Davison Community Schools
ADVISORY CURRICULUM COUNCIL
Phase 2, April 25, 2013

AP Chemistry

Course Essential Questions (from Phase I report):

1. How does scientific inquiry and reflection impact how we understand and communicate about topics in chemistry?
2. How do you describe substances and their component parts?
3. How do substances interact with each other in chemical reactions?
4. What determines the rates of chemical reactions?
5. What role does energy play in explaining and predicting changes in matter?
6. What are the characteristics of acids and bases and the properties of their interaction?
7. How do particles behave as they undergo changes?

Unit 1: Building Blocks; Atomic Theory, Periodic Table, and Quantum Mechanics (Chapters 1, 2, 3, and 4)

Essential Questions:	Essential Understanding:
1. How does the Atomic theory explain changes in substances? 2. How is the periodic table organized and useful? 3. What is the Quantum Theory about?	• All matter is made of atoms. There are a limited number of types of atoms; these are the elements. • The periodic table organizes all known elements and provides useful information for making predictions in chemistry • Quantum Theory provides a foundation for the atomic model and the understanding of electron behavior and arrangement

Curriculum Standards

LO 1.1 The student can 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. **[*See* SP 6.1]**
LO 1.2 The student is able to select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures. **[*See* SP 2.2]**
LO 1.3 The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance. **[*See* SP 2.2, 6.1]**
LO 1.2 The student is able to select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures. **[*See* SP 2.2]**
LO 1.3 The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance. **[*See* SP 2.2, 6.1]**
LO 1.4 The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively. **[*See* SP 7.1]**
LO 1.5 The student is able to explain the distribution of electrons in an atom or ion based upon data. **[*See* SP 1.5, 6.2]**
LO 1.6 The student is able to analyze data relating to electron energies for

patterns and relationships. **[***See* **SP 5.1]**

LO 1.7 The student is able to 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. **[***See* **SP 5.1, 6.2]**

LO 1.8 The student is able to explain the distribution of electrons using Coulomb's law to analyze measured energies. **[***See* **SP 6.2]**

LO 1.9 The student is able to predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model. **[***See* **SP 6.4]**

LO 1.10 Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity. **[***See* **SP 6.1]**

LO 1.11 The student can 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. **[***See* **SP 3.1, 5.1]**

LO 1.12 The student is able to 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. **[***See* **SP 6.3]**

LO 1.13 Given information about a particular model of the atom, the student is able to determine if the model is consistent with specified evidence. **[***See* **SP 5.3]**

LO 1.14 The student is able to use data from mass spectrometry to identify the elements and the masses of individual atoms of a specific element. **[***See* **SP 1.4, 1.5]**

LO 1.15 The student can justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules. **[***See* **SP 4.1, 6.4]**

LO 1.16 The student can 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. **[***See* **SP 4.2, 5.1]**

LO 1.17 The student is able to express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings. **[***See* **SP 1.5]**

LO 1.18 The student is able to apply conservation of atoms to the rearrangement of atoms in various processes. **[***See* **SP 1.4]**

LO 1.19 The student can design, and/or interpret data from, an experiment that uses gravimetric analysis to determine the concentration of an analyte in a solution. **[***See* **SP 4.2, 5.1, 6.4]**

LO 1.20 The student can design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution. **[***See* **SP 4.2, 5.1, 6.4]**

Knowledge/Content Students will know about….	**Skills/Processes** Students will be able to……
• Protons, neutrons, and electrons and their properties • Chemical/physical changes and properties • Classifications of matter • Element names and symbols • Scientific method and how they are applied in a chemistry class • Units of measurement and the quantities they describe • Unit conversion • Precision and accuracy • Significant figures and how they are used • The locations of groups and properties those groups share • Elemental notation • Avogadro's number and the mole • Wave properties • Quantum numbers and how they describe the location and behavior of the electrons • Electron configuration • Trends from the periodic table	• Identify the number of protons, neutrons and electrons in an isotope • Identify examples of chemical/physical changes/properties and identify elements that share those properties • Classify the type of matter of a substance • Write electron configurations • Convert between units • Write symbols for isotopes • Calculate the average atomic mass from the % abundance • Describe the shapes of s and p orbitals • Identify metals, nonmetals, and metalloids • Predict general trends of atomic radius, ionization energy, and electro-negativity • Calculate wavelength, frequency, and energy of waves

