CHEMISTRY
GRADES 10-12

EWING PUBLIC SCHOOLS
2099 Pennington Road
Ewing, NJ 08618

Board Approval Date: September 19, 2022 Michael Nitti
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In accordance with The Ewing Public Schools' Policy 2230, Course Guides, this curriculum has been reviewed and found to be in compliance with all policies and all affirmative action criteria.

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Course Description and Rationale

Students taking Chemistry will continue to develop their understanding of the four core ideas from the Next Generation Science Standards in the physical sciences. The high school performance expectations in physical science build on the middle school ideas and skills and allow high school students to develop more in-depth explanations of phenomena. These performance expectations blend the core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge to explain ideas across the science disciplines.

Chemistry, one of the main branches of science, focuses on the structure, organization and interactions of matter. In the performance expectations in the topic *Structure and Properties of Matter*, Chemistry strives to explain natural phenomena in terms of understanding of the substructure of atoms and provide more mechanistic explanations of the properties of substances. Students are able to use the periodic table as a tool to explain and predict the properties of elements. Phenomena involving nuclei are also important to understand, as they explain the formation and abundance of the elements, radioactivity, the release of energy from the sun and other stars and the generation of nuclear power. The theories of yesterday inspire the experiments of today, which then evolve into the practical applications of tomorrow.

The world around us is composed of objects whose structure is based on internal interactions. We take the result of these interactions for granted. Few of us consider what is occurring within the objects and substances we use to make them what they are. In the performance expectations in the topic *Chemical Reactions,* Chemistry will help students characterize and explain these reactions and make predictions about them. In the performance expectation in the topic *Forces and Interactions*, Chemistry will help students' understanding of ideas why some materials are attracted to each other while others are not. In the performance expectations in the topic *Energy,* students will understand that the properties and interactions of a system depend on energy transfer. Students will come to understand the how and why of these interactions through developing and using models, using mathematical thinking, constructing explanations and designing solutions and use these practices to demonstrate understanding of the core ideas.

This course will discuss the components in the field of chemistry such as the structure, properties and interactions of matter, nuclear and other topics as time allows. The number one priority is to learn how to think critically, in a scientific manner, about matter and how it behaves.

Chemistry at Ewing High School incorporates problem-solving, hands-on activities, experiments and projects. This course also includes real-world applications of the chemistry concepts, with the goal of helping students to become informed citizens that are not intimidated by new and emerging technologies. Chemistry is offered in a block schedule, meeting daily for 88 minutes for half of the academic year (90 days).

Textbook References:

Chemistry. Wilbraham, et al., 2012. Pearson

Career Readiness, Life Literacies, and Key Skills

During this course, students will work on developing, to an age appropriate level, the following Career Readiness, Life Literacies, and Key Skills:

Disciplinary Concepts:

- Career Awareness and Planning
  - An individual's strengths, lifestyle goals, choices, and interests affect employment and income.
  - Developing and implementing an action plan is an essential step for achieving one's personal and professional goals.
  - Communication skills and responsible behavior in addition to education, experience, certifications, and skills are all factors that affect employment and income.

- Creativity and Innovation
  - Gathering and evaluating knowledge and information from a variety of sources, including global perspectives, fosters creativity and innovative thinking.
- Critical Thinking and Problem-solving
  - Multiple solutions exist to solve a problem.
  - An essential aspect of problem solving is being able to self-reflect on why possible solutions for solving problems were or were not successful.
- Digital Citizenship
  - Detailed examples exist to illustrate crediting others when incorporating their digital artifacts in one's own work.
  - Digital communities are used by Individuals to share information, organize, and engage around issues and topics of interest.
  - Digital technology and data can be leveraged by communities to address effects of climate change.
- Global and Cultural Awareness

  - Awareness of and appreciation for cultural differences is critical to avoid barriers to productive and positive interaction.
- Information and Media Literacy
  - Increases in the quantity of information available through electronic means have heightened the need to check sources for possible distortion, exaggeration, or misrepresentation.

- Digital tools make it possible to analyze and interpret data, including text, images, and sound. These tools allow for broad concepts and data to be more effectively communicated.
- Sources of information are evaluated for accuracy and relevance when considering the use of information.
- There are ethical and unethical uses of information and media.

- Technology Literacy
  - Some digital tools are appropriate for gathering, organizing, analyzing, and presenting information, while other types of digital tools are appropriate for creating text, visualizations, models, and communicating with others. • Digital tools allow for remote collaboration and rapid sharing of ideas unrestricted by geographic location or time.

Technology Integration

<u>Computer Science and Design Thinking</u>
During this course, students will work on developing, to an age appropriate level, the following Computer Science and Design Thinking Skills:

Disciplinary Concepts and Core Ideas:

- Data & Analysis
  - People use digital devices and tools to automate the collection, use, and transformation of data.
  - The manner in which data is collected and transformed is influenced by the type of digital device(s) available and the intended use of the data.
  - Data is represented in many formats. Software tools translate the low-level representation of bits into a form understandable by individuals. Data is organized and accessible based on the application used to store it.
  - The purpose of cleaning data is to remove errors and make it easier for computers to process.
  - Computer models can be used to simulate events, examine theories and inferences, or make predictions.
- Engineering Design
  - Engineering design is a systematic, creative and iterative process used to address local and global problems.
  - The process includes generating ideas, choosing the best solution, and making, testing, and redesigning models or prototypes.

