AP CHEMISTRY | Curriculum Map and Pacing Guide

COURSE DESCRIPTION:	
This course is the equivalent of the general chemistry course taken during the first year of college. This course provides college-level chemistry instruction; college-level laboratory experience; and preparation for the AP Chemistry Exam. This course includes extensive use of technology in lab and classroom activities. Students will meet for an extended time during each week with the scheduled determined by the teacher.	**Course SCI347** **1 year, 1.25 credit** **Grade 12** **Prerequisite:** Honors Chemistry or Chemistry, teacher recommendation and completion of Algebra II

QUARTER 1

Topic: Foundations, Atomic Theory, and Stoichiometry

Key Terms: chemistry, matter, elements, atoms, property, molecule, gas, liquid, solid, states of matter, pure substances, compounds, law of constant composition, mixtures, solutions, impurities, physical properties, chemical properties, physical change, chemical change, energy, work, heat, kinetic energy, potential energy, SI Units, SI Prefixes, mass, volume, density, temperature, absolute zero, derived unit, accuracy, precision, uncertainty, error, percent error, significant figures, standard deviation, dimensional analysis, conversion factor, ratio, proportion, subatomic particles, cathode rays, nucleus, protons, electrons, neutrons, electronic charge, atomic mass, atomic number, mass number, mass spectroscopy, atomic weight, spectrometer, spectrograph, periodic table, group, period, metals, nonmetals, metalloids, molecules, molecular compounds, diatomic element, chemical formula, empirical formula, molecular formula, structural formula, ions, cations, anions, polyatomic ions, ionic compounds, chemical nomenclature, oxyanions, hydrocarbons, alkanes, alcohol, isomers, stoichiometry, law of conservation of mass, chemical equation, reactants, products, synthesis, decomposition, combustion, formula weight, molecular weight, elemental composition, Avogadro's number, mole, molar mass, percent composition, combustion analysis, limiting reactant, excess reactant, theoretical yield, percent yield

Measurable Skills: Justify, Select, Apply, Identify, Infer, Connect, Determine, Use, Express, Represent, Translate, Predict, Analyze, Relate, Design, Collect, Confirm, Draw, Explain, Interpret, Solve, Evaluate, Refine, Improve, Create, Model, Construct, Articulate, Make, Connect

AP College Board Essential Knowledge	Student Learning Targets (AP Learning Objectives and Science Practices)	Learning Activities/Investigations
1.A.1	1.1: Justify the observation that the ratio of the masses of the constituent elements in any pure sample of that compound is always identical on the basis of the atomic molecular theory. SP6.1	Activity: Polydensity Tubes Video Clips: Atomic Theory
1.A.2	1.2: Select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures. SP2.2	

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	1.3: Select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance. SP2.2, SP6.1	Lab: Green Chemistry
1.A.3	1.4: Connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively. SP7.1	Demo: Combustion of Mg in CO2
1.D.1	1.13: Given information about a particular model of the atom, determine if the model is consistent with specified evidence. SP5.3	
1.D.2	1.14: Use data from mass spectrometry to identify the elements and the masses of individual atoms of a specific element. SP1.4, SP1.5	Activity: Mass Spectroscopy
1.E.1	1.17: Express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings. SP1.5	Activity: Blue Crystals
1.E.2	1.18: Apply conservation of atoms to the rearrangement of atoms in various processes. SP1.4	Activity: Stress Ball Polymers
3.A.1	3.1: Translate among macroscopic observations of change, chemical equations, and particle views. SP1.5, SP7.1	Activity: MSDS Challenge Demo: Flaming Ramp

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3.A.2	3.3: Use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results. SP2.2, SP5.1	Lab: Some Measurements of Mass and Volume
	3.4: Relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion. SP2.2, SP5.1, SP6.4	Lab: Penny Wafer

QUARTER 1

Topic: Reactions in Aqueous Solutions and Thermochemistry

Key Terms: aqueous solutions, solute, solvent, electrolyte, solvation, chemical equilibrium, precipitation reactions, precipitate, solubility, metathesis, exchange reactions, molecular equation, complete ionic equation, net ionic equation, spectator ions, acids, bases, neutralization reaction, salt, oxidation, reduction, oxidation numbers, redox reactions, displacement reactions, activity series, concentration, molarity, dilution, titration, standard solution, equivalence point, indicators, end point, hydration, crystallization, saturated, unsaturated, supersaturated, thermodynamics, thermochemistry, joules, system, surroundings, work, heat, force, energy, internal energy, first law of thermodynamics, endothermic, exothermic, state function, ,path function, pressure-volume work, enthalpy, enthalpy of reaction, calorimetry, calorimeter, heat capacity, molar heat capacity, specific heat, Hess's Law, enthalpy of formation, standard states, standard enthalpy change, standard enthalpy of formation, phase change, heat of fusion, heat of sublimation, heat of vaporization, gravimetric analysis, conductimetric analysis, Maxwell-Boltzmann distribution

