Verona Public School District
Curriculum Overview

AP Chemistry

Curriculum Committee Members:
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Curriculum Developed:
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Verona Public Schools
121 Fairview Ave., Verona, NJ 07044
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Verona Public Schools Mission Statement:

The mission of the Verona Public Schools, the center of an engaged and supportive community, is to empower students to achieve their potential as active learners and productive citizens through rigorous curricula and meaningful, enriching experiences.

Course Description:

Advanced Placement (AP) Chemistry exposes students to college level Chemistry curriculum. The course moves at a very fast, demanding pace and is very math intensive. The students are challenged with complex problems on a variety of topics, both in the laboratory and in the classroom. The course is designed to maximize the students' chances to pass the AP Chemistry examination; passing this test can earn students up to 8 college credits toward General Chemistry, fulfilling a core college requirement.

Prerequisite(s):

Chemistry Honors or Teacher Recommendation

Standard 8: Technology Standards	
8.1: Educational Technology: *All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.*	**8.2: Technology Education, Engineering, Design, and Computational Thinking - Programming:** *All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.*
A. Technology Operations and Concepts B. Creativity and Innovation C. Communication and Collaboration D. Digital Citizenship E. Research and Information Fluency X F. Critical thinking, problem solving, and decision making	A. The Nature of Technology: Creativity and Innovation B. Technology and Society C. Design X D. Abilities for a Technological World E. Computational Thinking: Programming

SEL Competencies and Career Ready Practices	
Social and Emotional Learning Core Competencies: *These competencies are identified as five interrelated sets of cognitive, affective, and behavioral capabilities*	**Career Ready Practices:** *These practices outline the skills that all individuals need to have to truly be adaptable, reflective, and proactive in life and careers. These are researched practices that are essential to career readiness.*
Self-awareness: The ability to accurately recognize one's emotions and thoughts and their influence on behavior. This includes accurately assessing one's strengths and limitations and possessing a well-grounded sense of confidence and optimism.	X CRP2. Apply appropriate academic and technical skills. CRP9. Model integrity, ethical leadership, and effective management. CRP10. Plan education and career paths aligned to personal goals.
Self-management: The ability to regulate one's emotions, thoughts, and behaviors effectively in different situations. This includes managing stress, controlling impulses, motivating oneself, and setting and working toward achieving personal and academic goals.	CRP3. Attend to personal health and financial well-being. CRP6. Demonstrate creativity and innovation. X CRP8. Utilize critical thinking to make sense of problems and persevere in solving them. CRP11. Use technology to enhance productivity.
Social awareness: The ability to take the perspective of and empathize with others from diverse backgrounds and cultures, to understand social and ethical norms for behavior, and to recognize family, school, and community resources and supports.	CRP1. Act as a responsible and contributing citizen and employee. CRP9. Model integrity, ethical leadership, and effective management.
Relationship skills: The ability to establish and maintain healthy and rewarding relationships with diverse individuals and groups. This includes communicating clearly, listening actively, cooperating, resisting inappropriate social pressure, negotiating conflict constructively, and seeking and offering help when needed.	X CRP4. Communicate clearly and effectively and with reason. CRP9. Model integrity, ethical leadership, and effective management. CRP12. Work productively in teams while using cultural global competence.
Responsible decision making: The ability to make constructive and respectful choices about personal behavior and social interactions based on consideration of ethical standards, safety concerns, social norms, the realistic evaluation of consequences of various actions, and the well-being of self and others.	CRP5. Consider the environmental, social, and economic impact of decisions. CRP7. Employ valid and reliable research strategies. X CRP8. Utilize critical thinking to make sense of problems and persevere in solving them. CRP9. Model integrity, ethical leadership, and effective management.

Standard 9: 21st Century Life and Careers		
9.1: Personal Financial Literacy: *This standard outlines the important fiscal knowledge, habits, and skills that must be mastered in order for students to make informed decisions about personal finance. Financial literacy is an integral component of a student's college and career readiness, enabling students to achieve fulfilling, financially-secure, and successful careers.*	**9.2: Career Awareness, Exploration & Preparation:** *This standard outlines the importance of being knowledgeable about one's interests and talents, and being well informed about postsecondary and career options, career planning, and career requirements.*	**9.3: Career and Technical Education:** *This standard outlines what students should know and be able to do upon completion of a CTE Program of Study.*
X A. Income and Careers B. Money Management C. Credit and Debt Management D. Planning, Saving, and Investing X E. Becoming a Critical Consumer F. Civic Financial Responsibility G. Insuring and Protecting	A. Career Awareness (K-4) B. Career Exploration (5-8) X C. Career Preparation (9-12)	A. Agriculture, Food & Natural Res. B. Architecture & Construction C. Arts, A/V Technology & Comm. D. Business Management & Admin. E. Education & Training F. Finance G. Government & Public Admin. H. Health Science I. Hospital & Tourism J. Human Services K. Information Technology L. Law, Public, Safety, Corrections & Security M. Manufacturing N. Marketing X O. Science, Technology, Engineering & Math P. Transportation, Distribution & Log.

Course Materials	
Core Instructional Materials: *These are the board adopted and approved materials to support the curriculum, instruction, and assessment of this course.*	**Differentiated Resources**: *These are teacher and department found materials, and also approved support materials that facilitate differentiation of curriculum, instruction, and assessment of this course.*
● Chemistry AP 9th Edition by Zumdahl & Zumdahl	● Various Teacher Constructed Materials ● https://apcentral.collegeboard.org/courses/ap-chemistry/course?course=ap-chemistry

AP Chemistry

Unit Title / Topic: Structure of Matter **Big Idea 1:** The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions.	Unit Duration: 4 weeks

Stage 1: Desired Results

Established Goals:

- Learning objective 1.5 The student is able to explain the distribution of electrons in an atom or ion based upon data.
- Learning objective 1.6 The student is able to analyze data relating to electron energies for patterns and relationships.
- Learning objective 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.
- Learning objective 1.8 The student is able to explain the distribution of electrons using Coulomb's law to analyze measured energies.
- Learning objective 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.
- Learning objective 1.10 Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.

- Learning objective 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.
- Learning objective 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.
- Learning objective 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).
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.

Transfer Goal:

Students will be able to independently use their learning 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.

Students will understand that:

- Enduring understanding 1.A: All matter is made of atoms. There are a limited number of types of atoms; these are the elements
- Enduring understanding 1.B: The atoms of each element have unique structures arising from interactions between electrons and nuclei.
- Enduring understanding 1.C: Elements display periodicity in their properties when the elements are organized according to increasing atomic number. This periodicity can be explained by the regular variations that occur in the electronic structures of atoms. Periodicity is a useful principle for understanding properties and predicting trends in properties. Its modern-day uses range from examining the composition of materials to generating ideas for designing new materials.
- Enduring understanding 1.D: Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms.
- Enduring understanding 1.E: Atoms are conserved in physical and chemical processes.

Essential Questions:

- How has the model of the atom changed over time?
- How do subatomic particles determine the properties of the atom?
- Why do elements in the same group have similar properties?
- How can periodic trends be explained, in relation to Coulomb's Law?

Students will know:	**Students will be able to:**
Nuclear and Atomic Structure ● The Early History of Chemistry ● Fundamental Chemical Laws ● Types of Subatomic Particles ● The Nucleus ● Mass Spectroscopy and Isotopes ● Stability of the Nucleus ● Atomic Structure ● Rutherford Experiment ● Cathode Ray Experiments ● Atomic Structure Terms ● Electromagnetic Radiation ● Quantization of Energy ● Photoelectric Effect ● PES data ● Bohr Atom ● Spectroscopy ● Orbital Model of Atom ● Aufbau Diagram ● Para magnetism ● Quantum model Periodicity and Introduction to Bonding- ● Atomic Properties ● Periodic Law ● Elemental Properties ● Types of Bonds ● Metallic Bonding ● Properties of Group One ● Properties of Period Two ● Metals vs. Non Metals ● Multiple Oxidation States of Transition Metals ● Ionic Bonding ● Ionic Bonding and Potential Energy Diagrams ● Energy of Formation of Ionic Compounds ● Lattice energy	● Define an “atom” ● Evaluate the different atomic theories ● Explain how the quantum mechanical model evolved from a classical shell model. ● Name and describe the three subatomic particles in an atom ● Define isotopes and calculate average atomic mass ● use data from mass spectrometry to identify the elements ● Perform energy/frequency/ wavelength calculations ● Relate energies of electronic transitions to frequency or wavelength ● describe the electronic structure of the atom ● predict and justify trends in atomic properties ● Explain how each periodic trend reflects the electron configuration of the elements ● predict the type of bonding present between two atoms ● Draw and explain a particulate representation of an ionic solid ● Draw and explain a particulate representation of a metallic solid ● explain how the sea of electrons model is consistent with macroscopic properties of metals ● compare the properties of metal alloys with their constituent elements ● design or evaluate a plan to collect and/or interpret data needed to deduce the type of bonding in a sample of a solid.

Stage 2: Acceptable Evidence

Transfer Task

Work in a team to develop a set of criteria (chemical and physical) for determining the type of solid a sample represents. First decide what data to collect to develop the criteria by carrying out tests on known chemicals. Then apply the criteria to to test unknown samples and determine the type of bonding (ionic, metallic, network, molecular) in them.

AP Chemistry

Unit Title / Topic: Bonding & States of Matter **<u>Big Idea 2:</u> Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.**	**Unit Duration:** **8 weeks**

Stage 1: Desired Results

Established Goals:

- Learning objective 2.1 Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views.
- Learning objective 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. Learning objective 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.
- Learning objective 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.
- Learning objective 2.6 The student can apply mathematical relationships or estimation to determine macroscopic variables for ideal gases.
- Learning objective 2.7 The student is able to explain how solutes can be separated by chromatography based on intermolecular interactions.
- Learning objective 2.8 The student can draw and/or interpret representations of solutions that show the interactions between the solute and solvent.
- Learning objective 2.9 The student is able to create or interpret representations that link the concept of molarity with particle views of solutions.
- Learning objective 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.
- Learning objective 2.12 The student can qualitatively analyze data regarding real gases to identify deviations from ideal behavior and relate these to molecular interactions.
- Learning objective 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.

- Learning objective 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.Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 2.21The student is able to use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.

- Learning objective 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.
- Learning objective 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.

Transfer Goal:

Students will be able to <u>independently</u> use their learning to…

separate solutes (by chromatography) based on intermolecular interactions.

Students will understand that:	Essential Questions:
• Enduring understanding 2.A: Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces of attraction among them. • Enduring understanding 2.B: Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are	• Why do elements bond in nature? • How are the macroscopic properties of matter related to the microscopic arrangement of the particles? • Why do only certain factors determine the physical state of matter? • How do you measure a gas? • What is pressure? • What is the difference between heat and temperature?

important in determining many macroscopic properties of a substance, including how the observable physical state changes with temperature. • Enduring understanding 2.C: The strong electrostatic forces of attraction holding atoms together in a unit are called chemical bonds. • Enduring understanding 2.D: The type of bonding in the solid state can be deduced from the properties of the solid state.	• How does temperature change as pressure changes? How about as volume changes? • How can we use gas laws to predict the future? • What are the assumptions behind the gas laws? When are they bad assumptions? • Why cannot water clean grease spots? How does soap work? • Why do we salt the roads and driveways in the winter? •

Students will know:	Students will be able to:
Chemical Foundations ● Chemistry: An Overview ● Scientific Method ● Classification of Matter ● Separation Science example Distillation and chromatography ● Physical and Chemical Properties ● Meet the Elements ● Units of Measurement ● Uncertainty in Measurements ● Significant Figures ● Length and Volume ● Mass and Weight ● Density ● Temperature and its Measurement ● Conversion of units ● Dimensional Analysis ● Learning to Solve Problems **Covalent Bonding and Molecules** ● Types of Covalent Bonds ● Nonpolar Covalent Bonds ● Polar Covalent Bonds ● Coordinate Covalent Bonds- Lewis Acids and Lewis Bases ● Lewis Structures ● Resonance ● Hybridization ● Molecular Geometry ● Energy Effects on Molecules ● Isomerism ● Functional Groups ● Interactions of Functional Groups ● Classification of Molecules ● Intermolecular Interaction ● Dipole moments ● Dielectric Constants ● Types of Compounds ● Properties of Metallic, Molecular, Macromolecular and Ionic Compounds **Gases, Liquids and Solids** ● Real Gases versus Ideal Gases ● Ideal Gas Equation ● Derivations based on Ideal Gas Equation ● Gases collected Over Water ● Kinetic Molecular Theory ● Van Der Walls Equation ● Molecular Speeds ● Diffusion and Effusion ● Molecular Theory related to Phase ● Phase Changes ● Entropy ● Heating and Cooling Curves ● Interphases ● Pressure ● Vapor Pressure ● Boiling Point and Freezing Points ● Vapor Pressure Curves ● Phase Diagrams – Triple point, critical point ● Energy change during phase changes ● Viscosity ● Surface Tension ● Types of Solids and Crystal Structure **Solutions** ● Types of Solutions ● Electrolytes ● Miscibility and Immiscibility ● Process of Dissolution ● Dissolution versus Ionization ● Solubility Terms ● Solubility Curves ● Henry's Law ● Concentration Terms – Molarity. Molality, % , mole fractions ● Dilution Problems ● Stoichiometry Problems with Solutions- Review ● Raoult's Law ● Freezing and Boiling points of Solutions – Colligative Properties	● Determine whether a process is a chemical or physical change ● predict properties of substances based on their chemical formulas ● Explain properties of substances based on particle views ● predict the type of bonding present between two atoms in a compound ● rank and justify the ranking of bond polarity using electronegativity differences ● explain how the sea of electrons model is consistent with macroscopic properties of metals ● Draw Lewis dot structures of covalent molecules and apply the octet rule. ● Use Lewis diagrams and VSEPR to predict the geometry and polarity of molecules. ● Use Lewis diagrams to identify hybridization in molecules ● Relate the polarity of molecules to the forces of attraction (IMFs) between them ● Describe the different types of intermolecular forces ● draw a particulate representation of a covalent network solid ● draw a particulate representation of a covalent molecular solid ● Predict the relative magnitudes of the forces acting within collections of molecules based on the IMFs ● explain the properties (phase, vapor pressure, viscosity, etc.) of covalent compounds in terms of IMFs ● use particulate models to compare solid, liquid and gas phases. ● Describe the kinetic molecular theory and explain how it accounts for the behavior of gases ● State the gas laws and use them to predict the gas properties under different situations ● use KMT and IMFs to explain and predict macroscopic properties of gases ● Compare ideal and nonideal behaviors of gases ● draw and explain a particulate representation of solution formation ● Relate the energies of solution formation to other thermodynamic quantities ● explain how solutes can be separated by chromatography ● Perform molarity and dilution calculations ● Perform colligative properties calculations

- Van Hoff factor
- Osmosis
- Deviation from Raoult's Law
- Colloids

Organic Chemistry

A. Properties and Bonding in Carbon Compounds

- Introduction to organic chemistry: hydrocarbons and functional groups (structure, nomenclature, chemical properties).
- Physical and chemical properties of simple organic compounds

B. Hydrocarbons

- Petroleum
- Fractional Distillation
- Cracking
- Alkanes
- Alkenes
- Alkynes
- Benzene Series
- General Formulas
- Structural Formulas
- Saturated/unsaturated Compounds

C. Nomenclature

- Alkyl Groups
- IUPAC Nomenclature
- Isomers
- D. Other Organic Compounds
- Alcohols-.
- Primary, Secondary, and Tertiary Alcohols
- Diols and Triols
- Aldehydes
- Ketones
- Acids
- Esters
- Ethers
- Amines
- Polymers
- Addition Polymerization
- Condensation Polymerization
- Natural Polymers

E. Organic Reactions

Stage 2: Acceptable Evidence

Transfer Task

Students will work in a team and use liquid chromatography to separate the components of grape-flavored Kool-Aid. A non-polar Sep-Pak C_{18} column will be used for the stationary phase and isopropyl alcohol for the eluant. Measurements allow for the calculations of the selectivity and the resolution of the separation process of the red and blue dyes. Eluants of different polarities are then used to separate the polar components (citric acid and salt), slightly polar components (red and blue dyes) and non-polar flavoring oils.

AP Chemistry

Unit Title / Topic: Reactions **Big Idea 3:** Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.	Unit Duration: 6 weeks

Stage 1: Desired Results

Established Goals:

- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 1.17 The student is able to express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings.
- Learning objective 1.18 The student is able to apply conservation of atoms to the rearrangement of atoms in various processes.
- Learning objective 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.

- Learning objective 2.1 Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views.

- Learning objective 3.1Students can translate among macroscopic observations of change, chemical equations, and particle views.
- Learning objective 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. Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 3.8 The student is able to identify redox reactions and justify the identification in terms of electron transfer.
- Learning objective 3.9 The student is able to design and/or interpret the results of an experiment involving a redox titration.
- Learning objective 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.
- Learning objective 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.
- Learning objective 3.13 The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions.

- Learning objective 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.
- Learning objective 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.
- Learning objective 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.

- Learning objective 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.

Transfer Goal:

Students will be able to <u>independently</u> use their learning to…

design, and/or interpret data from, an experiment that uses gravimetric analysis to determine the concentration of an analyte in a solution.

Students will understand that:	Essential Questions:
• Enduring understanding 3.A: Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form.	• How do compounds form and what do we call them? • What is a reaction?

• Enduring understanding 3.B: Chemical reactions can be classified by considering what the reactants are, what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid-base, and oxidation-reduction reactions. • Enduring understanding 3.C: Chemical and physical transformations may be observed in several ways and typically involve a change in energy. • Enduring understanding 5.E: Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both. • Enduring understanding 6.B: Systems at equilibrium are responsive to external perturbations, with the response leading to a change in the composition of the system.	• What information is conveyed in a chemical equation? • Why do we balance things in the real world? Why in chemistry? • How do we count in chemistry? Why is math important in chemistry? • Why is the statue of liberty green? • How do batteries work? • How can you plate copper?
Students will know: **Predicting Reactions-** • Naming Compounds • Balancing Chemical Equations • Types of Chemical Equations • Predicting based on Stability • Predicting based on Type • Chemical reactivity and products of chemical reactions • Reaction types – Organic Functional Group Reactions, Acid-base reactions; concepts of Arrhenius, Brönsted-Lowry, and Lewis; coordination complexes; amphoterism ,Precipitation reactions, Oxidation-reduction reactions, Oxidation number, The role of the electron in oxidation-reduction **Measurement and Stoichiometry** • Law of Constant Composition and Calculations based on Law • Atomic Masses • Using Moles to find a Quantity • Determining Formulas • Stoichiometry • Limiting Reagents • Using Density • Solution Terms • Stoichiometry. - Solutions **Electrochemistry and Thermodynamics –** • Oxidation and Reduction • Substances gaining potential • Types of electrochemical cells • Voltaic cells • Cell Potentials • Concentration dependency of E • Nerst Equation • Cell potentials and Equilibrium • Metal Electrodes • Reference Electrodes • Indicator electrodes • Applications of Voltaic Cells • Electrolysis • Faraday's Law • Electrolytic Cells • Order of reduction • Applications of Electrolytic cells • Gibbs Free energy Equation (Free Work) • Relationship to Equilibrium and Q • Relationship to E	**Students will be able to:** • justify the observation that the ratio of the masses of the elements in any pure sample of a compound is always identical. • apply mathematical calculations to mass data to identify the composition and/or purity of a substance. • relate the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively. • use particulate drawings to represent a reaction. • Classify chemical reactions by type • predict the product of a chemical reaction • Balance a chemical reaction • predict properties of substances based on their chemical formulas • translate among macroscopic observations of change, chemical equations, and particle views. • use stoichiometric calculations to predict the results of a reaction and analyze deviations from the expected results. • identify stoichiometric relationships for a reaction, including situations involving limiting reactants • use data from synthesis or decomposition of a compound to identify the formula of the compound • identify redox reactions and justify the identification in terms of electron transfer. • design and/or interpret the results of an experiment involving a redox titration. • Classify a process as a physical change or a chemical change based on macroscopic observations • make qualitative or quantitative predictions about galvanic or electrolytic reactions • Calculate cell potentials and $\Delta G°$ • Calculate current, time and amount of deposit in electrolytic cells • analyze data regarding galvanic or electrolytic cells to identify properties of redox reactions. • determine whether a process is thermodynamically favorable by calculating the change in standard Gibbs free energy, $\Delta G°$. • calculate the equilibrium constant, K using $\Delta G°$ and RT

Stage 2: Acceptable Evidence

Transfer Task

A client seeks to move into your community, and he is hoping to find a location where a water softener will not be needed. Help the client identify which areas have the lowest hard water quantities. Several samples of water will be collected from around the community. The samples will be analyzed for their quantities of water hardness through principles of metal ion precipitation and separation. The samples will then be ranked in order of increasing water hardness.

AP Chemistry

Unit Title / Topic: Kinetics **<u>Big Idea 4:</u> Rates of chemical reactions are determined by details of the molecular collisions.**	**Unit Duration:** **2 weeks**

Stage 1: Desired Results

Established Goals:

- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 4.6The 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.

Transfer Goal:

Students will be able to <u>independently</u> use their learning to…

analyze concentration vs. time data to determine the rate law for a reaction.

Students will understand that:	**Essential Questions:**
• Enduring understanding 4.A: Reaction rates that depend on temperature and other environmental factors are determined by measuring changes in concentrations of reactants or products over time. • Enduring understanding 4.B: Elementary reactions are mediated by collisions between molecules. Only collisions having sufficient energy and proper relative orientation of reactants lead to products. • Enduring understanding 4.C: Many reactions proceed via a series of elementary reactions. • Enduring understanding 4.D: Reaction rates may be increased by the presence of a catalyst.	• Why doesn't graphite change to diamond? • How fast does a reaction occur? • What are the factors that affects the rate of a reaction? • How can you make a reaction go faster?

Students will know:	Students will be able to:
Kinetics • Rates relationship to collisions • Reaction Mechanisms • Activation energy • Nature of Reactants and Interfacial Surface Area • Temperature and Pressure effects on Rates • Catalyst – Homogeneous and Heterogeneous • Potential Energy Diagrams- Review • Activated Complex and Intermediates • Arrhenius Equation • Maxwell- Boltzman Diagram • Average Rate • Rates relationship to Stoichiometry • Graphical determination of Instantaneous Rate • Rate Laws • Determination of Rate Laws • Determination of Mechanisms • Order of Reactions • Calculations based on Order	• design and/or interpret the results of an experiment regarding the factors that influence the rate of a reaction. • analyze concentration vs. time data to determine the rate law for a reaction. • relate the half-life of a reaction $t_{1/2}$ to the rate constant of a first-order reaction and • justify the use of $t_{1/2}$ to determine the order of the reaction. • Explain an effective collision • relate the rate law for an elementary reaction to the frequency of effective collisions • use the energy profile for an elementary reaction to predict the relative temperature dependence of the reaction rate. • evaluate different reaction mechanisms, to determine which are consistent with data regarding the overall rate of a reaction • infer the presence of a reaction intermediate or catalyst fromthe mechanism. • Compare energy profile representations of a chemical reaction in the presence and absence of a catalyst. • explain changes in reaction rates arising from the use of catalysts

Stage 2: Acceptable Evidence

Transfer Task

The students will design an experiment to determine the rate law for the reaction between crystal violet (CV) and sodium hydroxide (NaOH).

First a Beer's Law calibration curve is generated by measuring the absorbance of a series of solutions with different known concentrations of CV.

Then the CV and NaOH solutions are mixed, and the concentration of the remaining CV is monitored in real time.

Graphical analysis allows the determination of the rate law.

AP Chemistry

Unit Title / Topic: Thermodynamics	Unit Duration:
<u>Big Idea 5:</u> The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.	**2 weeks**

Stage 1: Desired Results

Established Goals:

- Learning objective 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.

- Learning objective 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.
- Learning objective 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.
- Learning objective 5.3The 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.
- Learning objective 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.
- Learning objective 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 r a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.

Transfer Goal:

Students will be able to <u>independently</u> use their learning 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

Students will understand that:	Essential Questions:
• Enduring understanding 3.C: Chemical and physical transformations may be observed in several ways and typically involve a change in energy. • Enduring understanding 5.A: Two systems with different temperatures that are in thermal contact will exchange energy. The quantity of thermal energy transferred from one system to another is called heat. • Enduring understanding 5.B: Energy is neither created nor destroyed, but only transformed from one form to another. • Enduring understanding 5.C: Breaking bonds requires energy, and making bonds releases energy. • Enduring understanding 5.D: Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy. • Enduring understanding 5.E: Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both.	• What is the driving force in a reaction? • When is a reaction spontaneous?

Students will know:	Students will be able to:
Thermochemistry ● Introduction to thermodynamics ● Conservation of energy ● State Functions ● Potential Energy ● Kinetic Energy ● Calorimetry ● Heat of Fusion ● Heat of Vaporization ● Specific Heat ● Heat of Dilution ● Heat of Solution ● Hess's Law- direct and indirect ● Bond Dissociation Energies ● Gibbs Free Energy Equation	● interpret observations of energy changes associated with a reaction ● create graphical representations to relate potential energy to the distance between atoms ● relate temperature to the motions of particles ● use conservation of energy to relate the magnitudes of the energy changes occurring in two interacting systems ● relate energy changes associated with heating/cooling a substance to the heat capacity ● Use calorimetry to determine the change in enthalpy of a chemical process ● Calculate reaction enthalpy $\Delta H°$ from calorimetry, from heats of formation and from bonds energies. ● predict the sign and relative magnitude of the entropy change $\Delta S°$ ● Calculate the entropy change $\Delta S°$ given various data ● predict whether or not a process is thermodynamically favored by calculation of the change in standard Gibbs free energy, $\Delta G°$

Stage 2: Acceptable Evidence

Transfer Task

Students are challenged to use chemistry to design an effective, safe, environmentally benign and inexpensive hand warmer. The ideal hand warmer increases in temperature by 20° C as quickly as possible, has a volume of about 50 mL,costs as little as possible and uses chemicals that are environmentally friendly. Students will design and carry out an experiment to determine which substance and, in what amounts to use to make a hand warmer that meets the criteria.

AP Chemistry

Unit Title / Topic: Equilibrium Big Idea 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.	Unit Duration: 6 weeks

Stage 1: Desired Results

Established Goals:

- Learning objective 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.

- Learning objective 2.2 The student is able to explain the relative strengths of acids and bases based on molecular structure, interparticle forces, and solution equilibrium.

- Learning objective 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.

- Learning objective 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.
- Learning objective 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.
- Learning objective 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.

- Learning objective 6.1The 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.
- Learning objective 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.
- Learning objective 6.3The 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.
- Learning objective 6.4The student can, given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K, use the tendency of Qto approach Kto predict and justify the prediction as to whether the reaction will proceed toward products or reactants as equilibrium is approached.
- Learning objective 6.5The student can, given data (tabular, graphical, etc.) from which the state of a system at equilibrium can be obtained, calculate the equilibrium constant, K.
- Learning objective 6.6The 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 Kat equilibrium) to determine qualitatively and/or quantitatively the conditions at equilibrium for a system involving a single reversible reaction.
- Learning objective 6.7The 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 6.11The 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 concentration at equilibrium
- Learning objective 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.
- Learning objective 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 pKa for a weak acid, or the pKb for a weak base.
- Learning objective 6.14The student can, based on the dependence of Kwon temperature, reason that neutrality requires [H+] = [OH–] as opposed to requiring pH = 7, including especially the applications to biological systems.
- Learning objective 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

- Learning objective 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.
- Learning objective 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.
- Learning objective 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.
- Learning objective 6.19The 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 pKa associated with the labile proton. Essential knowledge
- Learning objective 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.
- Learning objective 6.21The student can predict the solubility of a salt, or rank the solubility of salts, given the relevant Ksp values.
- Learning objective 6.22The student can interpret data regarding solubility of salts to determine, or rank, the relevant Ksp values.
- Learning objective 6.23 The student can interpret data regarding the relative solubility of salts in terms of factors (common ions, pH) that influence the solubility.
- Learning objective 6.24 The student can analyze the enthalpic and entropic changes associated with the dissolution of a salt, using particulate level interactions and representations.
- Learning objective 6.25 The student is able to express the equilibrium constant in terms of ΔG° and RT and use this relationship to estimate the magnitude of K and, consequently, the thermodynamic favorability of the process.

Transfer Goal:

Students will be able to <u>independently</u> use their learning to…

interpret titration data for monoprotic acids involving titration of a weak by a strong base to determine the concentration of the titrant and the pKa for a weak acid.

Students will understand that:	**Essential Questions:**
• Enduring understanding 1.E: Atoms are conserved in physical and chemical processes. • Essential knowledge 3.B.2: In a neutralization reaction, protons are transferred from an acid to a base. • Enduring understanding 3.C: Chemical and physical transformations may be observed in several ways and typically involve a change in energy. • Enduring understanding 5.E: Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both. • Enduring understanding 6.A: Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal. • Enduring understanding 6.B: Systems at equilibrium are responsive to external perturbations, with the response leading to a change in the composition of the system. • Enduring understanding 6.C: Chemical equilibrium plays an important role in acid-base chemistry and in solubility.	• When is a system at equilibrium? • How can equilibrium be related to thermodynamic quantities? • How does a system at equilibrium respond when conditions are altered? • What is pH?

Students will know:	Students will be able to:
Equilibrium ● Reversible processes and Reactions ● Types of systems ● Kinetics relationship to Equilibrium ● Equilibrium Expressions ● Equilibrium Constants ● LeChatelier's Principle ● Equilibrium Stresses ● Equilibrium Calculations ● Molar Solubility ● Common Ion Effects ● Reaction Quotients **Acids, Bases and Salts** ● Dissociation versus Ionization ● Preparation of Acids, Bases and Salts ● Classification of Acids and Bases ● Bronsted- Lowry Theory of Acids and Bases ● Degree of Ionization ● Equilibrium Constants for Acids and Bases ● Weak Acids and Bases ● Binary acids versus Oxyacids ● Determination of Acid and Base properties based on structure ● Ionization of Water ● pH and pOH ● Acid- Base Stoichiometry Problems- Review ● Ionization calculations of Weak Acids and Bases ● Henderson-Hasselbalch Equation ● Titration Calculations ● Indicators ● Types of Salts ● Dissociation of salts and Buffers	● design, and/or interpret titration data from to determine the concentration of an analyte in a solution. ● compare the relative strengths of acids and bases based on molecular structure ● identify compounds as Brønsted-Lowry acids, bases, and/or conjugate acid-base pairs ● Predict the direction of a reaction when a stress is applied to the system by using Le Chatelier's principle ● explain why a thermodynamically favored chemical reaction may not produce large amounts of product ● determine the effects of a stress on the system on Q ● Predict the direction of a reaction by calculating Q and comparing it to K ● calculate the equilibrium constant, K when given data (tabular, graphical, etc.) ● determine the conditions at equilibrium and the concentrations of different species when given K ● Compare strong and weak acid solutions with similar values of pH ● interpret titration data to determine the concentration of the titrant and the pKa for a weak acid, or the pKb for a weak base. ● reason that neutrality requires [H+] = [OH–] (not pH = 7) ● calculate the pH along an acid/base titration curve ● identify a solution as being a buffer solution ● explain the buffer mechanism on addition of acid or base. ● design a buffer solution with a target pH ● predict the solubility of a salt given Ksp ● rank the solubility of salts, given the relevant Ksp values. ● interpret data regarding solubility of salts to determine Ksp. ● analyze the ΔH° and ΔS° changes associated with the dissolution of a salt, using particulate level representations.

Stage 2: Acceptable Evidence

Transfer Task

The students will standardize an NaOH solution of unknown concentration and then use the standardized NaOH to titrate a weak acid. A pH curve is plotted and used to determine the pKa of the weak acid.