        - Engineering design requirements and specifications involve making trade-offs between competing requirements and desired design features.
    - Interaction of Technology and Humans
        - Economic, political, social, and cultural aspects of society drive development of new technological products, processes, and systems.
        - Technology interacts with society, sometimes bringing about changes in a society's economy, politics, and culture, and often leading to the creation of new needs and wants.
        - New needs and wants may create strains on local economies and workforces.
        - Improvements in technology are intended to make the completion of tasks easier, safer, and/or more efficient.
    - Nature of Technology
        - Technology advances through the processes of innovation and invention which relies upon the imaginative and inventive nature of people.
        - Sometimes a technology developed for one purpose is adapted to serve other purposes.
        - Engineers use a systematic process of creating or modifying technologies that is fueled and constrained by physical laws, cultural norms, and economic resources. Scientists use systematic investigation to understand the natural world.
    - Effects of Technology on the Natural World
        - Resources need to be utilized wisely to have positive effects on the environment and society.
- Some technological decisions involve trade-offs between environmental and economic needs, while others have positive effects for both the economy and environment.

ELA Integration:

- **NJSLS.RST.9-10.3** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- **NJSLS.RST.9-10.4** Determine the meaning of symbols, key terms and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grade level texts and topics.
- **NJSLS.RST.9-10.5** Analyze the structure of the relationships among concepts in a text, including relationships among key terms.
- **NJSLS.RST.9-10.6** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.
- **NJSLS.RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

- **NJSLS.WHST.9-10.1.E -** Provide a concluding statement or section that follows from or supports the argument presented.
- **NJSLS.WHST.9-10.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (Honors, Level 1)
- **NJSLS.WHST.9-10.2a** Introduce a topic and organize ideas, concepts and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables) and multimedia when useful to aiding comprehension.
- **NJSLS.WHST.9-10.2.d** Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.
- **NJSLS.WHST.9-10.9** Draw evidence from informational texts to support analysis, reflection and research.

Math Integration:

- **NJSLS.MP.6** Mathematically proficient students try to communicate precisely to others.
- **NJSLS.HS.A-CED.A.1** Create equations and inequalities in one variable and use them to solve problems.
- **NJSLS.HS.A-CED.A.2** Create equations in two or more variables to represent relationships between quantities.
- **NJSLS.HS.A.CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
- **NJSLS.HS.A.REI.A.1** Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.
- **NJSLS.HSA.REI.B.3** Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.
- **NJSLS.HS.A-SSE.A.1** Interpret complicated expressions by viewing one or more of their parts as a single entity.
- **NJSLS.HS.A-SSE.A.2** Use the structure of an expression to identify ways to rewrite it.
- **NJSLS.HS.N.Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- **NJSLS.HS.N.Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Unit 1: Laboratory Procedure and Data Analysis (Pacing: 7 Days)

Why Is This Unit Important?

This introductory unit will serve to develop a 'mindset' that chemistry is a central science that is essential to advancements in technology. Constructing explanations with reasoning requires evidence to support contentions. Proper laboratory techniques are essential for the collection of data.

Disciplinary Core Ideas:

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)*

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),*(HS-PS2-6)

Science and Engineering Practices:

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)

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-PS2-6)

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-PS1-1),(HS-PS1-2),(HS-PS1-5),(HS-PS1-3)

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)

Enduring Understandings:

- There are global energy and climate issues that need to be understood and addressed in this and future generations.
- Following safety procedures, using personal protective equipment and selecting the appropriate equipment or tools will reduce the risk of injury.
- SI and Metrics are the preferred system for presenting scientific information.
- Planning, organizing and analyzing data are essential components of solving problems.

Essential Questions:

- Why is it necessary to follow safety protocol?
- How do we correctly use units of the metric system?
- Can we solve problems without the scientific method?
- How do we organize and analyze data?
- Why is the study of Chemistry necessary to understand global climate issues?
- What careers involve the study of Chemistry?

Acquired Knowledge and Skills:

- Asking questions and define problems
- Develop and use models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Acquired Skills:

- Asking questions and define problems
- Develop and use models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Assessments:

Formative Assessments:

- Group discussions
- Observation
- Homework
- Class work
- Class participation
- Lab work
- Quizzes

Summative Assessments:

- Construct an explanation of the outcome of the given investigation (Lab - Vocabulary of Scientific Method or Technological Tower)
- Students identify and describe the evidence to construct the explanation for the results of their investigation (Density labs)

Benchmarks:

- Students will be assessed on their ability to 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 of particles. [Clarification Statement: Emphasis is on the safe and efficient means of gathering evidence and that bulk scale properties can be used as evidence.]
- Students will be assessed on their ability to communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. [Clarification Statement: Emphasis is on the communication of information itself rather than the specifics of the functioning. Examples of metric units, outliers and predictions about the relationship of bulk properties.]

