AP Chemistry Scope & Sequence

Grading Period	Unit Title	Learning Targets
Throughout the School Year	B.(1) Scientific processes. The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. The student is expected to: (A) demonstrate safe practices during laboratory and field investigations, including chemical, electrical, and fire safety, and safe handling of live and preserved organisms; and (B) demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials. B.(2) Scientific processes. The student uses scientific methods during laboratory and field investigations. The student is expected to: (A) know the definition of science and understand that it has limitations, as specified in subsection (b)(2) of this section; (B) know that scientific hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power which have been tested over a wide variety of conditions are incorporated into theories; (C) know that scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well-established and highly-reliable explanations, but they may be subject to change as new areas of science and new technologies are developed; (D) distinguish between scientific hypotheses and scientific theories; (E) plan and implement investigative procedures, including asking questions, formulating testable hypotheses, and selecting, handling, and maintaining appropriate equipment and technology; (F) collect data individually or collaboratively, make measurements with precision and accuracy, record values using appropriate units, and calculate statistically relevant quantities to describe data, including mean, median, and range; (G) demonstrate the use of course apparatuses, equipment, techniques, and procedures;	

	(H) organize, analyze, evaluate, build models, make inferences, and predict trends from data; (I) perform calculations using dimensional analysis, significant digits, and scientific notation; and (J) communicate valid conclusions using essential vocabulary and multiple modes of expression such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports. B.(3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to: (A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student; (B) communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials; (C) draw inferences based on data related to promotional materials for products and services; (D) evaluate the impact of research and technology on scientific thought, society, and the environment; (E) describe the connection between aquatic science and future careers; and (F) research and describe the history of aquatic science and contributions of scientists.	
First Grading Period	Foundations in Chemistry	• Differentiate between homogeneous and heterogeneous mixtures. • Differentiate among elements, compounds and mixtures. • Describe various separation techniques. • Use drawing to illustrate the differences between the types of matter. • Differentiate between chemical and physical changes and properties. • Calculate the density of a substance and perform calculations using density. • Distinguish between accuracy and precision. • Distinguish between exact and inexact numbers. • Determine the number of significant figures in a measured quantity. • Determine the number of significant figures to report in the result of mathematical calculations • Describe mass differences and charge differences among electrons, protons and neutrons. • Define isotope, atomic number and mass number in terms of the number of electrons, protons and neutrons. • Calculate numbers of electrons, protons, and neutrons in an atom, given the atomic number and the mass number.

		• Name simple ionic and covalent compounds, given the formula. • Write the formula for simple ionic and molecular compounds given the IUPAC name. • Identify formulas for simple acids and bases. • Calculate the formula mass for a compound • Define the term mole and Avogadro's number. • Calculate the mass of a molar quantity of an element or compound and calculate the number of moles of atoms, molecules or formula units given the mass of a compound and its formula. • Calculate the percent composition from the chemical formula. • Write empirical and molecular formulas for a compound, given the relative amounts of each constituent element (in terms of atoms, grams, or moles) and the molar mass of the compound. • Calculate the amount of product formed, or reactant consumed, in a chemical reaction, given the initial amount of one reactant (or product) and assuming the other reactant is in excess. • Determine the limiting reagent for a chemical reaction and the maximum amount of product that can be formed, given the initial amounts of each reactant in the chemical equation. • Calculate percent yield, given the actual amount of product formed and the theoretical amount of product. • Calculate the average atomic mass given the isotopic abundance. • Determine empirical and molecular formulas through combustion analysis.
	Reactions in Solutions	• Differentiate between non, weak, and strong electrolytes. • Define the terms *concentration* and *molarity*. • Calculate the molarity of a solution. • Describe in detail how to make a solution. • Perform calculations using stoichiometry and limiting reagent given initial amounts of reactants (or products) in terms of molarity and volume of solution. • Know general solubility rules and prediction of precipitate production. • Be able to write molecular and total and net ionic equations of single replacement double replacement reactions. • Be able to predict the products of various types of redox reactions like: replaceme decomposition, addition,

