PUBLIC SCHOOLS OF EDISON TOWNSHIP

OFFICE OF CURRICULUM AND INSTRUCTION

AP Chemistry

Length of Course:	Term
Elective/Required:	Elective
Schools:	High School
Eligibility:	Grade 12
Credit Value:	7 Credits
Date Approved:	August 17, 2021

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Modifications will be made to accommodate IEP mandates for classified students.

Statement of Purpose

The AP Chemistry course is designed to be the equivalent of the general chemistry course usually taken during the first college year. For some students, this course enables them to undertake, in their first year, second-year work in the chemistry sequence at their institution or to register in courses in other fields where general chemistry is a prerequisite. For other students, the AP Chemistry course fulfills the laboratory science requirement and frees time for other courses. AP Chemistry should meet the objectives of a good college general chemistry course. Students in such a course should attain a depth of understanding of fundamentals and a reasonable competence in dealing with chemical problems. The course should contribute to the development of the students' abilities to think clearly and to express their ideas, orally and in writing, with clarity and logic. The AP Chemistry course enables students to develop the content understandings and skills described in the College Board's Course Framework.

Effective 2019, the AP Chemistry Course descriptions were updated by the College Board. This curriculum guide was updated in 2019 and the Summer of 2021 to reflect changes to the updated AP Course, Exam Description (CED), and the current NJSLS-S/NGSS standards.

The curriculum guide was updated: by:
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UNIT 1: MATTER AND MEASUREMENT **Time: 1.5 week**

Essential Questions: How do we classify matter? How is the scientific method used to solve problems in chemistry? How do chemists apply and practice safety? What are significant figures? Why do we use scientific notation?

Performance Expectations: (Students who demonstrate understanding can:)
NJSLS-HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

Unit Objectives/Enduring Understandings: (Students will understand that)

1. Chemistry is the study of the composition, structure, and properties of matter and the changes it undergoes.
2. There are differences between elements, compounds, and mixtures.
3. A pure sample contains particles (or units) of one specific atom or molecule
4. A mixture contains particles (or units) of more than one specific atom or molecule
5. Proper safety techniques are essential to any chemistry lab.
6. Measurements are quantitative information.

Unit Assessment: (What is the evidence (authentic) that students have achieved the unit objectives/enduring understanding?)
Labs, Activities and Summative Assessment

	Core Content Objectives		**Instructional Actions**	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
PS1.A: Structure and Properties of Matter Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.	• The proper way to behave in the chemistry lab. • The location of all safety equipment. • The basic terminology used to describe matter and the changes it undergoes. • The SI base units. • How to use the metric system. • How to use significant figures to properly report their measurements and perform calculations. • How to use dimensional analysis to make conversions between units.	• Locate and identify all safety equipment in the room. • Know the name and the application of the common laboratory equipment used in the course. • Classify matter and the changes it undergoes. • Define terms matter, energy, element, compound, mixture, solution. • Learn the meaning of the following thermodynamic terms: enthalpy, Delta H, exothermic, endothermic, heat of formation, heat of reaction, calorimetry, heat, calorie, joule, standard molar enthalpy of formation, molar heat of	• Go through a safety contract. • Worksheets, demos, labs related to safety and how to use basic equipment.	<u>**Formative Assessments:**</u> Class Discussions Worksheets with teacher feedback Drafts of lab reports with teacher feedback.

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
	.	combustion. ● Convert between metric units using dimensional analysis while keeping track of significant figures. ● Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept. ● Select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures.		**<u>Summative Assessments:</u>** Quizzes Tests Performance Assessments /Laboratory Investigations Research / Lab Reports

Resources: Essential Materials, Supplementary Materials, Links to Best Practices *Chemistry,* Zumdahl and Zumdahl, Brooks Cole/ Cengage Learning, 2012. Chapter 1 *AP Chemistry Teacher Lab Manual,* New York: The College Board, 2019. *AP Chemistry Course and Exam Description, The College Board, 2020.*	**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings

UNIT 2: ATOMS, MOLECULES, AND IONS **Time: 1.5 weeks**

Essential Questions: What is matter composed of? What do the parts of the atom tell us about the element? How can the law of conservation of mass be demonstrated in chemistry? Why are atoms attracted to one another? How do mathematical relationships and experimental data relate to chemical formulas?

Performance Expectations: (Students who demonstrate understanding can:)
NJSLS-HS-PS1-7. Use mathematical representations to support the claim that atoms, therefore mass, are conserved during a chemical reaction.

Unit Objectives/Enduring Understandings: (Students will understand that)
1. The average mass of any large number of atoms of a given element is always the same for a given element.
Because the molecules of a particular compound are always composed of the identical combination of atoms in a specific ratio, the ratio of the masses of the constituent elements in any pure sample of that compound is always the same.
Pairs of elements that form more than one type of molecule are nonetheless limited by their atomic nature to combine in whole number ratios. This discrete nature can be confirmed by calculating the difference in mass percent ratios between such types of molecules.
4. Express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings

Unit Assessment: (What is the evidence (authentic) that students have achieved the unit objectives/enduring understanding?)
Labs, Activities and Summative Assessment

	Core Content Objectives		**Instructional Actions**	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
PS1.B: Chemical Reactions 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.	• History of Chemistry • Fundamental Chemical Laws • Symbols and formulas • Periodic Table • Early Experiments to characterize the atom • Modern view of atomic structure • Molecules and ions • Conservation of mass • Introduction to Ionic & covalent bonds • Introduction to the Periodic Table • Nomenclature	• Name compounds and write formulas for ionic and molecular compounds. • Relate specific experiments to the discovery of subatomic particles. • Explain the relationship between the type of bonding and the properties of the elements participating in the bond. • Name the polyatomic ions, given the formula. • Name inorganic compounds, including acids, using the Stock system.	<u>**Labs:**</u> • Determination of the formula of a compound • Gravimetric a • Nalysis	<u>**Formative Assessments:**</u> Class Discussions Worksheets with teacher feedback Drafts of lab reports with teacher feedback.