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Boiling water in a paper cup
- Liter box demonstration ($1cm^3$=1ml)

In-Class Activities and Laboratory Experiences:

- Activity: The paper tower
- Project: Career exploration. Create a fictitious "Linked-In" bio, "Indeed" job posting, etc.
- Project: Notable figures in Chemistry.
- Lab: Vocabulary of Scientific Method
- Lab: Density of Solids
- Lab: Density of Liquids

Closure and Reflection Activities:

- Student Discussion
- Review Packet

Instructional Materials:

- Text books, note guides, guided practice, worksheets, PowerPoints and laboratories. Videos: Crash Course Chemistry: "Lab Safety" and "Unit conversion and significant digits".

Technology Connections:

- GSuite: i.e. Google Sheets
- Presentation software: i.e. Canva, Microsoft publisher, etc.
- Review games: Quizziz, Kahoot, Blooket.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-PS1-3**
- **HS-PS2-6**

Unit 2: Matter (Pacing: 10 Days)

Why Is This Unit Important?

This unit will enable students to understand that matter is the foundation of all components of life and that energy transfer affects both physical and chemical properties.

Disciplinary Core Ideas:

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)*

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),*(HS-PS2-6)

PS3.A: Definitions of Energy

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1),(HS-PS3-2)
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3)
- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)

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)

Science and Engineering Practices:

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)

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-PS2-6)

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-PS1-1),(HS-PS1-2),(HS-PS1-5),(HS-PS1-3)

Energy and Matter

- Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)

Systems and System Models

- 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-PS3-1)

Enduring Understandings:

- The classification of matter is based on unique properties.
- Everyday occurrences of changes in matter are related to energy transfer.

Essential Questions:

- How do we classify the things in the world around us?
- What is energy?
- How is kinetic molecular theory used to describe the states of matter and the relationship to phase changes they can undergo?

Acquired Knowledge and Skills:

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms**.**

Acquired Skills:

- Asking questions and define problems
- Develop and use models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Assessments:

Formative Assessments:

- Group discussions
- Observation
- Homework
- Class work
- Class participation
- Lab work
- Quizzes

Summative Assessments:

- Students describe the phenomenon under investigation, which includes the following idea: the relationship between the measurable properties of a substance.
- Students describe why the data about bulk properties would provide information about strength of the electrical forces between the particles of the chosen substances.
- Labs:
  - Physical and Chemical Changes
  - Phase Changes of Lauric Acid
  - Law of Conservation of Matter
  - Classification of Matter

Benchmarks:

- Students will be assessed on their ability to 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 of particles. [Clarification Statement: Emphasis is on states of matter, melting & freezing points and phase changes]
- Students will be assessed on their ability to communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. [Clarification Statement: Emphasis is on the states of matter functioning. Example: relationship of phase changes.]
- Students will be assessed on their ability to create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: emphasis is on graphical representation of phase changes.]
- Students will be assessed on their ability to develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles and energy associated with the relative positions of particles.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities

Anticipatory Sets:

- Decomposition of Sugar

In-Class Activities and Laboratory Experiences:

- Lab: Physical and Chemical Changes
- Lab: Phase changes of Lauric Acid
- Lab: Law of Conservation of Matter
- Activity: Classification of Matter
- Lab: Reaction in a Bag
- Activity: Investigation of pros and cons of gasoline, diesel and electric automobiles

Closure and Reflection Activities:

- Student Discussion
- Review Packet

Instructional Materials:

- Text books, note guides, guided practice, worksheets, PowerPoints, videos and laboratories.

Technology Connections:

- GSuite: students share data via Google Docs, Sheets, etc.
- Khan Academy, Crash Course: Chemistry, University of Colorado: PhET, Gizmo.
- Review games: Quizziz, Kahoot, Blooket.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-PS1-3**
- **HS-PS2-6**
- **HS-PS3-1**
- **HS-PS3-2**

Unit 3: Atomic Structure (Pacing: 15 Days)

Why Is This Unit Important?

This unit will serve to trace the development of the atomic model from early Greeks through the current Quantum Mechanical Model. The ability to analyze the relative structure of atoms will lay the foundation for the understanding of how atoms interact.

Disciplinary Core Ideas:

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)

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),*(HS-PS2-6)

PS3.D: Energy in Chemical Processes

- Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. *(secondary to HS-PS4-5)*

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)
- Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HS-PS4-5)
- [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3)

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)

PS4.C: Information Technologies and Instrumentation

- Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)

Science and Engineering Practices:

Developing and Using Models

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

Obtaining, Evaluating, and Communicating Information.

- Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HS-PS4-4)
- Communicate technical information or ideas (e.g. about phenomena and/or 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)

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1)

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)

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-PS1-1),(HS-PS1-2),(HS-PS1-5),(HS-PS1-3)

Energy and Matter

- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)

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-PS4-3)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)
- 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-PS4-4)
- Systems can be designed to cause a desired effect. (HS-PS4-5)

Enduring Understandings:

- In the universe, atoms are the fundamental building blocks of all matter.
- Modern atomic theory is a mathematical model describing electrons having both wave and particle nature.

- Subatomic particles affect the stability of an atom and unstable atoms can emit radiation.

Essential Questions:

- What are the relative charge, mass and location of the three major subatomic particles?
- How does the current model of the atom explain atomic structure?
- How do current atomic models of electron arrangement compare with scientific evidence from previous models?
- How are electrons configured around the nucleus?
- What happens when an electron absorbs or releases energy?
- How can an electron exhibit both a wave and a particle nature?
- What causes instability in the nucleus?
- What are the processes of fusion and fission?

Acquired Knowledge and Skills:

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
- 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.
- 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 (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.
- 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.
- Photoelectric materials emit electrons when they absorb light of a high-enough frequency.

Acquired Skills:

- Asking questions and define problems
- Develop and use models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking.
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Assessments:

Formative Assessments:

- Group discussions
- Observation
- Homework
- Class work
- Class participation
- Lab work
- Quizzes

Summative Assessments:

- Using a model, students identify and describe the components of the model that are relevant for their predictions, including: A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons, the number of protons in each element and electrons in the outermost energy level of atoms (i.e., valence electrons).
- Bohr-Rutherford models
- Spectroscopy Lab
- Lab: Calculating Hydrogen Spectra

Benchmarks:

- Students will be assessed on their ability to 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. [Clarification Statement: Emphasis is on atomic number, mass number, energy levels and electron orbital designations and their relationship to the placement on the periodic table.]
- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to use mathematical representations to support a claim regarding relationships among the frequency, wavelength and speed of waves traveling in various media.
- Students will be assessed on their ability to evaluate the claims, evidence and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model and that for some situations one model is more useful than the other.
- Students will be assessed on their ability to evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
- Students will be assessed on their ability to communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Fireworks

- Tanning beds and sun screens
- Chernobyl

In-Class Activities and Laboratory Experiences:

- Activity: Average Atomic Mass of Veggium
- Activity: Half-life of flipping pennies
- Activity: Locating an Electron (probability)
- Project: Pros and Cons of Nuclear Energy
- Lab: Spectroscopy (Struggling learner); Calculating Hydrogen Spectra (Enrichment)

Closure and Reflection Activities:

- Exit Pass: Cathode Ray Tube
- Video: Pyrotechnics

Instructional Materials:

- Text books, note guides, guided practice, worksheets, PowerPoints and laboratories. Videos: Crash Course Chemistry videos: The nucleus, Nuclear Chemistry, The history of atomic chemistry, The electron, Orbitals; Annenberg series: The atom; and PBS video Wave Particle Duality.

Technology Connections:

- GSuite: students share data via Google Docs, Sheets, etc.
- Khan Academy, Crash Course: Chemistry, University of Colorado: PhET, Gizmo.
- Review games: Quizziz, Kahoot, Blooket.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-PS1-1**
- **HS-PS1-8**
- **HS-PS4-1**
- **HS-PS4-3**
- **HS-PS4-4**
- **HS-PS4-5**

Unit 4: Periodic Table (Pacing: 8 Days)

Why Is This Unit Important?

This unit will lay the foundation for understanding chemical bonding wherein students will predict the chemical and physical properties of elements based on their location in the periodic table.

Disciplinary Core Ideas:

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)
- 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),*(HS-PS2-6)

Science and Engineering Practices:

Developing and Using Models

- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

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)

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-PS2-6)

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-PS1-1),(HS-PS1-2),(HS-PS1-5),(HS-PS1-3)

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)

Enduring Understandings:

- The placement of elements on the periodic table is based upon specific properties and characteristics of elements.
- The characteristics of elements follow noticeable patterns and trends based upon their placement on the periodic.

Essential Questions:

- How do various properties influence the placement of elements on the periodic table?
- What is the relationship between an element's placement on the periodic table and the noticed trend?
- How can the placement of an element on the periodic table be used to predict a property when a specific trend is observed?

Acquired Knowledge and Skills:

- 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.