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3.B.1	3.5: Design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions. SP2.1, SP4.2, SP6.4	Lab: Decomposition of Hydrate
	3.6: Use data from synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions. SP2.2, SP6.1	
1.E.1	1.17: Express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings. SP1.5	
1.E.2	1.18 - Apply conservation of atoms to the rearrangement of atoms in various processes. SP1.4	Activity: Gel Precipitates
	1.19: Design, and/or interpret data from, an experiment that uses gravimetric analysis to determine the concentration of an analyte in a solution. SP4.2, SP5.1, SP6.1	Lab: Gravimetric Determination of a Precipitate
	1.20: Design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution. SP4.2, SP5.1, SP6.4	Lab: Conductimetric Titration Demo: Acid-Base Titration
2.A.3	2.3: Use aspects of particulate models (i.e., particle spacing, motion, and forces of attraction) to reason about observed differences between solid and liquid phases and among solid and liquid materials. SP6.4, SP7.1	

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	2.8: Draw and/or interpret representations of solutions that show the interactions between the solute and solvent. SP1.1, SP1.2, SP6.4	
	2.9: Create or interpret representations that link the concept of molarity with particle views of solutions. SP1.1, SP1.4	
3.A.1	3.1: Translate among macroscopic observations of change, chemical equations, and particle views. SP1.5, SP7.1	
	3.2: Translate an observed chemical change into a balanced chemical equation and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances. SP1.5, SP7.1	
3.A.2	3.4: Relate quantities (measured mass of substances and/or volumes of solutions.) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion. SP2.2, SP5.1, SP6.4	Lab: Synthesis of Aspirin
3.B.3	3.8: Identify redox reactions and justify the identification in terms of electron transfer. SP6.1	Demos: Zinc pyrotechnics, Rapid Oxidation, and the can ripper Video: Redox Titration Simulation: Redox Titration

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	3.9: Design and/or interpret the results of an experiment involving a redox titration. SP4.2, SP5.1	Lab: Redox Titration of Hydrogen Peroxide Demo: Bleach Redox
3.C.1	3.10: Evaluate the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions. SP1.4, SP6.1	
3.C.2	3.11: Interpret observations regarding macroscopic energy changes associated with a reaction or process to generate a relevant symbolic and/or graphical representation of the energy changes. SP1.5, SP4.4	
5.A.1	5.2: Relate temperature to the motions of particles, either via particulate representations, such as drawings of particles with arrows indicating velocities, and/or via representations of average kinetic energy and distribution of kinetic energies of the particles, such as plots of the Maxwell-Boltzmann distribution. SP1.1, SP1.4, SP7.1	
5.A.2	5.3: Generate explanations or make predictions about the transfer of thermal energy between systems based on this transfer being due to a kinetic energy transfer between systems arising from molecular collisions. SP7.1	

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5.B.1 5.B.2	5.4: Use conservation of energy to relate the magnitudes of the energy changes occurring in two or more interacting systems, including identification of the systems, the type (heat versus work), or the direction of energy flow. SP1.4, SP2.2	Demo: Dry Ice
	5.5: Use conservation of energy to relate the magnitudes of the energy changes when two nonreacting substances are mixed or brought into contact with one another. SP2.2	Demo: Liquid N2
5.B.3	5.6: Use calculations or estimations to relate energy changes associated with heating/cooling a substance to the heat capacity, relate energy changes associated with a phase transition to the enthalpy of fusion/vaporization, relate energy changes associated with a chemical reaction to the enthalpy of the reaction, and relate energy changes to $P\Delta V$ work. SP2.2, SP2.3	Lab: Preparation and Enthalpy of Combustion for Biodiesel
5.B.4	5.7: Design and/or interpret the results of an experiment in which calorimetry is used to determine the change in enthalpy of a chemical process (heating/cooling, phase transition, or chemical reaction) at constant pressure. SP4.2, SP5.1, SP6.4	Lab: The Handwarmer

QUARTERS 1-2

Topic: Electronic Structure and Periodicity

Key Terms: electronic structure, electromagnetic radiation, wavelength, frequency, quantum, Planck constant, photoelectric effect, photons, spectrum, continuous spectrum, line spectrum, principal quantum number, ground state, excited state, matter waves, momentum, uncertainty principle, wave functions, probability density, electron density, subshell, orbitals, Pauli exclusion principle, orbital diagram, Hund's rule, valence electrons, core electrons, representative elements, transition elements, PES, UV spectroscopy, Infrared Spectroscopy, effective nuclear charge, Coulomb's Law, bonding atomic radius, isoelectronic series, ionization energy, periodic trends, electron affinity, metallic character, alkali metals, alkaline earth metals, hydride ion, oxides, halogens, noble gasses, photochemical reactions, Beer's Law, photoionization

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1.B.1	1.5: Explain the distribution of electrons in an atom or ion based upon data. SP1.5, SP6.2	Demo: Tonic Water
	1.6: Analyze data relating to electron energies for patterns and relationships. SP5.1	
1.B.2	1.7: Describe the electronic structure of the atom, using PES data, ionization energy data, and/or Coulomb's Law to construct explanations of how the energies of electrons within shells in atoms vary. SP5.1, SP6.2	Demo: Radiated NaCl
	1.8: Explain the distribution of electrons using Coulomb's Law to analyze measured energies. SP6.2	
1.C.1	1.9: Predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model. SP6.4	Demo: Periodicity of Halogens Demo: Trends in Transition Metals and Complex Ions
	1.10: Justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity. SP6.1	Activity: Photochemical Reactions and T-Shirts
	1.11: Analyze data, based on periodicity and the properties of binary compounds, to identify patterns and generate hypotheses related to the molecular design of compounds for which data are not supplied. SP3.1, SP5.1	Demo: Paramagnetic O2
1.C.2	1.12: Explain why a given set of data suggests, or does not suggest, the need to refine the atomic model from a classical shell model with the quantum mechanical model. SP6.3	Activity: Flinn Models

QUARTERS 1-2

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1.D.1	1.13: Given information about a particular model of the atom, determine if the model is consistent with specified evidence. SP5.3	Demo: Titanium White and UV
1.D.3	1.15: Justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules. SP4.1, SP6.4	Activity: Flinn Spectroscopy
	1.16: Design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in a solution. SP4.2, SP5.1	Lab: Beer's Law and Percent Copper in Brass

QUARTER 2

Topic: Bonding I – Intraparticle Forces, Molecular Geometry, Advanced Bonding Theories, and Solids

Key Terms: chemical bonds, ionic bond, covalent bond, metallic bond, Lewis symbols, octet rule, lattice energy, Lewis structures, nonbonding electron pairs, single bond, double bond, triple bond, bond polarity, nonpolar covalent bond, polar covalent bond, network covalent bond, electronegativity, polar molecule, dipole, dipole moment, formal charge, resonance structure, bond length, bond strength, bond energies, bond angle, VSEPR model, electron domains, bonding pairs, lone pairs, electron domain geometry, molecular geometry, valence bond theory, hybrid orbitals, hypervalent, sub-octet, sigma bond, pi bond, delocalized electrons, molecular orbital theory, molecular orbitals, energy level, bond order, paramagnetic, diamagnetism, metallic solids, ionic solids, covalent network solids, polymers, crystal lattice, alloys, interstitial alloy, substitutional alloy, electron sea model, bands, semiconductors, insulators, doping, n-type, p-type, nanomaterials

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1.C.1	1.11: Analyze data, based on periodicity and the properties of binary compounds, to identify patterns and generate hypotheses related to the molecular design of compounds for which data are not supplied. SP3.1, SP5.1	Lab: Synthesis of Alum
2.A.1	2.1: Predict properties of substances based on their chemical formulas and provide explanations of their properties based on particle views. SP6.4, SP7.1	Lab: Raku and the Reduction of Metal Oxides
2.C.1	2.17: Predict the type of bonding present between two atoms in a binary compound based on position in the periodic table and the electronegativity of the elements. SP6.4	
	2.18: Rank and justify the ranking of bond polarity on the basis of the locations of the bonded atoms in the periodic table. SP6.1	
2.C.2	2.19: Create visual representations of ionic substances that connect the microscopic structure to macroscopic properties, and/or use representations to connect the microscopic structure to macroscopic properties (e.g., boiling point, solubility, hardness, brittleness, low volatility, lack of malleability, ductility, or conductivity). SP1.1, SP1.4, SP7.1	Activity: Blowing Glass Activity: Making Glass Beads from Borax
2.C.3	2.20: Explain how a bonding model involving delocalized electrons is consistent with macroscopic properties of metals (e.g., conductivity, malleability, ductility, and low volatility) and the shell model of the atom. SP6.2, SP7.1	Demo: milk jug rearrangement
2.C.4	2.21: Use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity. SP1.4	