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		• Write formulas for the names of inorganic compounds and molecular formulas. • Justify the observation that the ratio of the masses of the constituent elements in any pure sample of that compound is always identical on the basis of the atomic molecular theory. • Select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance. • Design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the law of conservation of matter and the law of definite proportions • Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance.		**Summative Assessments:** Quizzes Tests Performance Assessments/ Laboratory Investigations Research / Lab Reports
Resources: Essential Materials, Supplementary Materials, Links to Best Practices *Chemistry,* Zumdahl and Zumdahl, Brooks Cole/ Cengage Learning, 2012. Chapter 2 *AP Chemistry Teacher Lab Manual,* New York: The College Board, 2019. *AP Chemistry Course and Exam Description, The College Board, 2020.*			**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings	

UNIT 3: STOICHIOMETRY AND CHEMICAL REACTIONS **Time 3 weeks**

Essential Questions: Why must a reaction be balanced? How do we predict the quantity of a product in a reaction? How do structures and properties of materials determine their use? How is matter quantified? How do mathematical relationships and experimental data relate to chemical formulas? What role does conservation play in mole relationships? What is a redox reaction and why are they important to us? What is a solution and why is its formation either exothermic or endothermic? How can a titration be used to determine the concentration of an unknown acid and base?

Performance Expectations: (Students who demonstrate understanding can:)
NJSLS-HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

Unit Objectives/Enduring Understandings: (Students will understand that)

1. Data from mass spectrometry can be used to identify the elements and the masses of individual atoms of a specific element.
2. Numbers of particles, moles, mass, and volume of a substance are related to one another, both qualitatively and quantitatively.
3. Chemical equations represent chemical changes, and must obey the law of conservation of matter.
4. When chemical changes occur, the new substances formed have properties that are distinguishable from the initial substances. Such chemical processes can be observed in a variety of ways.
5. Stoichiometric calculations can be used to make predictions of results that would be found in a laboratory and/or analyzing deviations from the expected results.
6. Data from the synthesis or decomposition of a compound can be used to confirm the Law of Conservation of Matter and the Law of Definite Proportions.
7. The amphoteric nature of water plays an important role in the chemistry of aqueous solutions, since water can both accept protons from and donate protons to dissolved species.
8. There are several different types of reactions that can take place in aqueous solutions
9. Reactions in aqueous solutions are crucial for many chemical applications.
10. The identity of a redox reaction can be justified based on electron transfer.

Unit Assessment: (What is the evidence (authentic) that students have achieved the unit objectives/enduring understanding?)
Labs, Activities and Summative Assessment

	Core Content Objectives		**Instructional Actions**	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
PS1.A: Structure and Properties of Matter The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.	• Reaction Types • Atomic masses • Mole and molar mass • Percent composition Chemical formulas • Balancing equations including redox • Stoichiometric calculations • Limiting reactant • Nature and composition of aqueous solutions • Types of reactions -Precipitation	• Analyze data from mass spectrometry to identify isotopes of an element. • Explain the quantitative relationship between the mass spectrum of an element and the masses of the element's isotopes. • Use Avogadro's number to relate numbers of moles of a substance to representative particles. • Use the properties of	<u>**Labs:**</u> • What makes hard water hard • Determination of mass and mole relationships in a chemical reaction • Concentration determination by redox titration	<u>**Formative Assessments:**</u> Class Discussions Worksheets with teacher feedback Drafts of lab reports with teacher feedback

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
PS1.B: Chemical Reactions 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.	- Acid Base - Oxidation/reduction ● Concepts of Arrhenius, Lowry- Bronsted, Lewis ● Oxidation number ● Electrochemistry	metals and nonmetals to predict reaction products. ● Represent changes in matter with a balanced chemical or net ionic equation: a. For physical changes b. For given information about the identity of the reactants and/or products. c. For ions in a given chemical reaction. ● Identify a reaction as acid-base, oxidation-reduction, or precipitation. ● Represent a given chemical reaction or physical process with a consistent particulate model. ● Use the periodic table to predict common oxidation states. ● Use the Activity series of elements to predict single replacement reactions. ● Identify species as Bronsted-Lowry acids, bases, and/or conjugate acid-base pairs, based on proton-transfer involving those species. ● Perform Acid-Base Titrations ● Represent a balanced redox reaction equation using half-reactions.		**<u>Summative Assessments:</u>** Quizzes Tests Performance Assessments /Laboratory Investigations Research / Lab Reports

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		• Use stoichiometric calculations involving limiting reactant and percent yield. • Explain the relationship between trends in the reactivity of elements and periodicity. • Draw and interpret representations of solutions that show the interactions between the solute and solvent. • Calculate the number of solute particles, volume, or molarity of a solution. • Perform dilutions • Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture. • Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process.		
Resources: Essential Materials, Supplementary Materials, Links to Best Practices *Chemistry,* Zumdahl and Zumdahl, Brooks Cole/ Cengage Learning, 2012. Chapters 3 & 4 *AP Chemistry Teacher Lab Manual,* New York: The College Board, 2019. *AP Chemistry Course and Exam Description, The College Board, 2020.*			**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings	

UNIT 4: KINETIC-MOLECULAR THEORY & STATES OF MATTER **Time: 2.5 weeks**

Essential Questions: How do the properties of matter change as phases change? How does the kinetic molecular theory apply to gases, liquids and solids?

Performance Expectations: (Students who demonstrate understanding can:)
NJSLS-HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

Unit Objectives/Enduring Understandings: (Students will understand that)

1. The kinetic-molecular theory is based on the idea that particles of matter are always in motion.
2. The K-M theory can be used to explain the properties of solids, liquids and gases in terms of the energy of particles and the forces that act between them.