Acquired Skills:

- Asking questions and define problems
- Develop and use models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Assessments:

Formative Assessments:

- Group discussions
- Observation
- Homework
- Class work
- Class participation
- Lab work
- Quizzes

Summative Assessments:

- Using a model, students identify and describe the components and the relationships between components in the model relevant for their predictions.
- Reactivity of Metals Lab
- Graphing of Periodic Trends Lab

Benchmarks:

- Students will be assessed on their ability to 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. [Clarification Statement: Emphasis is on properties that could be predicted from patterns such as reactivity, atomic size, electronegativity and valence electrons.]
- Students will be assessed on their ability to 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. [Clarification Statement: Emphasis is on properties that could be predicted from patterns such as reactivity of metals.]
- Students will be assessed on their ability to 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 of particles. [Clarification Statement: Emphasis is on structure of metals as related to the reactivity of metals.]
- Students will be assessed on their ability to communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. [Clarification Statement: Emphasis is on structure of metals and nonmetals that determine the functioning of the material.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities

Anticipatory Sets:

- Chemistry Cryptoquip
- Predicting patterns puzzles

In-Class Activities and Laboratory Experiences:

- Lab: Properties of Metals & Nonmetals
- Lab: Graphing Periodic Trends
- Lab: Bohr-Rutherford Models and the Periodic Table
- Lab: Reactivity of Metals

Closure and Reflection Activities:

- Student Discussion
- Review Packet
- Video: The Periodic Table
- Reactivity of Alkali metals: YouTube

Instructional Materials:

- Text books, note guides, guided practice, worksheets, PowerPoints and laboratories. Videos: Crash Course Chemistry: The Periodic Table; and Annenberg Series: The Periodic Table.

Technology Connections:

- GSuite: students share data via Google Docs, Sheets, etc.
- Khan Academy, Crash Course: Chemistry, University of Colorado: PhET, Gizmo.
- Review games: Quizziz, Kahoot, Blooket.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-PS1-1**
- **HS-PS1-2**
- **HS-PS1-3**
- **HS-PS2-6**

Unit 5: Bonding (Pacing: 15 Days)

Why Is This Unit Important?

Having an understanding of an element's properties lends to a student's understanding of how atoms can combine to form stable compounds. This unit will set the foundation for understanding chemical reactions.

Disciplinary Core Ideas:

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)
- 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),*(HS-PS2-6)

Science and Engineering Practices:

Developing and Using Models

- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

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)

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-PS2-6)

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-PS1-1),(HS-PS1-2),(HS-PS1-5),(HS-PS1-3)

Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)

Enduring Understandings:

- The formation of chemical bonds can be explained by the atom's ability to satisfy the Octet Rule and achieve stability.
- The type of chemical bond an element forms can be linked to its valence electrons and its location on the periodic table.
- Chemical formulas can be used to represent the ratios in which atoms combine to form compounds.
- A compound's structure and shape can be determined through an understanding of the interactions between valence pair electrons.
- Intermolecular forces determine the properties of compounds.

Essential Questions:

- Why do elements form chemical bonds in nature and how does this determine their properties?
- How are the properties of an element determined by its electron arrangement?
- How are ionic, covalent and metallic bonds formed and how are they characterized?
- How are the names and formulas of ionic and covalent compounds written?
- How does V.S.E.P.R. Theory allow us to predict molecular geometry?
- Why is an understanding of intermolecular forces important?

Acquired Knowledge and Skills:

- Attraction and repulsion between electric charges at the atomic scale explain structure, properties and transformations of matter, as well as the contact forces between material objects.
- 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.

Acquired Skills:

- Asking questions and define problems
- Develop and use models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Assessments:

Formative Assessments:

- Group discussions
- Observation
- Homework
- Class work
- Class participation
- Lab work
- Quizzes

Summative Assessments:

- Students describe the phenomenon under investigation, which includes the following idea: the relationship between the measurable properties of a substance and the strength of the electrical forces between the particles of the substance.
- Properties of Ionic Compounds Lab
- Building Molecular Molecules

Benchmarks:

- Students will be assessed on their ability to 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. [Clarification Statement: Emphasis is on properties that could be predicted from patterns such as valence electrons, types and numbers of bonds formed and empirical formulae.]
- Students will be assessed on their ability to 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 of particles. [Clarification Statement: Emphasis is on properties of ionic and covalent compounds.]
- Students will be assessed on their ability to communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. [Clarification Statement: Emphasis is on properties of ionic and covalent compounds.]

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities

Anticipatory Sets:

- Water droplets
- Tug of War

In-Class Activities and Laboratory Experiences:

- Properties of Ionic Compounds Lab
- Building Molecular Molecules
- Formulas and Oxidation Lab (Chippy)
- Ionic Puzzles

Closure and Reflection Activities:

- Student Discussion
- Review Packet
- Building Molecular Molecules

Instructional Materials:

- Text books, note guides, guided practice, worksheets, PowerPoints and laboratories. Videos: Crash Course Chemistry: Atomic Hook-ups: Types of Chemical Bonds, Polar and non-polar molecules and Bonding models and Lewis structures; Annenberg Series: Bonding.

Technology Connections:

- GSuite: students share data via Google Docs, Sheets, etc.
- Khan Academy, Crash Course: Chemistry, University of Colorado: PhET, Gizmo.
- Review games: Quizziz, Kahoot, Blooket.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-PS1-1**
- **HS-PS1-3**
- **HS-PS2-6**

Unit 6: Reactions (Pacing: 10 Days)

Why Is This Unit Important?

Chemistry occurs in diverse circumstances. Students should understand how substances combine, decompose, or react to form new and different compounds that are essential to drive the world around us.

