Monosaccharides 635
	Application: Glucose in Blood and Urine 636
21.7	Some Important Disaccharides 638
21.8	Variations on the Carbohydrate Theme 641
	Application: Cell Surface Carbohydrates and Blood Type 642
21.9	Some Important Polysaccharides 645
	Interlude: Tooth Decay 647
	Summary 648
	Additional Problems 649
22	Carbohydrate Metabolism 653
22.1	Digestion of Carbohydrates 654
Oliverani, quan propriorane	
22.1 22.2 22.3	Digestion of Carbohydrates 654
22.1 22.2	Digestion of Carbohydrates 654 Glucose Metabolism: An Overview 655
22.1 22.2 22.3	Digestion of Carbohydrates 654 Glucose Metabolism: An Overview 655 Glycolysis 657 Entry of Other Sugars into
22.1 22.2 22.3 22.4	Digestion of Carbohydrates 654 Glucose Metabolism: An Overview 655 Glycolysis 657 Entry of Other Sugars into Glycolysis 662
22.1 22.2 22.3 22.4 22.5	Digestion of Carbohydrates 654 Glucose Metabolism: An Overview 655 Glycolysis 657 Entry of Other Sugars into Glycolysis 662 The Fate of Pyruvate 662 Energy Output in Complete Catabolism
22.1 22.2 22.3 22.4 22.5 22.6	Digestion of Carbohydrates 654 Glucose Metabolism: An Overview 655 Glycolysis 657 Entry of Other Sugars into Glycolysis 662 The Fate of Pyruvate 662 Energy Output in Complete Catabolism of Glucose 665 Regulation of Glucose Metabolism and
22.1 22.2 22.3 22.4 22.5 22.6 22.7	Digestion of Carbohydrates 654 Glucose Metabolism: An Overview 655 Glycolysis 657 Entry of Other Sugars into Glycolysis 662 The Fate of Pyruvate 662 Energy Output in Complete Catabolism of Glucose 665 Regulation of Glucose Metabolism and Energy Production 666 Metabolism in Fasting and
22.1 22.2 22.3 22.4 22.5 22.6 22.7 22.8	Digestion of Carbohydrates 654 Glucose Metabolism: An Overview 655 Glycolysis 657 Entry of Other Sugars into Glycolysis 662 The Fate of Pyruvate 662 Energy Output in Complete Catabolism of Glucose 665 Regulation of Glucose Metabolism and Energy Production 666 Metabolism in Fasting and Starvation 668
22.1 22.2 22.3 22.4 22.5 22.6 22.7 22.8 22.9	Digestion of Carbohydrates 654 Glucose Metabolism: An Overview 655 Glycolysis 657 Entry of Other Sugars into Glycolysis 662 The Fate of Pyruvate 662 Energy Output in Complete Catabolism of Glucose 665 Regulation of Glucose Metabolism and Energy Production 666 Metabolism in Fasting and Starvation 668 Metabolism in Diabetes Mellitus 668 Application: Glycogen Storage
22.1 22.2 22.3 22.4 22.5 22.6 22.7 22.8 22.9	Digestion of Carbohydrates 654 Glucose Metabolism: An Overview 655 Glycolysis 657 Entry of Other Sugars into Glycolysis 662 The Fate of Pyruvate 662 Energy Output in Complete Catabolism of Glucose 665 Regulation of Glucose Metabolism and Energy Production 666 Metabolism in Fasting and Starvation 668 Metabolism in Diabetes Mellitus 668 Application: Glycogen Storage Diseases 670 Glycogen Metabolism: Glycogenesis and
22.1 22.2 22.3 22.4 22.5 22.6 22.7 22.8 22.9	Digestion of Carbohydrates 654 Glucose Metabolism: An Overview 655 Glycolysis 657 Entry of Other Sugars into Glycolysis 662 The Fate of Pyruvate 662 Energy Output in Complete Catabolism of Glucose 665 Regulation of Glucose Metabolism and Energy Production 666 Metabolism in Fasting and Starvation 668 Metabolism in Diabetes Mellitus 668 Application: Glycogen Storage Diseases 670 Glycogen Metabolism: Glycogenesis and Glycogenolysis 670
22.1 22.2 22.3 22.4 22.5 22.6 22.7 22.8 22.9 22.10	Digestion of Carbohydrates 654 Glucose Metabolism: An Overview 655 Glycolysis 657 Entry of Other Sugars into Glycolysis 662 The Fate of Pyruvate 662 Energy Output in Complete Catabolism of Glucose 665 Regulation of Glucose Metabolism and Energy Production 666 Metabolism in Fasting and Starvation 668 Metabolism in Diabetes Mellitus 668 Application: Glycogen Storage Diseases 670 Glycogen Metabolism: Glycogenesis and Glycogenolysis 670 Application: Glucose Tolerance Test 672 Gluconeogenesis: Glucose from

Summary 678 Additional Problems 679

23	Lipids 681
23.1	Structure and Classification of Lipids 682
23.2	Fatty Acids and their Esters 683  Application: Lipids in the Diet 686
23,3	Properties of Fats and Oils 687
23.4	Chemical Reactions of Triacylglycerols 689 Application: Detergents 690
23.5	Glycerophospholipids and Cell Membranes 692
23.6	Sphingolipids and Other Cell Membrane Lipids 694
23.7	Cell Membranes 696
23.8	Transport Across Cell Membranes 699
23.9	Steroids 701
	Application: Cardiac Glycosides 702
23.10	Steroid Hormones 702
23.11	Eicosanoids: Prostaglandins and Leukotrienes 705
	Application: Abuse of Steroids and Steroid Alternatives 706
	Interlude: Chemical
	Communication 708
	Summary 708
	Additional Problems 709
24	Lipid Metabolism 712
24.1	Digestion of Triacylglycerols 713
24.2	Triacylglycerol Metabolism: An

24.4 Activation, Membrane Transport, and Oxidation of Fatty Acids 720
24.5 Energy from Fatty Acid Oxidation 723

Application: Nutritional Value of Medium-Chain Triglycerides 720

Storage and Mobilization of

Overview 716

Triacylglycerols 718

24.3

xiv

24.6	Ketone Bodies and Ketoacidosis 725
	Application: The Liver, Clearinghouse for Metabolism 726
24.7	
4 <del>7</del> , /	Interlude: Lipids and
	Atherosclerosis 730
	Summary 732
	Additional Problems 732
	Protein and Amino Acid
25	Metabolism 734
25.1	Protein Digestion 735
25.2	Amino Acid Metabolism: An
	Overview 735
25.3	Amino Acid Catabolism: Removal of
	the Amino Group 737
25.4	The Urea Cycle 741
25.5	Amino Acid Catabolism: Fate of the
	Carbon Atoms 743
	Application: Nitrogen Balance and Kwashiorkor 744
25.6	
25.0	Acids 745
	Interlude: Xenobiotics 746
	Summary 748
	Additional Problems 748
	Nucleic Acids and Protein
26	Synthesis 750
26.1	DNA, Chromosomes, and Genes 751
26.2	Composition of Nucleic Acids 752
26.3	The Structure of Nucleic Acid
	Chains 756
26.4	Base Pairing in DNA: The
06.5	Watson-Crick Model 758
26.5	Nucleic Acids and Heredity 761
26.6	Replication of DNA 762
	Application: Serendipity and the Polymerase Chain Reaction 764
26.7	Structure and Function of RNA 767
26.8	Transcription: RNA Synthesis 768
	Application: Viruses and AIDS 770
26.9	The Genetic Code 772
	Translation: Transfer RNA and Protein
	Synthesis 772

