

## TABLE OF CONTENTS

<b>MODULE I .....</b>	<b>1</b>
<b>MEASUREMENT, UNITS, AND THE SCIENTIFIC METHOD</b>	
Experiment 1.1: Determining If Air Has Mass .....	2
Experiment 1.2: Determining If Air Takes Up Space .....	3
Units of Measurement .....	4
The Metric System .....	5
Manipulating Units .....	7
Converting between Units .....	9
Converting between Unit Systems .....	12
More Complex Unit Conversions and Problem Solving .....	13
Derived Units .....	15
Making Measurements .....	19
Accuracy, Precision, and Significant Figures .....	21
Scientific Notation .....	25
Using Significant Figures in Mathematical Problems .....	28
Experiment 1.3: Comparing Conversions to Measurements ..	30
Measuring Temperature .....	31
The Nature of a Scientific Law .....	34
Experimentation and the Scientific Method .....	36
Summary of Key Equations and Tables .....	37
Answers to the “On Your Own” Questions .....	38
Study Guide: Review Questions .....	41
Study Guide: Practice Problems .....	43

**MODULE 2 .....** 44**ATOMS AND MOLECULES**

Early Attempts to Understand Matter .....	45
The Law of Mass Conservation .....	46
Experiment 2.1: Conservation of Mass .....	47
Elements: The Basic Building Blocks of Matter .....	50
Compounds .....	54
The Law of Multiple Proportions .....	57
Dalton's Atomic Theory .....	58
Molecules: The Basic Building Blocks of Compounds .....	61
Abbreviating and Classifying Compounds .....	62
Classifying Matter as Ionic or Covalent .....	63
Experiment 2.2: Electrical Conductivity of Compounds Dissolved in Water .....	64
Naming Compounds .....	66
Classifying Matter .....	69
Experiment 2.3: Separating a Mixture of Sand and Salt .....	71
Summary of Tables .....	76
Answers to the "On Your Own" Questions .....	78
Study Guide: Review Questions .....	81
Study Guide: Practice Problems .....	82

**MODULE 3 .....** 84**ATOMIC STRUCTURE**

Historical Overview .....	85
Electrical Charge .....	87
Experiment 3.1: Investigating Electrical Charge .....	87
Electrical Charge and Atomic Structure .....	89
Determining the Number of Protons and Electrons in an Atom ..	90
Determining the Number of Neutrons in an Atom .....	90
Isotopes and Nuclear Bombs .....	93
Atomic Structure in More Detail .....	93
The Nature of Light .....	98
The Electromagnetic Spectrum .....	104
The Relationship between Frequency and Energy .....	107
How the Eye Detects Color .....	108
Experiment 3.2: How Our Eyes Detect Color .....	109
The Bohr Model of the Atom .....	110
The Quantum Mechanical Model of the Atom .....	114
Building Atoms in the Quantum Mechanical Model (Electron Configurations) .....	117
Abbreviated Electron Configurations .....	123
The Amazing Design of Atoms .....	124
Summary of Key Equations .....	125
Answers to the "On Your Own" Questions .....	126
Study Guide: Review Questions .....	130
Study Guide: Practice Problems .....	131

<b>MODULE 4 .....</b>	<b>132</b>
<b>MOLECULAR STRUCTURE</b>	
Electron Configurations and the Periodic Table .....	132
Lewis Structures .....	135
Lewis Structures for Ionic Compounds .....	136
Handling the Exceptions in Ionic Compounds .....	143
Ionization Energy and Periodic Properties.....	145
Electronegativity: Another Periodic Property .....	148
Atomic Radius: Another Periodic Property .....	149
Lewis Structures of Covalent Compounds.....	150
More Complicated Lewis Structures .....	156
An Application of Lewis Structures.....	160
Summary of Tables .....	163
Answers to the “On Your Own” Questions .....	164
Study Guide: Review Questions .....	170
Study Guide: Practice Problems .....	171
<b>MODULE 5 .....</b>	<b>172</b>
<b>POLYATOMIC IONS AND MOLECULAR GEOMETRY</b>	
Polyatomic Ions .....	173
Molecular Geometry: The VSEPR Theory .....	177
Nonpolar Covalent and Polar Covalent Bonds .....	185
Experiment 5.1: Comparing Polar Covalent and Nonpolar Covalent Compounds .....	188
Nonpolar Covalent and Polar Covalent Molecules .....	192
The Practical Consequence of Whether or Not a Molecule Is Polar Covalent .....	195
Experiment 5.2: Comparing Solubility of Ionic Compounds in Polar Covalent and Nonpolar Covalent Compounds ..	196
Summary of Tables .....	197
Answers to the “On Your Own” Questions .....	198
Study Guide: Review Questions .....	205
Study Guide: Practice Problems .....	206