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2.D.1	2.22: Design or evaluate a plan to collect and/or interpret data needed to deduce the type of bonding in a sample of a solid. SP4.2, SP6.4	Lab: Qualitative Analysis and Chemical Bonding
	2.23: Create a representation of an ionic solid that shows essential characteristics of the structure and interactions present in the substance. SP1.1	
	2.24: Explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level. SP1.1, SP6.2, SP7.1	
2.D.2	2.25: Compare the properties of metal alloys with their constituent elements to determine if an alloy has formed, identify the type of alloy formed, and explain the differences in properties using particulate level reasoning. SP1.4. SP7.2	Demo: Onion's Fusible Alloy Demo: Nitinol Wire
	2.26: Use the electron sea model of metallic bonding to predict or make claims about the macroscopic properties of metals or alloys. SP6.4, SP7.1	
	2.27: Create a representation of a metallic solid that shows essential characteristics of the structure and interactions present in the substance. SP1.1	Demo: Altering the crystal structure of iron
	2.28: Explain a representation that connects properties of a metallic solid to its structural attributes and to the interactions present at the atomic level. SP1.1, SP6.2, SP7.1	Activity: Brass Penny

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2.D.3	2.29: Create a representation of a covalent solid that shows essential characteristics of the structure and interactions present in the substance. SP1.1	Lab: Semiconductors
	2.30: Explain a representation that connects properties of a covalent solid to its structural attributes and to the interactions present at the atomic level. SP1.1, SP6.2, SP7.1	Lab: Make Silicon Crystals
2.D.4	2.31: Create a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance. SP1.1	
	2.32: Explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level. SP1.1, SP6.2, SP7.1	
5.C.1 5.C.2	5.1: Create or use graphical representations in order to connect the dependence of potential energy to the distance between atoms and factors, such as bond order (for covalent interactions) and polarity (for intermolecular interactions), which influence the interaction strength. SP1.1, SP1.4, SP7.2	Lab: Growing Giant Crystals
	5.8: Draw qualitative and quantitative connections between the reaction enthalpy and the energies involved in the breaking and formation of chemical bonds. SP2.3, SP7.1, SP7.2	Activity: Rockets, Reactions, and Ratios

QUARTER 2

Topic: Bonding II – States of Matter (Gas Laws, Intermolecular/Interparticle Forces, and Kinetic Molecular Theory)

Key Terms: vapor, pressure, STP, Gas Laws, Ideal Gas Law, gas constant, partial pressure, kinetic molecular theory, effusion, diffusion, ideal gas, real gas, intermolecular forces, molecular solid, dispersion forces, dipole-dipole forces, dipole-ion forces, hydrogen bonding, polarizability, surface tension, viscosity, distillation, chromatography, vapor pressure, volatile

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AP College Board Essential Knowledge	Student Learning Targets (AP Learning Objectives and Science Practices)	Learning Activities/Investigations
2.A.1	2.3: Use aspects of particulate models (i.e., particle spacing, motion, and forces of attraction) to reason about observed differences between solid and liquid phases and among solid and liquid materials. SP6.4, SP7.1	
2.A.2	2.4: Use KMT and concepts of intermolecular forces to make predictions about the macroscopic properties of gases, including both ideal and nonideal behaviors. SP1.4, SP2.4	
	2.5: Refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample. SP1.3, SP6.4, SP7.2	
	2.6: Apply mathematical relationships or estimation to determine macroscopic variables for ideal gases. SP2.2, SP2.3	
2.A.3	2.7: Explain how solutes can be separated by chromatography based on intermolecular interactions. SP6.2	
	2.8: Draw and/or interpret representations of solutions that show the interactions between the solute and solvent. SP1.1, SP1.2, SP6.4	
	2.10: Design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components. SP4.2, SP5.1, SP6.4	Lab: Paper, Liquid, Column, and Gas Chromatography
2.B.1	2.11: Explain the trends in properties and/or predict properties of samples consisting of particles with no permanent dipole on the basis of London dispersion forces. SP6.2, SP6.4	
2.B.2	2.12: Qualitatively analyze data regarding real gases to identify deviations from ideal behavior and relate these to molecular interactions. SP5.1, SP6.5	Lab – Molar Mass of Butane

QUARTER 2

Topic: Bonding II – States of Matter (Gas Laws, Intermolecular/Interparticle Forces, and Kinetic Molecular Theory)

Key Terms: vapor, pressure, STP, Gas Laws, Ideal Gas Law, gas constant, partial pressure, kinetic molecular theory, effusion, diffusion, ideal gas, real gas, intermolecular forces, molecular solid, dispersion forces, dipole-dipole forces, dipole-ion forces, hydrogen bonding, polarizability, surface tension, viscosity, distillation, chromatography, vapor pressure, volatile

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	2.13: Describe the relationships between the structural features of polar molecules and the forces of attraction between the particles. SP1.4, SP6.4	
	2.14: Apply Coulomb's law qualitatively (including using representations) to describe the interactions of ions, and the attractions between ions and solvents to explain the factors that contribute to the solubility of ionic compounds. SP1.4, SP6.4	
2.B.3	2.15: Explain observations regarding the solubility of ionic solids and molecules in water and other solvents on the basis of particle views that include intermolecular interactions and entropic effects. SP1.4, SP6.2	
	2.16: Explain the properties (phase, vapor pressure, viscosity, etc.) of small and large molecular compounds in terms of the strengths and types of intermolecular forces. SP6.2	
2.D.3	2.30: Explain a representation that connects properties of a covalent solid to its structural attributes and to the interactions present at the atomic level. SP1.1, SP6.2, SP7.1	
2.D.4	2.31: Create a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance. SP1.1	
	2.32: Explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level. SP1.1, SP6.2, SP7.1	
5.A.1	5.2: Relate temperature to the motions of particles, either via particulate representations, such as drawings of particles with arrows indicating velocities, and/or via representations of average kinetic energy and distribution of kinetic	

QUARTER 2

Topic: Bonding II – States of Matter (Gas Laws, Intermolecular/Interparticle Forces, and Kinetic Molecular Theory)

Key Terms: vapor, pressure, STP, Gas Laws, Ideal Gas Law, gas constant, partial pressure, kinetic molecular theory, effusion, diffusion, ideal gas, real gas, intermolecular forces, molecular solid, dispersion forces, dipole-dipole forces, dipole-ion forces, hydrogen bonding, polarizability, surface tension, viscosity, distillation, chromatography, vapor pressure, volatile

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AP College Board Essential Knowledge	Student Learning Targets (AP Learning Objectives and Science Practices)	Learning Activities/Investigations
	energies of the particles, such as plots of the Maxwell-Boltzmann distribution. SP1.1, SP1.4, SP7.1	
5.D.1	5.9: Make claims and/or predictions regarding relative magnitudes of the forces acting within collections of interacting molecules based on the distribution of electrons within the molecules and the types of intermolecular forces through which the molecules interact. SP6.4	Demos: Poly-Ox with a Twist; Lopsided Liquid
5.D.2	5.10: Support the claim about whether a process is a chemical or physical change (or may be classified as both) based on whether the process involves changes in intramolecular versus intermolecular interactions. SP5.1	Lab: Silver Ornaments
5.D.3	5.11: Identify the noncovalent interactions within and between large molecules, and/or connect the shape and function of the large molecule to the presence and magnitude of these interactions. SP7.2	

QUARTER 3

Topic: Kinetics and Equilibrium

Key Terms: kinetics, reaction rates, instantaneous rate, rate law, specific rate constant, reaction order, zero order, first order, second order, half-life, elementary reaction, collision model, activation energy, activated complex, reaction mechanism, molecularity, intermediate, catalyst, rate determining step, integrated rate law, kinetic control, chemical equilibrium, equilibrium constant expression, equilibrium constant, reaction quotient, Le Chatelier's principle

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AP College Board Essential Knowledge	Student Learning Targets (AP Learning Objectives and Science Practices)	Learning Activities/Investigations
4.A.1	4.1: Design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction. SP4.2, SP5.1	Lab: Kinetics – Rate vs Concentration and Rate vs Temperature
4.A.2	4.2: Analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction. SP5.1, SP6.4	
4.A.3	4.3: Connect the half-life of a reaction to the rate constant of a first-order reaction and justify the use of this relation in terms of the reaction being a first-order reaction. SP2.1, SP2.2	Activity: Half-Life
4.B.1	4.4: Connect the rate law for an elementary reaction to the frequency and success of molecular collisions, including connecting the frequency and success to the order and rate constant, respectively. SP7.1	Lab: Decomposition of Hydrogen Peroxide
4.B.2	4.5: Explain the difference between collisions that convert reactants to products and those that do not in terms of energy distributions and molecular orientation. SP6.2	Demo: Underwater Fireworks
4.B.3	4.6: Use representations of the energy profile for an elementary reaction (from the reactants, through the transition state, to the products) to make qualitative predictions regarding the relative temperature dependence of the reaction rate. SP1.4, SP6.4	
4.C.1 4.C.2 4.C.3	4.7: Evaluate alternative explanations, as expressed by reaction mechanisms, to determine which are consistent with data regarding the overall rate of a reaction, and data that can be used to infer the presence of a reaction intermediate. SP6.5	

QUARTER 3

Topic: Kinetics and Equilibrium

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AP College Board Essential Knowledge	Student Learning Targets (AP Learning Objectives and Science Practices)	Learning Activities/Investigations
4.D.1	4.8: Translate among reaction energy profile representations, particulate representations, and symbolic representations (chemical equations) of a chemical reaction occurring in the presence and absence of a catalyst. SP1.5	Demo: Lycopodium Powder
4.D.2	4.9: Explain and predict changes in reaction rates arising from the use of acid-base catalysts, surface catalysts, or enzyme catalysts, including selecting appropriate mechanisms with or without the catalyst present using rate laws and energy profile diagrams. SP6.2, SP7.2	Demos: Elephant Toothpaste, Glow Stick
6.A.1	6.1: Given a set of experimental observations regarding physical, chemical, biological, or environmental processes that are reversible, construct an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes. SP6.2	
6.A.2	6.2: Given a manipulation of a chemical reaction or set of reactions (e.g., reversal of reaction or addition of two reactions), determine the effects of that manipulation on Q or K. SP2.2	Demo: Thermit Reaction
6.A.3	6.3: Connect kinetics to equilibrium by using reasoning about equilibrium, such as Le Chatelier's principle, to infer the relative rates of the forward and reverse reactions. SP7.2	
	6.4: Given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K, use the tendency of Q to approach K to predict and justify the prediction as to whether the reaction will proceed toward products or reactants as equilibrium is approached. SP2.2, SP6.4	
	6.5: Given data (tabular, graphical, etc.) from which the state of a system at equilibrium can be obtained, calculate the equilibrium constant, K. SP2.2	Lab-The Determination of an Equilibrium Constant

QUARTER 3

Topic: Kinetics and Equilibrium

Key Terms: kinetics, reaction rates, instantaneous rate, rate law, specific rate constant, reaction order, zero order, first order, second order, half-life, elementary reaction, collision model, activation energy, activated complex, reaction mechanism, molecularity, intermediate, catalyst, rate determining step, integrated rate law, kinetic control, chemical equilibrium, equilibrium constant expression, equilibrium constant, reaction quotient, Le Chatelier's principle

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	6.6: Given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K, use stoichiometric relationships and the law of mass action (Q equals K at equilibrium) to determine qualitatively and/or quantitatively the conditions at equilibrium for a system involving a single reversible reaction. SP2.2, SP6.4	
6.A.4	6.7: Determine, for a reversible reaction that has a large or small K, which chemical species will have very large versus very small concentrations at equilibrium. SP2.2, SP2.3	
6.B.1	6.8: Use Le Chatelier's principle to predict the direction of the shift resulting from various possible stresses on a system at chemical equilibrium. SP1.4, SP6.4	Lab: Gas phase Equilibrium
	6.9: Use Le Chatelier's principle to design a set of conditions that will optimize a desired outcome, such as product yield. SP4.2	
6.B.2	6.10: Connect Le Chatelier's principle to the comparison of Q to K by explaining the effects of the stress on Q and K. SP1.4, SP7.2	

QUARTER 3		
Topic: Acids, Bases, Buffers, and Solubility Equilibrium		
Key Terms: conjugate acid-base pair, autoionization, ion-product constant, pH scale, strength, acid-dissociation constant, percent ionization, polyprotic acid, base-dissociation constant, salt hydrolysis, oxyacids, pKa, pKb, pOH, common ion effect, buffered solution, buffer capacity, pH titration curve, half equivalence point, solubility product constant, complex ions, selective precipitation		
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AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	2.2: Explain the relative strengths of acids and bases based on molecular structure, interparticle forces, and solution equilibrium. SP7.2	
3.B.2	3.7: Identify compounds as Bronsted-Lowry acids, bases, and/or conjugate acid-base pairs, using proton-transfer reactions to justify the identification. SP6.1	
6.C.1	6.11: Generate or use a particulate representation of an acid (strong or weak or polyprotic) and a strong base to explain the species that will have large versus small concentrations at equilibrium. SP1.1, SP1.4, SP2.3	
	6.12: Reason about the distinction between strong and weak acid solutions with similar values of pH, including the percent ionization of the acids, the concentrations needed to achieve the same pH, and the amount of base needed to reach the equivalence point in a titration. SP1.4, SP6.4	
	6.13: Interpret titration data for monoprotic or polyprotic acids involving titration of a weak or strong acid by a strong base (or a weak or strong base by a strong acid) to determine the concentration of the titrant and the pKa for a weak acid, or the pKb for a weak base. SP5.1, SP6.4	Lab: Acidity of Beverages
	6.14: Reason, based on the dependence of Kw on temperature, that neutrality requires [H+] = [OH–] as opposed to requiring pH = 7, including especially the applications to biological systems. SP2.2, SP6.2	
	6.15: Identify a given solution as containing a mixture of strong acids and/or bases and calculate or estimate the pH (and concentrations of all chemical species) in the resulting solution. SP2.2, SP2.3, SP6.4	
	6.16: Identify a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), calculate the	

QUARTER 3

Topic: Acids, Bases, Buffers, and Solubility Equilibrium

Key Terms: conjugate acid-base pair, autoionization, ion-product constant, pH scale, strength, acid-dissociation constant, percent ionization, polyprotic acid, base-dissociation constant, salt hydrolysis, oxyacids, pKa, pKb, pOH, common ion effect, buffered solution, buffer capacity, pH titration curve, half equivalence point, solubility product constant, complex ions, selective precipitation

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AP College Board Essential Knowledge	Student Learning Targets (AP Learning Objectives and Science Practices)	Learning Activities/Investigations
	pH and concentration of all species in the solution, and/or infer the relative strengths of the weak acids or bases from given equilibrium concentrations. SP2.2, SP6.4	
	6.17: Given an arbitrary mixture of weak and strong acids and bases (including polyprotic systems), determine which species will react strongly with one another (i.e., with K >1) and what species will be present in large concentrations at equilibrium. SP6.4	Lab: Equilibria with Weak Acids and Bases
6.C.2	6.18: Design a buffer solution with a target pH and buffer capacity by selecting an appropriate conjugate acid-base pair and estimating the concentrations needed to achieve the desired capacity. SP2.3, SP4.2, SP6.4	Lab: Buffers
	6.19: Relate the predominant form of a chemical species involving a labile proton (i.e., protonated/deprotonated form of a weak acid) to the pH of a solution and the pKa associated with the labile proton. SP2.3, SP5.1, SP6.4	Demo: Nylon Demo: pH Indicators
	6.20: Identify a solution as being a buffer solution and explain the buffer mechanism in terms of the reactions that would occur on addition of acid or base. SP6.4	
6.C.3	6.21: Predict the solubility of a salt, or rank the solubility of salts, given the relevant Ksp values. SP2.2, SP2.3, SP6.4	
	6.22: Interpret data regarding solubility of salts to determine, or rank, the relevant Ksp values. SP2.2, SP2.3, SP6.4	Lab: Determining the Ksp of Ca(OH)2
	6.23: Interpret data regarding the relative solubility of salts in terms of factors (common ions, pH) that influence the solubility. SP5.1, SP6.4	Demo: Common Ion Effect

QUARTER 3

Topic: Acids, Bases, Buffers, and Solubility Equilibrium

Key Terms: conjugate acid-base pair, autoionization, ion-product constant, pH scale, strength, acid-dissociation constant, percent ionization, polyprotic acid, base-dissociation constant, salt hydrolysis, oxyacids, pKa, pKb, pOH, common ion effect, buffered solution, buffer capacity, pH titration curve, half equivalence point, solubility product constant, complex ions, selective precipitation

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	6.24: Analyze the enthalpic and entropic changes associated with the dissolution of a salt, using particulate level interactions and representations. SP1.4, SP7.1	Demo: Solution Discrepant Event

QUARTERS 3-4

Topic: Thermodynamics and Electrochemistry

Key Terms: enthalpy, entropy, second law of thermodynamics, free energy, coupled reactions, reversible process, translational motion, vibrational motion, rotational motion, third law of thermodynamics, standard molar entropy, standard free energies of formation, temperature dependence, thermodynamic control, electrochemistry, reducing agent, oxidizing agent, half reactions, voltaic (galvanic) cell, anode, cathode, salt bridge, cell potential, standard cell potential, standard reduction potential, standard hydrogen electrode, Faraday's constant, nonstandard conditions, concentration cell, battery, fuel cell, metal-air cell, electrolytic cell, electrolysis, sacrificial anode, photoionization

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3.B.3	3.8: Identify redox reactions and justify the identification in terms of electron transfer. SP6.1	
	3.9: Design and/or interpret the results of an experiment involving a redox titration. SP4.2, SP5.1	

QUARTERS 3-4

Topic: Thermodynamics and Electrochemistry

Key Terms: enthalpy, entropy, second law of thermodynamics, free energy, coupled reactions, reversible process, translational motion, vibrational motion, rotational motion, third law of thermodynamics, standard molar entropy, standard free energies of formation, temperature dependence, thermodynamic control, electrochemistry, reducing agent, oxidizing agent, half reactions, voltaic (galvanic) cell, anode, cathode, salt bridge, cell potential, standard cell potential, standard reduction potential, standard hydrogen electrode, Faraday's constant, nonstandard conditions, concentration cell, battery, fuel cell, metal-air cell, electrolytic cell, electrolysis, sacrificial anode, photoionization

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AP College Board Essential Knowledge	Student Learning Targets (AP Learning Objectives and Science Practices)	Learning Activities/Investigations
3.C.3	3.12: Make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/or Faraday's law. SP2.2, SP2.3, SP6.4	Lab: Electrochemical cells and Spontaneity
	3.13: Analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions. SP5.1	Lab: Making batteries and Fuel Cells
5.E.1	5.12: Use representations and models to predict the sign and relative magnitude of the entropy change associated with chemical or physical processes. SP1.4	
5.E.2	5.13: Predict whether or not a physical or chemical process is thermodynamically favored by determination of (either quantitatively or qualitatively) the signs of both $\Delta H°$ and $\Delta S°$, and calculation or estimation of $\Delta G°$ when needed. SP2.2, SP2.3, SP6.4	
5.E.3	5.14: Determine whether a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy. SP2.2	
5.E.4	5.15: Explain how the application of external energy sources or the coupling of favorable with unfavorable reactions can be used to cause processes that are not thermodynamically favorable to become favorable. SP6.2	Demo: Measuring Faraday's constant using Hoffman apparatus
	5.16: Use Le Chatelier's principle to make qualitative predictions for systems in which coupled reactions that share a common intermediate drive formation of a product. SP6.4	

QUARTERS 3-4		
Topic: Thermodynamics and Electrochemistry		
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AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	5.17: Make quantitative predictions for systems involving coupled reactions that share a common intermediate, based on the equilibrium constant for the combined reaction. SP6.4	Lab: Metal Air Cell
5.E.5	5.18: Explain why a thermodynamically favored chemical reaction may not produce large amounts of product (based on consideration of both initial conditions and kinetic effects), or why a thermodynamically unfavored chemical reaction can produce large amounts of product for certain sets of initial conditions. SP1.3, SP7.2	
6.D.1	6.25: Express the equilibrium constant in terms of $\Delta G°$ and RT and use this relationship to estimate the magnitude of K and, consequently, the thermodynamic favorability of the process. SP2.3	Lab – Electroplating

District Instructional Resource:

Chemistry AP Edition (2018) / Cengage (6-year online subscription: 2019-2020 to 2024-2025)

Standards Alignment:

AP Chemistry Course and Exam Description (2014) – retrieved Jan. 2, 2019 http://media.collegeboard.com/digitalServices/pdf/ap/ap-chemistry-course-and-exam-description.pdf