26.11	Gene Mutation and Hereditary Disease 776	
	Application: The Human Genome Project 778	
26.12	Recombinant DNA 779	
	Interlude: Biotechnology and	
	Agriculture 781	
	Summary 783	
	Additional Problems 784	
27 E	Body Fluids	786
27.1	Body Water and Its Solutes 787	
	Application: Keeping Skin	
	Hydrated 790	
27.2	Fluid Balance 791	
	Blood 792	
27.4	Plasma Proteins, White Blood Cel	ls, and
	Immunity 794	
	Application: The Blood-Brain Barrier 796	
	Blood Clotting 799	
	Application: Organ	
	Cryopreservation 800	
27.6	Red Blood Cells and Blood Gases	801
27.7	The Kidney and Urine Formation	806
	Urine Composition and Function	807
	Interlude: Automated Clinical	
	Laboratory Analysis 809	
	Summary 811	
	Additional Problems 812	
	mondive	
	ppendixes	A1
	ientific Notation A1	
	nversion Factors A4	
C Th	e Henderson-Hasselbalch Equation	and
All	nino Acids A5	
Glossa	ary	A7
Select	ted Answers to Problems	A17
Photo,	/Illustration Credits	A28

A30

Index

# **Applications and Inter**

## Applications:

A Chemical Reaction 8 What's In a Name 10

Apothecary Units 24
Measuring Body Fat 40
Chernobyl and Cesium 62
Homeostasis 82
Biologically Important Ions 88
Coordinate Covalent Bonds and Living
Organisms 112
Carbon Monoxide: A Surprising
Molecule 126
Gout and Kidney Stones: Problems in
Solubility 150
Energy From Food 172
Regulation of Body Temperature 184
Inhaled Anesthetics 210
Water 220
Breathing and Oxygen Transport 240
Dialysis 256
Ulcers and Antacids 272
pH of Body Fluids 282
Medical Uses of Radioactivity 304
Body Imaging 314
Natural Versus Synthetic 334
Displaying Molecular Shapes 338
The Chemistry of Vision 366

# ludes

Polycyclic Aromatic Hydrocarbons and
Cancer 378
Ethyl Alcohol as a Drug and a Poison 402
Antioxidants 406
Chemical Information 422
Organic Compounds in Body Fluids and the "Solubility Switch" 430
Opening the Door to the Age of Plastics 450
Is It Poisonous or Isn't It? 454
Acids for the Skin 482
Acid Salts as Food Additives 486
Nitrate Esters for Treating Angina 502
Protein Analysis by Electrophoresis 526
Protein Structure—Insulin Has Led the Way 530
Determining Protein Structure 534
Enzymes in Medical Diagnosis 562
Vitamins, Minerals, and Food Labels 576
Basal Metabolism 600
Diets, Babies, and Hibernating Bears 614
Carbohydrates in the Diet 630
Glucose in Blood and Urine 636
Cell Surface Carbohydrates and Blood
Type 642
Glycogen Storage Diseases 670
Glucose Tolerance Test 672

#### **XVI** Applications and Interludes

Lipids in the Diet 686

Detergents 690
Cardiac Glycosides 702
Abuse of Steroids and Steroid
Alternatives 706
Nutritional Value of Medium-Chain
Triglycerides 720
The Liver, Clearinghouse for Metabolism 726

#### Interludes:

Why We See Color 383

Chemicals, Toxicity, and Risk 13 Powers of 10 43 Are Atoms Real? Minerals and Gems 97 Polymers: How Big Can a Molecule Be? 129 Photography: A Series of Redox Reactions 162 Nitrogen Fixation 193 Bone and Biomaterials 225 Timed-Release Medications 259 Acid Rain 293 Archaeological Radiocarbon Dating 320 Petroleum 352

Chlorofluorocarbons and the Ozone Hole 411

Nitrogen Balance and Kwashiorkor 744
Serendipity and the Polymerase Chain
Reaction 764
Viruses and AIDS 770
The Human Genome Project 778
Keeping Skin Hydrated 790
The Blood-Brain Barrier 796
Organ Cryopreservation 800

Prodrugs 438 Chemical Warfare Among the Insects Polyamides and Polyester 504 The Food Pyramid and Proteins in the Diet. 542 A Drug Family 584 Plants and Photosynthesis 616 Tooth Decay 647 Biochemistry of Running 676 Chemical Communication 708 Lipids and Atherosclerosis 730 Xenobiotics 746 Biotechnology and Agriculture 781 Automated Clinical Laboratory Analysis

809