Unit Assessment: (What is the evidence (authentic) that students have achieved the unit objectives/enduring understanding?)
Labs, Activities and Summative Assessment

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
PS1.A: Structure and Properties of Matter A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.	• 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. • That it is assumed that the particles in a gas phase move independently of one another because the attractive forces between them are minimal. • That temperature is a measure of the average kinetic energy of atoms and molecules in a sample of matter. • Forces of attraction	• Represent the differences between solid, liquid, and gas phases using a particulate-level model. • Identify evidence of chemical and physical changes in matter. • Explain the relationship between the motion of particles and the macroscopic properties of gases with: a. the KMT b. a particulate model c. a graphical representation • Apply mathematical relationships or estimation to determine macroscopic variables for ideal gases. • Connect the number of particles, moles, mass, and volume of a gas to one another, both quantitatively and qualitatively.	**<u>Labs:</u>** • Molecular mass of a volatile liquid by vapor density. • Graham's Law Inquiry Activity	**<u>Formative Assessments:</u>** Class Discussions Worksheets with teacher feedback Drafts of lab reports with teacher feedback. **<u>Summative Assessments:</u>** Quizzes Tests Performance Assessments /Laboratory Investigations Research / Lab Reports

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
	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. • 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. • 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 • Dipole forces result from the attraction among the positive ends and negative ends of polar molecules. • Hydrogen bonding is a	• Explain the relationship between the macroscopic properties of a sample of gas or mixture of gases using the ideal gas law. • Relate quantities of macroscopic properties of gases to identify stoichiometric relationships for a reaction, including involving limiting reactions and reactions that have not gone to completion. • Relate temperature to the motion of particles, either via particulate representations, such as drawings of particles with arrows indicating velocities, and/or via representations of average kinetic energy and distribution of kinetic energies of the particles, such as plots of the Maxwell-Boltzman distribution. • Explain the relationship among non-ideal behaviors of gases, interparticle forces and/or volumes. • Predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views.		

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
	a strong type of dipole dipole force that exists when very electronegative atoms (N O F) are involved. ● Intermolecular forces play a key role in determining the properties of substances, including biological structures and interactions. ● Noncovalent and intermolecular interactions play important roles in many biological and polymer systems.	● Use aspects of particulate models (particle spacing, motion, and forces of attraction) to reason about observed differences between solid and liquid phases and among solid and liquid materials. ● Explain the trends in properties and/or predict properties of samples consisting of particles with no permanent dipole on the basis of London dispersion forces. ● Explain the relationship between the chemical structures of molecules and the relative strength of their intermolecular forces when: a. The molecules are of the same chemical species. b. The molecules are of two different chemical species. ● Identify the noncovalent interactions within and between large molecules and connect the shape and function of the large molecule to the presence and magnitude of these interactions.		

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		• Explain the properties (phase, vapor pressure, viscosity, etc) of small and large molecular compounds in terms of the strengths and types of intermolecular forces. • Explain the relationship among the macroscopic properties of a substance, the particulate-level structure of the substance, and the interactions between these particles (bp, solubility, hardness, brittleness, low volatility, lack of malleability, ductility, or conductivity), • Design or evaluate a plan to collect or interpret data needed to deduce the type of bonding in a sample of a solid. • Create a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance. • Compare the properties of metal alloys with their constituent elements to determine if an alloy has formed, identify the type of alloy formed, and explain the differences in properties using particulate level reasoning.		

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		• Use the electron sea model of metallic bonding to predict or make claims about the macroscopic properties of metals or alloys. • Create a representation of a metallic solid that shows essential characteristics of the structure and interactions present in the substance. • Explain a representation that connects properties of a metallic solid to its structural attributes and to the interactions present at the atomic level. • Create a representation of a covalent solid that shows essential characteristics of the structure and interactions present in the substance. • Explain a representation that connects properties of a covalent solid to its structural attributes and to the interactions present at the atomic level. • Create a representation of an ionic solid that shows essential characteristics of the structure and interactions present in the substance.		

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		• Explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level.		

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings
Chemistry, Zumdahl and Zumdahl, Brooks Cole/ Cengage Learning, 2012. Chapters 5 & 10 *AP Chemistry Teacher Lab Manual,* New York: The College Board, 2019. *AP Chemistry Course and Exam Description, The College Board, 2020.*	

UNIT 5: THERMODYNAMICS **Time: 2.5 weeks**

Essential Questions: How is energy transferred in chemical systems? How does the potential energy and kinetic energy of molecules change during thermo-dynamic processes? How can Hess's law be used to determine the heat of reaction that is not practical to carry out? What is calorimetry? What changes will result in an increase in entropy? What must occur in a chemical reaction for it to proceed spontaneously? How is the Gibbs free energy related to the equilibrium constant for a chemical reaction?

Performance Expectations: (Students who demonstrate understanding can:)
NJSLS-HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Unit Objectives/Enduring Understandings: (Students will understand that)

1. Thermochemistry is the study of the transfers of energy as heat that accompany chemical reactions and physical changes.
2. Macroscopic observations of energy changes when chemicals react are made possible by measuring temperature changes
3. These observations should be placed within the context of the language of exothermic and endothermic change.
4. Specific heat capacity is essential to monitoring heat flow between a system and its surroundings.
5. Energy cannot be created or destroyed; it is just changed from one form to another.
6. It is important to be able to use an understanding of energy changes in chemical reactions to identify the role of endothermic or exothermic reactions in real world processes.
7. Molecules in a warmer body have more kinetic energy and do the molecules in a cooler body.
8. Collisions of molecules that are in thermal contact transfer energy.
9. Eventually, thermal equilibrium is reached as the molecular collisions continue.
10. Heat is not a substance, it is energy that is transferred from a hot to a cold body in thermal contact.
11. Energy can be transferred through work.
12. Reaction enthalpy is related to the energies associated with the breaking and formation of chemical bonds.
13. Entropy is a measure of the dispersal of matter and energy.
14. Entropy increases as matter is dispersed or more free to move, occupy a greater volume, number of particles increase as a reaction proceeds, and energy is dispersed.
15. Chemical and physical processes are driven by an decrease in free energy.

