

Table of Contents

Preface	x
Study Guide Checklist	x
Introduction	1
New Format of the AP Chemistry Exam	1
Topics Covered by the AP Chemistry Exam	2
Questions Commonly Asked	4
Strategies for Taking the AP Chemistry Exam	6
Section I: The Multiple-Choice Section	6
Section II: The Free-Response (Essay) Section	7

PART I: SUBJECT REVIEW

Atoms	15
The Aufbau Principle	15
Noble Gas Core Abbreviation	15
Bohr Model	16
Quantum Numbers	16
Diamagnetism vs. Paramagnetism	17
Important People, Experiments, and Theories	17
Energy and Other Relationships	18
Multiple-Choice Questions	19
Free-Response Questions	22
Answers and Explanations	23
Multiple Choice	23
Free Response	24
Periodic Table	28
Periodic Trends	28
Summary of Periodic Trends	32
Chemical Properties and Periodicity	33
Metals vs. Nonmetals	35
Important People, Experiments, and Theories	35
Multiple-Choice Questions	36
Free-Response Questions	38
Answers and Explanations	39
Multiple Choice	39
Free Response	40
Bonding	45
Lewis Dot Diagrams	45
Incomplete Octets	46
Expanded Octets	46
Ionic Bonds	47
Lattice Energy	48
Covalent Bonds	48
Bond Length	48
Intermolecular and Intramolecular Forces	48
Network Covalent Bonds	49
Hydrogen Bonds	49
Metallic Bonding	49

Atomic Radii	51
Covalent Radii	51
Van der Waals Radii	52
Radicals	52
Bond Strength	52
Resonance	53
Multiple-Choice Questions	53
Free-Response Questions	55
Answers and Explanations	57
Multiple Choice	57
Free Response	58
Molecular Geometry and Hybridization	64
Molecular Geometry	64
Sigma and Pi Bonds	67
Dipole Moments	67
Hybridization	68
Multiple-Choice Questions	70
Free-Response Questions	72
Answers and Explanations	73
Multiple Choice	73
Free Response	77
Stoichiometry	80
Significant Figures	80
Log ₁₀ and Natural Log (ln)	81
Factor-Label Method	81
Moles	82
Balancing Equations	82
Determination of Empirical and Molecular Formulas	83
Percentage Composition	83
Average Atomic Mass	84
Limiting Reactant	84
Theoretical and Actual Yield	85
Multiple-Choice Questions	86
Free-Response Questions	88
Answers and Explanations	89
Multiple Choice	89
Free Response	91
Gases	95
Properties of Gases	95
Mole Fractions	95
Pressure and Temperature	96
STP	96
Gas Laws	96
Kinetic Molecular Theory	100
The Maxwell-Boltzmann Distribution	100
Multiple-Choice Questions	101
Free-Response Questions	104
Answers and Explanation	106
Multiple Choice	106
Free Response	108

Liquids and Solids	111
Properties of Liquids	111
Properties of Water	112
Properties of Solids	112
Phase Changes	112
Liquid-Vapor Equilibrium	112
Heat of Vaporization and Boiling Point	113
Liquid-Solid Equilibrium	113
Solid-Vapor Equilibrium	114
Phase Diagrams	114
Multiple-Choice Questions	116
Free-Response Questions	119
Answers and Explanations	121
Multiple Choice	121
Free Response	122
Thermodynamics	126
Energy	126
Temperature vs. Heat	127
A System vs. Surroundings	127
State Functions	127
Standard State	127
Laws of Thermodynamics	127
Enthalpy	127
Hess's Law	128
Heat of Formation (ΔH°_f)	129
Specific Heat and Heat Capacity	129
Calorimetry	130
Entropy (ΔS)	131
Gibbs Free Energy (ΔG)	132
Energy Diagrams	133
Catalyst Added	134
Multiple-Choice Questions	134
Free-Response Questions	138
Answers and Explanations	139
Multiple Choice	139
Free Response	141
Solutions	144
Molarity	144
Molality	145
Density and Percent	145
Mole Fraction and Fractional Distillation	146
Colligative Properties	147
Boiling Point Elevation	147
Freezing Point Depression	148
Vapor Pressure Lowering (Raoult's Law)	148
Osmotic Pressure	149
Multiple-Choice Questions	150
Free-Response Questions	153
Answers and Explanations	154
Multiple Choice	154
Free Response	157