**MODULE 6 .....** 207**CHANGES IN MATTER AND CHEMICAL REACTIONS**

Classifying Changes That Occur in Matter .....	207
Experiment 6.1: Distinguishing between Chemical and Physical Change .....	209
Phase Changes .....	211
Experiment 6.2: Condensing Steam. ....	212
The Kinetic Theory of Matter .....	214
Experiment 6.3: The Relation between the Speed and Temperature of Molecules.....	216
Density .....	217
Experiment 6.4: Comparing the Density of Liquids .....	218
Phase Changes in Water .....	221
Chemical Reactions and Chemical Equations .....	221
Determining Whether or Not a Chemical Equation Is Balanced.....	226
Balancing Chemical Equations .....	229
Summary of Key Equations and Tables.....	232
Answers to the “On Your Own” Questions .....	233
Study Guide: Review Questions .....	239
Study Guide: Practice Problems .....	240

**MODULE 7 .....** 241**DESCRIBING CHEMICAL REACTIONS**

Three Basic Types of Chemical Reactions .....	241
Decomposition Reactions .....	242
Formation Reactions.....	248
Combustion Reactions .....	249
Combustion of Metals .....	250
Complete Combustion Reactions .....	250
Incomplete Combustion Reactions .....	252
Atomic Mass.....	254
Molecular Mass .....	256
The Mole Concept .....	257
Experiment 7.1: Measuring the Width of a Molecule .....	261
Using the Mole Concept in Chemical Equations .....	265
Summary of Key Equations and Tables.....	269
Answers to the “On Your Own” Questions .....	270
Study Guide: Review Questions .....	274
Study Guide: Practice Problems .....	275

<b>MODULE 8 .....</b>	<b>276</b>
<b>STOICHIOMETRY</b>	
Mole Relationships in Chemical Equations .....	276
Limiting Reactants and Excess Components .....	279
Experiment 8.1: Determining Which Reactant Is the Limiting Reactant. ....	279
Fully Analyzing Chemical Equations.....	282
Relating Products to Reactants in Chemical Equations .....	283
Using Chemical Equations When the Limiting Reactant Is Identified .....	285
Volume Relationships for Gases in Chemical Equations .....	287
Mass Relationships in Chemical Equations.....	289
Using Stoichiometry to Determine Chemical Formulas .....	295
Empirical and Molecular Formulas.....	297
More Complicated Experiments for Determining Chemical Formulas .....	301
Answers to the “On Your Own” Questions .....	304
Study Guide: Review Questions .....	310
Study Guide: Practice Problems .....	311
<b>MODULE 9 .....</b>	<b>313</b>
<b>ACID-BASE CHEMISTRY</b>	
Acids and Bases.....	313
Experiment 9.1: Common Household Examples of Acids and Bases .....	315
The Chemical Definitions of Acids and Bases .....	317
The Behavior of Ionic Compounds in Aqueous Solutions ..	319
Identifying Acids and Bases in Chemical Reactions .....	320
Recognizing Acids and Bases from Their Chemical Formulas .....	323
Predicting the Reactions That Occur between Acids and Bases .....	324
The Reactions between Acids and Covalent Bases.....	328
Molarity .....	330
The Dilution Equation .....	332
The Importance of Concentration in Chemistry .....	333
Using Concentration in Stoichiometry.....	334
Acid-Base Titrations .....	336
Experiment 9.2: Determining the Concentration of Ammonia.....	337
Summary of Key Equations and Tables.....	341
Answers to the “On Your Own” Questions .....	342
Study Guide: Review Questions .....	347
Study Guide: Practice Problems .....	348

<b>MODULE 10 .....</b>	<b>349</b>
<b>THE CHEMISTRY OF SOLUTIONS</b>	
How Solutes Dissolve in Solvents .....	350
Solubility .....	355
Experiment 10.1: Determining the Effect of Temperature on the Solubility of Solid Solutes .....	356
Experiment 10.2: Determining the Effect of Temperature on the Solubility of a Gas.....	358
Energy Changes That Occur When Making a Solution .....	360
Experiment 10.3: Investigating a Solute That Releases Heat When Dissolved .....	360
Applying Stoichiometry to Solutions.....	363
Molality .....	365
Freezing-Point Depression .....	367
Experiment 10.4: Measuring Freezing-Point Depression ..	367
Boiling-Point Elevation .....	372
Summary of Key Equations and Tables.....	374
Answers to the “On Your Own” Questions .....	375
Study Guide: Review Questions .....	380
Study Guide: Practice Problems .....	381
<b>MODULE 11 .....</b>	<b>382</b>
<b>THE GAS PHASE</b>	
The Definition of Pressure.....	382
Boyle’s Law .....	384
Charles’s Law .....	386
The Combined Gas Law .....	391
Ideal Gases .....	394
Dalton’s Law of Partial Pressures .....	395
Vapor Pressure .....	396
An Alternative Statement of Dalton’s Law .....	399
The Ideal Gas Law .....	402
Experiment 11.1: Determining the Ideal Gas Constant .....	403
Using the Ideal Gas Law in Stoichiometry.....	405
Experiment 11.2: Using the Ideal Gas Equation to Determine the Amount of Acid in Vinegar.....	406
Summary of Key Equations and Tables.....	410
Answers to the “On Your Own” Questions .....	411
Study Guide: Review Questions .....	416
Study Guide: Practice Problems .....	417