Unit 2: Chemical Structure and Intermolecular Forces(Chapters 7, 8, 9, 10, 13)	
Essential Questions: 1. What are the essential attractive forces that occur between atoms? 2. How do you correctly write chemical formulas, and how are compounds named? 3. How do you predict the relative ratios of the substance in a chemical reaction? 4. What are the intermolecular forces that exist and what are their properties?	**Essential Understanding:** • There are attractions between atoms that increase their stability. • Elements form compounds in predictable ratios that can be named systematically. • Chemical reactions are described by balanced chemical equations which obey the Law of Conservation of Mass. • Many physical properties of substances can be determined by knowing the type of intermolecular forces that exists between particles.

Curriculum Standards

LO 2.1 Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views. **[*See* SP 6.4, 7.1]**
LO 2.2 The student is able to explain the relative strengths of acids and bases based on molecular structure, interparticle forces, and solution equilibrium. **[*See* SP 7.2,** *connects to* **Big Idea 5, Big Idea 6]**
LO 2.3 The student is able to 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. **[*See* SP 6.4, 7.1]**
LO 2.4 The student is able to use KMT and concepts of intermolecular forces to make predictions about the macroscopic properties of gases, including both ideal and nonideal behaviors. **[*See* SP 1.4, 6.4]**
LO 2.5 The student is able to 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. **[*See* SP 1.3, 6.4, 7.2]**
LO 2.6 The student can apply mathematical relationships or estimation to determine macroscopic variables for ideal gases. **[*See* SP 2.2, 2.3]**
LO 2.7 The student is able to explain how solutes can be separated by chromatography based on intermolecular interactions. **[*See* SP 6.2]**
LO 2.8 The student can draw and/or interpret representations of solutions that show the interactions between the solute and solvent. **[*See* SP 1.1, 1.2, 6.4]**
LO 2.9 The student is able to create or interpret representations that link the concept of molarity with particle views of solutions. **[*See* SP 1.1, 1.4]**
LO 2.10 The student can 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. **[*See* SP 4.2, 5.1, 6.4]**
LO 2.11 The student is able to 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. **[*See* SP 6.2, 6.4]**
LO 2.12 The student can qualitatively analyze data regarding real gases to identify deviations from ideal behavior and relate these to molecular interactions. **[*See* SP 5.1, 6.5,** *connects to* **2.A.2]**
LO 2.13 The student is able to describe the relationships between the structural features of polar molecules and the forces of attraction between the particles.

[*See* **SP 1.4, 6.4]**

LO 2.14 The student is able to 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. **[***See* **SP 1.4, 6.4]**

LO 2.15 The student is able to 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. **[***See* **SP 1.4, 6.2,** *connects to* **5.E.1]**

LO 2.16 The student is able to explain the properties (phase, vapor pressure, viscosity, etc.) of small and large molecular compounds in terms of the strengths and types of intermolecular forces. **[***See* **SP 6.2]**

LO 2.17 The student can 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. **[***See* **SP 6.4]**

LO 2.18 The student is able to rank and justify the ranking of bond polarity on the basis of the locations of the bonded atoms in the periodic table. **[***See* **SP 6.1]**

LO 2.19 The student can 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). **[***See* **SP 1.1, 1.4, 7.1,** *connects to* **2.D.1, 2.D.2]**

LO 2.20 The student is able to 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. **[***See* **SP 6.2, 7.1,** *connects to* **2.D.2]**

LO 2.21 The student is able to use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity. **[***See* **SP 1.4]**

LO 2.22 The student is able to design or evaluate a plan to collect and/or interpret data needed to deduce the type of bonding in a sample of a solid. **[***See* **SP 4.2, 6.4]**

LO 2.23 The student can create a representation of an ionic solid that shows essential characteristics of the structure and interactions present in the substance. **[***See* **SP 1.1]**

LO 2.24 The student is able to explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level. **[***See* **SP 1.1, 6.2, 7.1]**

LO 2.25 The student is able to 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. **[***See* **SP 1.4, 7.2]**

LO 2.26 Students can use the electron sea model of metallic bonding to predict or make claims about the macroscopic properties of metals or alloys. **[***See* **SP 6.4, 7.1]**

LO 2.27 The student can create a representation of a metallic solid that shows essential characteristics of the structure and interactions present in the substance. **[***See* **SP 1.1]**

LO 2.28 The student is able to explain a representation that connects properties of a metallic solid to its structural attributes and to the interactions present at the atomic level. **[***See* **SP 1.1, 6.2, 7.1]**

LO 2.29 The student can create a representation of a covalent solid that shows essential characteristics of the structure and interactions present in the substance. **[*See* SP 1.1]** **LO 2.30** The student is able to explain a representation that connects properties of a covalent solid to its structural attributes and to the interactions present at the atomic level. **[*See* SP 1.1, 6.2, 7.1]** **LO 2.31** The student can create a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance. **[*See* SP 1.1]** **LO 2.32** The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level. **[*See* SP 1.1, 6.2, 7.1]**

Knowledge/Content Students will know about….	**Skills/Processes** Students will be able to……
• the properties of ionic, covalent and metallic bonds • the rules for naming and formula writing • the relative strengths of ionic and covalent bonds • empirical and molecular formulas • dipole-induced dipole, dipole-dipole, hydrogen bonding, and London dispersion forces and their relative strengths • the geometric arrangement of atoms based on the VSEPR theory • polar versus nonpolar compounds • the different classifications of chemical reactions • balanced chemical reactions • coefficients relating the molar ratios of the compounds in a chemical reaction	• identify ionic versus covalent molecules • name binary ionic and molecular compounds • write chemical formulas using oxidation numbers • draw Lewis dot structures • calculate % by weight of each element in a compound • predict the states of matter based on intermolecular forces • identify if a molecule is polar or nonpolar • determine the geometric structure of a compound using the VSEPR theory • balance chemical equations • predict the products of single and double replacement reactions • use stoichiometry to determine amounts of substances in a chemical reaction, % yield, and limiting reactants

Unit 3: Rearrangement of Matter/Electrons (Chapters 5, 17, 18, 20)	
Essential Questions: 1. How does attraction between particles affect the state of matter? 2. What is the relationship between Pressure, Volume, Temperature and Quantity? 3. How do we know a solution is acidic, base, or neutral? 4. How do electrons drive oxidation-reduction reactions and what applications do these reactions have for electrical devices?	**Essential Understanding:** • States of matter can be explained by attraction between particles. • States of matter can be explained under various conditions of temperature, volume and pressure • Electron transfers as described by redox reactions impacts humans in both positive and negative ways. • Hydrogen ion concentration determines pH of the solution which allows its classification and nomenclature as either acidic, basic or neutral

Curriculum Standards

LO 3.1 Students can translate among macroscopic observations of change, chemical equations, and particle views. **[***See* **SP 1.5, 7.1]**
LO 3.2 The student can 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. **[***See* **SP 1.5, 7.1]**
LO 3.3 The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results. **[***See* **SP 2.2, 5.1]**
LO 3.4 The student is able to 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. **[***See* **SP 2.2, 5.1, 6.4]**
LO 3.5 The student is able to 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. **[***See* **SP 2.1, 4.2, 6.4]**
LO 3.6 The student is able to use data from synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions. **[***See* **SP 2.2, 6.1]**
LO 3.7 The student is able to identify compounds as Brønsted-Lowry acids, bases, and/or conjugate acid-base pairs, using proton-transfer reactions to justify the identification. **[***See* **SP 6.1]**
LO 3.8 The student is able to identify redox reactions and justify the identification in terms of electron transfer. **[***See* **SP 6.1]**
LO 3.9 The student is able to design and/or interpret the results of an experiment involving a redox titration. **[***See* **SP 4.2, 5.1]**
LO 3.10 The student is able to 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. **[***See* **SP 1.4, 6.1,** *connects to* **5.D.2]**
LO 3.11 The student is able to 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. **[***See* **SP 1.5, 4.4]**
LO 3.12 The student can make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/

or Faraday's laws. **[***See* **SP 2.2, 2.3, 6.4]**
LO 3.13 The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions. **[***See* **SP 5.1]**

Knowledge/Content Students will know about….	**Skills/Processes** Students will be able to……
• The five assumptions of the kinetic molecular theory • Physical properties that are based on the kinetic molecular theory • Ideal and non-ideal gases • The motion of particles in gases, liquids and solids • Phase changes • Phase diagrams • The properties of gases and how they are related (P, T, V laws) • Naming acids and bases • Neutralization reactions • General properties of acids and bases • The various definitions of acids and bases • The pH scale • Hydronium and hydroxide ion concentrations • Steps in titration • Oxidation and reduction • Half-reactions • Oxidation numbers of elements/ions • Anodes and cathodes • Voltaic and electrolytic cells • The arrangement of the standard reduction potential chart	• Solve problems using the gas laws • Explain the relationships between pressure, temperature, and volume • Interpret phase diagrams • Identify and describe the changes between states of matter • Predict products of and balance neutralization reactions • Name acids and bases • Identify conjugate acid/base pairs • Calculate pH and pOH and $[H_3O^+]$ and $[OH^-]$ • Perform a titration • Write an equilibrium expression

Unit 4: Reaction Rates (Chapter 13,14, 15)	
Essential Questions: 1. How does stress change equilibrium? 2. Why are solution concentrations important? 3. How do the nature and concentration of reactants affect the rate of the reaction?	**Essential Understanding:** • Predicting shifts in chemical systems caused by changing conditions • The concentration of a solution is important because different concentrations effect the interaction between substances and solution
Curriculum Standards	

LO 4.1 The student is able to 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. **[*See* SP 4.2, 5.1]**

LO 4.2 The student is able to analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction.
[*See* SP 5.1, 6.4, *connects to* **4.A.3]**

LO 4.3 The student is able to 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. **[*See* SP 2.1, 2.2]**

LO 4.4 The student is able to 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.
[*See* SP 7.1, *connects to* **4.A.3, 4.B.2]**

LO 4.5 The student is able to explain the difference between collisions that convert reactants to products and those that do not in terms of energy distributions and molecular orientation. **[*See* SP 6.2]**

LO 4.6 The student is able to 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. **[*See* SP 1.4, 6.4]**

LO 4.7 The student is able to 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. **[*See* SP 6.5,** *connects to* **4.C.1, 4.C.2, 4.C.3]**

LO 4.8 The student can 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.
[*See* SP 1.5]

LO 4.9 The student is able to explain 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.
[*See* SP 6.2, 7.2]

Knowledge/Content Students will know about….	**Skills/Processes** Students will be able to……
• Concentration of solutions • Properties of solutions, suspensions and colloids • Properties of saturated, unsaturated and supersaturated solutions • Electrolyte versus nonelectrolyte • Le Chatlier's principle • Equilibrium expressions • Catalysts • Rate laws • Orders of reactions • Factors affecting the rate of a reaction	• Calculate molarity and molality • Identify the type of mixture • Predict shifts in equilibrium using le Chatlier's principle • Write an equilibrium expression • Use the rate influencing factors to predict reaction rates • Determine rate laws given scientific data and reaction mechanisms • Understand the effect of a catalyst on a reaction • Interpret graphs to determine reaction order

Unit 5: Thermodynamics and Reaction Energy (Chapter 6, 13, 14, 16 and 19)	
Essential Questions: 1. How is the behavior of matter determined by the flow of energy? 2. What is the relationship between entropy, enthalpy and the spontaneity of a reaction?	**Essential Understanding:** • The flow of energy, measured by temperature, influences the behavior of matter. • The spontaneity of a reaction is determined by the change in Gibbs Free Energy which is dependent on temperature and the changes in enthalpy and entropy.
Curriculum Standards	
LO 5.1 The student is able to 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. **[*See* SP 1.1, 1.4, 7.2,** *connects to* **Big Idea 2]** **LO 5.2** The student is able to 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. **[*See* SP 1.1, 1.4, 7.1]** **LO 5.3** The student can 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. **[*See* SP 7.1]** **LO 5.4** The student is able to 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. **[*See* SP 1.4, 2.2,** *connects to* **5.B.1, 5.B.2]** **LO 5.5** The student is able to 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. **[*See* SP 2.2,** *connects to* **5.B.1, 5.B.2]** **LO 5.6** The student is able to 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. **[*See* SP 2.2, 2.3]** **LO 5.7** The student is able to 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. **[*See* SP 4.2, 5.1, 6.4]** **LO 5.8** The student is able to draw qualitative and quantitative connections between the reaction enthalpy and the energies involved in the breaking and formation of chemical bonds. **[*See* SP 2.3, 7.1, 7.2]** **LO 5.9** The student is able to 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. **[*See* SP 6.4]** **LO 5.10** The student can 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. **[***See* **SP 5.1]**

LO 5.11 The student is able to 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. **[***See* **SP 7.2]**

LO 5.12 The student is able to use representations and models to predict the sign and relative magnitude of the entropy change associated with chemical or physical processes. **[***See* **SP 1.4]**

LO 5.13 The student is able to 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. **[***See* **SP 2.2, 2.3, 6.4,** *connects to* **5.E.3]**

LO 5.14 The student is able to determine whether a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy. **[***See* **SP 2.2,** *connects to* **5.E.2]**

LO 5.15 The student is able to 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. **[***See* **SP 6.2]**

LO 5.16 The student can 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. **[***See* **SP 6.4,** *connects to* **6.B.1]**

LO 5.17 The student can make quantitative predictions for systems involving coupled reactions that share a common intermediate, based on the equilibrium constant for the combined reaction. **[***See* **SP 6.4,** *connects to* **6.A.2]**

LO 5.18 The student can 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. **[***See* **SP 1.3, 7.2,** *connects to* **6.D.1]**

Knowledge/Content Students will know about….	**Skills/Processes** Students will be able to……
• Heat, entropy, enthalpy and temperature • Endothermic and exothermic reactions • Temperature scales • Energy calculations using the specific heat, mass and temperature change • The relationships between activation energy, catalysts and enthalpy of products and reactants • Calorimeters • Phase changes and relative energy released or absorbed	• Use a calorimeter to determine the specific heat of an object • Draw a graph showing the relationship between activation energy, enthalpy of products and reactants in an exothermic and endothermic reaction • Calculate the enthalpy of a reaction using Hess' law • Predict the spontaneity of a reaction using Gibbs Free Energy • Calculate energy changes based off the mass, specific heat and change in temperature • Calculate between Celcius and Kelvin temperature scales • Calculate Gibbs Free Energy for a reaction based off enthalpy and entropy changes • Calculate the energy that is absorbed or released as a substance undergoes a phase change

Unit 6: Acids/Bases and Equilibrium (Chapter 16, 17, and 18)	
Essential Questions: 1. How do we know a solution is acidic, base, or neutral? 2. How does stress change equilibrium?	**Essential Understanding:** • Hydrogen ion concentration determines pH of the solution which allows its classification and nomenclature as either acidic, basic or neutral • Predicting shifts in chemical systems caused by changing conditions

Curriculum Standards

LO 6.1 The student is able to, 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. **[***See* **SP 6.2]**
LO 6.2 The student can, 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*. **[***See* **SP 2.2]**
LO 6.3 The student can 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. **[***See* **SP 7.2]**
LO 6.4 The student can, 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. **[***See* **SP 2.2, 6.4]**
LO 6.5 The student can, given data (tabular, graphical, etc.) from which the state of a system at equilibrium can be obtained, calculate the equilibrium constant, *K*. **[***See* **SP 2.2]**
LO 6.6 The student can, 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. **[***See* **SP 2.2, 6.4]**
LO 6.7 The student is able, for a reversible reaction that has a large or small *K*, to determine which chemical species will have very large versus very small concentrations at equilibrium. **[***See* **SP 2.2, 2.3]**
LO 6.8 The student is able to use Le Chatelier's principle to predict the direction of the shift resulting from various possible stresses on a system at chemical equilibrium. **[***See* **SP 1.4, 6.4]**
LO 6.9 The student is able to use Le Chatelier's principle to design a set of conditions that will optimize a desired outcome, such as product yield. **[***See* **SP 4.2]**
LO 6.10 The student is able to connect Le Chatelier's principle to the comparison of *Q* to *K* by explaining the effects of the stress on *Q* and *K*. **[***See* **SP 1.4, 7.2]**
LO 6.11 The student can 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. **[***See* **SP 1.1, 1.4, 2.3]**
LO 6.12 The student can 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. **[***See* **SP 1.4, 6.4,** *connects to*

1.E.2]

LO 6.13 The student can 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 p*Ka* for a weak acid, or the p*Kb* for a weak base. **[*See* SP 5.1, 6.4,** *connects to* **1.E.2]**

LO 6.14 The student can, based on the dependence of *K*w on temperature, reason that neutrality requires [H+] = [OH–] as opposed to requiring pH = 7, including especially the applications to biological systems. **[*See* SP 2.2, 6.2]**

LO 6.15 The student can 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. **[*See* SP 2.2, 2.3, 6.4]**

LO 6.16 The student can 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 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. **[*See* SP 2.2, 6.4]**

LO 6.17 The student can, 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. **[*See* SP 6.4]**

LO 6.18 The student can 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. **[*See* SP 2.3, 4.2, 6.4]**

LO 6.19 The student can 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 p*Ka* associated with the labile proton. **[*See* SP 2.3, 5.1, 6.4]**

LO 6.20 The student can 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. **[*See* SP 6.4]**

LO 6.21 The student can predict the solubility of a salt, or rank the solubility of salts, given the relevant *Ksp* values. **[*See* SP 2.2, 2.3, 6.4]**

LO 6.22 The student can interpret data regarding solubility of salts to determine, or rank, the relevant *Ksp* values. **[*See* SP 2.2, 2.3, 6.4]**

LO 6.23 The student can interpret data regarding the relative solubility of salts in terms of factors (common ions, pH) that influence the solubility. **[*See* SP 5.1, 6.4]**

LO 6.24 The student can analyze the enthalpic and entropic changes associated with the dissolution of a salt, using particulate level interactions and representations. **[*See* SP 1.4, 7.1,** *connects to* **5.E]**

LO 6.25 The student is able to 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. **[*See* SP 2.3]**

Knowledge/Content Students will know about….	**Skills/Processes** Students will be able to……
• Naming acids and bases • Neutralization reactions • General properties of acids and bases • The various definitions of acids and bases • The pH scale • Hydronium and hydroxide ion concentrations • Steps in titration • Acid/base equilibria • Buffer solutions • Le Chatlier's principle • Equilibrium expressions •	• Predict products of and balance neutralization reactions • Name acids and bases • Identify conjugate acid/base pairs • Calculate pH and pOH and $[H_3O^+]$ and $[OH^-]$ • Perform a titration • Use the Henderson-Hasselbach equation or ICE charts to determine pH of a buffer solution • Write an equilibrium expression • Predict shifts in equilibrium using le Chatlier's principle

<table>
<tr><th colspan="2">Unit 7: Organic Chemistry (Chapter 22)</th></tr>
<tr><td>Essential Questions:
1. How do the unique bonding properties of carbon allow it to form a diversity of structures?</td><td>Essential Understanding:
• The structure and bonding of carbon lead to the diversity in number of organic compounds.</td></tr>
<tr><th colspan="2">Curriculum Standards</th></tr>
<tr><td colspan="2">C1.1C Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).
C1.1E Describe a reason for a given conclusion using evidence from an investigation.
C1.1f Predict what would happen if the variables, methods, or timing of an investigation were changed.
C1.1g Based on empirical evidence, explain and critique the reasoning used to draw a scientific conclusion or explanation.
C1.1i Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.
C1.2A Critique whether or not specific questions can be answered through scientific investigations.
C1.2E Evaluate the future career and occupational prospects of science fields.
C1.2i Explain the progression of ideas and explanations that lead to science theories that are part of the current scientific consensus or core knowledge.
C5.7A Recognize formulas for common inorganic acids, carboxylic acids, and bases formed from families I and II.
C5.8A Draw structural formulas for up to ten carbon chains of simple hydrocarbons.
C5.8B Draw isomers for simple hydrocarbons.
C5.8C Recognize that proteins, starches, and other large biological molecules are polymers.</td></tr>
<tr><th>Knowledge/Content
Students will know about….</th><th>Skills/Processes
Students will be able to……</th></tr>
<tr><td>• The chemical structure of carbon
• Structural formulas
• Isomers
• Hydrocarbons (saturated/unsaturated)</td><td>• Draw and name simple hydrocarbons
• Distinguish between saturated and unsaturated hydrocarbons
• Distinguish between alkanes, alkenes and alkynes</td></tr>
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