HIGH SCHOOL ELECTIVE
CHEMISTRY (USED AS A YEAR-LONG OR BLOCK-SCHEDULED COURSE)
Physical Sciences Standard (PS)

11-12 Benchmarks	Grade Level Indicators and Sub-Objectives	Teaching Strategies/Resources
By the end of the 11-12 program, the student will, **<u>Physical Sciences</u>** ✶ **Explain how variations in the arrangement and motion of atoms and molecules form the basis of a variety of biological, chemical and physical phenomena. (PS-A)** ✶ **Recognize that some atomic nuclei are unstable and will spontaneously break down. (PS-B)** ✶ **Describe how atoms and molecules can gain or lose energy only in discrete amounts. (PS-C)** ✶ **Summarize the historical development of scientific theories and ideas within the study of physical sciences. (PS-E)**	**By the end of Eleventh/Twelfth Grades, the student will:** **<u>Nature of Matter</u>** ✶ **Explain that elements with the same number of protons may or may not have the same mass and those with different masses (different numbers of neutrons) are called isotopes. Some of these are radioactive. (PS-11-1)** ✶ **Explain that humans have used unique bonding of carbon atoms to make a variety of molecules (e.g., plastics). (PS-11-2)** ✶ **Explain how atoms join with one another in various combinations in distinct molecules or in repeating crystal patterns. (PS-12-1)** ✶ **Describe how a physical, chemical or ecological system in equilibrium may return to the same state of equilibrium if the disturbances it experiences are small. Large disturbances may cause it to escape that equilibrium and eventually settle into some other state of equilibrium. (PS-12-2)** ✶ **Explain how all matter tends toward more disorganized states and describe real world examples (e.g., erosion of rocks and expansion of the universe). (PS-12-3)** **<u>Forces and Motion</u>** ✶ **Describe real world examples showing that all energy transformations tend toward disorganized states (e.g., fossil fuel combustion, food pyramids and electrical use). (PS-11-3)** ✶ **Recognize that the nuclear forces that hold the nucleus of an atom together, at nuclear distances, are stronger than the electric forces that would make it fly apart. (PS-12-6)**	

	✶ **Recognize that nuclear forces are much stronger than electromagnetic forces, and electromagnetic forces are vastly stronger than gravitational forces. The strength of the nuclear forces explains why greater amounts of energy are released from nuclear reactions (e.g., from atomic and hydrogen bombs and in the sun and other stars). (PS-12-7)** **<u>Nature of Energy</u>** ✶ **Explain the characteristics of isotopes. The nucleus of radioactive isotopes is unstable and spontaneously decays emitting particles and/or wavelike radiation. It cannot be predicted exactly when, if ever, an unstable nucleus will decay, but a large group of identical nuclei decay at a predictable rate. (PS-12-10)** ✶ **Use the predictability of decay rates and the concept of half-life to explain how radioactive substances can be used in estimating the age of materials. (PS-12-11)** ✶ **Describe how different atomic energy levels are associated with the electron configurations of atoms and electron configurations (and/or conformations) of molecules. (PS-12-12)** ✶ **Explain how atoms and molecules can gain or lose energy in particular discrete amounts (quanta or packets); therefore they can only absorb or emit light at the wavelengths corresponding to these amounts. (PS-12-13)** **<u>Historical Perspectives and Scientific Revolutions</u>** ✶ **Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., nuclear energy, quantum theory and theory of relativity). (PS-12-14)** ✶ **Describe concepts/ideas in physical sciences that have important, long-lasting effects on science and society (e.g., quantum theory, theory of relativity, age of the universe). (PS-12-15)**	

	Sub-Objectives to Meet Indicators: **Scientific Method** • Demonstrate an understanding that chemistry occurs all around us. • Use the proper scientific method to make predictions, determine the next steps to be taken in an experiment, and organize and report scientific information in its correct form. • Exhibit proper safety and lab techniques. **Data Analysis and Interpretation** • Properly collect, convert, calculate, interpret, and analyze data. • Convert data into different graphic representations and analyze accordingly. • Use dimensional analysis to solve problems and make SI conversions. **Stoichiometry** • Calculate solutions to problems involving conversions from moles to moles, moles to grams, grams to moles, and grams to grams. • Calculate the mass in grams of a product given two reactants, one of which is a limiting reactant. • Distinguish among theoretical yield, actual yield, and percent yield. • Solve problems of stoichiometry. • Classify matter according to its composition. **Matter and Energy** • Distinguish among elements, compounds, homogeneous mixtures, and heterogeneous mixtures. • Compare and contrast physical and chemical changes. • Demonstrate an understanding of matter versus energy and their properties, including endothermic and exothermic reactions. • Measure and calculate energy changes. • Apply the Law of Conservation of Mass-Energy to chemical changes. • Compare and contrast nuclear and chemical reactions and write equations that represent these reactions. • Describe the relationship between emission and absorption of light energy to electron transition.	

	Atomic Theory • Illustrate the modern model of atomic theory. • Interpret information available about each element from the periodic table. • Describe the role of electron in modern atomic theory. • Compare and contrast the characteristics of a solids, liquids, and gases. • Describe the Kinetic Theory of Matter related to the properties of solids, liquids, and gases. • Interpret changes in temperature and changes in state of a substance in terms of the Kinetic Theory of Matter. **How Elements React** • Compare and contrast electron energy levels within an atom. • Illustrate valence electrons by Lewis electron dot structures. • Demonstrate how and why atoms achieve chemical stability by bonding. • Describe molecular polarity through three dimensional geometry and illustrations of bond polarity. • Measure heat of reactions using Kelvin scale and Celsius-scale temperatures. • Analyze the effects of temperature and pressure on changes of state. **Compounds** • Determine the properties of compounds from those of the elements of which they are composed. • Interpret the information in a chemical formula. • Analyze and conclude the differences that exist in the way compounds bond and form. • Model the two basic types of compound formation (ionic and covalent) at the atomic level. • Compare, using examples, the effects of ionic and covalent bonding on the physical properties of a compound. • Apply ionic charge to writing formulas for ionic compounds. • Apply formulas to name ionic compounds. • Apply formulas to name molecular compounds. • Describe the role of electrons in covalent bonding. • Compare and contrast the characteristics of ionic, covalent, and polar-covalent bonds. • Compare and contrast acids and bases.	

	Reactions • Demonstrate how chemical equations describe chemical reactions. • Illustrate how to balance chemical equations by changing coefficients. • Formulate a model to demonstrate an understanding of the concept of equilibrium • Distinguish among the five types of chemical reactions. **Periodicity** • Predict similarities in properties of elements by using the periodic table. • Recognize the relationship between an element's valence electron structure and its position on the periodic table. • Use the periodic table to identify and compare the properties of metals, non-metals, or metalloids. • Use the periodic table to state the energy sublevels and orbitals within atoms. • Distinguish among the s, p, d, and f blocks on the periodic table and relate them to an element's electron configuration. • Predict the electron configuration of an atom using the periodic table. • Describe the position of any main group element in the periodic table in order to predict its electron configuration. • Predict the chemical behavior of the main group elements. • Analyze electron configuration to determine the chemical behavior of an element. • Explain how the stability of an atom is related to its electron structure. **Physical Characteristics of Gases** • List the five assumptions of the Kinetic-Molecular Theory of Matter and describe how the theory explains properties of matter. • Describe how pressure is measured and convert units of pressure. • Calculate volume-pressure changes using Boyle's Law. • Calculate volume-temperature changes using Charles' Law. • Calculate pressure-temperature changes using Gay-Lusak's Law. • Calculate volume-pressure-temperatures changes using the combined gas law. • Calculate total and partial pressure using Dalton's Law.	

	Molecular Composition of Gases • Describe Avogadro's Law and recognize its relationship to standard molar volume of a gas. • Using the Ideal Gas Law, calculate pressure, volume, temperature, or amount of gas when the other three quantities are known. • Calculate the molar mass or density of gas using the Ideal Gas Law. • Calculate volumes, masses, or molar amounts of gaseous reactants and products, using stoichiometry and gas laws. • Calculate the relative rates of effusion of two gases using Graham's Law. **Liquids and Solids** • Describe the properties of liquids and solids using the Kinetic-Molecular Theory of Gases. • Differentiate between crystalline and amorphous solids. • Predict changes in equilibrium using LeChatelier's Principle. • Interpret phase diagrams. • Determine the physical properties of water using its structure. **Solutions** • Compare and contrast the properties of suspensions, colloids, and solutions. • Differentiate between electrolytes and nonelectrolytes as solutes. • Use polar and nonpolar substances to demonstrate "like dissolves like". • Describe the effects of temperature and pressure on solubility. • Calculate molarity and molality given mass of solute and volume of solvent. • Calculate amount of solute required to produce a specific molarity or molality **Aqueous Solutions and Colligative Properties** • Write net ionic equations for precipitation reactions. • Distinguish between strong and weak electrolytes. • List the four colligative properties and describe their effects on solutions. • Calculate the freezing point depression and boiling point elevation for electrolytic and nonelectrolytic solutions. **Acids and Bases (Optional)** • List five general properties of aqueous acids and bases. • Name common binary acids and oxyacids, given their chemical formulas.	

	• Identify conjugate acids and bases from a neutralization reaction. • Describe what determines whether an amphoteric substance acts as an acid or base. • Describe and differentiate between the Arrhenius, Bronsted-Lowry, and Lewis definitions for acids and bases. **Acid-Base Titration and pH (Optional)** • Describe self-ionization of water and its relationship to pH scale. • Calculate pH and pOH, given hydronium or hydroxide ion concentration. • Calculate hydronium or hydroxide ion concentration, given pH or pOH. • Identify acid-base indicators and their functions. • Calculate the molarity of a solution from titration data. **Oxidation-Reduction Reactions (Optional)** • Assign oxidation numbers to reactant and product species. • Differentiate between oxidation and reduction reactions. • Balance oxidation reactions by using the half-reaction method. • Describe how chemical activity is related to oxidizing and reducing strength.	