		• Recognize and explain complex ions and their reactions. • Know strong vs. weak acids and bases • Write the neutralization equation for a reaction between an acid and a base, either as a molecular equation or as a net ionic equation • Solve for concentrations involving both titrations and dilutions
	Kinetics	• Identify four factors which effect the speed at which a reaction takes place. • Define the term *chemical kinetics*. • Define the term *reaction rate*. • Distinguish between *average rate*, *instantaneous rate* and *initial rate* of a chemical reaction. • Write the general rate equation for a chemical reaction and define each term in the rate equation. • Define the term *reaction order* and explain how the order for a chemical reaction can be determined. • Use the method of initial rates to determine the specific rate law for a chemical reaction. • Write and use the mathematical equation which relates the change in concentration with time (integrated rate law) for simple first order reactions. • Determine the half-life for reactions which follow simple first order kinetics. • Recognize the order and determine the rate constant for a simple reaction from a plot of *ln*[concentration] versus time. • Write and use the mathematical equation which relates the change in concentration with time (integrated rate law) for simple second order reactions. • Determine the half-life for reactions which follow simple second order kinetics. • Recognize the order and determine the rate constant for a simple reaction from a plot of $\frac{1}{\text{concentration}}$ versus time. • Define the term *activation energy* for chemical reactions. • Write and use the mathematical equation which describes the relationship between the rate constant and temperature. • Sketch an energy profile diagram for a simple reaction and label the important features. • Define the terms *reaction mechanism* and *rate determining step*.

		• Write the rate law for a chemical reaction given the mechanism and the rate determining step. • Suggest a possible mechanism for a chemical reaction given the balanced chemical equation and the rate law. • Define the terms *reaction intermediate* and *catalyst*. • State the two factors which determine if a collision is effective, and how the arrhenius equation takes these factors into account • Describe the basic structure and function of different catalysts • Use energy distribution diagrams to show how lowering the termperature lowers the reaction rate • Use energy distribution diagrams and progress of reaction diagrams to show how a catalyst increases the rate of a reaction
	Equilibrium	• Define DYNAMIC EQUILIBRIUM • Understand the temperature dependence of K • Write and equilibrium expression (also known as “law of mass action”) • Understand how manipulating the form of a reaction changes the numerical value of K • Understand that pure liquids and solids are not included in equilibrium expressions. • Calculate K from equilibrium concentrations and pressures • Convert Kc to or from Kp • Explain what the magnitude of K means regarding the favoritism of the forward or reverse reaction • Create and use a RICE table to find K or to solve for equilibrium conditions • Use the quadratic formula to solve for “x” in a rice table • Define LeChatlier’s Principle • Know the effects of changes in concentration, volume and temperate on equilibrium systems. • Determine direction of shift after a reaction stress is applied to a reaction at equilibrium • Calculate Q and apply to direction of shift in a RICE table • Understand the relationship between K and heat of a reaction • Determine the rate law of a mechanism in which an equilibrium substitution is required.

		• Be able to determine the solubility or the K_{sp} of a very slightly soluble compound. • Be able to determine if precipitation will occur if 2 solutions are mixed based on K_{sp} calculations.
Second Grading Period	Acid Base Chemistry	• Define an Arrhenius Acid and Base • Define a Bronsted-Lowry Acid and Base • Write an expression for Ka or Kb • Associate the magnitude of K with the strength of the acid or base • Indicate if an acid or base is strong or weak • Write an expression for Kw of a water • Find the hydronium or hydroxide ion concentration in a solution given pH • Find the pH of strong acids and bases • Find the pH of weak acids and bases • Know the difference between the pH and pOH scales • Know at what pH solutions are acidic or basic • Find the Ka or the Kb of weak acids and bases • Write a hydrolysis equation given a salt • Determine the pH of a salt in solution • Find the pH of a solution containing a POLYPROTIC acid • Know the effect of structure on acid base properties
	Solution Equilibrium	• Determine the pH of solutions of weak acids/bases, strong acids/bases, buffers, and salts (hydrolysis). • Be able to determine the pH of any solution from above after adding a given amount of strong acid/base to the mix!! Remember the TIPS I gave you in class. • Be able to do calculations for titrations given different increments of titrant added (strong/strong or weak/strong combinations). • Be able to sketch the curve of the titrations from the third bullet being able to find the equivalence point, the mid point and also being able to choose an appropriate indicator for a particular titration. • Be able to determine the range of color change of an indicator knowing the K_a and it's appropriateness for certain titrations.

