Rumson-Fair Haven Regional High School

Course: *AP Chemistry*
Staff Writers: Jaclyn Toner, Susan Pagano and Jessica Olszewski
Supervisor: Jon Pennetti
Board Approval: August 2025

Section I: Course Description

AP Chemistry is a laboratory course designed and implemented to be the equivalent of a first year college chemistry course. Out of class preparation is a vital component of this course along with the ability to apply the students' level critical thinking skills. Direct student experience is required in all lab exercises. Emphasis is on stoichiometry, atomic structure and theory, bonding, kinetic molecular theory, solutions, various equilibria, kinetics, thermodynamics and electrochemistry. Students are expected to expand their understanding of the framework of notes delivered in class by studying their text and outlining each unit. Students are responsible for advanced placement level questions and problems throughout the year. Students who demonstrate proficiency are expected to take the *Advanced Placement Examination in Chemistry* offered in May.

Section II: NJSLS: New Jersey Student Learning Standards/Learning Objectives:

1. ***2020 New Jersey Student Learning Standards: Science:***
    - "Scientific and technological advances have proliferated and now permeate most aspects of life in the 21st century. It is increasingly important that all members of our society develop an understanding of scientific and engineering concepts and processes. Learning how to construct scientific explanations and how to design evidence-based solutions provides students with tools to think critically about personal and societal issues and needs. Students can then contribute meaningfully to decision-making processes, such as discussions about climate change, new approaches to health care, and innovative solutions to local and global problems."
2. ***2023 New Jersey Student Learning Standards – Mathematics:***
    - "A New Jersey education in Mathematics builds quantitatively and analytically literate citizens prepared to meet the demands of college and career, and to engage productively in an information-driven society; …A high-quality mathematics education fosters a population that…leverages data in decision-making and as a lens for discussing, analyzing, and responding to practical questions, persists to make sense of and model problems arising in everyday life, society, and the workplace, thinks critically and strategically to assess quantitative relationships and to solutions to complex problems, employs precise reasoning and constructs viable arguments to deduce conclusions, recognize false statements and assess peers' reasoning, interprets, evaluates and critiques the mathematics embedded in social, scientific and commercial systems, as well as the claims made in the private and public sectors, communicates precisely when conveying, representing, and justifying both qualitative and quantitative perspectives."
3. ***2023 New Jersey Student Learning Standards English Language Arts:***
    - A New Jersey education in English Language Arts builds readers, writers, and communicators prepared to meet the demands of college and career and to engage as productive American citizens with global responsibilities. Students will develop the necessary skills in reading, writing, speaking, and listening that are the foundations for creative and purposeful expression in language; read rich, challenging texts that build their knowledge of the world, grow their confidence and identities as readers, and develop critical thinking skills and vocabulary necessary for long-term success engage in regular, meaningful, writing authentic tasks, exploring valued topics, writing for impact and expression, and sharing their work with others (including authentic audiences) leverage complex texts and digital media to develop comprehension, active listening, and discussion skills ground daily writing and discussion in evidence, fostering an ability to read critically, build arguments, cite evidence, and communicate ideas to contribute meaningfully as productive citizens; evaluate the reliability, credibility, and perspective of authors and speakers across all forms of media; express ideas and knowledge through a variety of modalities and media, and serve as effective communicators who purposefully read, write, and speak across multiple disciplines and learn to persist in reading complex texts, establishing lifelong habits to read voluntarily for pleasure, for further education, for information on public policy, and for advancement in the workplace.
4. ***Standard 8.1 (Computer Science) and 8.2 (Design Thinking) of the 2020 NJSLS:***
    - "The 'Intent and Spirit of the Computer Science and Design Thinking Standards' is to focus on deep understanding of concepts that enable students to think critically and systematically about leveraging technology to solve local and global issues. Authentic learning experiences that enable students to apply content knowledge, integrate concepts across disciplines, develop computational thinking skills, acquire and incorporate varied perspectives, and communicate with diverse audiences about the use and effects of computing prepares New Jersey students for college and careers."
5. ***Standard 9.4 (Life Literacies and Key Skills) of the 2020 NJSLS:***
    - "This standard outlines key literacies and technical skills such as critical thinking, global and cultural awareness, and technology literacy that are critical for students to develop to live and work in an interconnected global economy."

***Climate Change:** The state of New Jersey has mandated instruction in, "Climate Change across all content areas, leveraging the passion students have shown for this critical issue and providing them opportunities to develop a deep understanding of the science behind the changes and to explore the solutions our world desperately needs."

6. ***[*Amistad Law: N.J.S.A. 18A 52:16A-88:]()***
   - The inclusion of lessons and resources/texts dealing with the African slave trade, slavery in America, the vestiges of slavery in this country and the contributions of African-Americans to our society will be implemented in English and Social Studies courses in accordance with state law: "Every board of education shall incorporate the information regarding the contributions of African-Americans to our country in an appropriate place in the curriculum of elementary and secondary school students."
7. ****Holocaust Law: N.J.S.A. 18A 35-28:***
   - The inclusion of lessons and resources/texts that enable pupils to identify and analyze applicable theories concerning human nature and behavior; to understand that genocide is a consequence of prejudice and discrimination; and to understand that issues of moral dilemma and conscience have a profound impact on life will be implemented in English and Social Studies courses in accordance with state law: "Every board of education shall include instruction on the Holocaust and genocides in an appropriate place in the curriculum of all elementary and secondary school pupils. The instruction shall further emphasize the personal responsibility that each citizen bears to fight racism and hatred whenever and wherever it happens."
8. ****LGBT and Disabilities Law: N.J.S.A. 18A:35-4.35:***
   - A transformative approach to the inclusion of lessons and resources/texts on the contributions and issues concerning the LGBTQ+ population and people with disabilities will be implemented across all core subjects in accordance with state law: "A board of education shall include instruction on the political, economic, and social contributions of persons with disabilities and lesbian, gay, bisexual, and transgender people, in an appropriate place in the curriculum of middle school and high school students as part of the district's implementation of the New Jersey Student Learning Standards (N.J.S.A.18A:35-4.36). A board of education shall have policies and procedures in place pertaining to the selection of instructional materials to implement the requirements of N.J.S.A. 18A:35-4.35."
9. ****Asian American and Pacific Islanders Legislation: N.J.S.A 4021/A6100:***
   - The inclusion of lessons and resources/texts on the history and contributions of Asian Americans and Pacific Islanders, will enable New Jersey's schools to provide a curriculum that reflects the diversity of our state. In accordance with state law: "A board of education shall include instruction on the history and contributions of Asian Americans and Pacific Islanders in an appropriate place in the curriculum of students in grades kindergarten through as part of the school district's implementation of the New Jersey Student Learning Standards in Social Studies."
10. Acquisition/development/refinement of the higher-order critical thinking skills aligned with the *Revised Bloom's Taxonomy of Cognitive Objectives*

Section III: Curriculum Modifications

The *AP Chemistry* curriculum is subject to case-by-case modifications to support/advance the needs of all students, including special education students, English language learners, gifted students, and those at risk of school failure. These modifications are based on Individualized Learning Programs (IEPs), recommendations made by the district's Multilingual Learners (ML) coordinator, feedback from members of the Intervention & Referral Services Team (*I&RS*) for at-risk students, and 504 Plans.

Coursework and assessments will be modified on an individual basis for students when necessary. Modifications may include but are not limited to those outlined on the Modifications/Accommodations for Science Courses chart.

Section IV: Preparation for Standardized Testing

Instruction in *AP Chemistry* is aligned with the requirements of state and national standardized assessments, including the *NJGPA*, *NJSLA*, the *ACT*, the *PSAT,* and the *SAT*.

Section V: Curriculum Pacing Guide

Curriculum Pacing Guide	
Course Title: *AP Chemistry*	**Grade Level:** 11-12

Unit I: Atomic Structure and Properties	Weeks 1 - 3
Unit II: Molecular and Ionic Compound Structure and Properties	Weeks 4 - 6
Unit III: Intermolecular Forces and Properties	Weeks 7 - 10
Unit IV: Chemical Reactions	Weeks 11 - 14
Unit V: Kinetics	Weeks 15 - 19
Unit VI: Thermodynamics	Weeks 20 - 23
Unit VII: Equilibrium	Weeks 24 - 27
Unit VIII: Acids and Bases	Weeks 28 - 31
Unit IX: Applications of Thermodynamics	Weeks 32 - 35
Unit X: Review and Post Exam Project	Weeks 36 - 40

Section VI: Primary Texts and Year-Long Instructional Resources

The following texts and instructional resources are employed for all students in *AP Chemistry*:

- Google Classroom
- Common Sense Education (www.commonsense.org)
- AP Chemistry Course and Exam Description (CED): (https://apcentral.collegeboard.org/pdf/ap-chemistry-course-and-exam-description.pdf)
- Flinn laboratory kits
- PhET Simulations: (https://phet.colorado.edu/en/simulations/filter?subjects=chemistry&sort=alpha&view=grid)
- AP Classroom: (https://myap.collegeboard.org/login)
- Brown, Theodore L., Eugene LeMay, and Bruce Edward Bursten. (2012). *Chemistry: The Central Science* (12 edition). New Jersey: Pearson Education.
- College Board, *AP Chemistry Guided-Inquiry Experiments: Applying the Science Practices Teacher Manual.*
- Flinn Scientific (https://www.flinnpavo.com)
- Kahoot (www.kahoot.com)
- Pivot (https://www.pivotinteractives.com)
- Edpuzzle (https://edpuzzle.com)
- Vernier (https://www.vernier.com)

Section VII: Grading Formula and Assessment Modes

Marking period grades in *AP Chemistry* are determined via a percentage weighting model. The specific grading categories and weightings of each will be determined before the start of each academic year and will be published in the posted/distributed course syllabi.

Assessments in *AP Chemistry* vary greatly in format, scope/content/skills assessed, and alternative assessments; differentiation in assessments and choice will be incorporated as appropriate. Preliminary assessments of each format will be used as benchmarks, and summative assessments will be created/revised collaboratively each year and planned by members of the *AP Chemistry* instructional team to inform future learning and to measure student growth.

Section VIII: Unit Templates

The following unit templates have been established for the *AP Chemistry* curriculum by the *AP Chemistry* instructional team:

Unit I: Atomic Structure and Properties

Unit Summary

This first unit sets the foundation for the course by examining the atomic theory of matter, the fundamental premise of chemistry. Although atoms represent the foundational level of chemistry, observations of chemical properties are made on collections of atoms. Macroscopic systems involve such large numbers that they require moles as a unit of comparison. The periodic table provides information about each element's predictable periodicity as a function of the atomic number. The electronic structure of an atom can be described by an electron configuration that provides a method for describing the distribution of electrons in an atom or ion. In subsequent units, students will apply their understanding of atomic structure to models and representations of chemical phenomena and explain changes and interactions of chemical substances.

Standards/Core Ideas/Performance Expectations/Progress Indicators

The state standards outlined below, and established by the New Jersey Department of Education, will guide instruction throughout this unit in *AP Chemistry:*

- *2020 New Jersey Student Learning Standards: Science:*
  - HS-PS1-1, HS-PS1-2, HS-PS1-7, HS-PS1-8
- *2023 New Jersey Student Learning Standards – Mathematics:*
  - N.Q.A.1-3; N.CN.C.7; A.CED.A. 1,2,4; A.REI.A.1-2; A.REI.B.3,4a,4b; A.REI.D.10; F.IF.C.7a; F.LE.A.1a-c,4; G.MG.A.1,2
- *2023 New Jersey Student Learning Standards English Language Arts:*
  - L.KL.11-12.2.A, RI.CR.11-12.1, RI.CI.11-12.2, RI.IT.11-12.3, RI.MF.11-12.6, W.AW.11-12.1.A, W.AW.11-12.1.D, W.IW.11-12.2.A, W.IW.11-12.2.B, W.WR.11-12.5, W.SE.11-12.6, SL.PE.11-12.1.A, SL.PE.11-12.1.B, SL.II.11-12.2, SL.PI.11-12.4, SL.UM.11-12.5
- *2020 New Jersey Student Learning Standards: Computer Science and Design Thinking*
  - 8.1.12.DA.5, 8.2.12.ED.1, 8.2.12.EC.3
- *2020 New Jersey Student Learning Standards: Career Readiness, Life Literacies, and Key Skills*
  - 9.4.12.CI.1, 9.4.12.CI.3, 9.4.12.CT.2, 9.4.12.IML.3-4, 9.4.12.TL.2

Unit Essential Questions	Unit Enduring Understandings
● How can large quantities of objects (like atoms or molecules) be counted by weighing? ● Why is Avogadro's number critical for quantitative chemical analysis? ● How do we know about the existence of isotopes and their relative abundances if atoms are too small to be observed directly? ● How is the average atomic mass of an element determined from experimental data like a mass spectrum? ● How does the elemental composition by mass relate to a pure substance's empirical formula? ● What fundamentally defines the structure of an atom and how are its electrons arranged? ● How do electrostatic forces (Coulomb's Law) govern electron	● Because macroscopic systems involve immense numbers of particles, chemists use the mole concept to translate between the macroscopic scale (mass) and the particulate scale (number of particles). ● Avogadro's number ($6.022 \times 10^{23}\ mol^{-1}$) provides the quantitative connection between the number of moles in a pure sample of a substance and the number of its constituent particles (atoms, molecules, or formula units). ● The existence and relative abundance of isotopes are determined experimentally using mass spectrometry. ● The average atomic mass of an element is calculated as a weighted average of the isotopic masses, where each isotope's mass is weighted by its relative abundance as identified from its mass spectrum. ● The elemental composition by mass of a pure substance is constant for any given compound, following the law of definite proportions. ● An atom consists of a positively charged nucleus (protons and neutrons) and negatively charged electrons. ● Coulomb's law ($F_{coulombic} \propto q_1q_2/r^2$) describes the attractive

interactions within an atom? • What experimental technique allows chemists to "see" the energy levels of electrons within an atom? • Why does the periodic table have the shape that it does, and how does this shape predict elemental properties? • How are periodic trends in atomic properties (like size or ionization energy) explained by atomic structure? • How do valence electrons and an element's position on the periodic table predict the charges of ions in ionic compounds? • How can the same element have different properties and therefore be found in different substances?	and repulsive forces between charged particles within an atom. • Photoelectron spectroscopy (PES) is an experimental technique that measures the energies required to remove electrons from different subshells within an atom. • The shape and organization of the periodic table reflect the periodic (recurring) patterns of element properties as a function of atomic number. • Trends in atomic properties such as ionization energy, atomic/ionic radii, electron affinity, and electronegativity can be predicted by an element's position on the periodic table. • The typical charges of atoms in ionic compounds are primarily governed by the number of valence electrons an element possesses, which is directly predicted by its location (group) on the periodic table. • This question highlights the atomic theory of matter. The same element, such as carbon, can exist in different forms (allotropes like diamond and graphite) or be part of different compounds that have vastly different macroscopic properties and applications.

Evidence of Learning		
Formative & Alternative Assessments: • Unit I AP Classroom Multiple Choice Questions and Free Response Questions • Unit I - Sections 1-8 Practice Problems • Unit I Practice Assessment • Individual student check ins with teacher	**Benchmark & Summative Assessments:** • Summer Assignment Test (Benchmark) • Tables Quiz • Unit I Summative • Flinn Safety Quiz • Lab - Gravimetric Analysis of a Metal Carbonate (Benchmark)	**Resources Needed:** • Chemistry "The Central Science" textbook • Chemistry "The Central Science" workbook • Periodic Table • AP Classroom: (https://myap.collegeboard.org/login) • Lab software • Scientific Calculator • Safety Contract • Laboratory Equipment • Lab Safety Practice

Unit II: Molecular and Ionic Compound Structure and Properties

Unit Summary

In Unit II, students apply their knowledge of atomic structure at the particulate level and connect it to the macroscopic properties of a substance. Both the chemical and physical properties of materials can be explained by the structure and arrangement of atoms, ions, or molecules and the forces between them. These forces, called chemical bonds, are distinct from typical intermolecular interactions. Electronegativity can be used to make predictions about the type of bonding present between two atoms. In subsequent units, students will use the periodic table and the atomic properties to predict the type of bonding present between two atoms based on position.

Standards/Core Ideas/Performance Expectations/Progress Indicators

The state standards outlined below, and established by the New Jersey Department of Education, will guide instruction throughout this unit in *AP Chemistry:*

- *2020 New Jersey Student Learning Standards: Science:*
  - HS-PS1-1, HS-PS1-2, HS-PS1-7, HS-PS1-8,
- *2023 New Jersey Student Learning Standards – Mathematics:*
  - N.Q.A.1-3; N.CN.C.7; A.CED.A. 1,2,4; A.REI.A.1-2; A.REI.B.3,4a,4b; A.REI.D.10; F.IF.C.7a; F.LE.A.1a-c,4; G.MG.A.1,2
- *2023 New Jersey Student Learning Standards English Language Arts:*
  - L.KL.11-12.2.A, RI.CR.11-12.1, RI.CI.11-12.2, RI.IT.11-12.3, RI.MF.11-12.6, W.AW.11-12.1.A, W.AW.11-12.1.D, W.IW.11-12.2.A, W.IW.11-12.2.B, W.WR.11-12.5, W.SE.11-12.6, SL.PE.11-12.1.A, SL.PE.11-12.1.B, SL.II.11-12.2, SL.PI.11-12.4, SL.UM.11-12.5
- *2020 New Jersey Student Learning Standards: Computer Science and Design Thinking*
  - 8.1.12.DA.5, 8.2.12.ED.1, 8.2.12.EC.3
- *2020 New Jersey Student Learning Standards: Career Readiness, Life Literacies, and Key Skills*
  - 9.4.12.CI.1, 9.4.12.CI.3, 9.4.12.CT.2, 9.4.12.IML.3-4, 9.4.12.TL.2

Unit Essential Questions	Unit Enduring Understandings

• How are the chemical and physical properties of materials explained at the particulate level? • How do chemical bonds relate to typical intermolecular interactions? • How can electronegativity be used to predict the type of bonding between two atoms? • What distinguishes a nonpolar covalent bond from a polar covalent bond? • What is the general rule for characterizing bonds between metals/nonmetals, and how distinct are ionic and covalent bonding? • How is metallic bonding represented at the particulate level? • What does a graph of potential energy versus internuclear distance illustrate about atomic interactions and bond strength? • What factors influence bond length and bond energy in covalent bonds? • How are the atoms arranged in an ionic solid, and what governs this arrangement? • What are the primary types of alloys? • How are alloy structures described? • What is the basis for constructing Lewis diagrams? • When should resonance be included in a Lewis diagram, and how are formal charges used to refine structures? • How does VSEPR theory predict molecular geometry and electron properties? • What are the ideal bond angles associated with sp, sp2, and sp3 hybridized central atoms? • How are sigma and pi bonds formed?	• The chemical and physical properties of materials can be explained by the structure and arrangement of atoms, ions, or molecules and the forces between them. • Chemical bonds are distinct from typical intermolecular interactions. • Electronegativity can be used to make predictions about the type of bonding present between two atoms. • Nonpolar covalent bonds consist of valence electrons shared between atoms of similar electronegativity, whereas Polar covalent bonds involve valence electrons shared between atoms of unequal electronegativity, causing the atom with higher electronegativity to develop a partial negative charge. • Generally, bonds between a metal and a nonmetal are ionic, and bonds between two nonmetals are covalent. • Metallic bonding can be represented as an array of positive metal ions surrounded by delocalized valence electrons. • Such a graph of potential energy versus internuclear distance illustrates both the equilibrium bond length (the separation between atoms at which the potential energy is lowest) and the bond energy (the energy required to separate the atoms). • In a covalent bond, the bond length is influenced by both the size of the atom's core and the bond order (i.e., single, double, triple). • The cations and anions in an ionic crystal are arranged in a systematic, periodic 3-D array that maximizes the attractive forces among cations and anions while minimizing the repulsive forces. • The primary types are interstitial alloys and substitutional alloys. • In interstitial alloys, smaller atoms fill the interstitial spaces between larger atoms (e.g., carbon in iron steel). In substitutional alloys, atoms of comparable radius substitute for the original atoms in the lattice (e.g., zinc in brass). • Lewis diagrams can be constructed according to an established set of principles, leading to uniformity in structures. • Resonance must be included when more than one equivalent Lewis structure can be constructed, which provides qualitatively accurate predictions of molecular structure and properties. • VSEPR theory uses the Coulombic repulsion between electrons as a basis for predicting the arrangement of electron pairs around a central atom. • When the central atom is sp hybridized, its ideal bond angles are 180°; for sp2 hybridized atoms, the bond angles are 120°; and for sp3 hybridized atoms, the bond angles are 109.5°. • Bond formation is associated with overlap between atomic orbitals, so when there are multiple bonds, this overlap leads to the formation of both sigma and pi bonds.

Evidence of Learning		
Formative & Alternative Assessments: • Unit II AP Classroom Multiple Choice Questions and Free Response Questions • Unit II - Sections 1-7 Practice Problems • Unit II Practice Assessment • Individual student check ins with teacher	**Benchmark & Summative Assessments:** • Unit II Quiz • Unit II Assessment • Lab - Qualitative Analysis of Chemical Bonding, Molecular Shapes, Hydrates	**Resources Needed:** • Textbook and workbook • Periodic Table • AP Classroom: (https://myap.collegeboard.org/login) • Lab software • Scientific Calculator • Laboratory Equipment

Unit III: Intermolecular Forces and Properties
Unit Summary
This unit examines how transformations of matter can be observed in ways that are generally categorized as either a chemical or physical change. The shapes of the particles involved and the space between them are key factors in determining the nature of physical changes. The properties of solids, liquids, and gases reflect the relative orderliness of the arrangement of particles in those states, their relative freedom of motion, and the nature and strength of the

interactions between them. There is a relationship between the macroscopic properties of solids, liquids, and gases, as well as the structure of the constituent particles of those materials on the molecular and atomic scale. In subsequent units, students will explore chemical transformations of matter.

Standards/Core Ideas/Performance Expectations/Progress Indicators

The state standards outlined below, and established by the New Jersey Department of Education, will guide instruction throughout this unit in *AP Chemistry:*

- *2020 New Jersey Student Learning Standards: Science:*
    - HS-PS1-3, HS-PS1-7, HS-PS1-8, HS-PS2-4, HS-PS2-6, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-PS4-4, HS-ESS-2, HS-ETS1-2
- *2023 New Jersey Student Learning Standards – Mathematics:*
    - N.Q.A.1-3; N.CN.C.7; A.CED.A. 1,2,4; A.REI.A.1-2; A.REI.B.3,4a,4b; A.REI.D.10; F.IF.C.7a; F.LE.A.1a-c,4; G.MG.A.1,2
- *2023 New Jersey Student Learning Standards English Language Arts:*
    - L.KL.11-12.2.A, RI.CR.11-12.1, RI.CI.11-12.2, RI.IT.11-12.3, RI.MF.11-12.6, W.AW.11-12.1.A, W.AW.11-12.1.D, W.IW.11-12.2.A, W.IW.11-12.2.B, W.WR.11-12.5, W.SE.11-12.6, SL.PE.11-12.1.A, SL.PE.11-12.1.B, SL.II.11-12.2, SL.PI.11-12.4, SL.UM.11-12.5
- *2020 New Jersey Student Learning Standards: Computer Science and Design Thinking*
    - 8.1.12.DA.5, 8.2.12.ED.1, 8.2.12.EC.3
- *2020 New Jersey Student Learning Standards: Career Readiness, Life Literacies, and Key Skills*
    - 9.4.12.CI.1, 9.4.12.CI.3, 9.4.12.CT.2, 9.4.12.IML.3-4, 9.4.12.TL.2

Unit Essential Questions	Unit Enduring Understandings
• How do interactions between particles influence the properties of pure substances and mixtures? • Why do odors such as the smell of perfume only last for a short time? • Why can you pass through certain substances and not others? • How does the spacing and motion of particles relate to a substance's state of matter and the properties of gases? • How can one determine the structure and concentration of a chemical species in a mixture? • What are the different types of intermolecular forces, and how do they arise? • How do the chemical structures of molecules influence the relative strength of their intermolecular forces? • How do the types of solids (ionic, covalent network, molecular, metallic) relate to their macroscopic properties? • How can the differences between solid, liquid, and gas phases be represented at the particulate level? • How does the Ideal Gas Law describe gas behavior, and what causes real gases to deviate from ideal behavior? • How can knowledge of intermolecular interactions be used to separate components of a mixture? • What principle governs the solubility of substances in different solvents?	• The chemical and physical properties of materials are explained by the structure and arrangement of atoms, ions, or molecules and the forces between them. • The fading smell of odors such as perfume is due to the vaporization of its molecules, a physical change where intermolecular interactions are completely overcome. • One passes through certain substances and not others due to the relative orderliness of particle arrangement, their freedom of motion, and the nature and strength of interparticle interactions in liquids versus solids. • In the gas phase, particles are in constant motion, with their collision frequencies and average spacing influenced by temperature, pressure, and volume. Due to this constant motion and minimal interparticle forces, gases lack definite volume or shape. • Elemental analysis can determine the relative numbers of atoms and the purity of a substance. • London dispersion forces originate from Coulombic interactions between temporary, fluctuating dipoles. Dipole-induced dipole interactions occur between a polar molecule and a nonpolar molecule. Dipole-dipole interactions are present between polar molecules. Ion-dipole forces occur between ions and polar molecules and are generally stronger than dipole-dipole forces. Hydrogen bonding is a strong type of intermolecular interaction formed when hydrogen atoms covalently bonded to highly electronegative atoms (N, O, or F) are attracted to the negative end of a dipole involving N, O, or F in another molecule. • London dispersion forces increase with increasing contact area between molecules and with increasing polarizability. Polarizability, in turn, increases with a greater number of electrons and a larger electron cloud size, and is enhanced by pi bonding. The strength of dipole-dipole interactions is influenced by the magnitude of the dipoles and their relative orientation. Hydrogen bonding specifically occurs due to the strong electronegativity of N, O, and F when bonded to hydrogen. Ultimately, substances with similar intermolecular interactions tend to be miscible or soluble in one another. • Macroscopic properties of solids are determined by their interparticle interactions: ionic solids have strong interactions between ions, covalent network solids (e.g., diamond) have atoms covalently bonded in a 3-D network, molecular solids consist of distinct

● How can the absorption of light be used to identify and quantify chemical species?	molecules held by relatively weak intermolecular forces, and metallic solids are good conductors of electricity and heat due to a "sea of delocalized valence electrons." ● In solids, particles are arranged in a regular (crystalline) or irregular (amorphous) 3-D structure, with limited motion and no overall translation. In liquids, particles are in close contact and are continually moving and colliding, with arrangement and movement influenced by interparticle forces. In the gas phase, particles are in constant, random motion, widely spaced, and have no definite volume or shape due to minimal forces between them. ● The ideal gas law (PV = nRT) relates the macroscopic properties of pressure, volume, temperature, and number of moles for ideal gases. ● Liquid solution components can be separated by processes that exploit differences in their intermolecular interactions. Chromatography separates chemical species by utilizing the differential strength of intermolecular interactions between the solution's components (mobile phase) and the stationary phase surface, whereas distillation separates components by taking advantage of the differential strengths of intermolecular interactions that affect the components' vapor pressures. ● The primary principle governing solubility is that substances with similar intermolecular interactions tend to be miscible or soluble in one another. ● Differences in the absorption or emission of photons in various spectral regions are linked to different types of molecular motion or electronic transitions.

Evidence of Learning		
Formative & Alternative Assessments: ● Unit III AP Classroom Multiple Choice Questions and Free Response Questions ● Unit III - Sections 1-13 Practice Problems ● Unit III Practice Assessment ● Individual student check ins with teacher	**Benchmark & Summative Assessments:** ● Unit III Quiz ● Unit III Summative ● Labs - Beer's Law, Intermolecular Forces, Lava Lamp	**Resources Needed:** ● Textbook and workbook ● Periodic Table ● AP Classroom: (https://myap.collegeboard.org/login) ● Lab software ● Scientific Calculator ● Laboratory Equipment

Unit IV: Chemical Reactions
Unit Summary
This unit explores chemical transformations of matter by building on the physical transformations studied in Unit III. Chemical changes involve the making and breaking of chemical bonds. Many properties of a chemical system can be understood using the concepts of varying strengths of chemical bonds and weaker intermolecular interactions. When chemical changes occur, the new substances formed have properties that are distinguishable from the initial substance or substances. Chemical reactions are the primary means by which transformations in matter occur. Chemical equations are a representation of the rearrangement of atoms that occur during a chemical reaction. In subsequent units, students will explore rates at which chemical changes occur.
Standards/Core Ideas/Performance Expectations/Progress Indicators
The state standards outlined below, and established by the New Jersey Department of Education, will guide instruction throughout this unit in *AP Chemistry:* ● *2020 New Jersey Student Learning Standards: Science:* ○ HS-PS1-1, HS-PS1-2, HS-PS1-4, HS-PS1-5, HS-PS1-7, HS ● *2023 New Jersey Student Learning Standards – Mathematics:* ○ N.Q.A.1-3; N.CN.C.7; A.CED.A. 1,2,4; A.REI.A.1-2; A.REI.B.3,4a,4b; A.REI.D.10; F.IF.C.7a; F.LE.A.1a-c,4; G.MG.A.1,2 ● *2023 New Jersey Student Learning Standards English Language Arts:* ○ L.KL.11-12.2.A, RI.CR.11-12.1, RI.CI.11-12.2, RI.IT.11-12.3, RI.MF.11-12.6, W.AW.11-12.1.A, W.AW.11-12.1.D, W.IW.11-12.2.A, W.IW.11-12.2.B, W.WR.11-12.5, W.SE.11-12.6, SL.PE.11-12.1.A, SL.PE.11-12.1.B, SL.II.11-12.2, SL.PI.11-12.4, SL.UM.11-12.5 ● *2020 New Jersey Student Learning Standards: Computer Science and Design Thinking*

- 8.1.12.DA.5, 8.2.12.ED.1, 8.2.12.EC.3
- *2020 New Jersey Student Learning Standards: Career Readiness, Life Literacies, and Key Skills*
    - 9.4.12.CI.1, 9.4.12.CI.3, 9.4.12.CT.2, 9.4.12.IML.3-4, 9.4.12.TL.2

Unit Essential Questions	Unit Enduring Understandings
• In what ways can a chemical change be described and documented? • How can it be predicted that a chemical reaction will generate enough product? • What is the fundamental distinction between physical and chemical changes at the molecular level? • What are the main classifications of chemical reactions? • Why is it crucial for chemical equations to be balanced? • How are titrations used to determine the concentration of an unknown solution? • What is the significance of oxidation numbers in identifying and understanding redox reactions? • Describe the role of water in Brønsted-Lowry acid-base reactions. • How can particulate models enhance the understanding of chemical reactions? • What are half-reactions, and how are they used to construct balanced redox equations? • How do macroscopic observations provide evidence for chemical vs. physical changes? • How can stoichiometric calculations be integrated with gas laws and solution chemistry to solve problems?	• Chemical changes can be described and documented symbolically using balanced equations. • Predicting the amount of product generated by a chemical reaction relies on stoichiometric calculations. • A physical change involves a change in a substance's properties or state, but does not alter its chemical composition, whereas a chemical change involves the breaking of existing chemical bonds and/or the formation of new chemical bonds, leading to the transformation of substances into entirely new substances with different compositions. • Acid-base reactions involve the transfer of one or more protons (H+ ions) between chemical species, Oxidation-reduction (redox) reactions are characterized by the transfer of one or more electrons between chemical species, indicated by changes in their oxidation numbers, combustion reactions are a type of redox reaction where a substance reacts with oxygen gas and Precipitation reactions typically occur when ions in an aqueous solution combine to form an insoluble or sparingly soluble ionic compound. • Balancing chemical equations is crucial because it visually and quantitatively demonstrates the conservation of mass and charge during a chemical reaction. • Titrations are quantitative analytical methods used to determine the concentration of an unknown analyte in a solution. • Oxidation numbers are a bookkeeping tool that assigns a value to each atom in a compound or ion, representing its apparent charge. • In Brønsted-Lowry acid-base chemistry, an acid is defined as a proton donor and a base as a proton acceptor. • Particulate models visually represent the structure and interactions of atoms, molecules, or formula units at the sub-microscopic level, thereby enhancing the understanding of chemical reactions. • Half-reactions are individual equations that represent either the oxidation (electron loss) or reduction (electron gain) component of an overall redox reaction. • Macroscopic observations provide direct evidence to distinguish between chemical and physical changes. • Stoichiometric calculations, which relate the quantitative amounts of reactants and products based on balanced chemical equations and the mole concept, can be combined with the ideal gas law (PV=nRT) and molarity (M=nsolute/Lsolution) to address a wider range of chemical problems.

Evidence of Learning

Formative & Alternative Assessments:	Benchmark & Summative Assessments:	Resources Needed:
• Unit IV AP Classroom Multiple Choice Questions and Free Response Questions • Unit IV - Sections 1-9 Practice Problems • Unit IV Practice Assessment • Individual student check ins with teacher	• Unit IV Quiz • Unit IV Assessment • Labs - Single Replacement Reactions, Precipitate Reactions	• Textbook and workbook • Periodic Table • AP Classroom: (https://myap.collegeboard.org/login) • Lab software • Scientific Calculator • Laboratory Equipment

Unit V: Kinetics

Unit Summary

In Unit V, students will develop an understanding of the rates at which chemical changes occur and the factors that influence the rates. Those factors include the concentration of reactants, temperature, catalysts, and other environmental

factors. Chemical changes are represented by chemical reactions, and the rates of chemical reactions are determined by the details of the molecular collisions. Rates of change in chemical reactions are observable and measurable. When measuring rates of change, students are measuring the concentration of reactant or product species as a function of time. These chemical processes may be observed in a variety of ways and often involve changes in energy as well. In subsequent units, students will describe the role of energy in changes in matter.
Standards/Core Ideas/Performance Expectations/Progress Indicators
The state standards outlined below, and established by the New Jersey Department of Education, will guide instruction throughout this unit in *AP Chemistry:* ● *2020 New Jersey Student Learning Standards: Science:* ○ HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS3-1 ● *2023 New Jersey Student Learning Standards – Mathematics:* ○ N.Q.A.1-3; N.CN.C.7; A.CED.A. 1,2,4; A.REI.A.1-2; A.REI.B.3,4a,4b; A.REI.D.10; F.IF.C.7a; F.LE.A.1a-c,4; G.MG.A.1,2 ● *2023 New Jersey Student Learning Standards English Language Arts:* ○ L.KL.11-12.2.A, RI.CR.11-12.1, RI.CI.11-12.2, RI.IT.11-12.3, RI.MF.11-12.6, W.AW.11-12.1.A, W.AW.11-12.1.D, W.IW.11-12.2.A, W.IW.11-12.2.B, W.WR.11-12.5, W.SE.11-12.6, SL.PE.11-12.1.A, SL.PE.11-12.1.B, SL.II.11-12.2, SL.PI.11-12.4, SL.UM.11-12.5 ● *2020 New Jersey Student Learning Standards: Computer Science and Design Thinking* ○ 8.1.12.DA.5, 8.2.12.ED.1, 8.2.12.EC.3 ● *2020 New Jersey Student Learning Standards: Career Readiness, Life Literacies, and Key Skills* ○ 9.4.12.CI.1, 9.4.12.CI.3, 9.4.12.CT.2, 9.4.12.IML.3-4, 9.4.12.TL.2

Unit Essential Questions	Unit Enduring Understandings
● Why are some reactions faster than others? ● How can the speed of a reaction be controlled by understanding the collisions that occur on the particle level? ● In what ways can a chemical reaction's rate be measured and described? ● What is a rate law, and how is it determined from experimental data? ● How do elementary reactions and molecularity contribute to understanding reaction rates? ● What is activation energy, and how does it relate to the energy profile of a reaction? ● How are multi-step reactions (mechanisms) composed, and how does the rate-determining step influence the overall rate law? ● What is the role of a catalyst in a chemical reaction, and how does it achieve its effect? ● How can graphical representations be used to determine the order of a reaction and its rate constant? ● How do chemical reactions involve changes in energy, and how are these visualized? ● What is the meaning of the rate constant (k), and how does its value change?	● The rate of a chemical reaction, or how fast it proceeds, is fundamentally determined by the details of molecular collisions. ● Increasing reactant concentrations leads to more frequent collisions, thus increasing the rate, raising the temperature increases the average kinetic energy of the particles, which means a greater proportion of collisions will have the necessary energy to react, increasing the surface area of reactants, especially for heterogeneous reactions, provides more sites for collisions, speeding up the reaction and introducing a catalyst provides an alternative reaction pathway with a lower activation energy or increases the number of effective collisions, significantly accelerating the reaction without being consumed. ● A chemical reaction's rate is defined as the rate at which reactants are converted to products per unit of time. ● A rate law is an experimentally determined expression that quantifies the relationship between the rate of a reaction and the concentrations of its reactants. ● For elementary reactions, the rate law can be directly determined from its stoichiometry and the overall rate law for a multi-step reaction is governed by the slowest elementary step, known as the rate-determining step. ● Activation energy is the minimum energy that colliding reactant particles must possess to initiate the breaking of existing bonds and the formation of new ones, leading to a successful reaction. ● A reaction mechanism is a proposed sequence of elementary reactions that describes the pathway from reactants to products. ● A catalyst is a substance that increases the rate of a chemical reaction without being consumed in the process. ● For a zeroth-order reaction, a plot of [A] (concentration) vs. time will yield a straight line with a slope equal to -k, for a first-order reaction, a plot of ln[A] vs. time will be linear, with a slope equal to -k, for a second-order reaction, a plot of 1/[A] vs. time will be linear, with a slope equal to k so the linearity of these plots directly indicates the reaction order, and the slope provides the value of the rate constant (k). ● Chemical reactions involve changes in energy because they involve the breaking of existing chemical bonds and the formation of new ones, which alters the potential energy of the system and these energy changes are visualized using a reaction energy profile, a

	diagram that plots the energy of the system as it progresses from reactants to products along a reaction coordinate. ● The rate constant (k) is the proportionality constant in a rate law expression, representing the inherent efficiency of a reaction at a specific temperature.

Evidence of Learning		
Formative & Alternative Assessments: ● Unit V AP Classroom Multiple Choice Questions and Free Response Questions ● Unit V - Sections 1-11 Practice Problems ● Unit V Practice Assessment ● Individual student check ins with teacher	**Benchmark & Summative Assessments:** ● Unit V Quiz ● Unit V Assessment ● Labs - Kinetics of Burning Candle, Rates of Reactions	**Resources Needed:** ● Textbook and workbook ● Periodic Table ● AP Classroom: (https://myap.collegeboard.org/login) ● Lab software ● Scientific Calculator ● Laboratory Equipment

Unit VI: Thermodynamics

Unit Summary

Students will examine how the laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter. The availability or disposition of energy plays a role in virtually all observed chemical processes. Thermodynamics provides tools for understanding this key role, particularly the conservation of energy, including energy transfer in the forms of heat and work. Chemical bonding is central to chemistry. A key concept to know is that the breaking of a chemical bond inherently requires an energy input, and because bond formation is the reverse process, it will release energy. In subsequent units, the application of thermodynamics will determine the favorability of a reaction occurring.

Standards/Core Ideas/Performance Expectations/Progress Indicators

The state standards outlined below, and established by the New Jersey Department of Education, will guide instruction throughout this unit in *AP Chemistry:*

- *2020 New Jersey Student Learning Standards: Science:*
  - HS-PS1-4, HS-PS1-5, HS-PS1-7, HS-PS1-8, HS-PS3-1, HS-PS3-4
- *2023 New Jersey Student Learning Standards – Mathematics:*
  - N.Q.A.1-3; N.CN.C.7; A.CED.A. 1,2,4; A.REI.A.1-2; A.REI.B.3,4a,4b; A.REI.D.10; F.IF.C.7a; F.LE.A.1a-c,4; G.MG.A.1,2
- *2023 New Jersey Student Learning Standards English Language Arts:*
  - L.KL.11-12.2.A, RI.CR.11-12.1, RI.CI.11-12.2, RI.IT.11-12.3, RI.MF.11-12.6, W.AW.11-12.1.A, W.AW.11-12.1.D, W.IW.11-12.2.A, W.IW.11-12.2.B, W.WR.11-12.5, W.SE.11-12.6, SL.PE.11-12.1.A, SL.PE.11-12.1.B, SL.II.11-12.2, SL.PI.11-12.4, SL.UM.11-12.5
- *2020 New Jersey Student Learning Standards: Computer Science and Design Thinking*
  - 8.1.12.DA.5, 8.2.12.ED.1, 8.2.12.EC.3
- *2020 New Jersey Student Learning Standards: Career Readiness, Life Literacies, and Key Skills*
  - 9.4.12.CI.1, 9.4.12.CI.3, 9.4.12.CT.2, 9.4.12.IML.3-4, 9.4.12.TL.2

Unit Essential Questions	Unit Enduring Understandings
● What is thermochemistry, and why is understanding energy changes important in chemical processes? ● How are energy changes in chemical reactions and physical processes classified and observed? ● How are energy changes in reactions visualized, and what information can be obtained from a reaction energy profile? ● How is thermal energy transferred between substances, and what happens at the molecular level when thermal equilibrium is reached? ● How is the amount of heat transferred in chemical and physical processes measured and calculated?	● Thermochemistry is the study of energy changes that occur during chemical reactions and physical processes and this understanding is crucial because the availability or disposition of energy plays a role in virtually all observed chemical processes. ● Energy changes in a system are classified as endothermic or exothermic processes. ● Energy changes in chemical and physical processes are visualized using a reaction energy profile. It shows the relative energies of reactants and products, the energy of the transition state (the highest energy point), and the activation energy, which is the energy difference between the reactants and the transition state. The overall energy difference between products and reactants indicates whether the reaction is endothermic or exothermic. ● Thermal energy is transferred through collisions between particles in thermal contact. Particles in a warmer body have a greater average kinetic energy than those in a cooler body. As these particles collide, energy is transferred until thermal equilibrium is

• Why do substances absorb or release energy during phase changes, and how does this affect their temperature? • What is enthalpy of reaction, and how does it represent the energy change in a chemical reaction? • How are bond energies used to estimate the enthalpy change of a chemical reaction? • How are standard enthalpies of formation utilized to calculate the enthalpy change for a chemical reaction? • What is Hess's Law, and how does it allow for the calculation of enthalpy changes for complex reactions? • How does the breaking and forming of chemical bonds dictate the overall energy change of a reaction? • What is the fundamental principle of energy conservation, and how is it applied in thermochemistry? • How do macroscopic observations, such as temperature changes or physical state changes, relate to energy changes at the particulate level?	reached. At this point, the average kinetic energy of particles in both bodies is the same, resulting in equal temperatures. • The amount of heat transferred, often denoted as *q*, can be measured using calorimetry experiments. It can be quantified using the heat transfer equation: $q = mc\Delta T$. • During a phase change, such as melting or boiling, energy must be transferred to the system. This energy is used to overcome intermolecular forces and change the arrangement and motion of particles, increasing the system's energy. Conversely, a system releases energy when it freezes or condenses. Crucially, the temperature of a pure substance remains constant during a phase change, even while energy is being absorbed or released. • The enthalpy change of a reaction ($\Delta H°$) represents the amount of heat energy released (for negative values) or absorbed (for positive values) by a chemical reaction at constant pressure. This energy difference arises because the chemical potential energy of the products differs from that of the reactants due to the breaking and forming of bonds. • During a chemical reaction, existing bonds are broken (requiring energy input) and new bonds are formed (releasing energy). The enthalpy change of a reaction can be estimated by summing the average bond energies of all bonds broken in the reactants and subtracting the sum of the average bond energies of all bonds formed in the products. • Tables of standard enthalpies of formation can be used to calculate the standard enthalpy of a reaction using the equation: $\Delta H°$reaction $= \Sigma\Delta H°f$ products $- \Sigma\Delta H°f$ reactants. • Hess's Law states that if a reaction can be expressed as a series of steps (elementary reactions), the enthalpy change for the overall reaction is the sum of the enthalpy changes for each individual step. This is possible because total energy is conserved. • The breaking of a chemical bond inherently requires an energy input to overcome the attractive forces holding atoms together. Conversely, the formation of new chemical bonds releases energy. The net energy change of a reaction, whether exothermic or endothermic, is the difference between the energy required to break bonds in reactants and the energy released when bonds form in products. • The fundamental principle of energy conservation is the first law of thermodynamics, which states that energy is conserved in chemical and physical processes. In thermochemistry, this principle is applied to understand that any energy lost by a reacting system (e.g., in an exothermic reaction) is gained by the surroundings, and vice-versa for endothermic reactions. • A temperature increase in a solution indicates that thermal energy has been released by the chemical process (exothermic) and transferred to the particles in the solution, increasing their average kinetic energy. Similarly, when a substance changes phase, like water boiling, the absorption of energy at the macroscopic level corresponds to the energy being used to overcome intermolecular forces between water molecules at the particulate level, increasing their freedom of motion.

Evidence of Learning

Formative & Alternative Assessments:	**Benchmark & Summative Assessments:**	**Resources Needed:**
• Unit VI AP Classroom Multiple Choice Questions and Free Response Questions • Unit VI - Sections 1-9 Practice Problems • Unit VI Practice Assessment	• Unit VI quiz • Unit VI Assessment • Labs - Heats of Reaction, Hess's Law of Heat Summation	• Textbook and workbook • Periodic Table • AP Classroom: (https://myap.collegeboard.org/login) • Lab software • Scientific Calculator • Laboratory Equipment

• Individual student check ins with teacher		

Unit VII: Equilibrium

Unit Summary

This unit explains how chemical equilibrium is a dynamic state in which opposing processes occur at the same rate. In this unit, students learn that 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. A change in conditions, such as addition of a chemical species, change in temperature, or change in volume, can cause the rate of the forward and reverse reactions to fall out of balance. Le Châtelier's principle provides a means to reason qualitatively about the direction of the shift in an equilibrium system resulting from various possible stresses. The expression for the equilibrium constant, K, is a mathematical expression that describes the equilibrium state associated with a chemical change. An analogous expression for the reaction quotient, Q, describes a chemical reaction at any point, enabling a comparison to the equilibrium state. Subsequent units will explore equilibrium constants that arise from acid-base chemistry.

Standards/Core Ideas/Performance Expectations/Progress Indicators

The state standards outlined below, and established by the New Jersey Department of Education, will guide instruction throughout this unit in *AP Chemistry:*

- *2020 New Jersey Student Learning Standards: Science:*
  - HS-PS1-5, HS-PS1-6, HS-PS1-7, HS-PS1-8, HS-PS3-1
- *2023 New Jersey Student Learning Standards – Mathematics:*
  - N.Q.A.1-3; N.CN.C.7; A.CED.A. 1,2,4; A.REI.A.1-2; A.REI.B.3,4a,4b; A.REI.D.10; F.IF.C.7a; F.LE.A.1a-c,4; G.MG.A.1,2
- *2023 New Jersey Student Learning Standards English Language Arts:*
  - L.KL.11-12.2.A, RI.CR.11-12.1, RI.CI.11-12.2, RI.IT.11-12.3, RI.MF.11-12.6, W.AW.11-12.1.A, W.AW.11-12.1.D, W.IW.11-12.2.A, W.IW.11-12.2.B, W.WR.11-12.5, W.SE.11-12.6, SL.PE.11-12.1.A, SL.PE.11-12.1.B, SL.II.11-12.2, SL.PI.11-12.4, SL.UM.11-12.5
- *2020 New Jersey Student Learning Standards: Computer Science and Design Thinking*
  - 8.1.12.DA.5, 8.2.12.ED.1, 8.2.12.EC.3
- *2020 New Jersey Student Learning Standards: Career Readiness, Life Literacies, and Key Skills*
  - 9.4.12.CI.1, 9.4.12.CI.3, 9.4.12.CT.2, 9.4.12.IML.3-4, 9.4.12.TL.2

Unit Essential Questions	Unit Enduring Understandings
• What is chemical equilibrium, and what are its key characteristics? • What is chemical equilibrium, and what are its key characteristics? • How are the rates of forward and reverse reactions related to the direction a reversible reaction proceeds? • What is the reaction quotient (Q), and how does it relate to the equilibrium constant (K) for a reversible reaction? • How is the equilibrium constant (K) calculated from experimental data? • What does the magnitude of the equilibrium constant (K) indicate about a reaction? • How do changes in a chemical equation, such as reversal or multiplication by a factor, affect its equilibrium constant? • How can the concentrations of chemical species at equilibrium be predicted given initial conditions and the equilibrium constant? • How can particulate models be used to represent a system at equilibrium? • What is Le Châtelier's principle, and how is it used to predict the response	• Chemical equilibrium is a dyFor a reversible reaction, if the rate of the forward reaction is greater than the reverse reaction, there is a net conversion of reactants to products. namic state where opposing processes occur at the same rate. • The reaction quotient (Qc for concentrations, Qp for partial pressures) describes the relative concentrations of reaction species at any time. • The equilibrium constant (Kc or Kp) can be determined from experimental measurements of the concentrations or partial pressures of the reactants and products once the system has achieved equilibrium. • Very large K values indicate that the reaction proceeds essentially to completion, meaning that products are strongly favored at equilibrium. This corresponds to a thermodynamically favored process where K > 1 under standard conditions and very small K values indicate that the reaction barely proceeds at all, meaning that reactants are strongly favored at equilibrium. • When a reaction is reversed, the equilibrium constant K is inverted (the new K' = 1/K), when the stoichiometric coefficients of a reaction are multiplied by a factor 'c', K is raised to the power 'c' (the new K' = K^c), when two (or more) reactions are added together to obtain an overall reaction, the equilibrium constant for the resulting overall reaction is the product of the K values for the individual steps (K_overall = K1 * K2 * ...). • The concentrations or partial pressures of species at equilibrium can be predicted when given the balanced reaction, the initial concentrations, and the appropriate equilibrium constant (K).

of an equilibrium system to external stresses? ● How do changes in Q and K relate to Le Châtelier's principle in re-establishing equilibrium after a disturbance? ● How is the solubility of a salt related to its solubility-product constant (Ksp)? ● What is the common-ion effect, and how does it influence the solubility of a salt?	● Particulate representations are valuable tools to describe the relative numbers of reactant and product particles present both prior to and at equilibrium. ● Le Châtelier's principle is used to predict the response of a system at equilibrium to external stresses. These stresses can include: addition or removal of a chemical species, change in temperature, change in volume/pressure for a gas-phase system, dilution of a reaction system. ● A disturbance to a system at equilibrium causes the reaction quotient (Q) to differ from the equilibrium constant (K), thereby taking the system out of equilibrium and the system then responds by bringing Q back into agreement with K, thus establishing a new equilibrium state. ● The solubility of a substance can be calculated from its Ksp for the dissolution process, and this relationship is also useful for predicting the relative solubility of different substances. ● The solubility of a salt is reduced when it is dissolved into a solution that already contains one of the ions present in the salt.

Evidence of Learning		
Formative & Alternative Assessments: ● Unit VII AP Classroom Multiple Choice Questions and Free Response Questions ● Unit VII - Sections 1-12 Practice Problems ● Unit VII Practice Assessment ● Individual student check ins with teacher	**Benchmark & Summative Assessments:** ● Unit VII Quiz ● Unit VII Assessment ● Labs - Le Chatelier's Principle and Shifting Equilibrium	**Resources Needed:** ● Textbook and workbook ● Periodic Table ● AP Classroom: (https://myap.collegeboard.org/login) ● Lab software ● Scientific Calculator ● Laboratory Equipment

Unit VIII: Acids and Bases

Unit Summary

This unit builds on the content about chemical equilibrium studied in Unit VII. Chemical equilibrium plays an important role in acid-base chemistry and solubility. The proton-exchange reactions of acid-base chemistry are reversible reactions that reach equilibrium quickly, and much of acid-base chemistry can be understood by applying the principles of chemical equilibrium. Most acid-base reactions have either large or small values of K, which means qualitative conclusions regarding equilibrium state can often be drawn without extensive computations. The dissolution of a solid in a solvent can also be understood by applying the principles of chemical equilibrium because it is a reversible reaction that often reaches equilibrium quickly. In the final unit, the equilibrium constant is related to temperature and the difference in Gibbs free energy between the reactants and products.

Standards/Core Ideas/Performance Expectations/Progress Indicators

The state standards outlined below, and established by the New Jersey Department of Education, will guide instruction throughout this unit in *AP Chemistry:*

- *2020 New Jersey Student Learning Standards: Science:*
  - HS-PS1-6, HS-PS1-7, HS-PS1-8, HS-PS3-1
- *2023 New Jersey Student Learning Standards – Mathematics:*
  - N.Q.A.1-3; N.CN.C.7; A.CED.A. 1,2,4; A.REI.A.1-2; A.REI.B.3,4a,4b; A.REI.D.10; F.IF.C.7a; F.LE.A.1a-c,4; G.MG.A.1,2
- *2023 New Jersey Student Learning Standards English Language Arts:*
  - L.KL.11-12.2.A, RI.CR.11-12.1, RI.CI.11-12.2, RI.IT.11-12.3, RI.MF.11-12.6, W.AW.11-12.1.A, W.AW.11-12.1.D, W.IW.11-12.2.A, W.IW.11-12.2.B, W.WR.11-12.5, W.SE.11-12.6, SL.PE.11-12.1.A, SL.PE.11-12.1.B, SL.II.11-12.2, SL.PI.11-12.4, SL.UM.11-12.5
- *2020 New Jersey Student Learning Standards: Computer Science and Design Thinking*
  - 8.1.12.DA.5, 8.2.12.ED.1, 8.2.12.EC.3
- *2020 New Jersey Student Learning Standards: Career Readiness, Life Literacies, and Key Skills*
  - 9.4.12.CI.1, 9.4.12.CI.3, 9.4.12.CT.2, 9.4.12.IML.3-4, 9.4.12.TL.2

Unit Essential Questions	Unit Enduring Understandings
● What does pH measure, and how is it related to pOH in aqueous solutions?	● pH measures the hydronium ion concentration ([H3O+]) in a solution, and its sum with pOH (measuring hydroxide ion concentration) equals 14.0 at 25°C (pKw = pH + pOH).

• How can the pH of a neutral solution change with temperature? • How do strong acids and bases differ from weak acids and bases in terms of ionization in water? • What is the significance of Ka and Kb in understanding weak acid and base behavior? • How are the ionization constants of a conjugate acid-base pair related? • What happens when a strong acid is mixed with a strong base in terms of reaction and resulting pH? • How is a buffer solution formed, and what is its primary function? • What information can be obtained from the half-equivalence point in a weak acid-strong base titration? • How does the molecular structure of an acid influence its strength? • How can the predominant form of a weak acid or base in solution be predicted at a given pH? • What is the purpose of an acid-base indicator in a titration, and how is it chosen? • What determines a buffer solution's capacity to neutralize added acid or base? • How does pH qualitatively affect the solubility of a salt?	• The pH of pure, neutral water will deviate from 7.0 at temperatures other than 25°C because the Kw value is temperature dependent. • Strong acids and bases completely ionize or dissociate in aqueous solutions, while weak acids and bases only partially ionize, leaving a significant portion of their molecules un-ionized. • Ka and Kb are equilibrium constants that quantify the extent to which weak acids and bases react with water to produce hydronium or hydroxide ions, respectively. • For any conjugate acid-base pair, the acid ionization constant (Ka) and base ionization constant (Kb) are related by the water autoionization constant (Kw): Kw = Ka × Kb. • A strong acid and a strong base react quantitatively to form water, and the pH of the resulting solution is determined by the concentration of any excess reagent. • A buffer solution is formed when a weak acid (or base) is mixed with a strong base (or acid) such that the weak acid/base is in excess, and its primary function is to stabilize pH upon the addition of small amounts of acid or base. • At the half-equivalence point in a weak acid titration, the concentrations of the weak acid and its conjugate base are equal, which means the pH of the solution equals the pKa of the weak acid. • The molecular structure of an acid determines which protons participate in acid-base reactions and their relative strength, with electronegative elements increasing acid strength by stabilizing the conjugate base. • The predominant form of a weak acid (HA or A-) can be predicted by comparing the solution pH to the acid's pKa: if pH < pKa, HA predominates; if pH > pKa, A- predominates. • An acid-base indicator changes color at a specific pH, signaling the endpoint of a titration, and should be chosen such that its pKa is close to the pH at the equivalence point for accurate results. • A buffer's capacity is determined by the absolute concentrations of its conjugate acid and conjugate base components: higher concentrations mean greater capacity. • The solubility of a salt is pH sensitive if one of its constituent ions is a weak acid, a weak base, or the hydroxide ion, which can be understood qualitatively using Le Châtelier's principle.

Evidence of Learning

Formative & Alternative Assessments:	**Benchmark & Summative Assessments:**	**Resources Needed:**
• Unit VIII AP Classroom Multiple Choice Questions and Free Response Questions • Unit VIII - Sections 1-10 Practice Problems • Unit VIII Practice Assessment • Individual student check ins with teacher	• Unit VIII Quiz • Unit VIII Summative • Labs - Determining Ka of Weak Acid, Titrations	• Textbook and workbook • Periodic Table • AP Classroom: (https://myap.collegeboard.org/login) • Lab software • Scientific Calculator • Laboratory Equipment

Unit IX: Applications of Thermodynamics

Unit Summary

This unit allows students to connect principles and calculations across Units V-VIII. The thermodynamics of a chemical reaction is connected to both the structural aspects of the reaction and the macroscopic outcomes of the reaction. All changes in matter involve some form of energy change. One key determinant of chemical transformations is the change in potential energy that results from changes in electrostatic forces. Chemical systems undergo three main processes that change their energy: heating/cooling, phase transitions, and chemical reactions. Applying the laws of thermodynamics will allow students to describe the essential role of energy and explain and predict the direction of changes in matter.

Standards/Core Ideas/Performance Expectations/Progress Indicators

The state standards outlined below, and established by the New Jersey Department of Education, will guide instruction throughout this unit in *AP Chemistry:*

- *2020 New Jersey Student Learning Standards: Science:*
  - HS-PS1-1-8, HS-PS2-5, HS-PS3-1, HS-PS3-5
- *2023 New Jersey Student Learning Standards – Mathematics:*
  - N.Q.A.1-3; N.CN.C.7; A.CED.A. 1,2,4; A.REI.A.1-2; A.REI.B.3,4a,4b; A.REI.D.10; F.IF.C.7a; F.LE.A.1a-c,4; G.MG.A.1,2
- *2023 New Jersey Student Learning Standards English Language Arts:*
  - L.KL.11-12.2.A, RI.CR.11-12.1, RI.CI.11-12.2, RI.IT.11-12.3, RI.MF.11-12.6, W.AW.11-12.1.A, W.AW.11-12.1.D, W.IW.11-12.2.A, W.IW.11-12.2.B, W.WR.11-12.5, W.SE.11-12.6, SL.PE.11-12.1.A, SL.PE.11-12.1.B, SL.II.11-12.2, SL.PI.11-12.4, SL.UM.11-12.5
- *2020 New Jersey Student Learning Standards: Computer Science and Design Thinking*
  - 8.1.12.DA.5, 8.2.12.ED.1, 8.2.12.EC.3
- *2020 New Jersey Student Learning Standards: Career Readiness, Life Literacies, and Key Skills*
  - 9.4.12.CI.1, 9.4.12.CI.3, 9.4.12.CT.2, 9.4.12.IML.3-4, 9.4.12.TL.2

Unit Essential Questions	Unit Enduring Understandings
• How is entropy change related to the dispersion of matter and energy? • How can the standard entropy change for a process be calculated? • What does a negative Gibbs free energy change (ΔG°) indicate about a chemical process? • How is the standard Gibbs free energy change calculated using enthalpy and entropy? • How does temperature influence the thermodynamic favorability of a reaction based on ΔH° and ΔS°? • Why might a thermodynamically favored reaction not occur at a measurable rate? • How is the standard Gibbs free energy change (ΔG°) related to the equilibrium constant (K)? • What factors contribute to the free energy change of dissolution for a substance? • How can thermodynamically unfavorable processes be made to occur? • What is the fundamental difference between galvanic (voltaic) and electrolytic cells? • What common processes occur at the anode and cathode in all electrochemical cells? • How does the standard cell potential (E°) relate to the thermodynamic favorability of an electrochemical reaction? • How do concentrations of species affect cell potential under nonstandard conditions? • What relationships does Faraday's law allow chemists to determine in electrochemical cells?	• Entropy increases when matter becomes more dispersed (e.g., solid to liquid, liquid to gas, or increased gas volume/moles) and when energy is dispersed. • The standard entropy change (ΔS°reaction) for a process can be calculated from the absolute entropies (S°) of the species involved before and after the process occurs. • A negative ΔG° for a process means it is thermodynamically favored, which implies that products are favored at equilibrium under standard conditions. • The standard Gibbs free energy change (ΔG°) can be directly calculated from the standard enthalpy change (ΔH°) and standard entropy change (ΔS°) using the equation $\Delta G° = \Delta H° - T\Delta S°$. • The temperature conditions for a process to be thermodynamically favored ($\Delta G° < 0$) are predicted by the signs of ΔH° and ΔS°, determining if it is favored at all, no, high, or low temperatures. • A thermodynamically favored process might not occur at a measurable rate if it is under kinetic control, frequently due to a high activation energy. • The equilibrium constant (K) is related to the standard Gibbs free energy change (ΔG°) by the equations K = e^−ΔG°/RT or $\Delta G° = -RT \ln K$. • The free energy change for dissolution (ΔG° for dissolution) reflects the breaking of intermolecular interactions in the solid, the reorganization of the solvent, and the interaction of the dissolved species with the solvent. • Thermodynamically unfavorable processes can be made to occur by supplying external energy (e.g., electrical energy) or by coupling them with a thermodynamically favorable reaction. • Galvanic (voltaic) cells involve a thermodynamically favored reaction (positive voltage), whereas electrolytic cells involve a thermodynamically unfavored reaction (negative voltage) that requires an external potential. • For all electrochemical cells, oxidation always occurs at the anode, and reduction always occurs at the cathode. • A positive standard cell potential (E°) indicates a thermodynamically favored reaction, while a negative E° indicates a thermodynamically unfavored reaction. • Under nonstandard conditions, the cell potential varies with the concentrations of active species, decreasing as the system approaches equilibrium (where cell potential is zero) and increasing as it moves further from equilibrium. • Faraday's laws can be used to determine the stoichiometry of redox reactions, including the number of electrons transferred, mass of material deposited or removed, current, time elapsed, and charge of ionic species.

Evidence of Learning

Formative & Alternative Assessments:	Benchmark & Summative Assessments:	Resources Needed:
• Unit IX AP Classroom Multiple Choice Questions and Free Response Questions • Unit IX - Sections 1-11 Practice Problems • Unit IX Practice Assessment • Individual student check ins with teacher	• Unit IX Quiz • Unit IX Assessment • Labs - Calculating Cell Potential with Galvanic Cells	• Textbook and workbook • Periodic Table • AP Classroom: (https://myap.collegeboard.org/login) • Lab software • Scientific Calculator • Laboratory Equipment

Unit X: Review and Post Exam Project	
Unit Summary	
In the final weeks of the *AP Chemistry* course, students will review and prepare for the *AP Chemistry* exam and then instruction will center on a creative culminating project and targeted enrichment. Students will apply their chemistry knowledge by authoring and illustrating a children's book that explains a scientific concept to a K–3 audience. Working in pairs, students will simplify complex ideas using metaphors, analogies, and storytelling, accompanied by a hands-on lesson plan and activity tailored for a 30–40 minute visit to a local elementary school. This engaging project reinforces content mastery, communication skills, and pedagogical thinking. Concurrently, students planning to continue studying chemistry will receive focused instruction to prepare them for future coursework in high school or college.	
Standards/Core Ideas/Performance Expectations/Progress Indicators	

The state standards outlined below, and established by the New Jersey Department of Education, will guide instruction throughout this unit in *AP Chemistry:*
• *2020 New Jersey Student Learning Standards: Science:*
  ○ HS-PS1-1-8, HS-PS2-4-6, HS-PS3-1, HS-PS3-3, HS-PS3-5, HS-PS4-1, HS-PS4-3, HS-PS4-4, HS-ESS-1, HS-ESS-2,
• *2023 New Jersey Student Learning Standards – Mathematics:*
  ○ N.Q.A.1-3; N.CN.C.7; A.CED.A. 1,2,4; A.REI.A.1-2; A.REI.B.3,4a,4b; A.REI.D.10; F.IF.C.7a; F.LE.A.1a-c,4; G.MG.A.1,2
• *2023 New Jersey Student Learning Standards English Language Arts:*
  ○ L.KL.11-12.2.A, RI.CR.11-12.1, RI.CI.11-12.2, RI.IT.11-12.3, RI.MF.11-12.6, W.AW.11-12.1.A, W.AW.11-12.1.D, W.IW.11-12.2.A, W.IW.11-12.2.B, W.WR.11-12.5, W.SE.11-12.6, SL.PE.11-12.1.A, SL.PE.11-12.1.B, SL.II.11-12.2, SL.PI.11-12.4, SL.UM.11-12.5
• *2020 New Jersey Student Learning Standards: Computer Science and Design Thinking*
  ○ 8.1.12.DA.5, 8.2.12.ED.1, 8.2.12.EC.3
• *2020 New Jersey Student Learning Standards: Career Readiness, Life Literacies, and Key Skills*
  ○ 9.4.12.CI.1, 9.4.12.CI.3, 9.4.12.CT.2, 9.4.12.IML.3-4, 9.4.12.TL.2	

Unit Essential Questions	**Unit Enduring Understandings**
• How does the culminating project in the final weeks effectively reinforce *AP Chemistry* content mastery and essential skills? • What pedagogical strategies are employed to translate advanced chemical concepts for a foundational K-3 understanding? • What is the dual instructional focus for *AP Chemistry* students during the final weeks of the course? • How does authoring and illustrating a children's book enhance a high school student's scientific communication and application abilities? • What specific academic support is provided to students intending to pursue higher-level chemistry studies after the AP course?	• The culminating project reinforces content mastery, communication skills, and pedagogical thinking by requiring students to simplify complex chemical ideas for a K-3 audience through authoring a children's book and developing a hands-on lesson. • Advanced chemical concepts are effectively translated for a K-3 audience by simplifying complex ideas using metaphors, analogies, and storytelling, and developing a hands-on lesson plan and activity tailored for an elementary school visit. • The dual instructional focus during the final weeks is review and preparation for the AP Chemistry exam combined with a creative culminating project and targeted enrichment for students continuing chemistry studies. • Authoring and illustrating a children's book enhances scientific communication and application by requiring students to simplify complex scientific concepts for a K-3 audience, thereby applying chemistry knowledge and reinforcing communication skills. • Students planning to continue studying chemistry receive focused instruction and targeted enrichment

	explicitly designed to prepare them for future coursework in high school or college.

Evidence of Learning		
Formative & Alternative Assessments: ● AP Classroom Review ● AP Practice Multiple Choice Questions ● AP Practice Free Response Questions ● Rough Draft-Book Project ● Individual student check ins with teacher	**Benchmark & Summative Assessments:** ● Unit X Culminating Book Project	**Resources Needed:** ● Textbook and workbook ● Periodic Table ● AP Classroom: (https://myap.collegeboard.org/login) ● Lab software ● Scientific Calculator ● Laboratory Equipment

Section IX: Unit Reflection

The *AP Chemistry* instructional team must confer upon the completion of each instructional unit in the *AP Chemistry* curriculum and rate the degree to which the instructional units meet performance criteria established by the New Jersey Department of Education using the Unit Reflection Form. Completed unit reflection forms must be submitted to the Department Supervisor for approval upon completion of curriculum implementation with a complementing list of suggested modifications to the *AP Chemistry* curriculum.

Unit Reflection Form: *AP Chemistry*			
Lesson Activities:	**Strongly**	**Moderately**	**Weakly**
Foster student use of technology as a tool to develop critical thinking, creativity, and innovation skills;			
Are challenging and require higher-order thinking and problem-solving skills;			
Allow for student choice;			
Provide scaffolding for acquiring targeted knowledge/skills;			
Integrate modern, global perspectives, especially those regarding diversity, genocide, global issues, and historical ones regarding racial relations;			
Integrate 21st century skills;			
Provide opportunities for interdisciplinary connection and transfer of knowledge and skills;			
Are varied to address different student learning styles and preferences;			
Are differentiated based on student needs;			
Are student-centered, with the teacher acting as a facilitator and co-learner during the teaching and learning process;			
Provide means for students to demonstrate knowledge and skills and progress in meeting learning goals and objectives;			
Provide opportunities for student reflection and self-assessment;			

Provide data to inform and adjust instruction to better meet the varying needs of learners.			

Appendix

Writing Instruction and the RFH Community

Writing instruction should happen across the RFH Community. Writing across the curriculum is a philosophy that advances the belief that writing is a method of learning. Since all departments are committed to helping students learn, writing must be used as a methodology to advance student learning.

Each academic discipline has its own unique conventions, formats and structures. It is the responsibility of each department to agree upon domain-specific writing praxes, model them for students, and require them to utilize them on a consistent basis. Students must understand that acceptable writing in one domain may not be acceptable writing in another area. The development of domain-specific writing skills supports the overall development of the student writer because all writing is grounded in the writing situation: audience, context, purpose, subject, and writer. Representatives from the academic disciplines must share their domain-specific writing praxes with each other, identify intersections, and determine how to address perceived gaps that limit student learning.

Students must experience writing situations that help them learn how to think creatively and critically and communicate effectively in the academic disciplines. Writing instruction, regardless of the academic discipline, must always reinforce student understanding of the writing situation. When students experience writing situations, they must study examples of domain-specific writing in order to understand how writers communicate in discipline-related contexts. This does not mean information embedded in textbooks. Domain-specific writing is writing that is used to inform and influence readers as it draws them into an established circle of discourse. Students must use these non-fiction texts to develop the close reading skills that will shape their own writing. Focused engagement with domain-specific writing should not be limited to basic reading comprehension and topical understanding. It must also include the analysis of the writing situation that is represented in the text: audience, context, purpose, subject, and writer. The close reading of well-written texts—regardless of the domain—will show students the importance of writing mechanics, diction, and syntax. The development of close reading skills will also help the students grow in terms of their ability to construct and advance independent and original claims that are well-supported by evidence. Domain-specific writing is grounded in positioning of claims and the effective use of evidence.

The final written product is important; nevertheless, the learning that results in this production must not be devalued. The writing process is not limited to the basic steps of planning, drafting, revising, and editing/proofreading. It is a complex sequence of critical and creative thinking and writing that leads to the production of a text that provides evidence of learning and understanding. Students must ultimately develop the ability to self-assess the effectiveness of their writing as a representation of the writing situation. Without the use of models that evidence learning and understanding, students will not develop the ability to self-assess their own work—the true outcome of the writing process.

What types of writing situations should RFH students engage in?

RFH students should engage in writing situations across the curriculum that require them to:

- write to improve mechanical proficiency, diction usage, and syntactical sophistication
- write to narrate, describe, and reflect
- write to summarize and report
- write to classify and define
- write to explain how process leads to an outcome
- write to compare, contrast and evaluate
- write to speculate on cause and effect
- write to propose solutions and solve problems
- write to analyze

These writing situations should be positioned in a coordinated, developmental sequence that extends across the academic disciplines.

Upon Completion of Grade 12, RFH students must be ready to transition to the following writing situations:

- write to analyze
- write to persuade (argument)

The core foci of first-year college writing courses are analysis and argument. These courses orient the students to the demands and expectations of writing for the academic culture of college. At colleges/universities with carefully coordinated writing programs, students must demonstrate proficiency in analysis and argument before they transition to upper level courses that require them to engage in the following writing situation:

- write to investigate (research)