Equilibrium	161
Interpretation of K	162
K_{sp}	163
Le Chatelier's Principle	164
Reaction Quotient, Q_c or Q_p	165
Free Energy and Equilibrium Constants	165
Common Ion Effect	166
Multiple-Choice Questions	167
Free-Response Questions	170
Answers and Explanations	171
Multiple Choice	171
Free Response	174
Acids and Bases	177
Brønsted-Lowry Theory	177
Arrhenius Theory	178
Lewis Acid-Base Theory	178
Conjugate Acids and Bases	179
pH and pOH	180
K_a and pK_a	180
K_b and pK_b	181
Polyprotic Acids	182
Oxoacids	183
Acid-Base Properties of Common Ions in Aqueous Solution	184
Salts	184
Molecular Structure and Acid Strength	185
Titration	186
Titration Curves	186
% Ionization	189
Buffers	190
Henderson-Hasselbalch Equation	190
Indicators	191
Anhydrides	191
Amphoteric Substances	192
Multiple-Choice Questions	193
Free-Response Questions	196
Answers and Explanations	197
Multiple Choice	197
Free Response	199
Kinetics	203
Reaction Rates	203
Zero Order	203
First Order	204
Second Order	205
Collision Theory	206
Activation Energy (E_a)	206
Reaction Mechanisms	207
Kinetics and Equilibrium	208
Catalysis	209
Multiple-Choice Questions	211
Free-Response Questions	215
Answers and Explanations	217
Multiple Choice	217
Free Response	219

Oxidation-Reduction (Redox)	225
Oxidation States	225
Oxidation	226
Reduction	226
Oxidizing and Reducing Agents	226
Activity Series	227
Balancing Oxidation-Reduction (Redox) Reactions	227
Galvanic (Voltaic) Cells	229
Electrolytic Cells	230
Spontaneity	232
Voltage and Equilibrium	233
Multiple-Choice Questions	234
Free-Response Questions	237
Answers and Explanations	238
Multiple Choice	238
Free Response	240
Nuclear Chemistry	243
Nuclear Reactions	243
Types of Nuclear Decay	243
Alpha (α) Emission	243
Beta (β) Emission	244
Positron (${}^0_+e$) Emission	244
Electron Capture (${}^0_+e$)	245
Gamma (γ) Rays	246
Balancing Nuclear Equations	246
Nuclear Stability	246
Half-life	248
Binding Energy and Mass Defect	248
Fission vs. Fusion	249
Multiple-Choice Questions	249
Free-Response Questions	252
Answers and Explanations	253
Multiple Choice	253
Free Response	255
Organic Chemistry	258
Properties of Organic Compounds	259
Condensed Formulas	259
Hydrocarbons	260
Alkanes	261
Alkenes	262
Alkynes	263
Cyclic Hydrocarbons	264
Ring (Aromatic) Compounds	265
Functional Groups	267
Alcohols	267
Organic (Carboxylic) Acids	267
Amides	268
Amines	268
Aldehydes	269
Ketones	269
Esters	270
Ethers	270

Isomers	271
Structural Isomerism	271
Stereoisomerism	273
Multiple-Choice Questions	274
Free-Response Questions	277
Answers and Explanations	279
Multiple Choice	279
Free Response	283
Chemical Reactions	289
Solubility Rules	290
Writing Net Ionic Reactions	291
I. Synthesis ($A + B \rightarrow AB$): two or more substances react together to form a single compound	292
II. Decomposition ($AB \rightarrow A + B$): a compound breaks apart into two or more substances	294
III. Single Displacement ($A + BX \rightarrow AX + B$)	297
IV. Double Displacement (metathesis) ($AX + BY \rightarrow AY + BX$)	298
V. Combustion: Substance + Oxygen \rightarrow Oxides of Elements	300
VI. Metallic Oxide + $H_2O \rightarrow$ Base (metallic hydroxide)	302
VII. Nonmetallic Oxide + $H_2O \rightarrow$ Acid	302
VIII. Metallic Oxide + Acid \rightarrow Metal Ion + H_2O	303
IX. Nonmetallic Oxide (acidic anhydride) + Base \rightarrow Salt + Water	304
X. Metallic Oxide + Nonmetallic Oxide \rightarrow Complex (non-binary) Salt	305
XI. Acid + Metal \rightarrow Salt + Hydrogen Gas	306
XII. Base + Amphoteric Metal \rightarrow Complex Ion (containing oxygen) + Hydrogen Gas	306
XIII. Strong Acid + Salt of a Weak Acid \rightarrow Salt of Strong Acid + Weak Acid	307
XIV. Weak Acid + Weak Base \rightarrow Conjugate Base + Conjugate Acid	308
XV. Weak Acid + Strong Base \rightarrow Water + Conjugate Base	309
XVI. Strong Acid + Weak Base \rightarrow Conjugate Acid	310
XVII. Acid + Carbonate \rightarrow Salt + CO_2 + Water	311
XVIII. Metallic Oxide + Nonmetallic Oxide (acidic anhydride + basic anhydride) \rightarrow Salt	312
XIX. Redox	312
XX. Precipitation Reactions	315
XXI. Complex Ions	316
XXII. Strong Acid + Strong Base \rightarrow Salt + H_2O (neutralization)	317
XXIII. Organic Reactions	318
Quick Quiz Answers	323
Practice Sets	325
Practice Set #1	325
Practice Set #2	326
Practice Set #3	326
Practice Set #4	326
Practice Set Answers	327
Laboratory Experiments	329
Experiment 1: Determination of the Empirical Formula of a Compound	330
Experiment 2: Determination of the Percentage of Water in a Hydrate	332
Experiment 3: Determination of Molar Mass by Vapor Density	334
Experiment 4: Determination of Molecular Mass by Freezing Point Depression	336
Experiment 5: Determination of the Molar Volume of a Gas	339

Experiment 6: Standardization of a Solution Using a Primary Standard	340
Experiment 7: Determination of Concentration by Acid-Base Titration	340
Experiment 8: Determination of Concentration by Oxidation-Reduction Titration	344
Experiment 9: Determination of Mass and Mole Relationship in a Chemical Reaction	345
Experiment 10 A: Determination of the Equilibrium Constant, K_{eq} , for a Chemical Reaction	348
Experiment 10 B: Determination of the Equilibrium Constant, K_{sp} , for a Chemical Reaction	350
Experiment 10 C: Determination of the Equilibrium Constant, K_c , for a Chemical Reaction	352
Experiment 11: Determination of Appropriate Indicators for Various Acid-Base Titrations	354
Experiment 19: Preparation and Properties of Buffer Solutions	354
Experiment 12: Determination of the Rate of a Reaction and Its Order	359
Experiment 13: Determination of Enthalpy Changes Associated with a Reaction and Hess's Law	362
Experiment 14: Separation and Qualitative Analysis of Cations and Anions	365
Experiment 15: Synthesis of a Coordination Compound and Its Chemical Analysis	368
Experiment 17: Colorimetric or Spectrophotometric Analysis	368
Experiment 16: Analytical Gravimetric Determination	373
Experiment 18: Separation by Chromatography	374
Experiment 20: Determination of Electrochemical Series	376
Experiment 21: Measurements Using Electrochemical Cells and Electroplating	376
Experiment 22: Synthesis, Purification, and Analysis of an Organic Compound	381

PART II: PRACTICE EXAMS

Practice Exam 1	393
Section I: Multiple-Choice Questions	393
Section II: Free-Response Questions	402
Answer Key for Practice Exam 1	406
Section I: Multiple-Choice Questions	406
Answers and Explanations for Practice Exam 1	407
Multiple Choice	407
Free Response	413
Practice Exam 2	427
Section II: Free-Response Questions	437
Answer Key for Practice Exam 2	441
Section I: Multiple-Choice Questions	441
Answers and Explanations for Practice Exam 2	442
Multiple Choice	442
Free Response	451
Appendix	460
Mathematical Operations	460
Significant Figures	460
Logs and Antilogs	460
Scientific Notation	460
Precision	461
Rounding Off Numbers	462
Mathematics Self-Test	462
Answers to Mathematics Self-Test	464