<b>MODULE 12 .....</b>	<b>418</b>
<b>ENERGY, HEAT AND TEMPERATURE</b>	
Energy and Heat .....	418
The First Law of Thermodynamics .....	420
Units for Measuring Heat and Energy .....	421
Experiment 12.1: Thermometer Calibration and Confirmation of Boiling and Freezing Temperatures of Water .....	422
The Calorie Unit .....	427
Measuring Heat .....	429
Calorimetry.....	433
Experiment 12.2: Measuring the Specific Heat of a Metal...	438
Summary of Key Equations and Tables.....	440
Answers to the “On Your Own” Questions .....	441
Study Guide: Review Questions .....	446
Study Guide: Practice Problems .....	447
<b>MODULE 13 .....</b>	<b>448</b>
<b>THERMODYNAMICS</b>	
Enthalpy .....	448
Determining $\Delta H$ for a Chemical Reaction by Experiment ..	452
Experiment 13.1: Determining the $\Delta H$ of a Chemical Reaction	452
Determining the $\Delta H$ of a Chemical Reaction Using Bond Energies .....	454
Hess’s Law .....	460
Applying Enthalpy to Stoichiometry .....	465
Energy Diagrams .....	467
The Second Law of Thermodynamics .....	470
The Proper Application of the Second Law of Thermodynamics .....	475
Gibbs Free Energy .....	477
Summary of Key Equations and Tables.....	481
Answers to the “On Your Own” Questions .....	482
Study Guide: Review Questions .....	489
Study Guide: Practice Problems .....	490

**MODULE 14 .....**.....492**KINETICS**

Reaction Kinetics .....	493
Factors That Affect the Kinetics of a Chemical Reaction .....	493
Experiment 14.1: How Concentration and Temperature Affect Chemical Reaction Rates .....	494
The Rate Equation .....	497
Using Experiments to Determine the Details of the Rate Equation .....	499
Rate Orders .....	506
Using Rate Equations .....	507
Temperature Dependence in the Rate Equation .....	509
Catalysts and Reaction Rate .....	512
Experiment 14.2: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide .....	512
Summary of Key Equations.....	517
Answers to the “On Your Own” Questions .....	518
Study Guide: Review Questions .....	521
Study Guide: Practice Problems .....	522

**MODULE 15 .....**.....524**CHEMICAL EQUILIBRIUM**

The Definition of Chemical Equilibrium .....	525
Experiment 15.1: A Demonstration of Equilibrium .....	527
The Equilibrium Constant .....	529
A Few More Details about the Equilibrium Constant .....	533
Using the Equilibrium Constant to Predict the Progress of a Reaction .....	535
Le Chatelier’s Principle .....	537
Pressure and Le Chatelier’s Principle .....	541
Temperature and Le Chatelier’s Principle .....	543
Experiment 15.2: Temperature Effects on Reactions and Le Chatelier’s Principle .....	544
Acid-Base Equilibria .....	547
The pH Scale .....	550
Acid Rain .....	551
Summary of Key Equations.....	552
Answers to the “On Your Own” Questions .....	553
Study Guide: Review Questions .....	556
Study Guide: Practice Problems .....	557

<b>MODULE 16 .....</b>	<b>559</b>
<b>REDUCTION-OXIDATION REACTIONS</b>	
Oxidation Numbers .....	559
Determining Oxidation Numbers .....	562
Oxidation and Reduction .....	565
Recognizing Reduction-Oxidation Reactions .....	567
An Important Characteristic of Reduction-Oxidation Reactions .....	568
Experiment 16.1: Demonstrating an Oxidation-Reduction Reaction .....	569
How Batteries Work .....	570
Experiment 16.2: Creating a Galvanic Cell from Lemons ..	577
Real Batteries .....	578
Corrosion .....	581
Some Final Words .....	581
Answers to the “On Your Own” Questions .....	583
Study Guide: Review Questions .....	586
Study Guide: Practice Problems .....	587
<b>GLOSSARY .....</b>	<b>589</b>
<b>APPENDIXES.....</b>	<b>603</b>
Appendix A: Tables, Laws, and Equations .....	603
Appendix B: Extra Practice Problems .....	615
Appendix C: Complete List of Lab Supplies .....	631
<b>REFERENCES .....</b>	<b>639</b>
<b>INDEX .....</b>	<b>641</b>