	Thermodynamics	• Define the terms *thermodynamics* and *thermochemistry*. • Distinguish between the system and the surrounding in a chemical process. • Define the terms *exothermic* and *endothermic* as they apply to chemical reactions. • Define the terms *specific heat* and *heat capacity* and use both concepts to calculate heat flow. • Calculate heat flow in a coffee-cup calorimetry experiment. • State the first law of thermodynamics. • Write the mathematical equation defining the internal energy change in a chemical reaction. • Calculate the internal energy change for a chemical process in terms of heat flow and work. • Write the mathematical equation for heat flow in chemical reactions at constant volume and constant pressure. • Define the term *enthalpy* (H) • Describe and recognize state functions. • Calculate the enthalpy change in a chemical reaction using Hess's Law • Define the term *standard state* as it is applied to an element or compound. • Write a chemical equation describing the formation of any compound and look up its heat of formation in table of standard heats of formation. • Write a chemical equation describing the combustion of any compound • Calculate the enthalpy change in any chemical reaction using standard enthalpies of formation. • Define the first law of thermodynamics as energy of the universe being constant • Define the second law of thermodynamics as for any spontaneous process there is always in increase in entropy in the universe. • Predict the sign of entropy on a system looking both at numbers and the reaction with states of matter included • Calculate entropy of a system (ΔS)
Third Grading Period	Atomic Structure & Periodicity	• State the mathematical relationship between wavelength and frequency and calcu the wavelength of light, given its frequency and the speed of light. • State the mathematical relationship between energy and frequency for light and calculate the energy of photons of light at a given frequency or wavelength.

		• Differentiate between emission and absorption spectrum. • Define the terms: *excited state*; *ground state; diamagnetic; paramagnetic* • Recognize the shapes of *'s'*, *'p'* and *'d'* orbitals. • Define the terms *effective nuclear charge* and *screening effect* and explain how th energy of the atomic orbitals are affected by the presence of more than one electr • Write the electron configuration for any element OR ion • Define and apply *Hund's rule, Aufbau Principle, Pauli exclusion principle and Heisenberg Uncertainty Principle*. • Define *valence electrons* and *core electrons* and distinguish between them for any element in the periodic table. • Identify electron configurations for charged atoms and explain why they form tho charges • Describe the trend in atomic radii and ionic radii among elements within groups a periods of the periodic table. • Describe the trend in ionization energy among elements within groups and period the periodic table. • Describe the trend in electronegativity among elements within groups and periods the periodic table. • Draw the photoelectron spectrum (PES) of a particular element or given a spectrum identify what element is represented.
	Bonding	• Draw the electron–dot representation of valence electrons (Lewis structure) for ar • Explain and apply the octet rule. • Predict the chemical formula for any pair of elements that form an ionic compour • Define the term *lattice energy*. • State the classifications of elements that typically form ionic bonds and determine whether or not ionic bonds are present in a particular compound of known elemer composition. • Define the term *covalent bond*. • Define the term *electronegativity* and explain electronegativity differences among elements within periods and groups in the periodic table. • Identify polar bonds in covalent molecules and describe how electronegativity dif between bound atoms influence bond polarity. • Draw the Lewis structures for a covalent molecule, given linkages of constituent • Identify covalent compounds that do not conform to the octet rule.

		• Draw resonance structures for covalent molecules that cannot be represented by a Lewis structure. • Define the term *bond dissociation energy* and explain its relationship to the streng chemical bond. • Calculate the ΔH° for a reaction, given all requisite bond energies. • Distinguish between bonding pairs and nonbonding pairs of electrons in the mole covalent compound. • Differentiate between the electron–pair geometry and the molecular geometry for simple covalent molecule. • Apply the molecular geometry, using valence–shell electron pair repulsion (VSE model to predict molecular geometry. • Describe molecular geometries that result from bond angles in a given covalent m • Describe the effect of nonbonding electrons on bond angle in a given series of co molecules. • Identify the molecular geometry about any non-terminal atom in any molecule la single central atom. • Define the term *polar* and *nonpolar* as it is used in covalent molecules. • Define the term *dipole moment* and predict its presence or absence in a covalent n • Define the term *overlap* and diagram the orbital overlap of two *s* orbitals, of an *s* orbital, and of two *p* orbitals. • Distinguish between sigma and a pi chemical bonds. • Describe how a set of hybrid orbitals differ from a collection of atomic orbitals. • Show how the geometry of a covalent molecule to a particular set of hybrid orbitals on a central atom. • Identify the atomic orbitals used to bind atoms in covalent molecules containing r bonds. • Calculate formal charges on atoms in a given compound • Use the argument of formal charges to determine the most stable Lewis structure
	Liquids & Solids	• Define the term *equilibrium vapor pressure* and sketch the kinetic-molecular model of a liquid in equilibrium with its vapor. • Describe how temperature affects the vapor pressure of a liquid using kinetic-molecular model. • Illustrate common properties of liquids and explain how they differ from liquid

