AP Chemistry

Summit High School
Summit, NJ

Grade Level / Content Area:

10th Grade
Advanced Placement Chemistry

Length of Course: 1 year

Developed by
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Summit High School
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Course Description:

Students will learn the basic principles and concepts in chemistry, develop principles from experimental data, and apply these to the solutions of problems. The course is designed for students who have demonstrated both aptitude for and interest in the sciences. Areas covered by students in the course are fundamental concepts of matter and energy, structure and properties of atoms and molecules, chemical bonding and properties of aggregates, and principles of reactions. Descriptive chemistry will be used by students in order to cover all areas studied more effectively, and to understand how chemical phenomena are included in everyday activities. Extra laboratory periods are required during the school day. **There is a summer assignment required for this course. All students enrolled in an AP class are required to prepare for and take the AP exam in May.**

Outline and Pacing guide

Unit 1: Matter, Reactions, Stoichiometry: Chapters 1- 4 (Summer assignment + 6 Weeks)

A. Scientific process
B. Measurement and number treatment
C. Dimensional analysis and quantities in matter
D. Classification of matter
E. Atomic structure and early experiments to characterize the atom
F. Ions and isotopes: mass spectrophotometer
G. Introduction to the periodic table
H. Ionic Compounds: formulas and names
I. The mole
J. Percent composition
K. Chemical Equations
L. Stoichiometry
M. Solution Chemistry
N. Volumetric and Gravimetric calculations
O. Introduction to acid base chemistry
P. Introduction to oxidation reduction reactions

Unit 2: Thermochemistry, Atomic Structure, Periodicity, Bonding: Chapters 6-9 (8 Weeks)

A. Heat and Phase Changes
B. Heat and chemical reactions
C. Enthalpy: endothermic and exothermic reactions
D. Hess's Law
E. Electromagnetic Radiation
F. Wave particle duality, the photoelectric effect
G. Bohr model of the atom

H. Quantum Mechanical model of the atom
I. Electron configuration and quantum numbers
J. Photon Electron Spectroscopy
K. Periodic trends and properties
L. Nature of the chemical bond
M. Ionic Bonding: Born Haber cycle
N. Covalent bonding
O. Lewis structures
P. VSEPR Theory

Unit 3: States of Matter, Intermolecular Forces, Solution Chemistry: Chapters 5, 10, 11 (4 Weeks)

A. The gas phase
B. Empirical gas laws
C. Ideal gas law
D. Kinetic molecular theory of gases
E. Real gases
F. Atmospheric Chemistry and climate change (HS-ESS2-2,3,4)
G. Intermolecular forces
H. Liquid phase
I. Structure and properties of solids
J. Phase diagrams
K. Solution chemistry
L. Factors affecting solubility
M. Colligative properties

Unit 4: Kinetics, Equilibrium, Acid Base Chemistry and Solubility Equilibria: Chapters 12 - 16 (9 Weeks)

A. Reaction rates and collision theory
B. Rate laws: Integrated and differential
C. Reaction mechanisms
D. Experimental determination of Energy of Activation
E. Chemical Equilibrium
F. Equilibrium expressions
G. Calculations in equilibrium
H. Le Chatelier's Principle
I. Defining Acids and bases
J. Factors affecting acid strength
K. pH scale
L. Calculations for weak and strong acids and bases
M. Common ion effect
N. Acid base qualities of salts

O. Buffer solutions properties and calculations
P. Titrations and pH curves
Q. Acid base indicators
R. Solubility and the solubility product: Ksp
S. Precipitation and qualitative analysis

Unit 5: 2nd Law of Thermodynamics and Electrochemistry: Chapters 17 & 18 (3 weeks)

A. Entropy in chemical and physical changes
B. 2nd Law of thermodynamics
C. Free Energy
D. Free energy, work and equilibrium
E. Balancing Redox reactions
F. Redox titrations
G. Galvanic Cells and cell potential
H. Cell potential, equilibrium and free energy
I. Electrolytic Cells, current and electrical work

Review and practice for the AP test

Unit 6: Nuclear Chemistry, Stellar Chemistry and Geochemistry: Chapter 19 (3 Weeks)

A. Nuclear stability and radiation
B. Types of radiation and nuclear equations
C. Using the integrated rate law and timing nuclear decay
D. Energy and matter
E. Fission and fusion
F. Creation of atoms
G. The big bang theory and evidence supporting it
H. The life cycle of stars
I. Radiation within the Earth

Unit 1
Matter, Reactions, Stoichiometry

Big Ideas: Developing and Using Models:

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4), (HS-PS1-8)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Big Ideas: Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

Big Ideas: Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to support claims. (HS-PS1-7)

Big Ideas: Constructing Explanations and Designing Solutions

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)

Big Ideas: Obtaining, Evaluating and Communicating Information

- Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS4-5) (HS-ESS1-3)