Unit Assessment: (What is the evidence (authentic) that students have achieved the unit objectives/enduring understanding?)
Labs, Activities and Summative Assessment

	Core Content Objectives		**Instructional Actions**	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
PS1.B: Chemical Reactions 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 rearrangements of atoms into new molecules, with consequent	● Thermal energy, heat and temperature ● Enthalpy and Calorimetry ● Enthalpies of formation ● Hess's Law ● Spontaneous Process and Entropy	● Define the following thermodynamic terms: enthalpy, delta H, exothermic, endothermic, systems, surroundings, universe, heat of formation, heat of reaction, calorimetry, heat, calorie, joule, standard molar heat of combustion.	**<u>Labs:</u>** ● Calorimetry ● Heats of Reaction	**<u>Formative Assessments:</u>** Class Discussions Worksheets with teacher feedback

	Core Content Objectives		**Instructional Actions**	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	• Second law of Thermodynamics • Effect of Temperature on Spontaneity • Free energy • Entropy changes in a chemical reaction • Free Energy and chemical reactions, pressure, equilibrium, and work	• Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation. • Calculate the heat, q, absorbed or released by a system undergoing heating/cooling based on the amount of the substance, the heat capacity, and the change in temperature. • Calculate the heat, q, absorbed or released by a system undergoing a chemical reaction in relationship to the amount of the reacting substance in moles and the molar enthalpy of reaction. • Interpret observations regarding macroscopic energy changes associated with a reaction or process to generate a relevant symbolic and or graphical representation of the energy change. • Generate explanations or make predictions about the transfer of thermal energy between systems based on the transfer being due to a kinetic energy transfer between system arising from molecular collisions.		Drafts of lab reports with teacher feedback. **Summative Assessments:** Quizzes Tests Performance Assessments/ Laboratory Investigations Research / Lab Reports

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		• Use conservation of energy to relate magnitude of the energy changes occurring in two or more interacting systems. • Use calculations or estimations to relate energy changes associated with heating/cooling a substance to the heat capacity, relate energy changes associated with a phase transition to the enthalpy of fusion/ vaporization, relate energy changes associated with a chemical reaction to the enthalpy of the reaction, and relate energy changes to $P\Delta V$ work. • Identify the sign and relative magnitude of the entropy change associated with a chemical or physical process. • Calculate the entropy change for a chemical or physical process based on the absolute entropies of the species involved in the process. • Identify the non-covalent interactions within and between large molecules, and or connect the shape and function of the large molecule to the presence and magnitude of these interactions.		

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		• Explain why thermodynamically favored chemical reactions may not produce large amounts of energy. • Explain, in terms of kinetics, why a thermodynamically favored chemical reactions may not occur at a measurable rate (kinetic control). • Explain the relationship between external sources of energy or coupled reactions and their ability to drive thermodynamically unfavorable processes. • Calculate the enthalpy change of a reaction based on the average bond energies of bonds broken and formed in the reaction. • Calculate the enthalpy of change for a chemical or physical process based on the standard enthalpies of formation. • Represent a chemical or physical process as a sequence of steps. • Explain the relationship between the enthalpy of a chemical or physical process and the sum of the enthalpies of the individual steps		

	Core Content Objectives		**Instructional Actions**	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		● Explain the relationship between the solubility of a salt and changes in enthalpy and entropy that occur in the dissolution process. ● Explain whether a physical or chemical process is thermodynamically favored based on an evaluation of Delta G^{o} ● Explain whether a process is thermodynamically favored using the relationships between K, Delta G^{o} , and T.		

Resources: Essential Materials, Supplementary Materials, Links to Best Practices *Chemistry,* Zumdahl and Zumdahl, Brooks Cole/ Cengage Learning, 2012. Chapter 6 *AP Chemistry Teacher Lab Manual,* New York: The College Board, 2019. *AP Chemistry Course and Exam Description, The College Board, 2020.*	**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings

UNIT 6: ATOMIC STRUCTURE, PERIODICITY & NUCLEAR STRUCTURE Time: 3 weeks

Essential Questions: How does the structure of the periodic table allow us to predict the chemical and physical properties of an element? What is radioactivity? How do radioactive emissions occur? How is nuclear chemistry beneficial in our lives? How is nuclear chemistry harmful to our lives? What is periodic lab? How are electrons situated about the nucleus?

Performance Expectations: (Students who demonstrate understanding can:)
NJSLS-HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

NJSLS-HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

NJSLS-HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle, and that for some situations one model is more useful than the other.

Unit Objectives/Enduring Understandings: (Students will understand that)

1. An atom is the smallest particle of an element that retains the chemical properties of that element.
2. The emission of light is fundamentally related to the behavior of electrons.
3. The physical and chemical properties of the elements are periodic functions of their atomic numbers.
4. Energy of photon is related to frequency by Plank’s equation.
5. Different types of molecular motion lead to absorption or emission of photons in different spectral regions.
6. Infrared radiation is associated with transitions in molecular vibrations and can be used to detect the presence of different types of bonds
7. Ultraviolet/visible radiation is associated with transitions in electronic energy levels and so can be used to probe electronic structure.
8. The amount of light absorbed by a solution can be used to determine the concentration of the absorbing molecules in that solution. (Beer-Lambert Law)
9. Electrons to not travel in fixed energy orbits, rather they exist in regions of space about the nucleus called orbitals.
10. The quantum model addresses known problems with the classical shell model and is also consistent with atomic electronic structures that correspond with the periodic table.
11. Construction of a shell model of the atom through ionization energy information provides an opportunity to show how a model can be refined and changed as additional information is considered.
12. Electron configurations provide a method for describing the distribution of electrons in an atom or ion.
13. The structure of the Periodic table is a consequence of the pattern of electron configurations and the presence of shells and subshells of electrons in atoms.
14. Many atomic properties, trends within the periodic table can be qualitatively understood and explained using Coulomb’s law, the shell model, and the concept of shielding and effective nuclear charge.
15. In nuclear reactions, the nuclei of unstable isotopes, called radioisotopes, gain stability by undergoing changes.
16. Nuclear reactions are always accompanied by the emission of large amounts of energy.
17. Nuclear reactions are not affected by changes in temperature, pressure or the presence of a catalyst.

Unit Assessment: (What is the evidence (authentic) that students have achieved the unit objectives/enduring understanding?)
Labs, Activities and Summative Assessment

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
PS1.C: Nuclear Processes Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. **PS4.A: Wave Properties** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	• Electromagnetic radiation • Electronic Structure • Atomic theory • Atomic Mass • Atomic number & mass number • Electron energy levels: atomic spectra, quantum numbers, atomic orbitals. • Periodic relationships. • Nuclear Structure a. Nuclear equations b. Half-lives c. Radioactivity d. Chemical Applications	• List the types of radioactive emissions. • Discuss the Bohr model of the atom, and compare it to the quantum mechanical model of an atom. • Discuss the major differences in the classical mechanical model and the quantum mechanical model. • Work problems involving quantum numbers and energies of electron transitions. • Explain the properties of an absorbed or emitted photon in relationship to an electronic transition in an atom or molecule. • Define and discuss the following terms or concepts: Heisenberg Uncertainty Principle, Pauli Exclusion Principle, wave-particle duality of matter, wave function of electrons (Y), radial probability density, orbitals, Aufbau process and Hunds's rule.	**<u>Labs:</u>** • Beer-Lambert Law. Relationship between the Concentration of a Solution and Amount of Transmitted Light	**<u>Formative Assessments:</u>** Class Discussions Worksheets with teacher feedback Drafts of lab reports with teacher feedback. **<u>Summative Assessments:</u>** Quizzes Tests Performance Assessments /Laboratory Investigations Research / Lab Reports

	Core Content Objectives		**Instructional Actions**	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		• Draw and name the s, p, and d orbitals. • The student can justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules. • Explain why a given set of data suggests, or does not suggest, the need to refine the atomic model from the classical shell model with the quantum mechanical model. • Predict and/ or explain the relationship between trends in atomic properties of elements and electronic structure and periodicity. • Justify with evidence the arrangement of the periodic table • Analyze data, based on periodicity and the properties of binary compounds, to identify patterns and generate hypotheses related to the molecular design of compounds for which data are not supplied		

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		• Explain the distribution of electrons in an atom or ion based upon data (photoelectron spectroscopy and electron configuration). • Analyze data relating to electron energies for patterns and relarelationships • Predict nuclear stability and mode of decay using N/Z ratio. • Solve problems involving half-life • Balance nuclear equations • Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity • Explain the relationship between a region of the electromagnetic spectrum and the types of molecular or electronic transitions associated with the region. • Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity.		

Resources: Essential Materials, Supplementary Materials, Links to Best Practices *Chemistry,* Zumdahl and Zumdahl, Brooks Cole/ Cengage Learning, 2012. Chapters 7 & 19 *AP Chemistry Teacher Lab Manual,* New York: The College Board, 2019. *AP Chemistry Course and Exam Description, The College Board, 2020.*	**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings

UNIT 7: CHEMICAL BONDING **Time: 3.5 weeks**

Essential Questions: How does a study of valence electrons help to explain most chemical phenomena? How does chemical naming exhibit organizational patterns? What causes ionic bonding? What is a covalent bond? How can the type of bonding exhibited in a substance be predicted? What constitutes a metallic bond? How can a structural formula be predicted?

Performance Expectations: (Students who demonstrate understanding can:)
NJSLS-HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Unit Objectives/Enduring Understandings: (Students will understand that)

1. Electronic structure can be explained through the use of PES data, ionization energy data, and Coulomb's law.
2. Electron configurations provide a method for describing the distribution of electrons in atoms.
3. Transformations of matter can be observed as chemical or physical changes. These changes can be distinguished by considering the electrostatic forces associated with a given change.
4. The shapes of particles involved, and the space between them, are key factors in determining the nature of these physical changes.
5. Properties of substances can be predicted based on their chemical formulas and provide explanations of their properties based on particle views.
6. Through bonding, atoms decrease in potential energy, thereby creating more stable arrangements of matter.

Unit Assessment: (What is the evidence (authentic) that students have achieved the unit objectives/enduring understanding?)
Labs, Activities and Summative Assessment

	Core Content Objectives		**Instructional Actions**	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students be will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
PS1.A: Structure and Properties of Matter The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. **PS2.B: Types of Interactions** 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.	• Binding forces a. Ionic b. Covalent c. Metallic d. Hydrogen bonding e. Van der Waals • Relationships to states, structures, and properties of matter • Polarity of bonds, Electronegativities • Molecular models a. Lewis Structures b. Valence bond • Hybridization of orbitals, resonance, sigma & pi bonds	• Explain the relationship between macroscopic characteristics and bond interactions for: a. Chemical processes b. Physical processes • Use electronegativity periodic trends to predict bond type. • Distinguish between polar and nonpolar molecules. • Use electronegativity values and bonding concepts to determine oxidation states. • Represent a molecule with a Lewis diagram that accounts for resonance between equivalent structures or that uses formal charge to select between nonequivalent structures.	**<u>Labs:</u>** • Model Building: Lewis Structures and VSEPR	**<u>Formative Assessments:</u>** Class Discussions Worksheets with teacher feedback Drafts of lab reports with teacher feedback.

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
	● VSEPR ● Geometry of molecules and ions. ● Structural, geometric, optical and conformational isomerisms of: ● Organic molecules ● Coordination complexes. ● Polarity of Molecules ● Relation of molecular structure to physical properties.	● Create or use graphical representations in order to connect the dependence of potential energy to the distance between atoms, based on factors, such as bond order and polarity which influence interaction strength. ● Rank and justify the ranking of bond polarity on the basis of the locations of the bonded atoms on the periodic table. ● Create a particulate model representation of an ionic solid that is consistent with Coulomb's law that shows essential characteristics of the structure and interactions present in the substance. ● Explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level. ● Based on the relationship between Lewis diagrams, VSEPR theory, bond orders, and bond polarities: a. Explain structural properties of models b. Explain electron properties of molecules.		**Summative Assessments:** Quizzes Tests Performance Assessments /Laboratory Investigations Research / Lab Reports
Resources: Essential Materials, Supplementary Materials, Links to Best Practices *Chemistry,* Zumdahl and Zumdahl, Brooks Cole/ Cengage Learning, 2012. Chapters 8 & 9 *AP Chemistry Teacher Lab Manual,* New York: The College Board, 2019. *AP Chemistry Course and Exam Description, The College Board, 2020.*			**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings	

UNIT 8: PROPERTIES OF SOLUTIONS **Time: 2.5 weeks**

Essential Questions: What factors determine the rate at which a substance dissolves? In what ways are solutions used in home, industry and nature?

Performance Expectations: (Students who demonstrate understanding can:)
NJSLS-HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Unit Objectives/Enduring Understandings: (Students will understand that)
1. Solutions are homogeneous mixtures of two or more substances in a single phase.
2. The nature of the solvent and of the solute are factors that affect whether a substance will dissolve.

Unit Assessment: (What is the evidence (authentic) that students have achieved the unit objectives/enduring understanding?)
Labs, Activities and Summative Assessment

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What Students will know.*	**Skills** *What Students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
PS1.A: Structure and Properties of Matter The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. **PS2.B: Types of Interactions** 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.	• Solutions are homogeneous 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. • Forces of attraction between particles are important in determining many macroscopic properties of a substance, including solubility. • At the particulate scale, chemical processes can be distinguished from physical processes because chemical bonds can be distinguished from intermolecular	• Draw and/or interpret representations of solutions that show the interactions between the solute and solvent. • Create or interpret representations that link the concept of molarity with particle views of solutions. • Apply Coulomb's law qualitatively (including using representations) to describe the interactions of ions, and the attractions between ions and solvents to explain the factors that contribute to the solubility of ionic compounds. • Explain observations regarding the solubility of ionic solids and molecules in water and other solvents on the basis of particle views that include intermolecular interactions	**<u>Labs:</u>** • Separation by Chromatography: How do you separate molecules that are attracted to one another? Research one of the dye molecules used in this lab and relate to present day societal issues concerning health and safety.	**<u>Formative Assessments:</u>** Class Discussions Worksheets with teacher feedback Drafts of lab reports with teacher feedback. **<u>Summative Assessments:</u>** Quizzes Tests Performance Assessments/ Laboratory Investigations

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What Students will know.*	**Skills** *What Students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
	interactions. ● The solubility of a substance can be understood in terms of chemical equilibrium.	and entropic effects. ● Support the claim about whether the process of dissolving a solute is a chemical or physical change based on whether the process involves changes in intramolecular versus intermolecular interactions. ● Analyze the enthalpic and entropic changes associated with the dissolution of a salt, using particulate level interactions and representations. ● Using particulate models for mixtures: a. Represent interactions between components. b. Represent concentrations of components ● Explain the relationship between the solubility of ionic and molecular compounds in aqueous and nonaqueous solvents, and the intermolecular interactions between particles. ● Explain how solutes can be separated by chromatography.		Research / Lab Reports

Resources: Essential Materials, Supplementary Materials, Links to Best Practices
Chemistry, Zumdahl and Zumdahl, Brooks Cole/ Cengage Learning, 2012. Chapter 11
AP Chemistry Teacher Lab Manual, New York: The College Board, 2019.
AP Chemistry Course and Exam Description, The College Board, 2020.

Instructional Adjustments: Modifications, student difficulties, possible misunderstandings

UNIT 9: CHEMICAL KINETICS **Time: 3 weeks**

Essential Questions: What factors influence the rate of a chemical reaction? What familiar applications exist that use an increased rate of reaction?

Performance Expectations: (Students who demonstrate understanding can:)
NJSLS-HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Unit Objectives/Enduring Understandings: (Students will understand that)

1. The enthalpy change, entropy change and free energy of a chemical reaction are independent of the actual route by which a reaction occurs.
2. The study of reaction rates is concerned with the factors that affect the rate and with the mathematical expressions that reveal the specific dependencies of the rate on concentration.
3. The area of chemistry that is concerned with reaction rates and reaction mechanisms is called chemical kinetics.

Unit Assessment: (What is the evidence (authentic) that students have achieved the unit objectives/enduring understanding?)
Labs, Activities and Summative Assessment

	Core Content Objectives		**Instructional Actions**	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**

PS1.B: Chemical Reactions 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 rearrangements 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.	• 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. • The magnitude and temperature dependence of the rate of reaction is contained quantitatively in the rate constant. • Elementary reactions can be unimolecular or involve collisions between two or more molecules.	• Design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction. • Analyze concentration vs. time data to determine the rate law for a zero, first, or second order reaction. • Represent experimental data with a consistent rate law expression. • Explain the relationship between the rate of a chemical reaction and experimental parameters. • Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time.	**Labs:** • Determination of the half life of a 1^{st} order reaction Catalysis Inquiry Activity	**Formative Assessments:** Class Discussions Worksheets with teacher feedback Drafts of lab reports with teacher feedback. **Summative Assessments:** Quizzes Tests

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
	• Not all collisions are successful because the colliding species need sufficient energy to get over the activation energy barrier and the orientations of the reactant molecules during the collision must allow for the rearrangement of reactant bonds to form product bonds. • A successful collision can be viewed as following a reaction path with an associated energy profile. • The mechanism of a multistep reaction consists of a series of elementary reactions that add up to the overall reaction. • In many reactions, the rate is set by the slowest elementary reaction, or rate-limiting step. • Reaction intermediates, which are formed during the reaction but not present in the overall reaction, play an important role in multistep reactions.	• Represent an elementary reaction as a rate law expression using stoichiometry. • Connect the half-life of a reaction to the rate constant of a first-order reaction and justify the use of this relation in terms of the reaction being a first-order reaction. • Explain the relationship between the rate of an elementary reaction and the frequency, energy, and orientation of molecular collisions. • Represent the activation energy and overall energy change in an elementary reaction and multistep reaction using a reaction energy profile. • Identify the components of a reaction mechanism. • Identify the rate law for a reaction from a mechanism in which the first step is rate limiting and/or the first step is not rate limiting. • Evaluate alternative explanations, as expressed by reaction mechanisms, to determine which are consistent with data regarding the overall rate of a reaction, and data that can be used to infer the presence of a reaction intermediate.		Performance Assessments/ Laboratory Investigations Research / Lab Reports

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
	• Steady-State approximations are made when the first elementary step is fast. • Catalysts function by lowering the activation energy of an elementary step in a reaction mechanism, and by providing a new and faster reaction mechanism. • Important classes in catalysis include acid-base catalysis, surface catalysis, and enzyme catalysis. • Data can be used to calculate rate laws. • Reaction Energy Profiles represent chemical substances or phenomena.	• Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism. • Explain changes in reaction rates arising from the use of acid-base catalysts, surface catalysts, or enzyme catalysts, including selecting appropriate mechanisms with or without the catalyst present.		

Resources: Essential Materials, Supplementary Materials, Links to Best Practices *Chemistry,* Zumdahl and Zumdahl, Brooks Cole/ Cengage Learning, 2012. Chapters 12 & 17 *AP Chemistry Teacher Lab Manual,* New York: The College Board, 2019. *AP Chemistry Course and Exam Description, The College Board, 2020.*	**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings

UNIT 10: EQUILIBRIUM **Time: 2.5 weeks**

Essential Questions: How can changing the reaction conditions influence the yield of a chemical reaction? How is the concept of reactants turning into productions an oversimplification? Where do we see evidence of chemical equilibrium in human systems?

Performance Expectations: (Students who demonstrate understanding can:)
NJSLS-HS-PS1-6 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

Unit Objectives/Enduring Understandings: (Students will understand that)
1. In systems that are in equilibrium, opposing processes occur at the same time and at the same rate.
2. External factors modify the direction and rate of chemical reactions.

Unit Assessment: (What is the evidence (authentic) that students have achieved the unit objectives/enduring understanding?)
Labs, Activities and Summative Assessment

	Core Content Objectives		**Instructional Actions**	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
PS1.B: Chemical Reactions In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. **ETS1.C: Optimizing the Design Solution** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others may be needed.	• In many classes of reactions, it is important to consider both the forward and reverse reaction. • 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. • When a system is at equilibrium, all macroscopic variables, such as concentrations, partial pressures, and temperature, do not change over time.	• Explain the relationship between the occurrence of a reversible chemical or physical process, and the establishment of equilibrium, to experimental observations. • Explain the relationship between the direction in which a reversible reaction proceeds and the relative rates of the forward and reverse reactions. • Represent Qc or Qp for a reversible reaction, and the corresponding Kc=Qp or Kp=Qp • Determine the effects of manipulation on Q or K given a manipulation of a chemical reaction or set of reactions (ie, reversal of reaction or addition of two reactions). • Calculate K, based on experimental observations of concentrations or pressures at equilibrium.	**<u>Labs:</u>** • Determining the equilibrium constant for a reaction • Separation and Qualitative analysis of cations and anions. • Inquiry Activity on the application of equilibrium on biological systems.	**<u>Formative Assessments:</u>** Class Discussions Worksheets with teacher feedback Drafts of lab reports with teacher feedback. **<u>Summative Assessments:</u>** Quizzes Tests

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
	• Equilibrium results from an equality between the rates of the forward and reverse reactions, at which point Q=K. • The magnitude of the equilibrium constant, K, can be used to determine whether the equilibrium lies toward the reactant side or product side. • Systems at equilibrium respond to disturbances by partially countering the effect of the disturbances (Le Chatelier's Principle) • 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. • The solubility of a substance can be understood in terms of chemical equilibrium.	• Use the tendency of Q to approach K to predict and justify the prediction as to whether the reaction will proceed toward products or reactants as equilibrium is approached if given a set of initial conditions (concentrations or partial pressures) and K. • Use stoichiometric relationships and the law of mass action (Q=K at equilibrium)to determine qualitatively and/or quantitatively the conditions at equilibrium for a system involving a single reversible reaction if they are given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K. • Represent multistep process with an overall equilibrium expression, using the constituent K expressions for each individual reaction. • Identify the concentrations or partial pressures of chemical species at equilibrium based on the initial conditions and the equilibrium constant.		Performance Assessments /Laboratory Investigations Research / Lab Reports

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		• Represent a system undergoing a reversible reaction with a particulate model. • Explain the relationship between very large or very small values of K and the relative concentrations of chemical species at equilibrium. • Identify the response of a system at equilibrium to an external stress, using Le Chatelier's principle. • Explain the relationships between Q,K, and the direction in which a reversible reaction will proceed to reach equilibrium. • Calculate the solubility of a salt, or rank the solubility of salts, based on the value of Ksp for the salt. • Identify the solubility of a salt, and/or the value of Ksp for the salt, based on the concentration of a common ion already present in solution. • Identify the qualitative effect of changes in pH on the solubility of a salt.		
Resources: Essential Materials, Supplementary Materials, Links to Best Practices *Chemistry,* Zumdahl and Zumdahl, Brooks Cole/ Cengage Learning, 2012. Chapters 13 & 16 *AP Chemistry Teacher Lab Manual,* New York: The College Board, 2019. *AP Chemistry Course and Exam Description, The College Board, 2020.*			**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings	

UNIT 11: ACIDS & BASES **Time: 3.5 weeks**

Essential Questions: How does the solution concentration affect the properties of the solution? What are the physical and chemical properties of acids and bases?How are acids and bases important to living things?

Performance Expectations: (Students who demonstrate understanding can:)
NJSLS-HS-PS1-6 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

Unit Objectives/Enduring Understandings: (Students will understand that)

1. Acids and bases are defined by the theories of Arrhenius, Bronsted-Lowry, and Lewis.
2. Chemical equilibrium plays an important role in acid-base chemistry.
3. Acids and bases display distinct characteristics that influence chemical reactions
4. Salt is a general term used to describe a substance that is created when an acid is neutralized by a base.

Unit Assessment: (What is the evidence (authentic) that students have achieved the unit objectives/enduring understanding?)
Labs, Activities and Summative Assessment

	Core Content Objectives		**Instructional Actions**	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
PS1.B: Chemical Reactions In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. **ETS1.C: Optimizing the Design Solution** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others may be needed.	• In a neutralization reaction, protons are transferred from an acid to a base. • Chemical equilibrium reasoning can be used to describe the proton-transfer reactions of acid-base chemistry. • 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.	• Calculate the values of pH and pOH, based on Kw and the concentrations of all species present in a neutral solution of water. • Calculate pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base. • Explain the relationship among pH, pOH, and concentrations of all species in a solution of a monoprotic weak acid or weak base. • Explain the relationship between the strength of an acid or base based on molecular structure, interparticle forces, and solution equilibrium. • Explain the relationship between the predominant form of a weak acid or base in solution at a given pH	**<u>Labs:</u>** • Standardization of a solution using a primary standard. • Determination of Buffer capacity • Titration of a solid acid to find its molecular weight.	**<u>Formative Assessments:</u>** Class Discussions Worksheets with teacher feedback Drafts of lab reports with teacher feedback. **<u>Summative Assessments:</u>** Quizzes Tests

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		and the pKa of the conjugate acid or the pKb of the conjugate base. ● Identify compounds as Bronsted-Lowry acids, bases, and/or conjugate acid-base pairs, using proton-transfer reactions for justification. ● Generate or use a particulate representation of an acid (strong, weak or polyprotic) and a strong base to explain the species that will have large v. small conc. at equilibrium. ● Reason about the distinction between strong and weak acid solutions with similar values of pH, including the percent ionization of the acids, the concentrations needed to achieve the same pH, and the amount of base needed to reach the equivalence point in a titration. ● Use stoichiometric calculations to predict the results of performing an acid-base titration. ● Identify the equivalence point in a titration based on the amounts of the titrant and analyte, assuming the titration reaction goes to completion.		Performance Assessments /Laboratory Investigations Research / Lab Reports

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		• Design an experiment that uses titration to determine the concentration of an unknown acid. • Explain titration results for monoprotic or polyprotic acids involving titration of a weak or strong acid by a strong base (or a weak or strong base by a strong acid) to determine the concentration of the titrant and the pKa for a weak acid, or the pKb for a weak base. • Reason that neutrality requires [H+] = [OH-] as opposed to requiring pH = 7, including especially the applications to biological systems based on the dependence of Kw on temperature. • Identify a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), calculate the pH and concentration of all species in the solution, ad/or infer the relative strengths of the weak acids or bases from given equilibrium concentrations. • Determine which species (given an arbitrary mixture of weak and strong acids and bases including polyprotic		

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		systems) will react strongly with one another (ie K>1) and what species will be present in large concentrations at equilibrium. ● Explain the relationship between the ability of a buffer to stabilize pH and the reactions that occur when an acid or a base is added to a buffered solution. ● Design a buffer solution with a target pH and buffer capacity by selecting an appropriate conjugate acid- base pair and estimating the concentrations needed to achieve the desired capacity. ● Identify the pH of a buffer solution based on the identity and concentrations of the conjugate acid-base pair used to create the buffer using the Henderson-Hasselbalch equation. ● Explain the relationship between the buffer capacity of a solution and the relative concentrations of the conjugate acid and the conjugate base components of the solution.		

	Core Content Objectives		Instructional Actions	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
		• Relate the predominate form of a chemical species involving a mobile proton (ie, protonated/deprotonate form of a weak acid) to the pH of a solution and the pKa associated with the labile proton. • Explain the relationship among the concentration of major species in a mixture of weak and strong acids and bases using the Henderson-Hasselbalch equation.		

Resources: Essential Materials, Supplementary Materials, Links to Best Practices *Chemistry,* Zumdahl and Zumdahl, Brooks Cole/ Cengage Learning, 2012. Chapters 14 & 15 *AP Chemistry Teacher Lab Manual,* New York: The College Board, 2019. *AP Chemistry Course and Exam Description, The College Board, 2020.*	**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings

UNIT 12: ELECTROCHEMISTRY **Time: 3 weeks**

Essential Questions: How do redox reactions make it possible for energy interconversions between electrical energy and chemical energy? What applications does electrochemistry have to home and industry? What biological systems use electrochemistry?

Performance Expectations: (Students who demonstrate understanding can:)
NJSLS-HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Unit Objectives/Enduring Understandings: (Students will understand that)

1. Oxidation-reduction reactions involve electron transfer, the net release or net absorption of the energy can occur in the form of electrical energy rather than as heat.
2. The branch of chemistry that deals with electricity-related application of oxidation-reduction reactions is called electrochemistry.

Unit Assessment: (What is the evidence (authentic) that students have achieved the unit objectives/enduring understanding?)
Labs, Activities and Summative Assessment

	Core Content Objectives		**Instructional Actions**	
Disciplinary Core Ideas	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
PS1.B: Chemical Reactions 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 rearrangements 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.	● In oxidation reduction reactions, there is a net transfer of electrons. ● The species that loses electrons is oxidized, and the species that gains electrons is reduced. ● Electrochemistry shows the interconversion between chemical and electrical energy in galvanic and electrolytic cells. ● External sources of energy (like a current of electrons) can be used to drive an electrolysis reaction in spite of the fact that the delta G for these reactions is positive.	● Identify redox reactions and justify the identification in terms of electron transfer. ● Make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/or Faraday's laws. ● Analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions. ● Balance complex redox reactions in acidic or basic solution. ● Explain how the application of an external energy source or the coupling of favorable with unfavorable reactions can	**<u>Labs:</u>** ● Predicting the Products of Chemical Reactions and Writing Chemical Equations ● Measurement Using Electrochemical Cells and Electroplating	**<u>Formative Assessments:</u>** Class Discussions Worksheets with teacher feedback Drafts of lab reports with teacher feedback. **<u>Summative Assessments:</u>** Quizzes Tests

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		cause processes that are not thermodynamically favorable to become favorable. ● Explain the relationship between the physical components of an electrochemical cell and the overall operational principles of the cell. ● Explain the relationship between deviations from standard cell conditions and changes in the cell potential (Nernst Equation). ● Explain whether an electrochemical cell is thermodynamically favored, based on its standard cell potential and the constituent half-reactions within the cell. ● Calculate the amount of charge flow based on changes in the amounts of reactants and products in an electrochemical cell.		Performance Assessments /Laboratory Investigations Research / Lab Reports

Resources: Essential Materials, Supplementary Materials, Links to Best Practices *Chemistry,* Zumdahl and Zumdahl, Brooks Cole/ Cengage Learning, 2012. Chapter 18 *AP Chemistry Teacher Lab Manual,* New York: The College Board, 2019. *AP Chemistry Course and Exam Description, The College Board, 2020.*	**Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings