# North Polk Community Schools Pacing & Course Description Guide

| Grade Level: 11-12 | Content: AP Chemistry | Year: 2022-2023 |
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## Course Description/Rationale

AP Chemistry is a rigorous two-semester course designed to be the equivalent of a college-level introductory chemistry course. Topics include 6 Big Ideas: Structure of Matter, Bonding and Intermolecular Forces, Chemical Reactions, Kinetics, Thermodynamics, and Chemical Equilibrium. Approximately 25 percent of the instructional time engages students in lab investigation. At the end of the course, students are eligible to take the AP Chemistry exam. Students will receive a weighted grade.

| Name of Unit | Time Frame | Essential Learning Target | Standard(s) |
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| 1: Atomic Structure & Properties | 3 weeks | ***SPQ-1.A:*** *Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept.*<br>***SPQ-1.B:*** *Explain the quantitative relationship between the mass spectrum of an element and the masses of the element's isotopes.*<br>***SPQ-2.A*** *Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance.*<br>***SPQ-2.B*** *Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture.*<br>***SAP-1.A*** *Represent the electron configuration of an element or ions of an element using the Aufbau principle.*<br>***SAP-1.B*** *Explain the relationship between the photoelectron spectrum of an atom or ion and: a. The electron configuration of the species. b. The interactions between the electrons and the nucleus.*<br>***SAP-2.A*** *Explain the relationship between trends in atomic properties of elements and electronic structure and periodicity.*<br>***SAP-2.B*** *Explain the relationship between trends in the reactivity of elements and periodicity.* | **SPQ-1** The mole allows different units to be compared.<br><br>**SPQ-2** Chemical formulas identify substances by their unique combination of atoms.<br><br>**SAP-1** Atoms and molecules can be identified by their electron distribution and energy.<br><br>**SAP-2** The periodic table shows patterns in electronic structure and trends in atomic properties. |
| 2: Molecular & Ionic Compound Structure and Properties | 3 weeks | **SAP-3.A** Explain the relationship between the type of bonding and the properties of the elements participating in the bond.<br>**SAP-3.B** Represent the relationship between potential energy and distance between atoms, based on factors that influence the interaction strength.<br>**SAP-3.C** Represent an ionic solid with a particulate model that is consistent with Coulomb's law and the properties of the constituent ions. | ***SAP-3*** *Atoms or ions bond due to interactions between them, forming molecules.* |

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| | | **SAP-3.D** Represent a metallic solid and/or alloy using a model to show essential characteristics of the structure and interactions present in the substance.<br>**SAP-4.A** Represent a molecule with a Lewis diagram.<br>**SAP-4.B** Represent a molecule with a Lewis diagram that accounts for resonance between equivalent structures or that uses formal charge to select between nonequivalent structures.<br>**SAP-4.C** Based on the relationship between Lewis diagrams, VSEPR theory, bond orders, and bond polarities:<br>a. Explain structural properties of molecules.<br>b. Explain electron properties of molecules. | ***SAP-4*** *Molecular compounds are arranged based on Lewis diagrams and Valence Shell Electron Pair Repulsion (VSEPR) theory.* |
| 3: Intermolecular Forces and Properties | 4 weeks | **SAP-5.A** Explain the relationship between the chemical structures of molecules and the relative strength of their intermolecular forces when:<br>a. The molecules are of the same chemical species.<br>b. The molecules are of two different chemical species.<br>**SAP-5.B** Explain the relationship among the macroscopic properties of a substance, the particulate-level structure of the substance, and the interactions between these particles.<br>**SAP-6.A** Represent the differences between solid, liquid, and gas phases using a particulate level model.<br>**SAP-7.A** Explain the relationship between the macroscopic properties of a sample of gas or mixture of gasses using the ideal gas law.<br>**SAP-7.B** Explain the relationship between the motion of particles and the macroscopic properties of gases with:<br>a. The kinetic molecular theory (KMT).<br>b. A particulate model.<br>c. A graphical representation.<br>**SAP-7.C** Explain the relationship among non-ideal behaviors of gases, interparticle forces, and/or volumes.<br>**SPQ-3.A** Calculate the number of solute particles, volume, or molarity of solutions.<br>**SPQ-3.B** Using particulate models for mixtures: a. Represent interactions between components. b. Represent concentrations of components.<br>**SPQ-3.C** Explain the relationship between the solubility of ionic and molecular compounds in aqueous and nonaqueous solvents, and the intermolecular interactions between particles.<br>**SAP-8.A** Explain the relationship between a region of the electromagnetic spectrum and the types of | **SAP-5** Intermolecular forces can explain the physical properties of a material.<br>**SAP-6** Matter exists in three states: solid, liquid, and gas, and their differences are influenced by variances in spacing and motion of the molecules.<br>**SAP-7** Gas properties are explained macroscopically—using the relationships among pressure, volume, temperature, moles, gas constant—and molecularly by the motion of the gas.<br>**SPQ-3** Interactions between intermolecular forces influence the solubility and separation of mixtures.<br>**SAP-8** Spectroscopy can determine the structure and concentration in a |

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| | | molecular or electronic transitions associated with that region.<br>**SAP-8.B** Explain the properties of an absorbed or emitted photon in relationship to an electronic transition in an atom or molecule.<br>**SAP-8.C** Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity. | mixture of a chemical species. |
| 4: Chemical Reactions | 4 weeks | **TRA-1.A** Identify evidence of chemical and physical changes in matter.<br>**TRA-1.B** Represent changes in matter with a balanced chemical or net ionic equation:<br>a. For physical changes.<br>b. For given information about the identity of the reactants and/or product.<br>c. For ions in a given chemical reaction.<br>**TRA-1.C** Represent a given chemical reaction or physical process with a consistent particulate model.<br>**TRA-1.D** Explain the relationship between macroscopic characteristics and bond interactions for: a. Chemical processes. b. Physical processes.<br>**SPQ-4.A** Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process.<br>**SPQ-4.B** Identify the equivalence point in a titration based on the amounts of the titrant and analyte, assuming the titration reaction goes to completion.<br>**TRA-2.A** Identify a reaction as acid base, oxidation-reduction, or precipitation.<br>**TRA-2.B** Identify species as BrønstedLowry acids, bases, and/or conjugate acid-base pairs, based on proton-transfer involving those species.<br>**TRA-2.C** Represent a balanced redox reaction equation using half-reactions. | ***TRA-1*** *A substance that changes its properties, or that changes into a different substance, can be represented by chemical equations.*<br><br>***SPQ-4*** *When a substance changes into a new substance, or when its properties change, no mass is lost or gained.*<br><br>***TRA-2*** *A substance can change into another substance through different processes, and the change itself can be classified by the sort of processes that produced it.* |
| 5: Kinetics | 4 weeks | **TRA-3.A** Explain the relationship between the rate of a chemical reaction and experimental parameters.<br>**TRA-3.B** Represent experimental data with a consistent rate law expression.<br>**TRA-3.C** Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time.<br>**TRA-4.A** Represent an elementary reaction as a rate law expression using stoichiometry.<br>**TRA-4.B** Explain the relationship between the rate of an elementary reaction and the frequency, energy, and orientation of molecular collisions. | **TRA-3** Some reactions happen quickly, while others happen more slowly and depend on reactant concentrations and temperature.<br><br>**TRA-4** There is a relationship between the speed of a reaction and the collision frequency of particle collisions. |

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| | | **TRA-4.C** Represent the activation energy and overall energy change in an elementary reaction using a reaction energy profile.<br>**TRA-5.A** Identify the components of a reaction mechanism.<br>**TRA-5.B** Identify the rate law for a reaction from a mechanism in which the first step is rate limiting.<br>**TRA-5.C** Identify the rate law for a reaction from a mechanism in which the first step is not rate limiting.<br>**TRA-5.D** Represent the activation energy and overall energy change in a multistep reaction with a reaction energy profile.<br>**ENE-1.A** Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism. | **TRA-5** Many chemical reactions occur through a series of elementary reactions. These elementary reactions when combined form a chemical equation.<br><br>**ENE-1** The speed at which a reaction occurs can be influenced by a catalyst. |
| 6: Thermodynamics | 3 weeks | **ENE-2.A** Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation.<br>**ENE-2.B** Represent a chemical or physical transformation with an energy diagram.<br>**ENE-2.C** Explain the relationship between the transfer of thermal energy and molecular collisions.<br>**ENE-2.D** Calculate the heat q absorbed or released by a system undergoing heating/ cooling based on the amount of the substance, the heat capacity, and the change in temperature.<br>**ENE-2.E** Explain changes in the heat q absorbed or released by a system undergoing a phase transition based on the amount of the substance in moles and the molar enthalpy of the phase transition.<br>**ENE-2.F** Calculate the heat q absorbed or released by a system undergoing a chemical reaction in relationship to the amount of the reacting substance in moles and the molar enthalpy of reaction<br>**ENE-3.A** Calculate the enthalpy change of a reaction based on the average bond energies of bonds broken and formed in the reaction<br>**ENE-3.B** Calculate the enthalpy change for a chemical or physical process based on the standard enthalpies of formation.<br>**ENE-3.C** Represent a chemical or physical process as a sequence of steps.<br>**ENE-3.D** Explain the relationship between the enthalpy of a chemical or physical process and the sum of the enthalpies of the individual steps. | **ENE-2** Changes in a substance's properties or change into a different substance requires an exchange of energy.<br><br>**ENE-3** The energy exchanged in a chemical transformation is required to break and form bonds. |
| 7: Equilibrium | 5 weeks | **TRA-6.A** Explain the relationship between the occurrence of a reversible chemical or physical process, and the establishment of equilibrium, to experimental observations. | **TRA-6** Some reactions can occur in both forward and reverse directions, sometimes proceeding in |

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| | | **TRA-6.B** Explain the relationship between the direction in which a reversible reaction proceeds and the relative rates of the forward and reverse reactions.<br>**TRA-7.A** Represent the reaction quotient Qc or Qp , for a reversible reaction, and the corresponding equilibrium expressions Kc = Qc or K p = Qp .<br>**TRA-7.B** Calculate Kc or K p based on experimental observations of concentrations or pressures at equilibrium.<br>**TRA-7.C** Explain the relationship between very large or very small values of K and the relative concentrations of chemical species at equilibrium.<br>**TRA-7.D** Represent a multistep process with an overall equilibrium expression, using the constituent K expressions for each individual reaction.<br>**TRA-7.E** Identify the concentrations or partial pressures of chemical species at equilibrium based on the initial conditions and the equilibrium constant.<br>**TRA-7.F** Represent a system undergoing a reversible reaction with a particulate model.<br>**TRA-8.A** Identify the response of a system at equilibrium to an external stress, using Le Châtelier's principle.<br>**TRA-8.B** Explain the relationships between Q, K, and the direction in which a reversible reaction will proceed to reach equilibrium.<br>**SPQ-5.A** Calculate the solubility of a salt based on the value of K sp for the salt.<br>**SPQ-5.B** Identify the solubility of a salt, and/or the value of K sp for the salt, based on the concentration of a common ion already present in solution.<br>**SPQ-5.C** Identify the qualitative effect of changes in pH on the solubility of a salt.<br>**SPQ-5.D** Explain the relationship between the solubility of a salt and changes in the enthalpy and entropy that occur in the dissolution process. | each direction simultaneously<br><br>**TRA-7** A system at equilibrium depends on the relationships between concentrations, partial pressures of chemical species, and equilibrium constant K.<br><br>**TRA-8** Systems at equilibrium respond to external stresses to offset the effect of the stress.<br><br>**SPQ-5** The dissolution of a salt is a reversible process that can be influenced by environmental factors such as pH or other dissolved ions. |
| 8: Acids and Bases | 5 weeks | **SAP-9.A** Calculate the values of pH and pOH, based on Kw and the concentration of all species present in a neutral solution of water.<br>**SAP-9.B** Calculate pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base.<br>**SAP-9.C** Explain the relationship among pH, pOH, and concentrations of all species in a solution of a monoprotic weak acid or weak base.<br>**SAP-9.D** Explain the relationship among the concentrations of major species in a mixture of weak and strong acids and bases.<br>**SAP-9.E** Explain results from the titration of a mono- or polyprotic acid or base solution, in relation to the properties of the solution and its components. | **SAP-9** The chemistry of acids and bases involves reversible proton-transfer reactions, with equilibrium concentrations being related to the strength of the acids and bases involved. |

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| | | **SAP-9.F** Explain the relationship between the strength of an acid or base and the structure of the molecule or ion.<br>**SAP-10.A** Explain the relationship between the predominant form of a weak acid or base in solution at a given pH and the pKa of the conjugate acid or the pKb of the conjugate base.<br>**SAP-10.B** Explain the relationship between the ability of a buffer to stabilize pH and the reactions that occur when an acid or a base is added to a buffered solution.<br>**SAP-10.C** Identify the pH of a buffer solution based on the identity and concentrations of the conjugate acid-base pair used to create the buffer.<br>**SAP-10.D** Explain the relationship between the buffer capacity of a solution and the relative concentrations of the conjugate acid and conjugate base components of the solution. | **SAP-10** A buffered solution resists changes to its pH when small amounts of acid or base are added. |
| 9: Application of Thermodynamics | 2 weeks | **ENE-4.A** Identify the sign and relative magnitude of the entropy change associated with chemical or physical processes.<br>**ENE-4.B** Calculate the entropy change for a chemical or physical process based on the absolute entropies of the species involved in the process.<br>**ENE-4.C** Explain whether a physical or chemical process is thermodynamically favored based on an evaluation of $\Delta G^o$ .<br>**ENE-4.D** Explain, in terms of kinetics, why a thermodynamically favored reaction might not occur at a measurable rate.<br>**ENE-5.A** Explain whether a process is thermodynamically favored using the relationships between K, $\Delta G^o$ , and T.<br>**ENE-5.B** Explain the relationship between external sources of energy or coupled reactions and their ability to drive thermodynamically unfavorable processes.<br>**ENE-6.A** Explain the relationship between the physical components of an electrochemical cell and the overall operational principles of the cell.<br>**ENE-6.B** Explain whether an electrochemical cell is thermodynamically favored, based on its standard cell potential and the constituent half-reactions within the cell.<br>**ENE-6.C** Explain the relationship between deviations from standard cell conditions and changes in the cell potential.<br>**ENE-6.D** Calculate the amount of charge flow based on changes in the amounts of reactants and products in an electrochemical cell. | **ENE-4** Some chemical or physical processes cannot occur without intervention.<br>**ENE-5** The relationship between $\Delta G^\circ$ and K can be used to determine favorability of a chemical or physical transformation.<br>**ENE-6** Electrical energy can be generated by chemical reactions. |