		to liquid based on IMF's (surface tension, capillary action, viscosity) • Use the given mathematical equation that describes the dependence of vapor pressure on temperature. • Define and illustrate using pictorial diagrams of atoms, ions or molecules, the inter-molecular attractive forces: dipole-dipole, London dispersion and hydrogen-bonding. • Predict the major types of intermolecular attractive force that occur between any two particles in the liquid phase. • Identify or create or give representative examples of all types of solids (atomic solids, molecular solids, ionic solids, covalent network solids, and metals) • Explain the concept 'like dissolves like' • List the important criteria for predicting whether a mixture will be homogeneous or heterogeneous when mixing two substances • Define the concentration terms; *weight percent*, *mole fraction*, *molarity* and use these concentration expressions to determine the concentration of any homogeneous mixture. • Define the term *colligative property* and list those physical properties of a solution which can be classified as colligative properties. • Explain how and why the freezing point and the boiling point of a liquid are affected by the addition of a nonvolatile solute. • Explain how the vapor pressure of a liquid solvent in a solution is affected by the presence of a solute. • Identify the IMF's associated with different organic functional group
	Gases	• Define the term *atmospheric pressure* and describe how a mercury barometer works. • State the units for measuring pressure and carry out conversions between different pressure units. • State the postulates of the kinetic-molecular theory. • Explain the relationship between the temperature of a sample of gas and the kinetic energy of the particles of the gas. • Relate the macroscopic behavior of an ideal gas to the kinetic-molecular model of a gas. (How molecular movement changes the way we see the gas) • State the mathematical relationship for Boyle's Law and carry out calculations using the relationship.

		• State the mathematical relationship for Charles' Law and carry out calculations using the relationship • State the mathematical relationship for Gay Lussac's Law and carry out calculations using the relationship • State the mathematical relationship for Daltons Law and carry out calculations using the relationship of partial pressures • State the mathematical relationship for Avogadro's Law and carry out calculations using the relationship • Write the ideal gas equation and define each variable. • Use the ideal gas equation to solve for any of its variables or a ratio of variables, such as density. • Use the ideal gas law to calculate the amount of product formed, or reactant consumed, in a chemical reaction, given the initial amount of one reactant (or product) and assuming the other reactant is in excess. • Determine the molecular weight of an unknown gas, and determine the molecular formula of that gas using that info. • Describe the experiment for determining the MM of a gas • Derive Grahams law from the root mean squared equation • Calculate relative effusion or diffusion rates of gases • State what conditions make a gas "ideal" • Explain the shortcomings of the ideal gas model when dealing with real gases
Fourth Grading Period	Electrochemistry	• Define Electrochemical Cells • Know the difference between Voltaic (Galvanic) and Electrolytic Cells • Balance Redox Equations using the half reaction method • Define EMF • Connect the sign of E to thermodynamic favorability (spontaneity) • Draw and label the parts of a voltaic cell (anode, cathode, +/-, salt bridge, direction of ion migration, voltmeter) • Produce short hand notation • Use a table of reduction potentials to find what's oxidized or what's reduced • Calculate a standard E° from a table of reduction potentials • Calculate a non standard E_{cell} using the Nernst Equation

		• Write the half reactions for the electrolysis of water and know which is oxidation and which is reduction • Draw and label the part of an Electrolytic cell (battery, anode, cathode, +/-) • Predict the products of the electrolysis of salt solutions and molten salts • Do a series of calculations using Faraday's constant (stoich problems with grams, amps, mole of e-, etc) • Find free energy from E° and vice versa (ΔG=-nFE) • Find K from E° using both (ΔG=-nFE and ΔG=-RTlnK)
	Spring Review	Review Exam 1: 1 Foundations 2 Rxns in Solutions 3 Kinetics 7 Thermodynamics Review Exam 2: 8 Atomic Structure & Periodicity 9 Bonding 10 Liquids & Solids 11 Gases Review Exam 3: 6 Equilibrium 7 Acids and Bases 8 Solution Equilibrium 12 Electrochemistry Mock AP Multiple Choice Exam