Disciplinary Core Ideas:

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)
- 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

- 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)

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),*(HS-PS2-6)

Science and Engineering Practices:

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)

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)

Using Mathematics and Computational Thinking

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

Constructing Explanations and Designing Solutions

- 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)

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-PS1-1),(HS-PS1-2),(HS-PS1-5),(HS-PS1-3)

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-PS1-4)
- The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)

Enduring Understandings:

- Chemical equations are used to represent chemical reactions and show that mass can neither be created nor destroyed.
- There are different types of chemical reactions that we observe in everyday life.

Essential Questions:

- Why must the mass of reactants equal the mass of products in a chemical reaction?
- What characteristics are used to classify chemical reactions?

Acquired Knowledge and Skills:

- 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.

Acquired Skills:

- Asking questions and define problems
- Develop and use models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Assessments:

Formative Assessments:

- Group discussions
- Observation
- Homework
- Class work
- Class participation
- Lab work
- Quizzes

Summative Assessments:

- Students construct an explanation that includes the idea that as the kinetic energy, temperature and concentration increases, the reaction rate increases.
- Students identify and describe potential changes in a component of the given chemical reaction system that will increase the amounts of particular species at equilibrium.
- Study of Reactions lab

Benchmarks:

- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to 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 of particles.
- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to use mathematical representations to support the claim that atoms and therefore mass, are conserved during a chemical reaction.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Did you ever wonder why the Statue of Liberty is green or why silver tarnishes?

In-Class Activities and Laboratory Experiences:

- Study of Reactions Lab
- Balanced by Redox

Closure and Reflection Activities:

- Student Discussion
- Review Packet

Instructional Materials:

- Text books, note guides, guided practice, worksheets, PowerPoints and laboratories**.**
- Videos: Crash Course Chemistry: Precipitation reactions and Redox reactions.

Technology Connections:

- GSuite: students share data via Google Docs, Sheets, etc.
- Khan Academy, Crash Course: Chemistry, University of Colorado: PhET, Gizmo.
- Review games: Quizziz, Kahoot, Blooket.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-PS1-2**
- **HS-PS1-3**
- **HS-PS1-4**
- **HS-PS1-7**

Unit 7: Stoichiometry (Pacing: 10 Days)

Why Is This Unit Important?

By understanding quantitative evaluations of reactions, students are able to predict the starting or ending products formed in a chemical reaction.

Disciplinary Core Ideas:

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)

Science and Engineering Practices:

Using Mathematics and Computational Thinking

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

Cross Cutting Concepts:

Energy and Matter

- The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)

Enduring Understandings:

- The mole is the chemist's unit for specifying the amount of the material.
- Mass ratios between different compounds in a reaction can answer quantitative questions concerning reactants and products.

Essential Questions:

- How can we quantify something that we can't see? How do we know that we are right?
- Why is a mathematical relationship an important measurement of chemistry?

Acquired Knowledge and Skills:

- 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.

Acquired Skills:

- Asking questions and define problems
- Develop and use models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Assessments:

Formative Assessments:

- Group discussions
- Observation
- Homework
- Class work
- Class participation
- Lab work
- Quizzes

Summative Assessments:

- Students identify and describe relevant components using mathematical representations.
- Copper and silver nitrate lab (Advanced learners)
- Conservation of mass lab

Benchmarks:

- Students will be assessed on their ability to use mathematical representations to support the claim that atoms and therefore mass, are conserved during a chemical reaction. (CCP)
- Students will be assessed on their ability to use mathematical representations to support the claim that final amounts of products can be determined from starting amounts of reactants and identify limiting reactants. (Enrichment)

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities

Anticipatory Sets:

- Five pounds of peanut butter and jelly and one loaf of bread.
- Conservation of matter lab

In-Class Activities and Laboratory Experiences:

- Copper and silver nitrate lab (Enrichment)
- Salt Lab (Enrichment)
- Metallic Crystals (Struggling learners)
- Conservation of mass

Closure and Reflection Activities:

- Student Discussion
- Review Packet
- Video: Stoichiometry

Instructional Materials:

- Text books, note guides, guided practice, worksheets, PowerPoints and laboratories. Videos: Crash Course Chemistry: Stoichiometry.

Technology Connections:

- GSuite: students share data via Google Docs, Sheets, etc.
- Khan Academy, Crash Course: Chemistry, University of Colorado: PhET, Gizmo.
- Review games: Quizziz, Kahoot, Blooket.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-PS1-7**

Unit 8: Solutions (Pacing: 5 Days)

Why Is This Unit Important?

Most of the substances we encounter in daily life are mixtures. Many essential chemical reactions occur in aqueous solutions because water is capable of dissolving so many substances.

Disciplinary Core Ideas:

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)*

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)

Science and Engineering Practices:

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)

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)

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-PS1-1),(HS-PS1-2),(HS-PS1-5),(HS-PS1-3)

Enduring Understandings:

- Concentration of a solution can be expressed in different ways.
- There are different factors that affect the solubility of a solution.

Essential Questions:

- What are the various types of concentration that are used to describe a solution?
- How can these different forms of concentrations of the solution be calculated?
- What factors affect the solubility of a solution?

Acquired Knowledge and Skills:

- 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

Acquired Skills:

- Asking questions and define problems
- Develop and use models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Assessments:

Formative Assessments:

- Group discussions
- Observation
- Homework
- Class work
- Class participation
- Lab work
- Quizzes

Summative Assessments:

- Students will provide an explanation about the effects of changing the concentration and temperature on solubility.
- Describe the relationship between solubility and electrostatic forces between the particles of the substance.
- Spot Plate dilutions
- Molarity of solutions lab

Benchmarks:

- Students will be assessed on their ability to 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 of particles. [Clarification Statement: Emphasis is on properties of solutions.]
- Students will be assessed on their ability to 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. [Clarification Statement: Emphasis is on properties of solutions.]

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Iced Tea versus Sweet Tea
- Kool Aid

In-Class Activities and Laboratory Experiences:

- Spot Plate dilutions
- Molarity of solutions lab

Closure and Reflection Activities:

- Student Discussion
- Review Packet
- Video: Solutions

Instructional Materials:

- Text books, note guides, guided practice, worksheets, PowerPoints and laboratories. Videos: Crash Course Chemistry: Water and solutions and Solutions.

Technology Connections:

- GSuite: students share data via Google Docs, Sheets, etc.
- Khan Academy, Crash Course: Chemistry, University of Colorado: PhET, Gizmo.
- Review games: Quizziz, Kahoot, Blooket.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-PS1-3**
- **HS-PS1-5**

Unit 9: Thermochemistry (Pacing: 5 Days)

Why Is This Unit Important?

Energy is the essence of our very existence as individuals and as a society. Students should understand that the interconversions of energy are fundamental to chemical processes.

Disciplinary Core Ideas:

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

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1),(HS-PS3-2)

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)

Science and Engineering Practices:

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)

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-PS1-1),(HS-PS1-2),(HS-PS1-5),(HS-PS1-3)

Systems and System Models

- 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-PS3-1)

Enduring Understandings:

- Energy is conserved during all chemical processes.

Essential Questions:

- How is energy involved in chemical processes?
- How are exothermic and endothermic reactions defined in terms of a system and its surroundings?

Acquired Knowledge and Skills:

- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration and kinetic energy.
- 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.

Acquired Skills:

- Asking questions and define problems
- Develop and use models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Assessments:

Formative Assessments:

- Group discussions
- Observation
- Homework
- Class work
- Class participation
- Lab work
- Quizzes

Summative Assessments:

- Students construct an explanation that includes the idea that as the kinetic energy, temperature and concentration increases, the reaction rate increases.

Benchmarks:

- Students will be assessed on their ability to 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. [Clarification Statement: Emphasis is on temperature.]
- Students will be assessed on their ability to create a model to calculate the change in energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system is known. [Clarification Statement: Emphasis is on temperature.]

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities:

Anticipatory Sets:

- Have you ever used a cold pack, Icy Hot, heat pack, or reusable hot packs?

In-Class Activities and Laboratory Experiences:

- Hess's law
- Cold pack, Icy pack, heat pack, reusable hot packs.

Closure and Reflection Activities:

- Student Discussion
- Review Packet

Instructional Materials:

- Text books, note guides, guided practice, worksheets, PowerPoints and laboratories. Videos: Crash Course Chemistry: Calorimetry, Energy and Chemistry.

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-PS1-5**
- **HS-PS3-1**

Unit 10: Rates and Equilibrium (Pacing: 5 Days)

Why Is This Unit Important?

The applications of chemistry focus largely on chemical reactions and their commercial applications require knowledge of several of its characteristics including stoichiometry, energy and rate.

Disciplinary Core Ideas:

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)
- 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)
- 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)

Science and Engineering Practices:

Constructing Explanations and Designing Solutions

- 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)
- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)
- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)

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-PS1-1),(HS-PS1-2),(HS-PS1-5),(HS-PS1-3)

Enduring Understandings:

- The rate of a reaction is influenced by several factors.
- All reactions work toward equilibrium.

Essential Questions:

- How does collision theory explain the factors affecting reaction rate?
- How does nature correct unbalance?
- How do chemical reactions attain and maintain a state of equilibrium?

Acquired Knowledge and Skills:

- 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 many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.

Acquired Skills:

- Asking questions and define problems
- Develop and use models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating and communicating information

Assessments:

Formative Assessments:

- Group discussions
- Observation
- Homework
- Class work
- Class participation
- Writing assessments
- Do-Now
- Lab work
- Quizzes

Summative Assessments:

- Students construct an explanation that includes the idea that as the kinetic energy, temperature and concentration increases, the reaction rate increases.
- Students identify and describe potential changes in a component of the given chemical reaction system that will increase the amounts of particular species at equilibrium.

Benchmarks:

- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to 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.
- Students will be assessed on their ability to refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Learning Experiences and Instructional Activities

Anticipatory Sets:

In-Class Activities and Laboratory Experiences:

- Iodine Clock
- Career Exploration: Forensic Chemist
- Famous Chemist Research Project

Closure and Reflection Activities:

- Student Discussion
- Review Packet
- Genie in a bottle- demo

Instructional Materials:

- Text books, note guides, guided practice, worksheets, PowerPoints and laboratories. Videos: Crash Course Chemistry: Equilibrium, Equilibrium equations

List of Applicable Performance Expectations (PE) Covered in This Unit:

- **HS-PS1-2**
- **HS-PS1-5**
- **HS-PS1-6**

Career Readiness, Life Literacies, and Key Skills

9.4.12.CI.1:

For example, in Unit 6 where students 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.

9.4.12.CT.2:

For example, in Unit 4 where students 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.

9.4.8.IML.3:

For example, in Unit 3 where students evaluate the claims, evidence and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model and that for some situations one model is more useful than the other.

8.1 Computer Science and Design Thinking
All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and create and communicate knowledge.

An example of the application of this standard is found in unit 4 Lab: Graphing Periodic Trends

LGBT and Disabilities Law:

In Unit 10 the Famous Chemists Research Project has students explore the contributions of famous chemists from varying minorities including those who are LGBTQ and have disabilities.

Career Exploration:

- In Unit 10 there is a Career Exploration: Forensic Chemist

Interdisciplinary Connections

NJSLS.RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
NJSLS.RST.9-10.4 Determine the meaning of symbols, key terms and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grade level texts and topics.

NJSLS.RST.9-10.5 Analyze the structure of the relationships among concepts in a text, including relationships among key terms.
NJSLS.RST.9-10.6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.
NJSLS.RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
NJSLS.WHST.9-10.1.E - Provide a concluding statement or section that follows from or supports the argument presented.
NJSLS.WHST.9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (Honors, Level 1)
NJSLS.WHST.9-10.2a Introduce a topic and organize ideas, concepts and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables) and multimedia when useful to aiding comprehension.
NJSLS.WHST.9-10.2.d Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.
NJSLS.WHST.9-10.9 Draw evidence from informational texts to support analysis, reflection and research
These standards are met through the completion of the benchmark performances in all 10 units. For example in:

- Unit 1: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. [Clarification Statement: Emphasis is on the communication of information itself rather than the specifics of the functioning. Examples of metric units, outliers and predictions about the relationship of bulk properties.]
- Unit 2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles and energy associated with the relative positions of particles.
- Unit 3: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.
- Unit 4: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. [Clarification Statement: Emphasis is on structure of metals and nonmetals that determine the functioning of the material.
- Unit 5: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. [Clarification Statement: Emphasis is on properties of ionic and covalent compounds.]
- Unit 6: 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 7: Use mathematical representations to support the claim that atoms and therefore mass, are conserved during a chemical reaction.

- Unity 8: 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. [Clarification Statement: Emphasis is on properties of solutions.]

- Unit 9: 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. [Clarification Statement: Emphasis is on temperature.]
- Unit 10: 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.

NJSLS.MP.6 Mathematically proficient students try to communicate precisely to others.
NJSLS.HS.A-CED.A.1 Create equations and inequalities in one variable and use them to solve problems.
NJSLS.HS.A-CED.A.2 Create equations in two or more variables to represent relationships between quantities.
NJSLS.HS.A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
NJSLS.HS.A.REI.A.1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.
NJSLS.HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.
NJSLS.HS.A-SSE.A.1 Interpret complicated expressions by viewing one or more of their parts as a single entity.
NJSLS.HS.A-SSE.A.2 Use the structure of an expression to identify ways to rewrite it.
NJSLS.HS.N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
NJSLS.HS.N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

These standards are met through the completion of the benchmark performances in all 10 units. For example in:

- Unit 1: 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 of particles. [Clarification Statement: Emphasis is on the safe and efficient means of gathering evidence and that bulk scale properties can be used as evidence.]
- Unit 2: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: emphasis is on graphical representation of phase changes.]
- Unit 3: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength and speed of waves traveling in various media.
- Unit 4: 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. [Clarification Statement: Emphasis is on properties that could be predicted from patterns such as reactivity, atomic size, electronegativity and valence electrons.]
- Unit 5: 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. [Clarification Statement: Emphasis is on properties that could be predicted from patterns such as valence electrons, types and numbers of bonds formed and empirical formula.]

- Unit 6: Use mathematical representations to support the claim that atoms and therefore mass, are conserved during a chemical reaction.
- Unit 7: Use mathematical representations to support the claim that atoms and therefore mass, are conserved during a chemical reaction.
- Unity 8: 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. [Clarification Statement: Emphasis is on properties of solutions.]
- Unit 9: Create a (computational- Honors) model to calculate the change in energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system is known. [Clarification Statement: Emphasis is on temperature.]
- Unit 10: 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.