Washington Township School District

The mission of the Washington Township Public Schools *is to provide a safe, positive, and progressive educational environment that provides opportunity for all students to attain the knowledge and skills specified in the NJ Learning Standards at all grade levels, so as to ensure their full participation in an ever-changing world as responsible, self-directed and civic-minded citizens.*

Course Title:	**Advanced Placement Chemistry**
Grade Level(s):	**11th, 12th grade**

Duration:	*Full Year:*	**X**	*Semester:*		*Marking Period:*	
Course Description:	**The Advanced Placement Chemistry course will provide highly motivated students with strong interests in science the opportunity to experience a college level general chemistry experience. This course is designed to follow the standards and expectations of set forth by the College Board using six "Big Ideas" to extend student understanding of chemistry topics. Students will build upon fundamentals from a previous chemistry course and be further challenged through new laboratory activities and extended problem solving. An inquiry-based learning environment will be provided in this course that mimics the curriculum and rigor of a collegiate level general chemistry course. Upon completion of the Advanced Placement Chemistry course, students will be prepared to pursue and succeed in future physical science classes on the advanced and collegiate level.**					
Grading Procedures:	**Grades will be determined using these categories and weights:** **Tests 50%, Quizzes 20%, Lab 20%, Independent Work 10%** **Midterm and Final examinations will be administered**					
Primary Resources:	**College Board: AP Chemistry Course Description and Course Planning and Pacing Guides** **Next Generation Science Standards (NGSS)** **New Jersey Student Learning Standards (NJSLS)** **Chemistry: A Molecular Approach (4th Edition), Tro, N.** **"Mastering Chemistry with Pearson" – e text**					

Washington Township Principles for Effective Teaching and Learning

- Implementing a standards-based curriculum
- Facilitating a learner-centered environment
- Using academic target language and providing comprehensible instruction
- Adapting and using age-appropriate authentic materials
- Providing performance-based assessment experiences
- Infusing 21st century skills for College and Career Readiness in a global society

Designed by:	Mr. Andrew Holmes
Under the Direction	Dr. Patricia Hughes

Written: July 2017

Revised: _____

BOE Approval: _____

Unit 1 Title: The Periodic Table and Chemical Bonding

Unit Description: This unit will review and extend knowledge of atoms and ions using examples and problem solving that highlights sub-atomic particles, atomic and ionic radius, electronegativity and ionization energy. This unit will also review and extend student understanding of ionic, covalent and metallic bonding with consideration of periodic table properties and trends. Formula writing, compound nomenclature, and molecular geometry will also be reviewed and practiced during this unit.

Unit Duration: 4 weeks

Desired Results

Standard(s): NGSS: HS-PS1-3, HS-PS2-6, HS-PS3-2

College Board: "Enduring Understanding" 1.A, 1.B, 1.C, 1.D, 2.A, 2.C, 2.D

NGSS Indicators: PS1.A "Structure and Properties of Matter", PS2.B "Types of Interactions", PS3.A "Definitions of Energy", PS3.C "Relationships between Energy and Forces"

College Board Indicators: "Essential Knowledge" 1.A.1, 1.A.2, 1.B.1, 1.B.2, 1.C.1, 1.C.2, 2.C.1, 2.C.2, 2.C.3, 2.C.4, 2.D.1, 2.D.2, 2.D.3, 2.D.4

AP BIG IDEA 1: "The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangement of atoms. These atoms retain their identity in chemical reactions"

AP BIG IDEA 2: "Chemical and physical properties of materials can be explained by the structure and arrangement of atoms, ion, or molecules and the forces between them"

Understandings:
Students will understand that…

All matter is made of atoms. There are a limited number of types of atoms; these are the elements (E.U.1.A)

Molecules are composed of specific combinations of atoms; different molecules are composed of combinations of different elements and of combinations of the same elements in differing amounts and proportions. (E.K.1.A.1)

Chemical analysis provides a method for determining the relative number of atoms in a substance, which can be used to identify the substance or determine its purity. (E.K.1.A.2)

The atoms of each element have unique structures arising from interactions between electrons and nuclei. (E.U.1.B)

The atom is composed of negatively charged electrons, which can leave the atom, and a positively charged

Essential Questions:

1. What sub-atomic particle details dictate the ratios by which atoms bond to form compounds?
2. What systematic naming and formula writing rules are used to accurately communicate compounds?
3. Why is the atomic mass of each element on the Periodic Table a single number rather than a collection of isotopic mass values?
4. What are the Laws of Definite Proportions and Multiple Proportions?
5. Why are atomic radii, electronegativity, and ionization energy considered together when making predictions about the chemical behavior of atoms?
6. How do the atomic radii, electronegativity and ionization energy property values compare across periods and down groups on the Periodic Table?

nucleus that is made of protons and neutrons. The attraction of the electrons to the nucleus is the basis of the structure of the atom. Coulomb's law is qualitatively useful for understanding the structure of the atom. (E.K.1.B.1)

The electronic structure of the atom can be described using an electron configuration that reflects the concept of electrons in quantized energy levels or shells; the energetics of the electrons in the atom can be understood by consideration of Coulomb's law. (E.K.1.B.2)

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. (E.U.1.C)

Many properties of atoms exhibit periodic trends that are reflective of the periodicity of electronic structure. (E.K.1.C.1)

The currently accepted best model of the atom is based on the quantum mechanical model. (E.K.1.C.2)

Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms. (E.U.1.D)

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. (E.U.2.A)

The strong electrostatic forces of attraction holding atoms together in a unit are called chemical bonds. (E.U.2.C)

In covalent bonding, electrons are shared between the nuclei of two atoms to form a molecule or polyatomic ion. Electronegativity differences between the two atoms account for the distribution of the shared electrons and the polarity of the bond. (E.K.2.C.1)

Ionic bonding results from the net attraction between oppositely charged ions, closely packed together in a crystal lattice. (E.K.2.C.2)

Metallic bonding describes an array of positively charged metal cores surrounded by a sea of mobile valence electrons. (E.K.2.C.3)

The localized electron bonding model describes and predicts molecular geometry using Lewis diagrams and the VSEPR model. (E.K.2.C.4)

7. How can Periodic Table property trends be used to predict observations and results during chemical reaction experiments?

8. How does the size, charge and ratios of ions contribute to forces of attraction according to Coulomb's Law?

9. How are ionic, polar covalent, non-polar covalent, and metallic materials different in terms of the way electrons are used to generate binding forces?

10. What are typical physical properties exhibited by solids held together by ionic, covalent, and metallic bonds?

11. How are the properties of ionic, covalent, and metallic materials a reflection of the localization or delocalization of electrons?

12. What is VSEPR theory and how does it govern the three-dimensional existence of particles in chemistry?

13. What geometric shapes results from different combinations of bonded and lone electron pairs competing for space around central atoms in molecules and polyatomic ions?

14. What factors contribute to the degree of polarity displayed by molecules and ions?

15. Why do certain atoms have the ability to form expanded octet molecules while other atoms do not?

16. What are isomers and why do isomers have different physical properties?

17. How do sigma bonds and pi bonds compare and how do they contribute to a deeper understanding of molecular geometry through bond hybridization models?

The type of bonding in the solid state can be deduced from the properties of the solid state. (E.U.2.D)

Ionic solids have high melting points, are brittle, and conduct electricity only when molten or in solution. (E.K.2.D.1)

Metallic solids are good conductors of heat and electricity, have a wide range of melting points, and are shiny, malleable, ductile, and readily alloyed. (E.K.2.D.2)

Covalent network solids have properties that reflect their underlying 2-D or 3-D networks of covalent bonds. Covalent network solids generally have extremely high melting points and are hard. (E.K.2.D.3)

Molecular solids with low molecular weight usually have low melting points and are not expected to conduct electricity as solids, in solution, or when molten. (E.K.2.D.4)

Assessment Evidence

Performance Tasks:

1. Identify particles that are isoelectronic
2. Choose atoms/ions with largest or smallest radius
3. Identify elements using PES spectrum data
4. Explain relationship between size and ionization energy
5. Apply effective nuclear charge and shielding effect to problems
6. Compare isotopes using mass number and symbolism
7. Explain attractive and repulsive forces within atoms
8. Predict properties of elements according to period/group location
9. Identify bond types using electronegativity difference
10. Recognize bond types in chemical formulas
11. Use Coulomb's Law to explain lattice energy data
12. Accurately use VSEPR theory to draw Lewis structures
13. Determine shapes, angles and hybridization for molecules
14. Determine hybridization for various molecules and ions
15. Explain polar and non-polar nature in different particles

Other Evidence:

UNIT 1 QUIZ 1 "The Periodic Table and Atomic Forces"

UNIT 1 QUIZ 2 "Chemical Bonding and Molecular Geometry"

Pre-Lab Assignments and Post-Lab Quizzes for the following experiments:

LAB: "Gravimetric Analysis of Metals in a Penny"

LAB: "Using Coulomb's Law to Compare Properties of Solids"

LAB: "Molecular Geometry and Polarity (pHet)"

Independent Work and Cooperative Learning Activities:

"Warm Up Questions" – Weekly completion and explanation of assigned AP Exam style multiple choice questions covering UNIT 1 topics

"APEQ Classwork" – Completion and discussion of answers and strategies for past AP Exam free response questions covering UNIT 1 topics

"Average Atomic Mass" – Determination of isotope properties from provided sub-atomic particle and abundance data

"Electron Configuration" – Analysis and problem solving related to valence electrons, energy shells, orbitals, and spin for atoms and ions

"Alloy Examination" – Research and communicate the atomic composition, ratios and unique properties of famous alloys

"Periodic Table Trends" –Problem solving and writing assignments that highlight Coulomb's law and atomic size and forces relationships

"Property Comparisons" – Prediction and follow up research linking atomic make-up, bond types, and observable physical properties

"Gravimetric Analysis" – Research into various ways that mass change in the laboratory can lead to quantitative answers and identification in the lab

	"Molecular Geometry Analysis" – Build Lewis structures and determine bond angles, polarity, molecular shape, and bond hybridization details

Benchmarks:

UNIT 1 TEST, Midterm Exam

Learning Plan

Learning Activities:

Chapter 2 – Atoms and Elements (1-2 class periods)

- Define and compare examples of atoms, ions, isotopes in terms of sub-atomic particles
- Review properties and periodic table placement for metals, nonmetals and metalloids
- Review symbolic representation of ions and isotopes and discuss factors influencing stability of ions and isotopes
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 7 – The Quantum-Mechanical Model of the Atom (2-3 class periods)

- Highlight electron properties included within an electron configuration
- Review and discuss orbitals and electron spin qualities using Hund's Rule and orbital diagrams
- Explain electron transitioning and reinforce relationship between electrons and energy
- Discuss wavelength and frequency as defining properties of electromagnetic energy waves
- Examine PES graphs to draw conclusion about the identity of an atom/ion
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 8 – Periodic Properties of the Elements (3-4 class periods)

- Review and extend periodic table trends for properties of atomic radius, valence electrons and oxidation state
- Explain relationships among atomic/ionic radius, ionization energies, and electronegativity
- Extend understanding of effective nuclear charge and the shielding effect
- Predict relative behavior tendencies for various atoms based on periodic table properties
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 3 – Molecules, Compounds, and Chemical Equations (3-4 class periods)

- Accurately write formulas and name ionic and molecular compounds, as well as acids
- Calculate molar mass and percent composition from compound formulas
- Determine empirical formulas from mass or mass percent data
- Balance equations to satisfy Law of Conservation of Matter
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 9 – Chemical Bonding I: The Lewis Model Equations (2-3 class periods)

- Deduce bond types within compounds using periodic table and electronegativity knowledge
- Explain role of particle size, charge, and ratio in determining ionic bond strength and lattice energy
- Identify ionic crystals that have greatest lattice energy
- Accurately draw Lewis structures to represent lone pairs as well as bonded pairs to satisfy the octet rule

- Correctly use single, double, and triple covalent bonds to build molecular structures
- Research and discuss resonance and isomerization using examples and comparison
- Practice all chapter topics using textbook, workbook, and College Board resource
- Use of vocabulary and examples to review and extend understanding

Chapter 10 – Chemical Bonding II: Molecular Shapes, Valence Bond Theory, and Molecular Orbital Theory (3-4 class periods)

- Review and discuss VSEPR theory and highlight patterns in molecular geometry
- Examine Lewis structures and label shape names and bond angles for traditional molecules and ions
- Examine Lewis structures and label shape names and bond angles for expanded octet molecules and ions
- Use examples and visuals to consider resulting polarity for molecules with certain geometries
- Identify molecular geometry details within larger molecules with multiple central atoms
- Model and discuss bond hybridization as a teaching viewpoint to better understand consistency in bonding
- Explain sigma and pi bond differences using electrons, orbitals, and forces knowledge
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 12 – Solids and Modern Materials (1-2 class periods)

- Read and examine visual models comparing traditional ionic crystals to more complex crystal lattices
- Research and discuss network covalent molecules and consider properties of this matter
- Discuss role of delocalized electrons in metallic bonding
- Justify typical properties of metallic elements and alloys using metallic bonding model
- Examine types of metallic alloys in terms of preparation and resulting properties
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Resources:

Textbook – Chapters 2, 3, 7, 8, 9, 10, 12 (w/ Mastering Chemistry E-Text)

Apcentral.collegeboard.com

Phet.colorado.edu: pHet Sims Activities - “Molecule Shapes”, “Molecule Polarity”

Crash Course Chemistry video series

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
Standard(s): PS1.A “The structure and interaction of matter at the bulk scale are determined by electrical forces within and between atoms”	
4.0	**Students will be able to:** • Predict properties and explain differences among solids by combining knowledge of Coulomb’s Law and knowledge of Periodic Table property trends • Accurately build Lewis structures using different combinations of electron pairs in a variety of molecules and polyatomic ions and analyze these models for molecular geometry details such as shape, bond angles, and bond hybridization

3.0	**Students will be able to:** • Communicate conclusions about the properties of ionic, covalent and metallic materials and how these properties reflect the use of valence electrons as a binding force between neighboring atoms • Identify hypovalent and hypervalent particles and explain energy factors that contribute to these non-traditional molecules
2.0	**Students will be able to:** • Write formulas for ionic and molecular compounds with consideration for valence electron data and according to systematic nomenclature rules • Recognize that atoms in the upper-right hand corner of the Periodic Table are much smaller and more able to attract and hold electrons, while atoms in the lower-left hand corner of the Periodic Table are larger and less able to attract and hold electrons. ***Students will recognize and recall specific vocabulary, including:*** Atom, Ion, Proton, Neutron, Electron, Valence Electron, Coulomb's Law, Charge, Lattice Energy, Polar, Non-Polar, Chemical Bond
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Standard(s): PS2.B: "Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects."	
4.0	**Students will be able to:** • Recognize polarity in molecules and communicate the impact of polarity on the properties of pure substances and mixtures through comparisons of matter examples • Build Lewis structures representing isomers of molecular substances and identify and communicate how specific functional groups contribute to polarity and therefore physical property differences
3.0	**Students will be able to:** • Use periodic table knowledge with Lewis structure construction to recognize and predict polar or non-polar nature in simple molecules • Explain the cause of traditional metal properties such as luster, conductivity, and malleability using knowledge of delocalized electrons, density and atomic forces of attraction and repulsion
2.0	**Students will be able to:** • Use electronegativity difference and basic knowledge of the elements to predict whether bond nature will be ionic, polar covalent, or non-polar covalent • Recognize similarities and differences among the typical physical and chemical properties among ionic, molecular and metallic solids ***Students will recognize and recall specific vocabulary, including:*** Crystalline, Lattice Energy, Polar, Non-Polar, Functional Group, Isomer, Bond Hybridization, Sigma Bond,

	Pi Bond, Malleable, Luster, Conductivity
1.0	**With help, partial success at level 2.0 content and level 3.0 content:**
0.0	**Even with help, no success**

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments to create challenge and foster discovery of knowledge
Struggling Learners	Facilitate access to review materials and remediation activities through OneNote content library and through online textbook content
English Language Learners	Coordinate with ELL advisors to modify activities where appropriate http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504 Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development	

of appropriate plans.	

Interdisciplinary Connections

Indicators:

ELA/Literacy –

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2), (HS-PS1-5)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3), (HS-PS1-6)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

SL.11-12.5Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5), (HS-PS1-7)

MP.4 Model with mathematics. (HS-PS1-4), (HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5),

Integration of 21st Century Skills

Indicators:

College Board Science Practices:

SP1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP2: The student can use mathematics appropriately.

SP3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

SP4: The student can plan and implement data collection strategies in relation to a particular scientific question.

SP5: The student can perform data analysis and evaluation of evidence.

SP6: The student can work with scientific explanations and theories.

SP7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.
CRP5 – Consider the environmental, social and economic impacts of decisions.
CRP6 – Demonstrate creativity and innovation.
CRP7 – Employ valid and reliable research strategies.
CRP8 – Utilize critical thinking to make sense of problems and persevere in solving them.
CRP10 – Plan education and career paths aligned to personal goals.
CRP11 – Use technology to enhance productivity.
CRP12 – Work productively in teams while using cultural global competence.
9.2 Career Awareness, Exploration, and Preparation
9.2.12.C.1 – Review career goals and determine steps necessary for attainment.
9.2.12.C.3 – Identify transferable career skills and design alternate career plans.
9.2.12.C.6 – Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources for owning and managing a business.

Unit 2 Title: Chemical Reactions and Mole Quantities

Unit Description: This unit will extend student knowledge of chemical reactions through detailed instruction and extended problem solving of topics such as net-ionic equations, solubility rules, mole conversions, mole concentration systems, and stoichiometric calculations. Classwork and laboratory activities in this unit will emphasize quantitative problem solving and stress accuracy in measurement and significant digits during scientific problem solving.

Unit Duration: 4 weeks

Desired Results

Standard(s): NGSS: HS-PS1-1, HS-PS1-2, HS-PS1-7

College Board: "Enduring Understanding" 1.A, 1.E, 3.A, 3.B, 3.C

NGSS Indicators: PS1.B "Chemical Reactions", PS2. B "Types of Interactions", PS3.D "Energy in Chemical Processes"

College Board Indicators: "Essential Knowledge" 1.A.1, 1.A.2, 1.A.3, 1.E.1, 1.E.2, 3.A.1, 3.A.2, 3.A.3, 3.B.1, 3.B.3, 3.C.1

AP BIG IDEA 1: "The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangement of atoms. These atoms retain their identity in chemical reactions"

AP BIG IDEA 3: "Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons"

Understandings:
Students will understand that…

All matter is made of atoms. There are a limited number of types of atoms; these are the elements (E.U.1.A)

Molecules are composed of specific combinations of atoms; different molecules are composed of combinations of different elements and of combinations of the same elements in differing amounts and proportions. (E.K.1.A.1)

Chemical analysis provides a method for determining the relative number of atoms in a substance, which can be used to identify the substance or determine its purity. (E.K.1.A.2)

The mole is the fundamental unit for counting numbers of particles on the macroscopic level and allows quantitative connections to be drawn between laboratory experiments, which occur at the macroscopic level, and chemical processes, which occur at the atomic level. (E.K.1.A.3)

Atoms are conserved in physical and chemical processes. (E.U.1.E)

Essential Questions:

1. Why do chemical equations that represent chemical reactions need to be balanced with coefficients?
2. How do balanced chemical reactions reflect and support the Law of Conservation of Matter?
3. How do synthesis and decomposition reactions compare and what role does energy play in these two types of chemical reactions?
4. What are single and double displacement reactions?
5. Why do some combinations of elements and compounds for single and double displacement reactions result in the formation of products while others do not?
6. How can previously gained knowledge of Coulomb's Law and Periodic Table properties such as ionization energy and atomic radius be

Physical and chemical processes can be depicted symbolically; when this is done, the illustration must conserve all atoms of all types. (E.K.1.E.1)

Conservation of atoms makes it possible to compute the masses of substances involved in physical and chemical processes. Chemical processes result in the formation of new substances, and the amount of these depends on the number and the types and masses of elements in the reactants, as well as the efficiency of the transformation. (E.K.1.E.2)

Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form. (E.U.3.A)

A chemical change may be represented by a molecular, ionic, or net ionic equation. (E.K.3.A.1)

Quantitative information can be derived from stoichiometric calculations that utilize the mole ratios from the balanced chemical equations. The role of stoichiometry in real-world applications is important to note, so that it does not seem to be simply an exercise done only by chemists (E.K.3.A.2)

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. (E.K.3.A.3)

Synthesis reactions are those in which atoms and/or molecules combine to form a new compound. Decomposition is the reverse of synthesis, a process whereby molecules are decomposed, often using heat. (E.K.3.B.1)

In oxidation-reduction (redox) reactions, there is a net transfer of electrons. The species that loses electrons is oxidized, and the species that gains electrons is reduced. (E.K.3.B.3)

Chemical and physical transformations may be observed in several ways and typically involve a change in energy. (E.U.3.C)

Production of heat or light, formation of a gas, and formation of a precipitate and/or a color change are possible evidences that a chemical change has occurred. (E.K.3.C.1)

used predict and justify results of chemical reactions?

7. What are combustion reactions and what value do they impart to society?
8. What factors cause many (but not all) chemical reactions to also classified as reduction-oxidation reactions?
9. What are the numerical definitions of a mole?
10. How can molar mass and percent composition be determined using knowledge of moles?
11. What is the molarity concentration system and how can experimental measurements be used to determine the molarity of particles in a solution?
12. What is an empirical formula and how can laboratory data and the mole concept be used together to determine empirical formulas?
13. How can the mole concept and knowledge of chemical reactions be combined to make predictions and solve problems through stoichiometry?
14. Why is stoichiometric problem solving so important to scientists?
15. What is a limiting reactant and how can a limiting reactant be determined using stoichiometric problem solving?
16. How does percent error calculation reflect laboratory efficiency?

Assessment Evidence

Performance Tasks:

1. Determine insoluble solids using solubility rules

Other Evidence:

UNIT 2 QUIZ 1 “Net-Ionic Equations and Chemical Reactions”

UNIT 2 QUIZ 2 “Mole Quantities and Stoichiometry”

2. Recognize and eliminate spectator ions from chemical equations
3. Write accurate net-ionic equations to represent aqueous reactions
4. Predict product and balance synthesis and decomposition reactions
5. Predict products and balance displacement and combustion
6. Recognize oxidation and reduction changes
7. Convert in and out of moles using mass, particles, and volume
8. Calculate molarity concentrations using provided data
9. Compare ion concentrations in various types of solutions
10. Determine empirical formulas through mole conversions
11. Calculate mass percent composition with pure substances
12. Use stoichiometry to predict quantities consumed and formed
13. Identify and explain limiting reactants
14. Calculate percent yield and examine sources of error during lab work

Pre-Lab Assignments and Post-Lab Quizzes for the following experiments:

LAB: "The Eight Solutions Experiment"

LAB: "Green Chemistry: Stoichiometry"

LAB: "Molar Volume of a Gas"

Independent Work and Cooperative Learning Activities:

"Warm Up Questions" – Weekly completion and explanation of assigned AP Exam style multiple choice questions covering UNIT 2 topics

"APEQ Classwork" – Completion and discussion of answers and strategies for past AP Exam free response questions covering UNIT 2 topics

"Mixed Mole Math" – Accurate calculation of mole quantities, mole concentrations, and empirical formulas from provided measurements

"Reaction Writing and Analysis" – Build and balance chemical equations using knowledge of formula writing and chemical reaction types

"Stoichiometry" – Use of mole math and reactions knowledge to make accurate predictions for reactants and products in chemical changes

"Net Ionic Equations" – Extend traditional reaction writing to include consideration for spectator ions and solubility realities of specific particles

"Discovering Color" – Research and communication of light energy topics including wavelength, frequency, absorbance and Beer's Law

"Water Treatment" – Post lab research and work investigating treatment measures to assure that public water is clean and healthy

"What is Green Chemistry?" – Post lab research and work investigating tenets of eco-conscious decision making in industrial chemistry

Benchmarks:

UNIT 2 Test, Midterm Exam

Learning Plan

Learning Activities:

Chapter 4 – Chemical Quantities and Aqueous Reactions (4-5 class periods)

- Review general formats for synthesis, decomposition, single and double displacement reactions
- Review qualities of combustions reactions that set them apart from other common reactions
- Build and balance reactions by interpreting data, predicting product and balancing equations
- Modify reaction writing to include consideration for physical states and solubility tendencies
- Identify and eliminate spectator ions in aqueous reactions
- Identify and highlight insoluble precipitates in aqueous reactions
- Examine reactions for reduction-oxidation behavior
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 1 – Matter, Measurement and Problem Solving (1-2 class periods)

- Use examples to review and extend understanding of significant digits in measurements
- Review and apply significant digit determination to express calculated answer with correct accuracy

- Discuss differences among accuracy and precision
- Use laboratory equipment to accurately read volume and temperature scales
- Calculate percent error during laboratory activities
- Use of vocabulary and examples to review and extend understanding of matter
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 3 – Molecules, Compounds and Equations (2-3 class periods)

- Review fundamental definitions of the mole concept
- Use mole definitions to accurately convert among moles, mass, particles and gas volume
- Extend mole problem solving to include empirical formulas and molarity
- Extend and apply mole concept to include ion concentration and precipitate formation problems
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 4 – Chemical Quantities and Aqueous Reactions (3-4 class periods)

- Review general format for stoichiometry problem solving and dimensional analysis
- Use examples to highlight correct use of conversion factors and units in stoichiometry problems
- Complete traditional stoichiometry problems to predict mass or moles of reactants or products
- Extend stoichiometry applications to include predictions of ion concentration and precipitate formation
- Discuss role of limiting reactants and identify limiting reactants using chemical equations and stoichiometry
- Calculate percent yield for experimental reactions and discuss possible sources of error during experimentation
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 21 – Organic Chemistry (1-2 class periods)

- Review organic chemistry vocabulary used to classify organic molecules in reactions
- Extend understanding of combustion reactions to include additional hydrocarbon reactants besides alkanes
- Research and examine common organic reaction types such as elimination, addition, and substitution
- Present and discuss chemical reaction types common for alcohols, carboxylic acids, and other functional groups
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 23 – Chemistry of Nonmetals (1-2 class periods)

- Review and discuss relationships among nonmetal elements
- Explain that reaction tendencies among nonmetals reflect atomic structure and periodic properties
- Examine common reactions among nitrogen, oxygen and the halogen elements
- Research and discuss conditions necessary for noble gases to participate in chemical reactions
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 24 – Metals and Metallurgy (1-2 class periods)

- Review and discuss relationships among metal elements
- Explain that reaction tendencies among metals reflect atomic structure and periodic properties
- Examine common reactions among main group metals
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 25 – Transition Metals and Coordination Compounds (1-2 class periods)

- Review and discuss relationships among transition metal elements
- Explain that reaction tendencies among transition metals reflect subtle differences in nucleus and electron cloud
- Examine coordination compounds, complex ions and chelation using transition metal examples
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Resources:

Textbook – Chapters 1, 3, 4, 21, 23, 24, 25 (w/ Mastering Chemistry E-Text)

Apcentral.collegeboard.com

Phet.colorado.edu

Crash Course Chemistry video series

PS1.B "The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions"	
4.0	***Students will be able to*:** • Write accurate net-ionic equations that both predict the products that will form during reactions but also correctly eliminate spectator ions and identify insoluble precipitates. • Solve complex stoichiometry problems that predict reactant and/or product quantities through a variety of measurement conversions in with reference to mole ratios in the balanced equation
3.0	***Students will be able to*:** • Recognize if chemical reactions qualify as redox reactions by determining oxidation states of reactants and comparing to oxidation states of reactants • Calculate empirical formulas for unknown compounds using mass data and applications of mole conversions and molar mass
2.0	***Students will be able to:*** • Predict products for traditional synthesis, decomposition, displacement, and combustion reactions • Convert measurements in and out of mass, volume, and particle quantity using fundamental definitions of the mole concept and algebra ***Students will recognize and recall specific vocabulary, including:*** • Compounds, Chemical Formulas, Cation, Anion, Molecule, Reactant, Product, Synthesis, Decomposition, Displacement, Combustion
1.0	***With help, partial success at level 2.0 content and level 3.0 content:***
0.0	***Even with help, no success***

PS3.D "Although energy cannot be destroyed it can be converted into less useful forms – for example, to thermal energy in the surrounding environment"	
4.0	***Students will be able to*:** • Predict bonding factors that cause some reactions to release energy while other reactions require an input of energy • Explain the relationships between light and color and explain how electromagnetic energy is generated and transferred by excited transitioning electrons
3.0	***Students will be able to*:** • Communicate how bond type and bond energy differences between reactants and products explains energy change during chemical changes • Hypothesize factors contributing to the exothermic or endothermic nature of reactions and why both types of energy change occur in the universe
2.0	***Students will be able to:*** • Recognize similarities and differences in energy, wavelength, and frequency among types of electromagnetic energy found in the world • Discover that energy can be neither created nor destroyed, but rather energy change during reactions is a transfer from one source to another ***Students will recognize and recall specific vocabulary, including:*** • Heat, Temperature, Law of Conservation of Energy, Exothermic, Endothermic, Light, Color, Wavelength, Frequency, Absorbance, Transmittance
1.0	***With help, partial success at level 2.0 content and level 3.0 content:***
0.0	***Even with help, no success***

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments to create challenge and foster discovery of knowledge
Struggling Learners	Facilitate access to review materials and remediation activities through OneNote content library and through online textbook content
English Language Learners	Coordinate with ELL advisors to modify activities where appropriate http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the

		curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Indicators:

ELA/Literacy –

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2), (HS-PS1-5)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3), (HS-PS1-6)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

SL.11-12.5Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5), (HS-PS1-7)

MP.4 Model with mathematics. (HS-PS1-4), (HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5),

Integration of 21st Century Skills

Indicators:

College Board Science Practices:

SP1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP2: The student can use mathematics appropriately.

SP3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

SP4: The student can plan and implement data collection strategies in relation to a particular scientific question.

SP5: The student can perform data analysis and evaluation of evidence.

SP6: The student can work with scientific explanations and theories.

SP7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.

CRP5 – Consider the environmental, social and economic impacts of decisions.
CRP6 – Demonstrate creativity and innovation.
CRP7 – Employ valid and reliable research strategies.
CRP8 – Utilize critical thinking to make sense of problems and persevere in solving them.
CRP10 – Plan education and career paths aligned to personal goals.
CRP11 – Use technology to enhance productivity.
CRP12 – Work productively in teams while using cultural global competence.
9.2 Career Awareness, Exploration, and Preparation
9.2.12.C.1 – Review career goals and determine steps necessary for attainment.
9.2.12.C.3 – Identify transferable career skills and design alternate career plans.
9.2.12.C.6 – Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources for owning and managing a business.

Unit 3 Title: States of Matter and Physical Changes

Unit Description: This unit will extend student knowledge of physical properties through comparisons among solids, liquids, solutions and gases. Extended instruction and problem solving focusing on intermolecular forces and physical change will occur during this unit and be used to compare and contrast with chemical property and chemical change content considered during Unit 2.

Unit Duration: 5 weeks

Desired Results

Standard(s): NGSS: HS-PS1-3, HS-PS3-1, HS-PS3-2

College Board: "Enduring Understanding" 1.B, 1.E, 2.A, 2.B, 2.C, 5.A, 5.B, 5.D

NGSS Indicators: PS1.A "Structure and Properties of Matter", PS2.B "Types of Interactions", PS3.A "Definitions of Energy", PS3.C "Relationships between Energy and Forces"

College Board Indicators: "Essential Knowledge" 1.B.1, 1.E.1, 2.A.1, 2.A.2, 2.A.3, 2.B.1, 2.B.2, 2.B.3, 2.C.1, 2.C.2, 5.A.1, 5.B.3, 5.D.1, 5.D.2

AP BIG IDEA 1: "The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangement of atoms. These atoms retain their identity in chemical reactions"

AP BIG IDEA 2: "Chemical and physical properties of materials can be explained by the structure and arrangement of atoms, ion, or molecules and the forces between them"

AP BIG IDEA 5: "The laws of thermodynamics describe the essential role of and energy and explain and predict the direction of changes in matter"

Understandings:
Students will understand that…

The atoms of each element have unique structures arising from interactions between electrons and nuclei. (E.U.1.B)

The atom is composed of negatively charged electrons, which can leave the atom, and a positively charged nucleus that is made of protons and neutrons. The attraction of the electrons to the nucleus is the basis of the structure of the atom. Coulomb's law is qualitatively useful for understanding the structure of the atom. (E.K.1.B.1)

Atoms are conserved in physical and chemical processes. (E.U.1.E)

Physical and chemical processes can be depicted symbolically; when this is done, the illustration must conserve all atoms of all types. (E.K.1.E.1)

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. (E.U.2.A)

The different properties of solids and liquids can be explained by differences in their structures, both at the particulate level and in their supramolecular structures. (E.K.2.A.1)

The gaseous state can be effectively modeled with a mathematical equation relating various macroscopic properties. A gas has neither a definite volume nor a definite shape; because the effects of attractive forces are minimal, we usually assume that the particles move independently. (E.K.2.A.2)

Solutions are homogenous mixtures in which the physical properties are dependent on the concentration of the solute and the strengths of all interactions among the particles of the solutes and solvent. (E.K.2.A.3)

Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance, including how the observable physical state changes with temperature. (E.U.2.B)

London dispersion forces are attractive forces present between all atoms and molecules. London dispersion forces are often the strongest net intermolecular force between large molecules. (E.K.2.B.1)

Dipole forces result from the attraction among the positive ends and negative ends of polar molecules. Hydrogen bonding is a strong type of dipole-dipole force

Essential Questions:

1. What are the fundamental differences between chemical changes and physical changes?
2. Why is energy either used or released during both chemical and physical changes?
3. How does the size and electron configuration of an atom influence the forces of attraction it has with other atoms in a sample?
4. What is polarizability and how is it generated in all particles by the electron cloud of atoms?
5. What are intermolecular forces and how are they different from chemical bonds?
6. How do London dispersion forces, dipole-dipole forces, ion-dipole forces, and hydrogen bonding forces compare in terms of occurrence and impact on physical properties?
7. Why are evaporation and melting endothermic processes while condensation and freezing are exothermic processes?
8. What occurs at the atomic/molecular level when pure substances undergo physical changes as energy is either added or removed?
9. How can previously gained knowledge of molecular geometry and polarity be used to better understand and predict physical properties such as density, physical state and boiling point?
10. Why is hydrogen bonding the strongest IMF and why are dispersion forces the weakest IMF?
11. How does the polarity of water explain is ability to act as a strong solvent of many solid and liquid solutes?
12. How can previously gained knowledge of atomic radius and ionization energy be used to comprehend why some ionic solutes dissolve better in water than others?
13. What conclusions can be made about the relationships among intermolecular forces and physical states?
14. What comparisons and problem solving can be done when provided with heating curve and phase diagram graphs?
15. What relationships are observed when applying Boyle's Law, Charles' Law, Avogadro's Law, Graham's Law, and Dalton's Law of Partial Pressures to gas problem solving?

that exists when very electronegative atoms (N, O, and F) are involved. (E.K.2.B.2)

Intermolecular forces play a key role in determining the properties of substances, including biological structures and interactions. (E.K.2.B.3)

The strong electrostatic forces of attraction holding atoms together in a unit are called chemical bonds. (E.U.2.C)

In covalent bonding, electrons are shared between the nuclei of two atoms to form a molecule or polyatomic ion. Electronegativity differences between the two atoms account for the distribution of the shared electrons and the polarity of the bond. (E.K.2.C.1)

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. (E.U.5.A)

Temperature is a measure of the average kinetic energy of atoms and molecules. (E.K.5.A.1)

Energy is neither created nor destroyed, but only transformed from one form to another. (E.U.5.B)

Chemical systems undergo three main processes that change their energy: heating/cooling, phase transitions, and chemical reactions. (E.K.5.B.3)

Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy. (E.U.5.D)

Potential energy is associated with the interaction of molecules; as molecules draw near each other, they experience an attractive force. (E.K.5.D.1)

At the particulate scale, chemical processes can be distinguished from physical processes because chemical bonds can be distinguished from intermolecular interactions. (E.K.5.D.2)

16. Why is the Ideal Gas Law such a useful tool when working with gases?

17. How do significant intermolecular forces cause some gas samples to deviate from ideal behavior and why is this significant?

18. What is the cause of direct and inverse relationships among temperature, pressure, volume, and moles when studying gas samples?

19. How can lack of intermolecular forces and kinetic molecular theory explain the unique nature and properties of gases as compared to liquids and solids?

Assessment Evidence

Performance Tasks:

1. Define and contrast types of intermolecular forces
2. Explain cause of intermolecular forces through atomic forces
3. Identify properties associated with extend of intermolecular forces
4. Explain properties of water in terms of polarity and hydrogen bonding
5. Describe dissolving process at the molecular level
6. Determine solutes most likely to have high/low solubility in water
7. Link color and concentration of solutions through Beer's law
8. Explain how/why chromatography separation methods work
9. Compare and contrast properties of solids, liquids, and gases
10. Examine and solve problems using heating curves
11. Examine and solve problems using phase diagrams
12. List fundamental gas properties within kinetic-molecular theory
13. Use temperature, pressure, and volume data to solve gas laws
14. Use Ideal gas law to calculate molar mass and density of gases
15. Solve problems for gas mixtures with consideration for Dalton's law
16. Explain conditions that cause gases to deviate from ideal behavior

Other Evidence:

UNIT 3 QUIZ 1 "Intermolecular Forces and Solutions"

UNIT 3 QUIZ 2 "States of Matter and Gas Laws"

Pre-Lab Assignments and Post-Lab Quizzes for the following experiments:

LAB: "Colorimetry and Concentration"

LAB: "Evaporation Examination"

LAB: "Thin Layer Chromatography"

Independent Work and Cooperative Learning Activities:

"Warm Up Questions" – Weekly completion and explanation of assigned AP Exam style multiple choice questions covering UNIT 3 topics

"APEQ Classwork" – Completion and discussion of answers and strategies for past AP Exam free response questions covering UNIT 3 topics

"Intermolecular Force Identification" – Use of Lewis structures and Periodic Table knowledge to determine extent of IMF's in atoms and molecules

"Physical Property Predictions"" – Determination of density, boiling point, freezing point, and physical state realities based on IMF criteria

"Gas Law Relationships" – Accurate problem solving using relationships among moles, volume, temperature, and pressure

"Heating Curve and Phase Diagram Analysis" – Use of graphs to draw conclusions about solid, liquid and gas phases

"Exploding Paint Can" – Demonstration requiring students to complete problem solving and explain observations using UNIT 2 and 3 knowledge

Benchmarks:

UNIT 3 TEST, Midterm Exam

Learning Plan

Learning Activities:

Chapter 5 – Gases (5-6 class periods)

- List and discuss qualities that distinguish gases from other forms of matter
- Read and discuss properties and behavior tendencies of gases set forth in kinetic-molecular theory
- Explain that all gases behave according to very minimal influence of intermolecular forces
- Discover and compare relationships between temperature, volume, pressure and moles found in gas laws
- Calculate volume, pressure and temperature data for gases using Boyle's, Charles', and Combined gas law
- Consider role of moles with other gas measurements for calculations using the Ideal gas law
- Examine gas mixtures through Dalton's Law of Partial Pressure
- Collect a gas during lab activity and mathematically confirm Avogadro's law
- Extend gas law instruction to include comprehensive Ideal gas law equation and consideration for "ideal" gases
- Research and discuss relationship between molecular mass and diffusion velocity using Graham's law
- Discuss environmental conditions that would cause gases to deviate from ideal behavior and properties
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 11 – Liquids, Solids, and Intermolecular Forces (3-4 class periods)

- Emphasize that forces of attraction among neighboring particles determine physical properties
- Define dispersion forces, dipole forces, and hydrogen bonding forces in terms of strength and occurrence
- Use examples and visual diagrams to highlight nature and impact of different types of IMF's
- Revisit Lewis structures and molecular compounds to link physical properties with degree of IMF's
- Explain many of water's impressive and unique properties in terms of hydrogen bonding ability
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 13 – Solutions (1-2 class periods)

- Explain why dissolving is a physical change and not a chemical change
- Use diagrams and models to highlight forces and interaction between solute and solvent particles
- Compare solubility values of various solutes using solubility curves and related problem solving
- Research various concentration systems, including molarity, and calculate concentration data for solutions
- Prepare solutions of various concentrations from scratch and via dilution using mole math
- Research and discuss properties of liquids such as boiling point, density, viscosity and surface tension
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 12 – Solids and Modern Materials (1-2 class periods)

- Examine unit cells and basic structures of crystalline structures
- Compare and contrast molecular solids with traditional ionic crystalline structures
- Research and share unique properties of ceramics, glasses, and cement
- Research and compare composition and structures of various polymers and plastics
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Resources:

Textbook – Chapters 5, 11, 12, 13 (w/ Mastering Chemistry E-Text)

Apcentral.collegeboard.com

Phet.colorado.edu: pHet Sims Activities - “States of Matter”, “Gas Properties”, “Concentration”, “Sugar and Salt Solutions”

Crash Course Chemistry video series

Unit Learning Goal and Scale *(Level 2.0 reflects a minimal level of proficiency)*	
PS2.B "Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects"	
4.0	***Students will be able to*:** • Predict relative physical property values for compared substances with consideration for molecular geometry, polarity, and the resulting type and magnitude of intermolecular forces found within a sample • Explain how dispersion forces, dipole-dipole forces, and hydrogen bonding forces are generated by attractions between electrons and nuclei in atoms and molecules
3.0	***Students will be able to*:** • Communicate why water is a supreme solvent compared to other liquids and diagram exactly how water molecules surround and dissolve ionic solutes • Accurately calculate concentration using mass and mole based systems to quantify the result of ion-dipole interactions between solutes and solvents
2.0	***Students will be able to:*** • Explain how temperature, pressure, and surface area changes contribute to changes in the rate or extent of solubility • Interpret heating curves and phase diagram graphs in order to solve problems about the role energy plays in determining physical state ***Students will recognize and recall specific vocabulary, including:*** • Intermolecular Force, London dispersion force, dipole-dipole force, ion-dipole force, hydrogen bonding force, temperature, pressure, surface area
1.0	***With help, partial success at level 2.0 content and level 3.0 content:***
0.0	***Even with help, no success***

PS3.A "These (definitions of energy) are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as either motions of particles or energy stored in fields."

4.0	***Students will be able to*:** • Explain why low temperature and high pressure conditions influence gas samples to deviate from relationships set forth by the Ideal Gas law equation • Accurately calculate unknown properties of gases using multi-step gas law problem solving and/or stoichiometry
3.0	***Students will be able to*:** • Communicate why certain compounds are more likely to exist as gases at STP while others are more likely to exist as liquids or solids. • Compare both direct and inverse relationships among volume, pressure, temperature, and moles through gas law problem solving
2.0	***Students will be able to:*** • Identify properties and characteristics of gases as compared to properties and characteristics of solids and liquids. • List characteristics of gas properties and behavior found within the kinetic-molecular theory of gases ***Students will recognize and recall specific vocabulary, including:*** • Gases, Pressure, Force, Temperature, Volume, Ideal Gas, Real Gas, Effusion, Diffusion, Boyle's Law, Charles' Law, Dalton's Law of Partial Pressure
1.0	***With help, partial success at level 2.0 content and level 3.0 content:***

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments to create challenge and foster discovery of knowledge
Struggling Learners	Facilitate access to review materials and remediation activities through OneNote content library and through online textbook content
English Language Learners	Coordinate with ELL advisors to modify activities where appropriate http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered

		• Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Interdisciplinary Connections
Indicators: **ELA/Literacy –** RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1) WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2), (HS-PS1-5) WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3), (HS-PS1-6) WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3) SL.11-12.5Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5), (HS-PS1-7)

MP.4 Model with mathematics. (HS-PS1-4), (HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5),

HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1), (HS-PS2-4)

HSA.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1), (HS-PS2-4)

HSA.CED.A.1 Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1), (HS-PS2-2)

HSA.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2-1), (HS-PS2-2)

HSA.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1), (HS-PS2-2)

Integration of 21st Century Skills

Indicators:

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SP1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP2: The student can use mathematics appropriately.

SP3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

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SP5: The student can perform data analysis and evaluation of evidence.

SP6: The student can work with scientific explanations and theories.

SP7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

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CRP11 – Use technology to enhance productivity.
CRP12 – Work productively in teams while using cultural global competence.
9.2 Career Awareness, Exploration, and Preparation
9.2.12.C.1 – Review career goals and determine steps necessary for attainment.
9.2.12.C.3 – Identify transferable career skills and design alternate career plans.
9.2.12.C.6 – Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources for owning and managing a business.

Unit 4 Title: Thermodynamics and Kinetics

Unit Description: This unit will present and extend student knowledge of energy factors that drive physical and chemical changes through detailed instruction and extended problem solving of topics such as heat, enthalpy, entropy. Free energy and spontaneity will also be observed, calculated and analyzed through a variety of reactions and experiments. Also, kinetics concepts such as rate order, rate law equations and reaction mechanisms will be studied and practiced during this unit.

Unit Duration: 6 weeks

Desired Results

Standard(s): **NGSS: HS-PS3-1, HS-PS3-2, HS-PS3-4, HS-PS1-4, HS-PS1-5**

College Board: "Enduring Understanding" 4.A, 4.B, 4.C, 4.D, 5.A, 5.B, 5.C, 5.E

NGSS Indicators: PS3.A "Definitions of Energy", PS3.B "Conservation of Energy and Energy Transfer", PS3.C "Relationship Between Energy and Forces", PS3.D "Energy in Chemical Processes"

College Board Indicators: "Essential Knowledge" 4.A.1, 4.A.2, 4.A.3, 4.B.1, 4.B.2, 4.B.3, 4.C.1, 4.C.2, 4.C.3, 4.D.1, 4.D.2, 5.A.2, 5.B.3, 5.B.4, 5.C.1, 5.C.2, 5.E.1, 5.E.2, 5.E.3, 5.E.4, 5.E.5

AP BIG IDEA 4: "Rate of chemical reactions are determined by details of the molecular collisions"

AP BIG IDEA 5: "The laws of thermodynamics describe the essential role of and energy and explain and predict the direction of changes in matter"

Understandings:
Students will understand that…

Reaction rates that depend on temperature and other environmental factors are determined by measuring changes in concentrations of reactants or products over time. (E.U.4.A)

The rate of a reaction is influenced by the concentration or pressure of reactants, the phase of the reactants and products, and environmental factors such as temperature and solvent. (E.K.4.A.1)

The rate law shows how the rate depends on reactant concentrations. (E.K.4.A.2)

The magnitude and temperature dependence of the rate of reaction is contained quantitatively in the rate constant. (E.K.4.A.3)

Elementary reactions are mediated by collisions between molecules. Only collisions having sufficient energy and proper relative orientation of reactants lead to products. (E.U.4.B)

Elementary reactions can be unimolecular or involve collisions between two or more molecules. (E.K.4.B.1)

Not all collisions are successful. To get over the activation energy barrier, the colliding species need sufficient energy. Also, the orientations of the reactant molecules during the collision must allow for the rearrangement of reactant bonds to form product bonds. (E.K.4.B.3)

A successful collision can be viewed as following a reaction path with an associated energy profile. (E.K.4.B.4)

Many reactions proceed via a series of elementary reactions. (E.U.4.C)

The mechanism of a multistep reaction consists of a series of elementary reactions that add up to the overall reaction. (E.K.4.C.1)

In many reactions, the rate is set by the slowest elementary reaction, or rate-limiting step. (E.K.4.C.2)

Reaction intermediates, which are formed during the reaction but not present in the overall reaction, play an important role in multistep reactions. (E.K.4.C.3)

Reaction rates may be increased by the presence of a catalyst. (E.U.4.D)

Essential Questions:

1. What role does energy play in determining the success or failure of a reaction?
2. How are temperature and heat different and how can temperature and other measurements be used to calculate heat?
3. What is enthalpy and how is it different from heat?
4. How can previously gained knowledge of bonding and intermolecular forces be used to better understand the tendencies for change in different physical and chemical reactions?
5. What are the different ways that data can be used to accurately calculate enthalpy change for a reaction?
6. What factors can be used to predict and determine whether a change is exothermic or endothermic?
7. What is entropy and how can it be observed in the laboratory?
8. What indicators present in reaction or chemical equation can be used to predict whether entropy is growing or diminishing during a change?
9. How can entropy change be calculated and why is entropy a temperature dependent property?
10. Why are certain combinations of entropy and enthalpy ($+\Delta S$, $-\Delta H$) indicative of more natural and spontaneous changes while other combinations ($-\Delta S$, $+\Delta H$) are indicative of unnatural and non-spontaneous changes?
11. How are enthalpy, entropy, and temperature combined to calculate free energy and determine the spontaneity of a reaction?
12. What are the factors that contribute to rate of a reaction at the molecular level?
13. What is activation energy and how does it relate to previously gained knowledge of forces and chemical bonds?
14. How can rate order be determined from laboratory data?
15. Why do some particle concentrations have direct effects on the rate of turnover from reactant to

Catalysts function by lowering the activation energy of an elementary step in a reaction mechanism, and by providing a new and faster reaction mechanism. (E.K.4.D.1)

Important classes in catalysis include acid-base catalysis, surface catalysis, and enzyme catalysis. (E.K.4.D.2)

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. (E.U.5.A)

The process of kinetic energy transfer at the particulate scale is referred to in this course as heat transfer, and the spontaneous direction of the transfer is always from a hot to a cold body. (E.K.5.A.2)

Energy is neither created nor destroyed, but only transformed from one form to another. (E.U.5.B)

Chemical systems undergo three main processes that change their energy: heating/cooling, phase transitions, and chemical reactions. (E.K.5.B.3)

Calorimetry is an experimental technique that is used to determine the heat exchanged/transferred in a chemical system. (E.K.5.B.4)

Breaking bonds requires energy, and making bonds releases energy. (E.U.5.C)

Potential energy is associated with a particular geometric arrangement of atoms or ions and the electrostatic interactions between them. (E.K.5.C.1)

The net energy change during a reaction is the sum of the energy required to break the bonds in the reactant molecules and the energy released in forming the bonds of the product molecules. The net change in energy may be positive for endothermic reactions where energy is required, or negative for exothermic reactions where energy is released. (E.K.5.C.2)

Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both. (E.U.5.E)

Entropy is a measure of the dispersal of matter and energy. (E.K.5.E.1)

Some physical or chemical processes involve both a decrease in the internal energy of the components under consideration and an increase in the entropy of those components. These processes are necessarily “thermodynamically favored” (E.K.5.E.2)

If a chemical or physical process is not driven by Both entropy and enthalpy changes, then the Gibbs free

product, while others have no effect or exponential effects on reaction rate?

16. What is a rate-determining step and why is a rate-determining step the focal point of a reaction mechanism?

17. Why does it make sense that most chemical reactions occur thanks to a series of elementary steps in a mechanism rather than just in a one step process?

18. How can potential energy diagrams be used to communicate both the thermodynamics and kinetics details of a reaction mechanism?

19. How do catalysts work to speed of reaction rate and why are catalysts so valuable to modern science?

20. Why is the thermodynamics of a change unaffected by a catalyst, while the kinetics of a reaction is affected by a catalyst?

energy change can be used to determine whether the process is thermodynamically favored. (E.K.5.E.3)

External sources of energy can be used to drive change in cases where the Gibbs free energy change is positive. (E.K.5.E.4)

A thermodynamically favored process may not occur due to kinetic constraints (kinetic vs. thermodynamic control). (E.K.5.E.5)

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Assessment Evidence

Performance Tasks:

1. Define heat, temperature and specific heat capacity
2. Calculate heat, temperature and specific heat capacity
3. Explain difference between heat and enthalpy
4. Calculate enthalpy using a heat to mole ratio problems
5. Differentiate between exothermic and endothermic nature
6. Calculate enthalpy change using bond energy data
7. Calculate enthalpy using standard enthalpy values
8. Explain and apply Hess's Law to enthalpy problems
9. Define entropy and compare/contrast with enthalpy
10. Predict and quantify entropy changes for specific reactions
11. Combine enthalpy, entropy and temperature to calculate free energy
12. Analyze free energy values to determine spontaneity
13. Communicate role of temperature in spontaneity for reactions
14. Define activation energy
15. Communicate role of collision orientation in kinetics
16. List and explain experimental factors that impact reaction rate
17. Analyze graphs and lab data to deduce rate order for reactants
18. Build and solve rate law expressions for various reactions

Other Evidence:

UNIT 4 QUIZ 1 "Thermodynamics"
UNIT 4 QUIZ 2 "Kinetics"

Pre-Lab Assignments and Post-Lab Quizzes for the following experiments:

LAB: "Enthalpy Change in a Chemical Reaction"

LAB: "Spontaneity of a Decomposition Reaction"

LAB: "Chemical Kinetics and Rate Order"

Independent Work and Cooperative Learning Activities:

"Warm Up Questions" – Weekly completion and explanation of assigned AP Exam style multiple choice questions covering UNIT 5 topics

"APEQ Classwork" – Completion and discussion of answers and strategies for past AP Exam free response questions covering UNIT 5 topics

"Calculating Enthalpy Change" – Use of various data to quantify the heat/mole ratio associated with specific exothermic and endothermic changes

"Spontaneity Situations" – Calculations and analysis for combined effect of enthalpy, entropy and temperature on the success or failure of a reaction

"Rate Order Determination" – Use of laboratory data to draw conclusions about rate order and allow for calculations through rate law expressions

"Mechanism Examination" – Thermodynamic and kinetic overview of contributing energy factors within a multi-step collision process

19. Define catalyst and explain the function of catalysts 20. Apply integrated rate laws to solve for time and concentration 21. Interpret provided reaction mechanisms for collision details 22. Create reaction mechanisms using energy diagram graphs 23. Identify intermediates and activated complexes	"Catalysts and Enzyme" – Research and communicate information for an assigned catalyst/enzyme having impact on society "Integrated Rate Laws" – Determination of rate order and half-life values through comparison of graphs utilizing different math functions

Benchmarks:

UNIT 4 TEST, Final Exam

Learning Plan

Learning Activities:

Chapter 6 – Thermochemistry (8-10 class periods)

- Discuss differences and relationships among temperature and heat using definitions
- Present method to calculate heat, temperature, and specific heat capacity from each other using lab activity
- Research and share foundational knowledge of energy and its existence and transformation during changes
- Compare and contrast terms exothermic and endothermic using examples
- Define enthalpy as a ratio of heat delivered per moles of matter created/consumed
- Predict and calculate enthalpy change using Lewis structures and bond energy data
- Research and use standard enthalpy values to determine enthalpy change for select reactions
- Connect and conclude relationships among matter and enthalpy change using Hess's law
- Emphasize that exothermic heat release is a more favorable energy change than endothermic heat input
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 18 – Free Energy and Equilibrium (8-10 class periods)

- Define entropy and discuss the Laws of Thermodynamics
- Use chemical equations and reaction descriptions to predict entropy change during reactions
- Quantify entropy change for reactions using standard entropy value data
- Compare and contrast similarities and differences between enthalpy and entropy energy factors
- Emphasize the entropy gain is more favorable than entropy loss in the universe
- Discuss and share examples of reactions that are spontaneous and reactions that are non-spontaneous
- Combine knowledge of enthalpy and entropy with temperature measurement to determine free energy
- Predict spontaneity through consideration of enthalpy and entropy nature and temperature data
- Observe, quantify and draw conclusions about spontaneity through in-class laboratory activities
- Calculate temperatures at which reactions will switch from spontaneous to non-spontaneous, and vice versa
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 14 – Chemical Kinetics (8-10 class periods)

- Brainstorm and list both controllable and uncontrollable factors affecting reaction rate
- Use molecular level collision theory viewpoints to explain how each factor influences reaction rate
- Define activation energy and consider bond reasoning for why activation energy values vary

- Recognize collision orientation as another contributing factor to reaction rate at the molecular level
- Observe impact of temperature change on reaction rate through laboratory activities
- Use concentration and rate data from graphs and tables to determine rate order for reactants
- Compare and contrast zero order, first order, and second order reactants
- Extend rate order work to include formation of rate law equations
- Use examples and practice problems to build rate laws equations and solve for specific rate or concentration
- Discuss why many reactions must occur in a series of collision steps rather than in one single step
- Examine and compare various reaction mechanism using elementary step equations and energy diagrams
- Identify and explain reasoning for selection of rate-determining steps in reaction mechanisms
- Define catalysts and enzymes and examine/discuss function and importance of each
- Observe and discuss impact of a catalyst on a chemical reaction through lab activity
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Resources:

Textbook – Chapters 6, 14, 18 (w/ Mastering Chemistry E-Text)

Apcentral.collegeboard.com

Phet.colorado.edu

Crash Course Chemistry video series

PS3.A "These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as either motions of particles or energy stored in fields. This last concept includes radiation, a phenomenon in which energy stored in fields moves across space"	
4.0	***Students will be able to*:** • Accurately calculate the Gibbs free energy of a system and rationalize how the contributing factors of enthalpy, entropy and temperature influenced the spontaneity of the change • Predict thermodynamic realities of various physical and chemical reactions with consideration for Periodic Table, chemical bonding and intermolecular forces factors for the involved particles
3.0	***Students will be able to*:** • Explain the differences among temperature, heat, specific heat capacity, and enthalpy using definitions, units, and with the support of problem solving • Communicate factors contributing to standard entropy and entropy change for both physical and chemical changes with reference to the second law of thermodynamics

2.0	***Students will be able to:*** • Recognize that endothermic and exothermic nature reflects potential energy differences between reactant and product bonds • Recognize that all changes in the physical world can be classified as one of four scenarios based on the various combinations of enthalpy and entropy change that can describe the change ***Students will recognize and recall specific vocabulary, including:*** • Heat, Temperature, Joules, Enthalpy, Entropy, Exothermic, Endothermic, Spontaneous, Non-Spontaneous
1.0	***With help, partial success at level 2.0 content and level 3.0 content:***
0.0	***Even with help, no success***

PS1.B "Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangement of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy"	
4.0	***Students will be able to*:** • Identify rate order for reactions through analysis of integrated rate law graphs that plot concentration data vs. time using inverse and log functions • Accurately calculate time, concentration, and/or half-life for reactions using appropriate integrated rate law equations
3.0	***Students will be able to*:** • Analyze provided reaction mechanism potential energy graphs and draw conclusions about stability of reactants, activated complexes, intermediates, and products involved in the collision pathway • Explain the function of catalysts and enzymes using molecular level considerations for surface area, shape, and polarity
2.0	***Students will be able to:*** • Determine zero effect, direct effect, or exponential effect relationships between concentration and rate from experimental data collected during experiments • List and explain the controllable and uncontrollable factors that affect the rate at which reactions convert reactants into products

	Students will recognize and recall specific vocabulary, including: Activation energy, Collision orientation, Kinetics, Rate Order, Rate Law, Reaction Mechanism, Intermediate, Activated Complex, Catalyst, Enzyme
1.0	***With help, partial success at level 2.0 content and level 3.0 content:***
0.0	***Even with help, no success***

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments to create challenge and foster discovery of knowledge
Struggling Learners	Facilitate access to review materials and remediation activities through OneNote content library and through online textbook content
English Language Learners	Coordinate with ELL advisors to modify activities where appropriate http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org

Learners with a 504	Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Indicators:

ELA/Literacy –

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2), (HS-PS1-5)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3), (HS-PS1-6)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

SL.11-12.5Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5), (HS-PS1-7)

MP.4 Model with mathematics. (HS-PS1-4), (HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and

the origin in graphs and data displays. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5)

Integration of 21st Century Skills

Indicators:

College Board Science Practices:

SP1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP2: The student can use mathematics appropriately.

SP3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

SP4: The student can plan and implement data collection strategies in relation to a particular scientific question.

SP5: The student can perform data analysis and evaluation of evidence.

SP6: The student can work with scientific explanations and theories.

SP7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.
CRP5 – Consider the environmental, social and economic impacts of decisions.
CRP6 – Demonstrate creativity and innovation.
CRP7 – Employ valid and reliable research strategies.
CRP8 – Utilize critical thinking to make sense of problems and persevere in solving them.
CRP10 – Plan education and career paths aligned to personal goals.
CRP11 – Use technology to enhance productivity.
CRP12 – Work productively in teams while using cultural global competence.
9.2 Career Awareness, Exploration, and Preparation
9.2.12.C.1 – Review career goals and determine steps necessary for attainment.
9.2.12.C.3 – Identify transferable career skills and design alternate career plans.
9.2.12.C.6 – Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources for owning and managing a business.

Unit 5 Title: Reversible Reactions and Chemical Equilibrium

Unit Description: This unit will extend student knowledge of reversible reactions through detailed instruction and extended problem solving of homogeneous, solubility, and acid-base equilibrium reactions. Instruction will consider both particle collision theory aspects as well as quantitative data analysis and calculations. Advanced instruction and problem solving related to pH, buffers, and laboratory titrations will also be covered during this unit.

Unit Duration: 7 weeks

Desired Results

Standard(s): **NGSS: HS-PS1-4, HS-PS1-5, HS-PS1-6, HS-PS3-2**

College Board: "Enduring Understanding" 3.B, 3.C, 4.A, 5.B, 6.A, 6.B, 6.C, 6.D

NGSS Indicators: **PS1.B "Chemical Reactions", PS3.A "Definitions of Energy", PS3.B "Conservation of Energy and Energy Transfer", PS3.D "Energy in Chemical Processes"**

College Board Indicators: **"Essential Knowledge" 3.B.2, 3.C.2, 4.A.1, 6.A.1, 6.A.2, 6.A.3, 6.A.4, 6.B.1, 6.B.2, 6.C.1, 6.C.2, 6.C.3, 6.D.1**

AP BIG IDEA 3: "Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons"

AP BIG IDEA 4: "Rate of chemical reactions are determined by details of the molecular collisions"

AP BIG IDEA 5: "The laws of thermodynamics describe the essential role of and energy and explain and predict the direction of changes in matter"

BIG IDEA 6: "Any bond or intermolecular attraction that can be formed can be broken. These two processes are in dynamic competition, sensitive to initial conditions and external perturbations"

Understandings:
Students will understand that…

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. (E.U.3.B)

In a neutralization reaction, protons are transferred from an acid to a base. (E.K.3.B.2)

Chemical and physical transformations may be observed in several ways and typically involve a change in energy. (E.U.3.C)

Net changes in energy for a chemical reaction can be endothermic or exothermic. (E.K.3.C.2)

Reaction rates that depend on temperature and other environmental factors are determined by measuring changes in concentrations of reactants or products over time. (E.U.4.A)

The rate of a reaction is influenced by the concentration or pressure of reactants, the phase of the reactants and products, and environmental factors such as temperature and solvent. (E.K.4.A.1)

Energy is neither created nor destroyed, but only transformed from one form to another. (E.U.5.B)

Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal. (E.U.6.A)

In many classes of reactions, it is important to consider both the forward and reverse reaction. (E.K.6.A.1)

The current state of a system undergoing a reversible reaction can be characterized by the extent to which reactants have been converted to products. The relative quantities of reaction components are quantitatively described by the reaction quotient, Q. (E.K.6.A.2)

When a system is at equilibrium, all macroscopic variables, such as concentrations, partial pressures, and temperature, do not change over time. Equilibrium results from an equality between the rates of the forward and reverse reactions, at which Q=K point. (E.K.6.A.3)

The magnitude of the equilibrium constant, K, can be used to determine whether the equilibrium lies toward the reactant side or product side. (E.K.6.A.4)

Systems at equilibrium are responsive to external perturbations, with the response leading to a change in the composition of the system. (E.U.6.B)

Systems at equilibrium respond to disturbances by partially countering the effect of the disturbance (Le Chatelier's principle). (E.K.6.B.1)

1. What causes recently formed product particles to collide and trigger a reverse reaction when some changes are studied in an enclosed system?
2. How does the potential for a reverse reaction change the possibilities of efficiency set forth by stoichiometry?
3. Why is energy conserved during the competition between forward and reverse reactions in an equilibrium system?
4. What observations are typical of a system that has settled into a state of equilibrium?
5. How can graphs of concentration and time data be used to discover the development of chemical equilibrium for a reaction?
6. What is LeChatelier's Principle and how does it allow students to make predictions of cause/effect on a reversible system?
7. How can previously gained knowledge of gas laws and thermodynamics be used to predict shifting of equilibrium position according to LeChatelier's Principle?
8. Why is equilibrium position quantified with a products over reactants ratio of either concentration or pressure measurements?
9. Why are pure solids and pure liquids not included in equilibrium expressions or calculations?
10. How can an equilibrium constant value be used to draw conclusions about the competing energy factors of a forward and reverse reaction, as well as the bond energies of particles in the system?
11. What is the relationship between the equilibrium constant (K) and free energy (G) and how can they both be used to draw conclusions about the nature/spontaneity of changes?
12. What ion components and behavior tendencies define acids and bases in chemistry?
13. How do strong and weak acids compare in terms of bond energies, pH and equilibrium constants?
14. How can ion concentration measurements be used to calculate pH values for aqueous solutions?
15. Why is pH a better way of communicating acid-base nature than ion concentrations in solution?
16. What is an equivalence point and how can a lab titration be used to determine an equivalence point?

A disturbance to a system at equilibrium causes Q to differ from K, thereby taking the system out of the original equilibrium state. The system responds by bringing Q back into agreement with K, thereby establishing a new equilibrium state. (E.K.6.B.2)

Chemical equilibrium plays an important role in acid-base chemistry and in solubility. (E.U.6.C)

Chemical equilibrium reasoning can be used to describe the proton-transfer reactions of acid-base chemistry. (E.K.6.C.1)

The pH is an important characteristic of aqueous solutions that can be controlled with buffers. Comparing pH to pKa allows one to determine the protonation state of a molecule with a labile proton. (E.K.6.C.2)

The solubility of a substance can be understood in terms of chemical equilibrium. (E.K.6.C.3)

The equilibrium constant is related to temperature and the difference in Gibbs free energy between reactants and products. (E.U.6.D)

When the difference in Gibbs free energy between reactants and products is much larger than the thermal energy, the equilibrium constant is either very small or very large. When is comparable to the thermal energy (RT), the equilibrium constant is near 1. (E.K.6.D.1)

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17. How can the data and shape of a titration curve be used to study and draw conclusions about ion concentrations and progress during and acid-base reaction?

18. How is the dissociation of monoprotic acids different from the dissociation of polyprotic acids?

19. Why is the pKa equal to the pH at the half-equivalence point of a weak acid vs. strong base titration?

20. What is a buffer and how are common buffers prepared?

21. How is buffer function often a reflection of the Common Ion effect and LeChatelier's Principle?

22. How can I-C-E chart be used to organize and adjust data for complex equilibrium problem solving?

Assessment Evidence

Performance Tasks:

1. Describe conditions that define equilibrium
2. Explain reversibility of reactions using collision theory
3. Write accurate equilibrium constant expressions
4. Solve equilibrium constant problems and explain K values
5. List and explain factors contributing to LeChatelier's Principle
6. Identify equilibrium states and LeChatelier's Principle on graphs
7. Explain applications of equilibrium to solubility of salts
8. Build and solve solubility product constant expressions
9. Compare relative Ksp values and explain contributing factors

Other Evidence:

UNIT 5 QUIZ 1 "Homogeneous and Solubility Equilibrium"

UNIT 5 QUIZ 2 "Acid-Base Equilibrium and Buffers"

Pre-Lab Assignments and Post-Lab Quizzes for the following experiments:

LAB: "LeChatelier's Principle"

LAB: "Determining the Ksp of Calcium Hydroxide"

LAB: "Titrations and Buffered Solutions"

Independent Work and Cooperative Learning Activities:

"Warm Up Questions" – Weekly completion and explanation of assigned AP Exam style multiple choice questions covering UNIT 4 topics

"APEQ Classwork" – Completion and discussion of answers and strategies for past AP Exam free response questions covering UNIT 4 topics

10. List properties common of acids and bases
11. Explain Arrhenius and Bronsted-Lowry models of acid-base behavior
12. Identify Bronsted-Lowry acids, bases, and conjugate acids and bases
13. Identify strong acid and strong bases using formulas
14. Communicate relationship between strong/weak nature and bonds
15. Build and solve equilibrium constant expressions for weak acids
16. Explain strong and weak nature using equilibrium data
17. Use ion concentration and Kw to calculate pH values
18. Explain similarities and differences among acid and base pH values
19. Interpret titration graphs to locate and explain equivalence point
20. Solve for Ka, Kb, and pH using provided lab measurements
21. Explain buffer function using LeChatelier's Principle
22. Solve weak acid problems involving buffer use with ICE charts

"Equilibrium Constants" – Solving and Interpreting the meaning of equilibrium constants calculated from product to reactant ratios

"Solubility Product Determination" – Quantifying extent of solubility using equilibrium constants specifically derived from ion concentrations in solution

"Acid-Base Calculations" – Determination of concentrations, pH, pOH, and equilibrium constants for strong and weak acids/bases

"Discovery via Titrations" – Problem solving and conclusions stemming from data and graphs collected during controlled acid-base reactions

"Acids and Bases in the Body" – Research and communicate of specific weak acid, weak base, and buffers vital to heath in biochemistry

Benchmarks:

UNIT 5 TEST, Final Exam

Learning Plan

Learning Activities:

Chapter 15 – Chemical Equilibrium (4-5 class periods)

- Discuss collision theory and use models to examine the possible reversibility of reaction collisions
- Examine and discuss graphs showing the onset of unchanging concentrations and state of equilibrium
- Observe laboratory demonstrations that settled into a state of equilibrium
- Quantify equilibrium states for different reactions using a product to reactant ratio known as equilibrium constant
- Solve for and analyze equilibrium constants in order to compare forward and reverse reaction tendencies
- List and discuss factors influencing equilibrium through LeChatelier's Principle research
- Predict reaction responses to experimental condition changes
- Examine various reversible reactions and determine lab conditions needed to maximize forward reaction yield
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 17 – Aqueous Ionic Equilibrium (3-4 class periods)

- Revisit solubility and physical process of salts dissolving in water and discuss
- Instruct relative solubility through general solubility rules

- Quantify and compare the solubility of salts through KSP calculations
- Research and explain relationships among Coulomb's law and solubility product constants
- Calculate molar and mass solubility limits for a variety of common ionic solutes
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 16 – Acids and Bases (10-12 class periods)

- Review and discuss common properties and typical behavior tendencies of acids and bases
- Label acids, bases, conjugate acids and conjugate bases in reactions according to Bronsted-Lowry model
- Explain amphoteric nature and examine reactants that behave as amphoteric species
- Research and list strong acids and explain relationship between strong nature and weak bonds
- Research and consider weak acid examples and explain relationship between weak nature and strong bonds
- Read and share knowledge of pH scale and measurements of pure water that define the pH scale
- Calculate pH and pOH measurements from provided ion concentration, and vice versa
- Compare and explain pH differences among strong and weak solutions using laboratory activities
- Complete titrations using accurate laboratory techniques to determine equivalence point
- Research and apply methods for how titration curves and equivalence points can be used to solve lab problems
- Compare and contrast monoprotic and polyprotic acids though titration lab activities
- Compare and contrast weak and strong acid-base titration according to pH and volume data
- Read and discuss how to identify and prepare a buffer solution
- Use LeChatelier's principle and the Common Ion effect to explain buffer function and effectiveness
- Discuss the value of buffers to the scientific community
- Solve advanced equilibrium problems focusing on the effect of buffers in solution
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Resources:

Textbook – Chapters 15, 16, 17 (w/ Mastering Chemistry E-Text)

Apcentral.collegeboard.com

Phet.colorado.edu: pHet Sims Activities - **"**Reversible Reactions", "Salts and Solubility", "pH Scale"

Crash Course Chemistry video series

PS1.B "In many reactions, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present"	
4.0	***Students will be able to*:** • Accurately calculate equilibrium concentrations and/or equilibrium constant values with the use of ICE charts to organize initial, change, and equilibrium data • Determine solubility product equilibrium values using laboratory measurements and observations from various experimental procedures

3.0	***Students will be able to*:** • Communicate factors that contribute to why specific reversible reactions would have large or small equilibrium constants when studied in an enclosed system • Use LeChatelier's principle to predict experimental environments that would allow the forward change progress of a reversible change to prosper and achieve maximum efficiency
2.0	***Students will be able to:*** • Construct equilibrium expressions and use data to accurately calculate equilibrium constant values for reversible reactions • Interpret concentration versus time graphs and draw conclusions about forward versus reaction collision dynamics ***Students will recognize and recall specific vocabulary, including:*** LeChatelier's Principle, Reversible Reaction, Equilibrium Constant, Reaction Quotient, Solubility Product Constant
1.0	***With help, partial success at level 2.0 content and level 3.0 content:***
0.0	***Even with help, no success***

PS3.B "Uncontrolled systems always evolve towards more stable states – that is, toward more uniform energy distribution"	
4.0	***Students will be able to*:** • Explain how buffers can be prepared in the laboratory and explain how they work according to LeChatelier's Principle and the Common Ion effect • Use Q vs. K calculation to quantify and compare stages of a reversible reaction and the direction of progress occurring to reach a most stable energy state
3.0	***Students will be able to*:** • Identify equivalence point and half-equivalence points during the titration of acid and base reactant solutions and explain how ion concentrations of all species compare at these points • Calculate and compare Ka and Kb values for weak acids and weak bases and communicate factors that influence the relative size of these equilibrium constants

2.0	***Students will be able to:*** • Compare pH values and hydronium ion concentration values to the same data for water in order to classify a solution as an acid or a base • Recognize and label conjugate acid-base pairs found in Bronsted-Lowry acid-base equations ***Students will recognize and recall specific vocabulary, including:*** Bronsted-Lowry Model, Acid, Base, Conjugate Acid, Conjugate Base, pH, Equivalence Point, Neutralization, Titration, Amphoteric, Monoprotic, Polyprotic, Weak Acid/Base, Strong Acid/Base, Reaction Quotient, Buffer
1.0	***With help, partial success at level 2.0 content and level 3.0 content:***
0.0	***Even with help, no success***

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments to create challenge and foster discovery of knowledge
Struggling Learners	Facilitate access to review materials and remediation activities through OneNote content library and through online textbook content
English Language Learners	Coordinate with ELL advisors to modify activities where appropriate http://www.state.nj.us/education/modelcurriculum/ela/ELLSupport.pdf
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here.

		Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	Refer to page four in the Parent and Educator Guide to Section 504 to assist in the development of appropriate plans.	

Indicators:

ELA/Literacy –

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2), (HS-PS1-5)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3), (HS-PS1-6)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

SL.11-12.5Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5), (HS-PS1-7)

MP.4 Model with mathematics. (HS-PS1-4), (HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and

the origin in graphs and data displays. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5)

Integration of 21st Century Skills

Indicators:

College Board Science Practices:

SP1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP2: The student can use mathematics appropriately.

SP3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

SP4: The student can plan and implement data collection strategies in relation to a particular scientific question.

SP5: The student can perform data analysis and evaluation of evidence.

SP6: The student can work with scientific explanations and theories.

SP7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.
CRP5 – Consider the environmental, social and economic impacts of decisions.
CRP6 – Demonstrate creativity and innovation.
CRP7 – Employ valid and reliable research strategies.
CRP8 – Utilize critical thinking to make sense of problems and persevere in solving them.
CRP10 – Plan education and career paths aligned to personal goals.
CRP11 – Use technology to enhance productivity.
CRP12 – Work productively in teams while using cultural global competence.
9.2 Career Awareness, Exploration, and Preparation
9.2.12.C.1 – Review career goals and determine steps necessary for attainment.
9.2.12.C.3 – Identify transferable career skills and design alternate career plans.
9.2.12.C.6 – Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources for owning and managing a business.

Unit 6 Title: Reduction-Oxidation Processes and Electrochemistry

Unit Description: This unit will extend student knowledge of redox reactions through detailed instruction and extended problem solving that utilizes knowledge of oxidation, reduction, cell potential, and voltaic cells. Applications of electrochemical processes will be studies through electrolysis and electroplating investigations.

Unit Duration: 4 weeks

Desired Results

Standard(s): **NGSS: HS-PS1-1, HS-PS1-2, HS-PS1-4, HS-PS3-5**

College Board: "Enduring Understanding" 3.A, 3.B, 3.C, 5.D, 6.A

NGSS Indicators: **PS1.A "Structure and Properties of Matter", PS2.B "Types of Interactions", PS1.B "Chemical Reactions", PS3.A "Definitions of Energy", PS3.D "Energy in Chemical Processes"**

College Board Indicators: "Essential Knowledge" 3.A.2, 3.B.3, 3.C.3, 6.A.4

BIG IDEA 3: "Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons"

BIG IDEA 5: "The laws of thermodynamics describe the essential role of and energy and explain and predict the direction of changes in matter"

BIG IDEA 6: "Any bond or intermolecular attraction that can be formed can be broken. These two processes are in dynamic competition, sensitive to initial conditions and external perturbations"

Understandings:
Students will understand that…

Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form. (E.U.3.A)

Quantitative information can be derived from stoichiometric calculations that utilize the mole ratios from the balanced chemical equations. The role of stoichiometry in real-world applications is important to note, so that it does not seem to be simply an exercise done only by chemists. (E.K.3.A.2)

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. (E.U.3.B)

In oxidation-reduction (redox) reactions, there

Essential Questions:

1. How can oxidation states be determined for atoms or ions within chemical reaction equations?
2. What does the positive, negative, or zero value of an oxidation state indicate about the behavioral tendency of that species?
3. How can oxidation and reduction processes be identified in balance chemical equations?
4. What previously gained knowledge about the Periodic Table can be used to predict whether atoms/ion will have a greater tendency to be oxidized or reduced in specific reactions?
5. How can balancing oxidation and reduction half reactions be balanced for atoms and electrons to create a complete redox reaction?

is a net transfer of electrons. The species that loses electrons is oxidized, and the species that gains electrons is reduced. (E.K.3.B.3)

Chemical and physical transformations may be observed in several ways and typically involve a change in energy. (E.U.3.C)

Electrochemistry shows the interconversion between chemical and electrical energy in galvanic and electrolytic cells. (E.K.3.C.3)

Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy. (E.U.5.D)

Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal. (E.U.6.A)

The magnitude of the equilibrium constant, K, can be used to determine whether the equilibrium lies toward the reactant side or product side. (E.K.6.A.4)

6. What is electromotive force and why is it measured in units of volts?
7. How can spontaneous electrochemical redox reactions be used to do work when they are included in the design of a voltaic cell (battery)?
8. What is the difference between an anode and a cathode in a battery?
9. Why is an electrolyte solution and salt bridge necessary for a dependable, long-lasting battery?
10. How can cell potential (voltage) be calculated using reference data about the standard reduction potential of various ions and atoms?
11. How are batteries used to power or drive non-spontaneous redox reactions such as electrolysis of water and electroplating of metals?
12. What stoichiometric problem solving can be done with balanced redox reactions and measurements such as mass, moles, current and Faraday's constant?
13. Why are electrolysis and electroplating processes valuable to modern society?

Assessment Evidence

Performance Tasks:

1. Define oxidation and reduction, oxidizing agent and reducing agent
2. Accurately label oxidation states in chemical equations
3. Identify oxidation state change during reactions
4. Explain relationship between oxidation and ionization energy
5. Explain relationship between reduction and electronegativity
6. Build and combine half reactions to create overall redox equations
7. Satisfy Law of Conservation of Matter for redox reaction equations
8. Explain why only some redox reactions are spontaneous
9. Solve for cell potential using standard reduction potential data
10. Explain differences between current and voltage for moving electrons
11. Identify components and their function within a voltaic cell

Other Evidence:

UNIT 6 QUIZ 1 "Oxidation and Reduction"

UNIT 6 QUIZ 2 "Applications of Electrochemistry"

Pre-Lab Assignments and Post-Lab Quizzes for the following experiments:

LAB: "Determining Iron via Redox Titration"

LAB: "Cell Potential and the Activity Series"

LAB: "Electroplating Metals and Electrolysis of Water"

Independent Work and Cooperative Learning Activities:

"Warm Up Questions" – Weekly completion and explanation of assigned AP Exam style multiple choice questions covering UNIT 6 topics

"APEQ Classwork" – Completion and discussion of answers and strategies for past AP Exam free response questions covering UNIT 6 topics

"Building Redox Equations" – Use of oxidation numbers and half reactions approach to build and balance atoms and electrons for redox changes

"Anatomy of a Battery" – Investigation into the components and function of a voltaic cell using common household batteries examples

"Cell Potential and Spontaneity" – Calculations and comparisons for voltaic cells using reactants having differing standard reduction potential

"Concentration and Voltage" – Investigation into equilibrium connection to electrochemistry through non-standard conditions and Nernst equation

12. Define anode and cathode and explain use of matter at each in a cell 13. Draw and label voltaic cell components and electron flow direction 14. Measure cell potential using laboratory equipment 15. Solve stoichiometry problems using electrochemical data 16. Quantify cell potential for both standard and non-standard cells 17. Identify redox reaction details for common modern day batteries 18. Explain electrolysis and electroplating processes	"Electrolysis" – Activities and research focusing on how batteries can be used to force valuable non-spontaneous redox reactions to occur

Benchmarks:

UNIT 6 TEST, Final Exam

Learning Plan

Learning Activities:

Chapter 4 – Chemical Quantities and Aqueous Reactions (4-5 class periods)

- Determine oxidation states of atoms contained within molecules and polyatomic ions
- Monitor oxidation state change in an equation and create balanced oxidation and reduction half reactions
- Identify oxidizing agents and reducing agents in chemical reactions
- Combine half reactions and balance both matter and electrons to accurately represent a redox change
- Use a balanced redox reaction and measurements to identify an unknown compound during lab activity
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 19 – Electrochemistry (6-8 class periods)

- Present and discuss list of particles included on the standard reduction potential chart
- Reflect on periodic table knowledge to link reduction tendencies with atomic size and nuclear charge
- Identify the necessary components to construct a voltaic cell that operates from a spontaneous redox reaction
- Compare and contrast the role of anode, cathode, and electrolytic salt bridge in a voltaic cell
- Calculate standard reduction potential using reference data and cell diagrams
- Examine the cross-section of a typical dry cell battery for components and engineering
- Associate battery power as the result of spontaneously moving electrons in a redox reaction
- Compare and contrast the redox reactions and resulting cell potential voltage for a variety of household batteries
- Present and discuss the possibilities for non-spontaneous redox reactions to be conducted and used
- Examine the electrolysis of water as an example of forced production of hydrogen and oxygen gas
- Observe and discuss electroplating as a useful application of electrochemistry to modern industry
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Chapter 18 – Free Energy and Equilibrium (2-3 class periods)

- Discuss redox reactions in terms of spontaneous and nonspontaneous nature
- Convert and calculate among free energy, cell potential, and equilibrium constants using equations

- Explain that cell potential, like free energy and equilibrium constants, can be used to compare tendencies
- Research and share relationships among periodic properties, bonding and redox reaction tendencies
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Resources:

Textbook – Chapters 4, 18, 19 (w/ Mastering Chemistry E-Text)

Apcentral.collegeboard.com

Phet.colorado.edu: pHet Sims Activities - "Battery Voltage", "Conductivity"

Crash Course Chemistry video series

PS3.B "The availability of energy limits what can occur in any system"	
4.0	***Students will be able to*:** • Discover, connect, and explain the cause and effect matter and energy factors the drive spontaneous electrochemical reduction-oxidation reactions but also limit non-spontaneous electrochemical reduction-oxidation reactions • Build and balance reduction-oxidation equations using reaction descriptions and with consideration for the Law of Conservation of Matter
3.0	***Students will be able to*:** • Predict whether specific electrochemical reactions will be spontaneous or non-spontaneous using knowledge of bonding and periodic table properties • Deduce factors that contribute to the rate at which electrochemical reactions convert reactants into products during reduction-oxidation changes
2.0	***Students will be able to:*** • Recognize oxidation and reduction in reactions through writing half-reactions and assigning oxidation numbers to atoms and molecules • Label reactants as oxidizing agents or reducing agent when provided with balanced redox equation examples ***Students will recognize and recall specific vocabulary, including:*** Oxidation, Reduction, Oxidation State, Half Reaction, Oxidizing Agent, Reducing Agent

1.0	***With help, partial success at level 2.0 content and level 3.0 content:***
0.0	***Even with help, no success***

PS3.A "Electrical energy may mean energy stored in a battery or energy transmitted by electric currents"	
4.0	***Students will be able to*:** • Recognize and communicate that non-standard concentrations of ions in a voltaic cell will result in non-standard cell potential according to equilibrium constant considerations found in the Nernst equation • Explain the industrial values of forcing certain non-spontaneous redox reaction with electrical energy in order to electroplate core metals with outer layers of different metals
3.0	***Students will be able to*:** • Calculate and compare standard cell potential (voltage) generated by exchanged electrons during reduction-oxidation reactions using data from standard reduction potential references • Calculate Gibbs free energy from cell potential voltage and recognize that positive voltage (spontaneous) always results in a negative free energy value (also spontaneous)
2.0	***Students will be able to:*** • Identify the differences between anodes and cathodes and communicate the function of electrodes, solutions in voltaic cells • Communicate the function of key components that generate and sustain the electromotive force within modern day batteries ***Students will recognize and recall specific vocabulary, including:*** Anode, Cathode, Voltaic Cell, Cell Potential, Standard Reduction Potential, Current, Voltage, Salt Bridge, Electrolysis, Electroplating
1.0	***With help, partial success at level 2.0 content and level 3.0 content:***

0.0	***Even with help, no success***

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MP.4 Model with mathematics. (HS-PS1-4), (HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5)

Integration of 21st Century Skills

Indicators:

College Board Science Practices:

SP1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.

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SP6: The student can work with scientific explanations and theories.

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Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.
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9.2.12.C.1 – Review career goals and determine steps necessary for attainment.
9.2.12.C.3 – Identify transferable career skills and design alternate career plans.
9.2.12.C.6 – Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources for owning and managing a business.

Unit 7 Title: Cumulative Review and AP Exam Preparation

Unit Description: This unit will provide opportunities to review and practice major concepts and themes from the course as preparation for the national AP Chemistry exam. Review materials and practice exams provided by the College Board will be used to prepare all students for success on the end of course standardized test. A retrospective examination of the laboratory activities from the curriculum will take place during this unit as well.

Unit Duration: 4 weeks

Desired Results

Standard(s): **NGSS: HS-PS1, HS-PS2, HS-PS3, HS-PS4 (All included in UNIT 1-6)**

College Board: "Enduring Understanding" 1-6 (All included in UNIT 1-6)

NGSS Indicators: PS1.A "Structure and Properties of Matter", PS1.B "Chemical Reactions", PS2. B "Types of Interactions", PS3.A "Definitions of Energy", PS3.B "Conservation of Energy and Energy Transfer", PS3.D "Energy in Chemical Processes"

College Board Indicators: "Essential Knowledge" 1 – 6 (All included in UNIT 1-6)

AP BIG IDEA 1: "The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangement of atoms. These atoms retain their identity in chemical reactions"

AP BIG IDEA 2: "Chemical and physical properties of materials can be explained by the structure and arrangement of atoms, ion, or molecules and the forces between them"

AP BIG IDEA 3: "Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons"

AP BIG IDEA 4: "Rate of chemical reactions are determined by details of the molecular collisions"

AP BIG IDEA 5: "The laws of thermodynamics describe the essential role of and energy and explain and predict the direction of changes in matter"

AP BIG IDEA 6: "Any bond or intermolecular attraction that can be formed can be broken. These two processes are in dynamic competition, sensitive to initial conditions and external perturbations"

Understandings:
Students will understand that…

Comprehensive knowledge of chemistry requires mastery of contributing fundamental concepts

Comprehensive knowledge of chemistry requires both quantitative problem solving as well as objective/descriptive problem solving

The "6 Big Ideas" are used as the pillars of this AP Chemistry course to emphasize and constantly stress the major themes and relationships among matter and energy that define chemistry

Essential Questions:

1. What properties and relationships among atoms and molecules determine the outcome of particle rearrangement during chemical reactions?

2. What are the similarities and differences among chemical bonds and intermolecular force attractions?

Successful achievement on the standardize AP Chemistry exam will come through dedication to cumulative review activities including AP practice exams

*Specific “Understandings” for UNIT 7 can be found in document in the UNIT 1 through UNIT 6 sections of this curriculum.

3. Why do chemical changes occur when bonds break and/or form while physical changes occur when intermolecular force attractions break and/or form?

4. How can electrons and forces of attraction and repulsion between nuclei and electron clouds dictate changes to matter?

5. What molecular level collision factors influence the success and reaction rate of chemical changes?

6. How do enthalpy, entropy, and temperature contribute to the energy of a system and ultimately determine the direction of changes in matter?

7. Why are many reactions observed in a state of chemical equilibrium where dynamic competition exists between forward and reverse reaction particle collisions?

8. How do relationships among matter and energy determine the nature of changes in the physical world?

Assessment Evidence

Performance Tasks:

1. Label and match essential vocabulary words to examples
2. Communicate relationships among unit content
3. Calculate answers for quantitative topics
4. Deduce information from data tables and graphs
5. Combine problem solving and analysis skills
6. Use laboratory experiences to draw conclusions
7. Explain cause and effect relationships in chemistry

Other Evidence:

UNIT 7 QUIZ 1 “Cumulative Review 1”

UNIT 7 QUIZ 2 “Cumulative Review 2”

Quizzes and Tests:

“AP Practice Exam 1”

“AP Practice Exam 2”

“Lab Curriculum Retrospective Quiz 1”

“Lab Curriculum Retrospective Quiz 2”

Independent Work and Cooperative Learning Activities:

“Warm Up Questions” – Weekly completion and explanation of assigned AP Exam style multiple choice questions covering UNIT 1-6 topics

“APEQ Classwork” – Completion and discussion of answers and strategies for past AP Exam free response questions covering UNIT1- 6 topics

	"Lab Retrospective Activities" – Review, discussion, and problem solving highlighting major themes and goals of this year's lab experiments "Kahoot Review Games" – Student generated review games used for energetic and competitive review of AP "6 Big Ideas" themes "AP Exam Prep Work Books" – In class use of AP Exam preparatory workbooks to identify and practice student weakness areas prior to exam "Practice Exams" – Timed and graded multiple choice and free response sections for recent College Board released AP practice exams

Benchmarks:

UNIT 7 TEST, AP Chemistry Exam

Learning Plan

Learning Activities:

Chapter 1-25 (15-10 class periods)

- Revisit and discuss major concepts and relationships from each unit
- Revisit and discuss major goals and conclusions from each laboratory experiment
- Use AP exam prep workbooks to solve qualitative and quantitative review questions
- Use cumulative review quizzes to assess growth and readiness for AP exam
- Use College Board issued practice tests to assess growth and readiness for AP exam
- Communicate via peer to peer problem solving and analysis activities
- Practice all chapter topics using textbook, workbook, and College Board resources
- Use of vocabulary and examples to review and extend understanding

Resources:

Textbook – Chapters 1 - 25 (w/ Mastering Chemistry E-Text)

Apcentral.collegeboard.com

Phet.colorado.edu

Crash Course Chemistry video series

AP Prep Workbooks

Unit Modifications for Special Population Students	
Advanced Learners	Create additional and alternative assignments and assessments to create challenge and foster discovery of knowledge
Struggling Learners	Facilitate access to review materials and remediation activities through OneNote content library and through online textbook content
English Language Learners	Coordinate with ELL advisors to modify activities where appropriate
Learners with an IEP	Each special education student has in Individualized Educational Plan (IEP) that details the specific accommodations, modifications, services, and support

	needed to level the playing field. This will enable that student to access the curriculum to the greatest extent possible in the least restrictive environment. These include: • Variation of time: adapting the time allotted for learning, task completion, or testing • Variation of input: adapting the way instruction is delivered • Variation of output: adapting how a student can respond to instruction • Variation of size: adapting the number of items the student is expected to complete • Modifying the content, process or product Additional resources are outlined to facilitate appropriate behavior and increase student engagement. The most frequently used modifications and accommodations can be viewed here. Teachers are encouraged to use the Understanding by Design Learning Guidelines (UDL). These guidelines offer a set of concrete suggestions that can be applied to any discipline to ensure that all learners can access and participate in learning opportunities. The framework can be viewed here www.udlguidelines.cast.org
Learners with a 504	Refer to page four in the Parent and Educator Resource Guide to Section 504 to assist in the development of appropriate plans.

Indicators:

ELA/Literacy –

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2), (HS-PS1-5)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3), (HS-PS1-6)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

SL.11-12.5Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5), (HS-PS1-7)

MP.4 Model with mathematics. (HS-PS1-4), (HS-PS1-8)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4), (HS-PS1-7), (HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2), (HS-PS1-3), (HS-PS1-4), (HS-PS1-5)

Integration of 21st Century Skills

Indicators:

College Board Science Practices:

SP1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.

SP2: The student can use mathematics appropriately.

SP3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

SP4: The student can plan and implement data collection strategies in relation to a particular scientific question.

SP5: The student can perform data analysis and evaluation of evidence.

SP6: The student can work with scientific explanations and theories.

SP7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

Career Ready Practices:

CRP2 – Apply appropriate academic and technical skills.
CRP5 – Consider the environmental, social and economic impacts of decisions.
CRP6 – Demonstrate creativity and innovation.
CRP7 – Employ valid and reliable research strategies.
CRP8 – Utilize critical thinking to make sense of problems and persevere in solving them.
CRP10 – Plan education and career paths aligned to personal goals.
CRP11 – Use technology to enhance productivity.
CRP12 – Work productively in teams while using cultural global competence.
9.2 Career Awareness, Exploration, and Preparation
9.2.12.C.1 – Review career goals and determine steps necessary for attainment.
9.2.12.C.3 – Identify transferable career skills and design alternate career plans.

9.2.12.C.6 – Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources for owning and managing a business.