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
• How are measurement and observation tools used to assist in categorizing, representing, and interpreting the natural and designed world? • What are the different ways in which matter can be classified? • How is one element different from another? • What does it mean for atoms to be conserved? • Why do chemical reactions occur? • How can we classify chemical reactions?	Students will understand that… **Cross Cutting Concepts** **Patterns** ▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Energy and Matter** ▪ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. ▪ The total amount of energy and matter in closed systems is conserved. ▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

● Is water required for the chemical reactions that are needed for life to exist?	**Stability and Change** ● Much of science deals with constructing explanations of how things change and how they remain stable.
Areas of Focus: Proficiencies (New Jersey Student Learning Standards)	**Lessons**
Students will: ▪ 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 routines to mass data to identify or infer the composition of pure substances and/or mixtures ▪ Select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance ▪ Connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively ▪ Design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in a solution ▪ Express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings ▪ Apply conservation of atoms in the rearrangement of atoms in various processes ▪ Design and/or interpret data from an experiment that uses gravimetric analysis to determine the concentration of an analyte in a solution ▪ Design and/or interpret data from an experiment that uses titration to determine the concentration of an analyte in a solution ▪ Translate among macroscopic observations of change, chemical equations, and particle views ▪ Translate an observed chemical change into a balanced chemical equation and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances ▪ Use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results ▪ Relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants	**Lesson 1:** ● Chapter 1: Chemical Foundations ● Lab #1: Some Measurements of Mass & Volume Accuracy, Precision and standard deviation **Lesson 2:** ● Chapter 2: Atoms, Molecules, and Ions ● Paper lab Mass spectrophotometer **Lesson 3:** ● Chapter 3: Stoichiometry ● Lab #2: Indirect Gravimetric Determination of a Hydrated Compound in a Mixture ● Lab #3: Stoichiometry of Silver **Lesson 4:** ● Chapter 4: Types of Chemical Reactions and Solution Stoichiometry ● Lab #4: What is the Relationship Between the Concentration of a Solution and the Amount of Light Transmitted Through the Solution? ● Lab #5: Chemical Reactions Observing different types and writing equations ● Lab #6: Quantitative Analysis of Unknown Solutions

and situations in which the reaction has not gone to completion ▪ Design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions ▪ Use data for synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions ▪ Evaluate the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions NJSLS DCIs: **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. (HS-PS1-1) ● 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. (HS-PS1-1),(HS-PS1-2) ● The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3),(secondary to HS-PS2-6) **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 (HS-PS1-2) (HS-PS1-7) **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. (secondary to HS-PS1-1),(secondary to HS-PS1-3) ● Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)	

Differentiation

Interdisciplinary Connections

- Writing: sufficient technical writing to achieve procedural objective
- Mathematics: calculation of standard deviation of a set of data
- History: Discussion of various scientists' lives and the relevant events occurring in their home countries as they worked

Technology Integration

- Use graphing calculator for standard deviation calculation
- Use spectrometers connected to computers to collect data for Beer's law lab
- Science and engineering complement each other in the cycle known as research and development.

Media Literacy Integration

- Use of Elements video to stimulate interest in the topic
- Comparison of treatment of hydrofluoric acid in scientific journal and on a TV show

Global Perspectives

- In order to effectively increase knowledge base in the scientific community, laboratory experiments must be repeatable; valid conclusions must be made from results; and the information must be shared in a systematic format with the scientific community.

Supports for English Language Learners

Sensory Supports	Graphic Supports	Interactive Supports
Real-life objects	Charts	In pairs or partners
Manipulatives	Graphic Organizers	In triands or small groups
Pictures	Tables	In a whole group

Assessments

Formative Assessments:

- quizzes
- having students show work on board
- AP problems: atomic structure, periodicity

Summative Assessments, Projects, and Celebrations:

- lab reports
- unit test
- mole day project

Illustrations, diagrams & drawings	Graphs	Using cooperative group
Magazines & Newspapers	Timelines	Structures
Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodations	**Interventions**	**Modifications**
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Unit 2
Thermochemistry, Atomic Structure, Periodicity, Bonding

Big Ideas: Developing and Using Models:
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4), (HS-PS1-8)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Big Ideas: Planning and Carrying Out Investigations
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

Big Ideas: Using Mathematics and Computational Thinking
- Use mathematical representations of phenomena to support claims. (HS-PS1-7)

Big Ideas: Constructing Explanations and Designing Solutions
- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)

Big Ideas: Obtaining, Evaluating and Communicating Information
- Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS4-5) (HS-ESS1-3)

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
• How are atomic models used to explain experimental data? • How are scientific models refined over time? • Why do elements display periodicity in their properties? • How can conceptual, mathematical, physical, and computational tools be applied when constructing and evaluating claims? • What determines the physical properties of matter?	Students will understand that… **Cross Cutting Concepts** **Patterns** ▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Energy and Matter** ▪ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. ▪ The total amount of energy and matter in closed systems is conserved.

● What is a chemical bond? ● How is energy change associated with chemical reactions? ● What is heat? ● What is the law of Conservation of Energy? ● How is energy related to the formation (or breaking) of chemical bonds?	▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. **Stability and Change** ● Much of science deals with constructing explanations of how things change and how they remain stable.
Areas of Focus: Proficiencies (New Jersey Student Learning Standards)	**Lessons**
Students will: ▪ Generate explanations or make predictions about the transfer of thermal energy between systems based on this transfer being due to a kinetic energy transfer between systems arising from molecular collisions. ▪ Use conservation of energy to relate the magnitudes of the energy changes occurring in two or more interacting systems, including identification of the systems, the type (heat versus work), or the direction of energy flow. ▪ Use conservation of energy to relate the magnitudes of the energy changes when two non reacting substances are mixed or brought into contact with one another. ▪ 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. ▪ Design and or interpret the results of an experiment in which calorimetry is used to determine the change in enthalpy of a chemical process (heating/cooling, phase transition, or chemical reaction) at constant pressure. ▪ Draw qualitative and quantitative connections between the reaction enthalpy and the energies involved in the breaking and formation of chemical bonds. ▪ Explain the distribution of electrons in an atom or ion based upon data ▪ Analyze data relating to electron energies for patterns and relationships ▪ Describe the electronic structure of the atom, using photoelectron spectroscopy data, ionization energy data, and/or Coulomb's Law to construct explanations of how the energies of electrons within shells in atoms vary	**Lesson 1:** ● Chapter 6: Thermochemistry ● Lab #7: Heat of Formation of Magnesium Oxide **Lesson 2:** ● Chapter 7: Atomic Structure and Periodicity ● Lab #8: Colorful Flames: Flame tests of salts ● Lab #9: Periodic Trends and the Properties of the Elements **Lesson 3:** ● Chapter 8: Bonding: General Concepts ● Lab #10: Covalent Bonding and Molecular Structure VSEPR lab with models **Lesson 4:** ● Chapter 9: Covalent Bonding: Orbitals

▪ Explain the distribution of electrons using Coulomb's Law to analyze measured energies ▪ Predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model ▪ Justify with evidence the arrangement of the periodic table; apply periodic properties to chemical reactivity ▪ 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 ▪ Explain why a given set of data suggests, or does not suggest, the need to refine the atomic model from a classical shell model with the quantum mechanical model ▪ Determine if a particular model of the atom is consistent with specified evidence if given information about the model ▪ Use data from mass spectrometry to identify the elements and the masses of individual atoms of a specific element ▪ Justify the selection of a particular type of spectroscopy to measure properties association with vibrational or electronic motions of molecules ▪ Predict the type of bonding present between two atoms in a binary compound based on position in the periodic table and the electronegativity of the elements ▪ Rank and justify the ranking of bond polarity on the basis of the locations of the bonded atoms in the periodic table ▪ Create or use graphical representations in order to connect the dependence of potential energy to the distance between atoms and factors, such as bond order (for covalent interactions) and polarity (for intermolecular interactions), which influence the interaction strength. NJSLS DCIs: **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. (HS-PS1-1) ● 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. (HS-PS1-1),(HS-PS1-2) ● The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3),(secondary to HS-PS2-6)	

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. (secondary to HS-PS1-1),(secondary to HS-PS1-3) ● Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) **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. (HS-PS4-1) **PS4.B: Electromagnetic Radiation** ● Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) ● When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4) ● Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5) ● Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary to HS-ESS1-2)	

Differentiation	Assessments
Interdisciplinary Connections ● Writing: sufficient technical writing to achieve procedural objective ● Mathematics: calculation of standard deviation of a set of data ● History: Discussion of various scientists' lives and the relevant events occurring in their home countries as they worked ● Physics: electromagnetic radiation, waves	**Formative Assessments:** ● quizzes ● having students show work on board ● AP problems: atomic structure, periodicity, bonding **Summative Assessments, Projects, and Celebrations:** ● lab reports ● unit test

- Music: standing waves, relationship to vibrations in a guitar string
- Medicine: quantized spins and MRI machines

Technology Integration

- Use graphing calculator for standard deviation calculation
- Use spectrometers connected to computers to collect data for Beer's law lab
- Science and engineering complement each other in the cycle known as research and development (R&D).

Media Literacy Integration

- Use of Elements video to stimulate interest in the topic
- Comparison of treatment of hydrofluoric acid in scientific journal and on a TV show

Global Perspectives

- In order to effectively increase knowledge base in the scientific community, laboratory experiments must be repeatable; valid conclusions must be made from results; and the information must be shared in a systematic format with the scientific community.

Supports for English Language Learners		
Sensory Supports	**Graphic Supports**	**Interactive Supports**
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Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group
Magazines & Newspapers	Timelines	Structures

Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodations	**Interventions**	**Modifications**
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Unit 3
States of Matter, Intermolecular Forces, Solution Chemistry

Big Ideas: Developing and Using Models:

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4), (HS-PS1-8)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Big Ideas: Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

Big Ideas: Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to support claims. (HS-PS1-7)

Big Ideas: Constructing Explanations and Designing Solutions

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)

Big Ideas: Engaging in Argument from Evidence

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3)

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
• What is the relationship between the spacing of particles in a sample of matter and that substance's physical properties? • How do the forces of attraction between particles affect physical properties of a sample of matter? • How are pressure, volume, and temperature of a gas related? • Why do different types of solids have different properties?	Students will understand that… **Cross Cutting Concepts** **Patterns** ▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1) (HS-PS-2) **Cause and Effect** ▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4) ▪ Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4) ▪ Systems can be designed to cause a desired effect. (HS-PS2) (HS-PS4)

	Systems and System Models ▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-PS4)
Areas of Focus: Proficiencies (New Jersey Student Learning Standards)	**Lessons**
Students will: ▪ Predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views ▪ Use aspects of particulate models (i.e.—particle spacing, motion, and forces of attraction) to reason about observed differences between solid and liquid phases and among solid and liquid materials ▪ Use KMT and concepts of intermolecular forces to make predictions about the macroscopic properties of gases, including both ideal and nonideal behaviors ▪ Describe the gases that make up our atmosphere, how this make up influences our climate and how changes in that makeup can impact the climate. ▪ Refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties of the sample ▪ Apply mathematical relationships or estimation to determine macroscopic variables for ideal gases ▪ Explain how solutes can be separated by chromatography based on intermolecular interactions ▪ 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 ▪ Design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components ▪ 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 ▪ Qualitatively analyze data regarding real gases to identify deviations from ideal behavior and relate these to molecular interactions	**Lesson 1:** ● Chapter 5: Gases ● Lab #11: Collecting Gas Over Water using a Eudiometer **Lesson 2:** ● Chapter 10: Liquids & Solids ● Lab #12: Classification of Solids. Identifying forces using experimental data **Lesson 3:** ● Chapter 11: Properties of Solutions

▪ Describe the relationships between the structural features of polar molecules and the forces of attraction between the particles ▪ 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 or particle views that include intermolecular interactions and entropic effects ▪ Explain the properties (phase, vapor pressure, viscosity, etc) of small and large molecular compounds in terms of the strengths and types of intermolecular forces ▪ Create visual representations of ionic substances that connect the microscopic structure to macroscopic properties, and/or use representations to connect the microscopic structure to macroscopic properties (e.g., boiling points, solubility, hardness, brittleness, low volatility, lack of malleability, ductility, or conductivity) ▪ Explain how a bonding model involving delocalized electrons is consistent with macroscopic properties of metals (e.g., conductivity, malleability, ductility, and low volatility) and the shell model of the atom ▪ Use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity ▪ Design or evaluate a plan to collect and/or interpret data needed to deduce the type of bonding in a sample of solid ▪ Create a representation of an ionic solid 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 ▪ 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 ▪ 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 a molecular solid that shows essential characteristics of the structure and interactions present in the substance ▪ Explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level ▪ Relate temperature to the motions of particles, either via particulate representations, such as drawings of particles with arrows indicating velocities, and/or via representations of average kinetic energy and distributions of kinetic energies of the particles, such as plots of the Maxwell-Boltzmann distribution. ▪ Make claims and or predictions regarding relative magnitudes of the forces acting within collections of interacting molecules based on the distribution of electrons with the molecules and the types of intermolecular forces through which the molecules interact. ▪ Support the claim about whether a process is a chemical or physical change (or may be classified as both) based on whether the process involves changes in intramolecular versus intermolecular interactions. ▪ Identify the noncovalent interactions within and between large molecules and/or connect the shape and function of the large molecule to the presence and magnitude of these interactions. NJSLS DCIs: **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. (HS-PS1-3),(secondary to HS-PS2-6) ● 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. (HS-PS1-4) **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. (secondary to HS-PS1-1),(secondary to HS-PS1-3)	

▪ Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) **ESS2.C: The Roles of Water in Earth's Surface Processes** ▪ The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5) **ESS2.D: Weather and Climate** ▪ The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's reradiation into space. (HS-ESS2-2), (HS-ESS2-4) ▪ Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6), (HS-ESS2-7) ▪ Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6), (HS-ESS2-4)	
Differentiation	**Assessments**
Interdisciplinary Connections ● Materials science: different polymers have different properties based on their structures (i.e., nylon vs. PVP) ● Mathematics: Analysis and graphing of experimental data, gas law calculations, dimensional analysis. ● Cooking: why cake mixes and pasta boxes have different recipes for high altitude cooking; use of supercritical CO_2 to decaffeinate coffee ● Biology: The structure and function of many biological systems depend on the strength and nature of the various Coulombic forces (i.e., substrate interactions with the active sites in enzyme catalysis and hydrophilic and hydrophobic regions in proteins that determine three- dimensional structure in water solutions) ● History: history of hot air ballooning.	**Formative Assessments:** ● quizzes ● having students show work on board ● AP problems: gases, types of solids/IMFs **Summative Assessments, Projects, and Celebrations:** ● lab reports ● unit test

- Sports: impact of the gas laws on SCUBA diving. Athletes use high altitude training to increase performance.

Technology Integration

- Use of the ChemDraw program to visualize molecules in three dimensions
- Science and engineering complement each other in the cycle known as research and development (R&D).

Media Literacy Integration

- Discussion of global warming and the ozone layer. Are humans affecting the atmosphere?
- Excerpt from the book Uncle Tungsten by Oliver Sacks to look at the work of Robert Boyle
- Viewing of Mentos/Diet Coke video on YouTube to generate interest in Henry's Law

Global Perspectives

- The unique properties of nano-particles has led to the decreasing size of common electronic devices
- Discussion of "acute mountain sickness" caused by oxygen deprivation in mountain climbers
- Case study: use of brass pitchers for storing water in India because the copper ions released by the brass kill harmful bacteria in the water

Supports for English Language Learners

Sensory Supports	Graphic Supports	Interactive Supports
Real-life objects	Charts	In pairs or partners
Manipulatives	Graphic Organizers	In triands or small groups
Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group

Magazines & Newspapers	Timelines	Structures
Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodations	**Interventions**	**Modifications**
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Unit 4
Kinetics, Equilibrium, Acid Base Chemistry and Solubility Equilibria

Big Ideas: Developing and Using Models

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4), (HS-PS1-8)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Big Ideas: Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

Big Ideas: Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to support claims. (HS-PS1-7)
- Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)

Big Ideas: Constructing Explanations and Designing Solutions

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)

Big Ideas: Engaging in Argument from Evidence

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3)
- Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (HS-ETS1-2)
- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (HS-ETS1-3)

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
• How are reaction rates measured and what factors affect rates of reactions? • Why is it important to be able to change the rates of reactions? • How do chemical reactions occur? • What is the function of a catalyst in a chemical reaction?	Students will understand that… **Cross Cutting Concepts** **Patterns** ▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1) (HS-PS-2)

● In what ways do the rates of chemical reactions directly impact our lives? ● What is chemical equilibrium? ● What happens when a stress is added to a system at chemical equilibrium? ● How is chemical equilibrium related to acid-base chemistry and solubility?	**Energy and Matter** ▪ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1) ▪ The total amount of energy and matter in closed systems is conserved. (HS-PS1) ▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1) ▪ Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3) **Stability and Change** ▪ Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1) **Systems and System Models** ▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4)
Areas of Focus: Proficiencies (New Jersey Student Learning Standards)	**Lessons**
Students will: ▪ Explain the relative strengths of acids and bases based on molecular structure, interparticle forces, and solution equilibrium ▪ Relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion ▪ Identify compounds as Bronsted-Lowry acids, bases, and/or conjugate acid-base pairs, using proton-transfer reactions to justify the identification ▪ Design and/or interpret the results of an experiment regarding the factors (i.e. temperature, concentration, surface area) that may influence the rate of reaction. ▪ Analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second- order reaction.	**Lesson 1:** ● Chapter 12: Chemical Kinetics ● Lab #13: The Rate of an Iodine Clock Reaction **Lesson 2:** ● Chapter 13: Chemical Equilibrium ● Lab #14: Determining an Equilibrium Constant for $FeSCN^{2+}$ ● Lab #15: Le Chatelier's Principle: Qualitative observations of shifting equilibria **Lesson 3:** ● Chapter 14: Acids and Bases ● Lab #16: Finding the Mass Percent of Acetic Acid in Vinegar in a titration **Lesson 4:** ● Chapter 15: Acid-Base Equilibria ● Lab #17: An Acid-Base Titration Curve **Lesson 5:**

▪ Connect the half-life of a reaction to the rate constant of a first-order reaction and justify the use of the relation in terms of reaction being a first-order reaction. ▪ Connect the rate law for an elementary reaction to the frequency and success of molecular collisions, including connecting the frequency and success to the order and rate constant, respectively. ▪ Explain the difference between collisions that convert reactants and products and those that do not in terms of energy distributions and molecular orientation. ▪ Use representations of the energy profile for an elementary reaction from the reactions through the transition state to the products to make qualitative predictions regarding the relative temperature dependence of the reaction rate. ▪ Evaluate alternative explanations, as expressed by reaction mechanisms, to determine which are consistent with data regarding the overall rate of a reaction, and data be used to infer the presence of a reaction rate. ▪ Translate among reaction energy profile representations, particulate representations, and symbolic representations (chemical equations) of a chemical reaction occurring in the presence and absence of a catalyst. ▪ 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. ▪ Given a set of experimental observations regarding physical, chemical, biological, or environmental processes that are reversible, construct an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes. ▪ Given a manipulation of chemical reaction or set of reactions (e.g. reversal or reaction or addition of two reactions). Determine the effects of that manipulation on Q or K. ▪ Connect kinetics to equilibrium by using reasoning about equilibrium, such as LeChatalier's principle, to infer the relative rates of the forward and reverse reactions. ▪ Given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K, use the tendency of Q to approach K to predict and justify the prediction as to whether the reaction will proceed toward products or reactants as equilibrium is approached. ▪ Give data (tabular, graphical, etc.) from which the state of a system at equilibrium can be obtained, calculate the equilibrium constant, K. ▪ Given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K, use stoichiometric relationships and the law of mass action (Q equals K at equilibrium) to determine qualitatively	● Chapter 16: Solubility and Complex Ion Equilibria ● Lab #18: Determination of a Solubility Product Constant using gravimetric analysis

and/or quantitatively the conditions at equilibrium for a system involving a single reversible reaction. ▪ For a reversible reaction that has a large or small K, determine which chemical species will have very large versus very small concentrations at equilibrium. ▪ Use LeChatelier's principle to predict the directions of the shift resulting from various possible stresses on a system at chemical equilibrium. ▪ Use LeChatelier's principle to design a set of conditions that will optimize a desired outcome, such as product yield. ▪ Use LeChatelier's principle to make qualitative predictions for systems in which coupled reactions share a common intermediate drive formation of a product. ▪ Make quantitative predictions for systems involving coupled reactions that share a common intermediate, based on the equilibrium constant for the combined reaction. ▪ Connect LeChatelier's principle to the comparison of Q to K by explaining the effects of the stress on Q and K. ▪ Explain why a thermodynamically favored chemical reaction may not produce large amounts of products (based on consideration of both initial conditions and kinetic effects), or why a thermodynamically unfavorable chemical reaction can produce large amounts of product for certain sets of initial conditions. ▪ Generate or use a particulate representation of an acid (strong or weak or polyprotic) and a strong base to explain the species that will have large versus small concentrations at equilibrium. ▪ Reason about the distinction between strong and weak acid solutions with similar values of pH, including the percent of ionization of the acids, the concentrations needed to achieve the sample pH, and the amount of base needed to reach the equivalence point in a titration. ▪ Interpret titration data for monoprotic or polyprotic acids involving the titration of 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 pK_a for a weak acid, or the pK_b for a weak base. ▪ Based on the dependence of K_w on temperature, reason that neutrality requires $[H^+]=[OH^-]$ as opposed to requiring pH=7, including especially the applications to biological systems. ▪ Identify a given solution as containing a mixture of strong acids and/or bases and calculate or estimate the pH (and concentrations of all chemical species) in the resulting solution. ▪ Identify a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), calculate the pH and	

concentration of all species in the solution, and/or infer the relative strengths of the weak acids or bases from given equilibrium concentrations. ▪ Given an arbitrary mixture of weak and strong acids and bases (including polyprotic systems), determine which species will react strongly with one another (i.e., with K>1) and what species will be present in large concentrations at equilibrium. ▪ 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. ▪ Relate the predominant form of a chemical species involving a labile proton (i.e., protonated /deprotonated form of a weak acid) to the pH of a solution and the pK_a associated with the labile proton. ▪ Identify a solution as being a buffer solution and explain the buffer mechanism in terms of the reactions that would occur upon addition of acid or base. ▪ Predict the solubility of a salt, or rank the solubility of salts, given the relevant K_{sp} values. ▪ Interpret data regarding the relative solubility of salts to determine, or rank, the relevant K_{sp} values. ▪ Interpret data regarding the relative solubility of salts in terms of factors (common ions, pH) that influence the solubility. ▪ Analyze the enthalpic and entropic changes associated with the dissolution of a salt, using particulate level interactions and representations. ▪ NJSLS DCIs: **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. (HS-PS1-3),(secondary to HS-PS2-6) ● 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. (HS-PS1-4) **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. (HS-PS1-4),(HS-PS1-5)	

▪ 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. (HS-PS1-2),(HS-PS1-7) **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. (HS-PS1-8) **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. (secondary to HS-PS1-1),(secondary to HS-PS1-3) ▪ Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)	
Differentiation	**Assessments**
Interdisciplinary Connections ● Mathematics: Graphical analysis of rate data; calculation of instantaneous rate (derivatives); use of quadratic equation. ● Health: correlation of biological half-lives of pharmaceuticals with dosing frequency. ● History: development of explosives; Haber process for synthesizing ammonia ● Biology: Enzymes are biological catalysts that increase the rate or reactions in our bodies. People who lack the enzyme lactase cannot digest the sugar in dairy products and are said to be lactose intolerant. ● Biology: pH of biological systems including blood chemistry. **Technology Integration** ● Use pH probes alone and when integrated with the Vernier software program to collect titration data. ● Use voltmeter to determine electrical conductivity. ● Use Google sheets for data analysis and calculations. ● Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific	**Formative Assessments:** ● quizzes ● having students show work on board ● AP problems: kinetics, equilibrium, acids/bases **Summative Assessments, Projects, and Celebrations:** ● lab reports ● lab presentations ● unit test

knowledge and engineering design practices to increase benefits while decreasing costs and risks.
- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Media Literacy Integration

- Comparison of treatment of hydrofluoric acid in scientific journal and on a TV show
- Use computer animations of voltaic cells.
- Compare the claims made in advertisements by the manufacturers of fuel cell, electric and hybrid cars.
- Read excerpt of article in Science about the role of manganese in redox reactions in the ocean

Global Perspectives

- Case study: Mohammed Bah Abba, a Nigerian teacher who developed a “refrigerator” that doesn’t use electricity
- Use of battery powered and fuel cell automobiles will reduce our dependence on petroleum.
- Case Study: allergic reactions to the new euro coins introduced in 2002 (due to the presence of nickel)

Supports for English Language Learners

Sensory Supports	Graphic Supports	Interactive Supports
Real-life objects	Charts	In pairs or partners
Manipulatives	Graphic Organizers	In triands or small groups
Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group
Magazines & Newspapers	Timelines	Structures

Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodations	**Interventions**	**Modifications**
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Unit 5
Thermodynamics and Electrochemistry

Big Ideas: Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

Big Ideas: Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to support claims. (HS-PS1-7)

Big Ideas: Constructing Explanations and Designing Solutions

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)

Big Ideas: Analyzing and Interpreting Data

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)
- Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)

Big Ideas: Engaging in Argument from Evidence

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3)

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
● How is energy related to the intermolecular forces of attraction between molecules or the electrostatic forces of attraction between atoms or ions? ● What combination of entropy and enthalpy changes is required for a chemical or physical process to occur? ● How can we determine if all thermodynamically favorable reactions actually occur? ● How is the equilibrium constant for a given reaction related to temperature and Gibbs free energy? ● How can a chemical reaction produce electricity?	Students will understand that… **Cross Cutting Concepts** **Systems and System Models** ▪ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3) ▪ Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3) ▪ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—

	including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4) **Energy and Matter** ▪ The total amount of energy and matter in closed systems is conserved. (HS-PS1) **Cause and Effect** ▪ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2) ▪ Systems can be designed to cause a desired effect. (HS-PS2) **Stability and Change** ▪ Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1)
Areas of Focus: Proficiencies (New Jersey Student Learning Standards)	**Lessons**
Students will: ▪ Express the equilibrium constant in terms of $\Delta G°$ and RT and use this relationship to estimate the magnitude of K and, consequently, the thermodynamic favorability of the process. ▪ Identify redox reactions and justify the identification in terms of electron transfer ▪ Design and/or interpret the results of an experiment involving a redox titration ▪ Interpret observations regarding macroscopic energy changes associated with a reaction or process to generate a relevant symbolic and/or graphical representation of the energy changes ▪ Use representations and models to predict the sign and relative magnitude of the entropy change associated with chemical or physical processes. ▪ Predict whether or not a physical or chemical process is thermodynamically favored by determination of (either quantitatively or qualitatively) the signs of both $\Delta H°$ and $\Delta S°$, and calculation or estimation of $\Delta G°$ when needed. ▪ Determine whether a chemical process is thermodynamically favored by calculating the change in standard Gibbs free energy. ▪ Explain how the application of external energy sources or the coupling of favorable with unfavorable reactions can be used to cause processes that are not thermodynamically favorable to become favorable.	**Lesson 1:** ● Chapter 17: Spontaneity, Entropy, and Free Energy ● Lab #19: Spontaneity **Lesson 2:** ● Chapter 18: Electrochemistry ● Lab: Measuring the potentials of different combinations of metals and solutions

▪ 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 NJSLS DCIs: **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. (HS-PS1-4) **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. (HS-PS1-4),(HS-PS1-5) **PS3.A: Definitions of Energy** ▪ "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary to HS-PS2-5) **PS3.B: Conservation of Energy and Energy Transfer** ▪ Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) ▪ Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) ▪ Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) ▪ The availability of energy limits what can occur in any system. (HS-PS3-1) ▪ Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution	

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(e.g., water flows downhill, objects hotter than their surrounding environment cool down).

PS3.D: Energy in Chemical Processes and Everyday Life
(HS-PS3-4 Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary to HS-ESS1-1) PS4.B Electromagnetic Radiation Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary to HS-ESS1-2)
ETS1.A: Defining and Delimiting Engineering Problems
Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS2-3)
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Interdisciplinary Connections
History: Contributions of Luigi Galvani, Alessandro Volta and Michael Faraday to the study of electricity.
Environmental Science: Consider the impact of batteries on the environment and use of renewable resources.
Technology Integration
Use electronic spreadsheets (Google sheets) and other analysis tools to examine mathematical relationships.
Classify reaction rate order by graphical analysis of reaction rate data using a graphing calculator.
Media Literacy Integration
Critique the “science” in the movie <u>The Martian</u> by performing internet research of the topics presented
Global Perspectives
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Formative Assessments:
quizzes
having students show work on board
AP problems: thermodynamics, electrochemistry
Summative Assessments, Projects, and Celebrations:
lab reports
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- Control of reaction rates by humans includes the use of refrigeration and preservatives to extend the shelf-life of foods.
- Nuclear power – derived from first order decay of radioactive elements – is used around the world as a clean and economical energy source. Recent nuclear disasters include the episode in Japan and Chernobyl.

Supports for English Language Learners		
Sensory Supports	**Graphic Supports**	**Interactive Supports**
Real-life objects	Charts	In pairs or partners
Manipulatives	Graphic Organizers	In triands or small groups
Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group
Magazines & Newspapers	Timelines	Structures
Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodation	**Interventions**	**Modifications**

s		
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectation s
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Unit 6
Nuclear Chemistry, Stellar Chemistry and Geochemistry

Big Ideas: Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3) (HS-PS3-4)

Big Ideas: Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to support claims. (HS-PS3-1)

Big Ideas: Constructing Explanations and Designing Solutions

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)
- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (HS-PS3-3)

Big Ideas: Developing and Using Models

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8) (HS-PS3-2) (HS-PS3-5)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
• Is man made radiation a positive or negative for mankind? • Are we the stuff of stars? • What is the future for nuclear energy? • How can we know the history of the Earth? • How can we know the history of the Universe? • Can we predict the future of the Earth?	Students will understand that… **Systems and System Models** ▪ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3) ▪ Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3) **Energy and Matter** ▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1) ▪ Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3) **Cause and Effect** ▪ Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3) **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1)
Areas of Focus: Proficiencies	**Lessons**

(New Jersey Student Learning Standards)	
Students will: ▪ Recognize the forces that act within the nucleus and the causes of radioactivity relating to the band of stability. ▪ Complete balanced nuclear reactions and differentiate between the different types of radioactive decay ▪ Use $E=mc^2$ to determine the source of energy from nuclear equations and nuclear binding energy ▪ Distinguish between fission and fusion nuclear reactions. ▪ Describe how fission and chain reactions are used to create electricity and nuclear explosions. ▪ Describe how fusion in stars creates elements and the forces that exist within stars. ▪ Describe the changes in the life cycle of a star like our sun. ▪ Describe the evolution of the universe citing key evidence that supports the Big Bang Theory and the age of the universe. ▪ Explain how nuclear decay within the Earth maintains geothermal energy and drives the events which shape our planet. ▪ Use rate laws to show how we can accurately predict the age of our planet. NJSLS DCIs: **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. (HS-PS1-4) **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. (HS-PS1-4),(HS-PS1-5)	**Lesson 1: Nuclear Chemistry** ● Chapter 19 Nuclear Stability ● Kinetics of decay ● Fission and Fusion ● Nuclear energy **Lesson 2: Stellar Chemistry** ● Formation of elements ● Life of a star ● Big Bang Theory **Lesson 3: Geochemistry** ● Radiation within the Earth ● Dating Rocks and the Earth

- 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. (HS-PS1-6)

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. (HS-PS1-8)

PS3.B: Conservation of Energy and Energy Transfer

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4)
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)
- The availability of energy limits what can occur in any system. (HS-PS3-1)
- Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4)

ESS1.A: The Universe and Its Stars

- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all

atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2),(HS-ESS1-3) • The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2) Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2), (HS-ESS1-3) **ESS1.C: The History of Planet Earth** • Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HSESS1-5) Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **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 (trade offs) may be needed. (secondary to HS-PS1-6)	
Differentiation	**Assessments**
Interdisciplinary Connections • Geology: formation of minerals. • History: Examine the various accidents that have occurred at nuclear power plants over the past 50 years **Technology Integration**	**Formative Assessments:** • quizzes • having students show work on board • Text problems on Nuclear **Summative Assessments, Projects, and Celebrations:** • lab reports • unit test • Independent research project on Nuclear Chemistry

- Use Vernier computer integrated pH meters and temperature probes with magnetic stir plates to collect titration data.
- Use Google Sheets for data analysis and calculations.

Media Literacy Integration

- Advertisement of pH balance shampoos.

Global Perspectives

- Cause and effect of acid rain on the environment.

Supports for English Language Learners		
Sensory Supports	**Graphic Supports**	**Interactive Supports**
Real-life objects	Charts	In pairs or partners
Manipulatives	Graphic Organizers	In triands or small groups
Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group
Magazines & Newspapers	Timelines	Structures
Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodations	**Interventions**	**Modifications**
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading