West Windsor-Plainsboro Regional School District
Course Title: Chemistry
Grade: 10-12

The Mission of the West Windsor-Plainsboro Science Department

Our mission is to cultivate science learners who have the foundational knowledge to make ethical, scientifically literate decisions and the ability to apply scientific practices in order to contribute to the needs of society and a changing world.

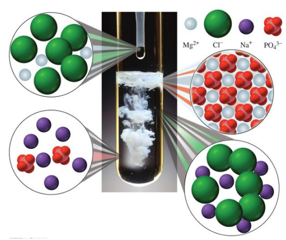
- **Vision**
  We envision a K-12 science experience that supports and challenges every student in their science learning journey. We will:
  - *Capitalize on diversity by reaching and exciting students at all levels and interests by differentiating learning within classrooms and by offering a robust program of studies.*
  - *Emphasize authentic science and engineering practices and leverage the interdisciplinary nature of science with arts, technology, math, reading, and writing.*
  - *Integrate scientific knowledge and 21st century competencies to prepare students to make informed decisions and take action to address real world problems.*
  - *Cultivate an inclusive and diverse community where all learners are welcomed, valued, respected, and celebrated.*

Chemistry Storyboard

Through the lens of Chemistry, students will explore our dynamic world and gain a deeper understanding of the fundamental principles that govern our universe; journeying from the unseen submicroscopic realm to the observable macroscopic scale to understand the environmental, technological, and societal implications of Chemistry and its' applications.

Essential Questions:

- How can Chemistry help you understand the world and address real world problems?
- How can macroscopic observations and models be used to explain microscopic phenomena and vice versa?
- How does energy and stability play a role in chemical processes?
- What are the environmental, technological, and societal implications of chemical processes and their applications?

The Tools of Chemistry *Unit 1*	**Structure & Properties of Matter** *Units 2-4*	**Chemical Bonding & Reactions** *Units 5-6*	**Matter, Energy, & Equilibrium** *Unit 7-9*
			
How can Chemistry help you understand the world?	*How does the structure of matter relate to its function?*	*How can we predict and understand the behavior of elements and compounds to cause chemical change?*	*How can we quantify changes in chemical systems and optimize them?*
The Focus of the Story	**The Focus of the Story**	**The Focus of the Story**	**The Focus of the Story**
This unit is designed to introduce students to essential and fundamental concepts in chemistry while emphasizing safety practices and techniques in the laboratory. Students will develop critical skills in measurement, data analysis, and graphing, while gaining a deeper	In this group of units, students explore the fundamental building blocks of matter, the intricate world of nuclear interactions, and how scientists came to understand the world at the sub-microscopic level to explain macroscopic phenomena. The concepts of energy and stability related to the atom are explored, as well as the real	In this group of units, students deepen their understanding of the substructure of atoms and how they interact and bond to form compounds, enabling them to better comprehend the properties and behaviors of different substances and mechanisms for chemical reactions. Students will explore the role of energy in transforming reactants into products, thereby gaining	In this group of units, students utilize mathematical thinking as it applies to chemical behavior and reactions, allowing them to quantitatively and qualitatively predict the behavior of chemical systems, outcomes of reactions, and how to optimize yields and limit waste. Students explore

understanding of the properties and behavior of matter.	world applications of chemical concepts learned so far.	insights into the driving forces behind chemical change. Focus is given to the importance of chemical reactions in everyday life and their impact on various aspects of society and the environment.	the impact of various factors on the stability of chemical systems and reactions and deepen their understanding of the changes that occur within these systems.
Learning Targets	**Learning Targets**	**Learning Targets**	**Learning Targets**
● I can employ laboratory techniques to gather data and analyze the properties of substances accurately. ● I can construct models to represent various systems and the relationships between them. ● I can formulate descriptive questions about observable phenomena and design an investigation to construct explanations to those questions.	● I can understand the structure of matter and the impact on its behavior and interactions. ● I can explain the relationship between energy and stability as it relates to the structure of matter and its interactions. ● I can analyze, interpret, and communicate my findings by developing explanations and supporting them with evidence and reasoning from investigations.	● I can apply knowledge of matter's structure and properties and patterns in the periodic table to predict and explain chemical bonding, reactions, and their outcomes. ● I can construct models based on evidence from observations and data to communicate the causal relationship between the submicroscopic and macroscopic scales of matter, energy, and stability.	● I can design and conduct experiments to investigate and explain the factors that influence chemical systems using scientific evidence, computational thinking, and models. ● I can apply knowledge of matter and energy to explain real-world phenomena and to design solutions to real-world problems.

Unit 1: Safety, the Tools of Chemistry, and Matter	
Content Area: Science	
Course & Grade Level: Chemistry, 10-12	
Summary and Rationale	
This unit is designed to introduce students to essential and fundamental concepts in chemistry while emphasizing safety practices and standards in the laboratory. Through hands-on activities, interactive lessons, and laboratory experiments, students will develop critical skills in measurement, data analysis, and graphing, while gaining a deeper understanding of the properties and behavior of matter. Before students engage in these activities, they must comprehend and practice lab safety protocols. The proper handling, storage and disposal of chemicals during a lab is emphasized. Students will begin to understand how we acquire, handle, and dispose of chemicals and the impact on the local environment and the overall climate system. Accurate measurement is crucial for obtaining reliable data. Students will further develop skills in using various measuring tools and units to make precise measurements including uncertain digits and record data effectively. Review of the metric system and mathematical operations will provide a foundation for future quantitative investigations. Students will review how to construct various types of graphs, interpret data patterns, and draw conclusions from graphical representations. Students are first introduced to models and how to communicate scientific understanding through the use of their own models. Students will begin their study of matter by exploring different states, chemical and physical properties, and the changes it can undergo. The crosscutting concept of matter and energy provides students with insights into the process of energy transfer in matter. The law of conservation of energy is used to support the investigation, understanding, and modeling of energy and structure changes that occur during phase changes. Students can make connections to global and ocean temperature rising, as well as melting ice caps. Furthermore, the cross-cutting concepts of patterns, scale, and structure and function are used in this unit to make sense of the concept of density. Students will explore densities' significance in identifying substances, predicting their behavior, and real-world applications. Students are introduced to the science and engineering practices that they will use throughout the course by designing their own investigation to solve a problem requiring mathematical thinking based on data they will collect and model.	
Recommended Pacing	
18 days	
NGSS Standards/Performance Expectations	
HS-PS1-3	**Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (Patterns)** *{Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.} [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]*
HS-PS2-6	**Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. (Structure and Function)** *{Clarification statement: Emphasis is on the attractive and repulsive forces that determine the functioning of material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.} [Assessment boundary- Assessment is limited to providing molecular structures of specific designed materials.]*
	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 (objects) and energy associated

HS-PS3-2	**with the relative positions of particles (objects).** *[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]*
HS-PS3-4	**Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics)**. *[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]*
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity.** *[Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]*
HS-ESS3-4	**Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems**. [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]
HS-ESS3-6	**Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity** (i.e., climate change). *[Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]*
New Jersey Student Learning Standards for English Language Arts Companion Standards	
Standard:	
CPI #	**Cumulative Progress Indicator (CPI)**
NJSLSA.SL5	Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.

W.9-10.7	Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. .
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1	Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2	Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others
9.2.12.C.4	Analyze how economic conditions and societal changes influence employment trends and future education.
9.2.12.C.3	Identify transferable career skills and design alternate career plans.
New Jersey Student Learning Standards for Computer Science and Design Thinking	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1.2.DA.1	Collect and present data, including climate change data, in various visual formats.
8.1.2.DA.3	Identify and describe patterns in data visualizations.
8.1.2.DA.4	Make predictions based on data using charts or graphs.
8.1.5.DA.1	Collect, organize, and display data in order to highlight relationships or support a claim.
8.1.5.DA.5	Propose cause and effect relationships, predict outcomes, or communicate ideas using data.
8.2.5.ED.2	Collaborate with peers to collect information, brainstorm to solve a problem, and evaluate all possible solutions to provide the best results with supporting sketches or models.
Interdisciplinary Standards (Math and Social Studies)	
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.
N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A-SSE.A.1	Interpret expressions that represent a quantity in terms of context
A-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
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.
A-REI.D.10	Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).
Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.

Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Phenomenon

- Diet Coke vs Regular Coke have differing densities
- Ocean current changes due to climate change (in relation to density)
- Fish's ability to rise, sink, float in water by changing the amount of oxygen in their bladder
- Build a raft to survive - need to choose material for a raft that will hold a certain amount of weight - how is it that you can build a raft out of wood and yet logs are harvested from the bottom of lakes?
- Example of dumping chemicals and impact on environment (see resources)

Unit Enduring Understandings

- Clear, accurate, organized and concise communication is essential for scientists.
- Safety in the chemistry laboratory requires using your common sense at all times.
- Different systems of measurement are used for different purposes.
- Correct selection of measurement instruments and measurement language will ensure accurate results**.**
- Mathematics is used in science to collect and compare data. The density of an object determines its ability to sink or float in water
- How we acquire, handle, and dispose of chemicals has an impact on the local environment and the overall climate system
- Matter can exist in four states (solid, liquid, gas and plasma) depending on temperature.
- The transfer of energy in and out of systems has an effect on the behavior of a substance's particles and the interaction between systems.

Unit Essential Questions

- Are all laboratory activities approached in the same manner?
- Why do we need to practice safe habits in the chemistry laboratory?
- Is it necessary to use a common set of measurement units? Why or why not?
- How is density determined?
- What are the possible effects of improper handling and disposal of materials and chemicals?
- What causes a substance to change phase?
- How do we model changes in the energy of particles within a system?

Objectives

We are learning to/that:

- Identify common lab equipment.
- Mass and volume have an effect on a substance's density, which will determine how it will behave in a system
- Demonstrate safe behavior in the laboratory.
- Properly use common laboratory equipment (ruler, glassware, balances; Bunsen burner may be covered later).
- Describe how disposal of chemicals may stabilize or destabilize the natural system
- Demonstrate proficient setup and data collection/analysis during a lab.
- Demonstrate proper graphical analysis techniques; including preparing and reading graphs, identifying the dependent and independent variables, interpolating and extrapolating data.
- Calculate an object's density using data collected through various methods (may be used to identify unknowns)

● Use mathematical skills to convert between metric units, write numbers in scientific notation, and solve for an unknown. (Dimensional analysis may be taught in the mole unit.) ● Construct particle models to demonstrate density at the atomic scale (atom-packing) ● Classify matter in terms of elements, compounds, mixtures, and pure substances ● Classify the three states of matter found in the laboratory by molecular level particle representations. ● Identify differences in the particle representations to classify them as pure substances, both elements and compounds, as well as mixtures. ● Phase changes occur due to the gain or loss of energy in a system. ● Characterize and draw particle models of the solid, liquid, and gas phases of matter. ● Analyze a heating or cooling curve to identify the melting/freezing point and boiling/condensation point of the substance. ● Students engage in argument from evidence to describe why the data about bulk properties would provide information about strength of the electrical forces between the particles of the chosen substances, including the following descriptions: ○ The spacing of the particles of the chosen substances can change as a result of the experimental procedure even if the identity of the particles does not change (e.g., when water is boiled the molecules are still present but further apart). ○ Thermal (kinetic) energy has an effect on the ability of the electrical attraction between particles to keep the particles close together. Thus, as more energy is added to the system, the forces of attraction between the particles can no longer keep the particles close together. ○ The patterns of interactions between particles at the molecular scale are reflected in the patterns of behavior at the macroscopic scale. ○ Together, patterns observed at multiple scales can provide evidence of the causal relationships between the strength of the electrical forces between particles and the structure of substances at the bulk scale.
Evidence of Learning
☑ **Formative Assessment -** Teachers will choose the most appropriate formative assessment strategy in order to assess students' understanding of the above objectives prior to a summative assessment and inform future instruction.
☑ **Summative Assessment -** Students will complete the three dimensional performance tasks listed below to demonstrate their proficiency in achieving mastery of the unit performance expectations and objectives. The focus is on having students apply their understanding of disciplinary core ideas and cross cutting concepts in the context of engaging in a science or engineering practice. The format or method in which these tasks are carried out are chosen by the teacher based on student needs and how best to demonstrate three-dimensional science proficiency; including but not limited to constructing models, designing and conducting investigations, constructing explanations for natural phenomena, or analyzing and interpreting data. Teachers - see “Integrating Science Practices Into Assessment Tasks” under resources for more examples.
☑ **Alternative Assessment -** During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students via differentiation and/or accommodations in process and product in order to provide an alternative modality for students to demonstrate three-dimensional science proficiency.
☑ **Benchmark -** Students will complete the common assessment(s) listed below to demonstrate their three-dimensional science proficiency. Students apply their understanding of disciplinary core ideas and cross cutting concepts as well as engage in science and engineering practices in order to solve a problem or explain a natural phenomenon.

Assessment Statement for Science Curriculum
The assessment plan includes teacher-designed formative and summative assessments, including common assessments, self-assessments, and performance tasks aligned with the NJSLS-S and the NJSLS-S for Climate Change. During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students. Accommodations
Sample Performance Tasks
● Students plan and carry out an investigation to determine the density of a specific material and determine how changing the structure of a substance results in the change of its density. **[HS-PS1-3]** ● Students gather and analyze mass and volume data from given unknown materials to determine the material's identity, communicate the results graphically, and infer the relative molecular-level structure. **[HS-PS2-6]** ● Students design a solution to separating a mixture of matter based on the structure and chemical and physical properties of the matter **[HS-PS2-6]** ● Students analyze and argue from evidence the effect of improper disposal of materials and chemicals on the overall stability of the natural system as well as cost, safety, reliability, and cultural and environmental impacts **[HS-ESS3-4]** ● Construct a model to demonstrate the changes in particle motion and structure as a result of changes in energy to the system **[HS-PS3-2, HS-PS3-4]** ● Use computational representations to construct an explanation for how energy transfer between particles and earth's systems are related to the increase in hazardous weather conditions **[HS-ESS3-6, HS-ESS3-1]**
Resources
Core Text: Inspire Chemistry ISBN: 978-0-07-688442-1 Unit 1, Module 1 - The Central Science Unit 1, Module 2 - Matter:Properties & Changes Unit 3, Module 11 - States of Matter **Suggested Instructional Resources:** *teachers may choose any resources they feel address the above objectives. Not all may be used.* ● Melting/boiling point of water or lauric acid lab ● States of Matter PhET simulation ● Gizmos (phase changes, temperature and particle motion, sticky molecules) ● Materials ID lab ● cm vs. in lab ● Golf Ball lab ● Spaghetti lab ● Density PHET simulation ● Density column (Launch lab from textbook) ● Measurement and Conversion lab ● Equipment for survival ● You're Fired! (safety activity- AACT) ● Escape Room (safety) ● Glassware Accuracy lab ● Pivot Interactive (measurement, density labs, mathematical models) ● Gizmos (triple beam balance, measuring volume, density labs) ● Separation Techniques Lab ● Article - 2 hurt in chlorine reaction and fire at New Jersey chemical plant ● https://oceanservice.noaa.gov/hazards/spills/

● NASA Climate Change Resources ● Climate.Gov ● Integrating Science Practices Into Assessment Tasks

Unit 2: Atomic Structure and Nuclear Chemistry	
Content Area: Science	
Course & Grade Level: Chemistry, 10-12	
Summary and Rationale	
In this unit students explore the fundamental building blocks of matter, the intricate world of nuclear interactions, and how scientists came to understand the world at the sub-microscopic level to explain macroscopic phenomena. Atomic structure serves as the foundation of chemistry and understanding of it is crucial for comprehending behavior and properties of elements, compounds, and reactions. Students will delve into the world of nuclear chemistry, understanding isotopes, radioactive decay, fission, fusion, half life, the practical applications, and the benefits and setbacks. Nuclear chemistry plays a vital role in various fields, including energy production, medicine, and environmental studies. Exploring this topic will enable students to recognize the applications and implications of nuclear reactions in their daily lives and develop a deep understanding of the nature of atoms, their stability, and the forces that govern their behavior. This robust unit utilizes all of the crosscutting concepts and SEP's as means to understand and demonstrate proficiency of the core ideas.	
Recommended Pacing	
20 days	
NGSS Standards/Performance Expectations	
HS-PS1-1	**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** *{Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.} [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]*
HS-PS1-2	**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.** *{Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.} [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]*
HS-PS1-3	**Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (Patterns)** *{Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions,*

	atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.} [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]
HS-PS1-8	**Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. (Energy and Matter)** *{Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.} [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]*
HS-PS1-7	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. (Energy and Matter)** *{Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.} [Assessment Boundary: Assessment does not include complex chemical reactions.]*
HS-PS2-6	**Communicate scientific and technical information in multiple formats about why the molecular-level structure is important in the functioning of designed materials. (e.g. why boron is a good choice for control rods)** *{Clarification statement: Emphasis is on the attractive and repulsive forces that determine the functioning of material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.} [Assessment boundary- Assessment is limited to providing molecular structures of specific designed materials.]*
HS-ESS1-3	**Communicate scientific ideas about the way stars, over their life cycle, produce elements. (Energy and Matter)** *{Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.} [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]*
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity.** *[Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]*
HS-ESS3-4	**Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.** *[Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering*

	design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]
HS-ETS1-3	**Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts**. *{Clarification Statement: Emphasis is placed on safety in the laboratory as well as the environmental impact of our actions.}*
New Jersey Student Learning Standards for English Language Arts Companion Standards	
CPI #	**Cumulative Progress Indicator (CPI)**
NJSLSA.W3	Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.
NJSLSA.W5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.
NJSLSA.W9	Draw evidence from literary or informational texts to support analysis, reflection, and research.
NJSLSA.R1	Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
NJSLSA.W7	Conduct short as well as more sustained research projects, utilizing an inquiry-based research process, based on focused questions, demonstrating understanding of the subject under investigation.
NJSLSA.W8	Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1	Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2	Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others
9.2.12.C.4	Analyze how economic conditions and societal changes influence employment trends and future education.
9.2.12.C.3	Identify transferable career skills and design alternate career plans.
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately.
9.1.12.EG.3	Explain how individuals and businesses influence government policies.
New Jersey Student Learning Standards for Computer Science and Design Thinking	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1.2.DA.1	Collect and present data, including climate change data, in various visual formats.
8.1.2.DA.3	Identify and describe patterns in data visualizations.
8.1.2.DA.4	Make predictions based on data using charts or graphs.

8.1.5.DA.1	Collect, organize, and display data in order to highlight relationships or support a claim.
8.1.5.DA.4	Organize and present climate change data visually to highlight relationships or support a claim.
8.1.5.DA.5	Propose cause and effect relationships, predict outcomes, or communicate ideas using data.
8.1.12.DA.5	Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.
8.1.12.DA.6	Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process.
8.2.5.ED.2	Collaborate with peers to collect information, brainstorm to solve a problem, and evaluate all possible solutions to provide the best results with supporting sketches or models.
8.2.12.ETW.3	Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation, and propose an innovative sustainable solution.
Interdisciplinary Standards	
N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling
N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A-SSE.A.1	Interpret expressions that represent a quantity in terms of its context
A-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
A-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Phenomenon

- The elements with smaller atomic numbers on the periodic table are more abundant in the universe and the earth's crust (observe graph of element abundance in universe)
- all atoms are made of the same type of subatomic particles but exhibit vastly different properties
- Prevalence of Radon gas in basements of homes in certain areas of state of NJ
- State and Federal Governments all over the globe are shutting down nuclear power plants.
- Radiation is used as a cancer treatment, but it also can harm or kill living things.

Unit Enduring Understandings

- Much of science deals with constructing explanations of how things change and how they remain stable
- 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
- The total amount of energy and matter in closed systems is conserved.
- Different models of the atom have been developed over time to include explanations of unexpected nuclear occurrences.
- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. **(PS1-1-A.1)**

- Nuclear reactions and chemical reactions are fundamentally different.
- There are risks and benefits associated with the use of nuclear energy.
- Nuclear processes differ by particle, rate, and energy
- The availability of natural resources influences human activity and changes in climate.

Unit Essential Questions

- How has our understanding of matter changed over time?
- What does an atom look like?
- To what extent are all atoms the same and/or different?
- How do nuclear fission and fusion compare and contrast as possible future energy sources?
- How have humans harnessed the knowledge of decay rates for practical uses?
- How can exposure to some types of radiation both hurt and help humans?
- Why is the energy released in a nuclear reaction very much greater than the energy released in a chemical reaction?
- How has the availability of natural resources or lack thereof influenced the need for alternative resources?

Objectives:

We are learning to/that:

- 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. **[PS1-8-1.C]**
- Atomic models have changed to reflect new data that revealed a more complex composition of the atom.
- Distinguish between protons, electrons, and neutrons in terms of their relative masses and charges.
- Describe the formation of anions and cations.
- Understand that Isotopes of an atom differ in terms of their number of neutrons and therefore their masses differ.
- Identify the relationship between the stability of an isotope and its effect on the abundance in nature
- Explain the electrostatic forces that hold the nucleus together
- Describe how the binding energy varies as a function of the mass number (calculation of mass defect are not necessary)
- Discuss general properties of electromagnetic radiation and properties of various regions of the electromagnetic spectrum and their biological effects.(ionizing vs. non-ionizing, particles vs. waves)
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved **[PS1-8]**
- Compare and contrast the general properties of alpha, beta, and gamma radiation, including penetrating power, and discuss safety considerations for each.
- Explain the concept of half-life and discuss the implication of half-life for natural radioactivity and nuclear waste disposal. (calculation involving half life are not necessary but may be taught)
- Explain nuclear transmutation using a nuclear equation model to illustrate the process.
- Distinguish nuclear fission from nuclear fusion.
- Identify the future hazards of nuclear phenomena (energy, weapons, waste, radiation, etc.)
- Students identify and communicate the relationships between the life cycle of the stars, the production of elements, and the conservation of the number of protons plus neutrons in stars. Students identify that atoms are not conserved in nuclear fusion, but the total number of protons plus neutrons is conserved. (do not need to know the specific life cycle of stars)
- Determine the number of subatomic particles given the isotopic symbol or atomic number, mass number, and/or net charge
- Use the concepts of isotopes to explain why the atomic masses of elements are not whole numbers (calculating the average atomic mass of an element from isotope data is not necessary but may be taught)
- Students develop and use radioactive decay models that illustrate the differences in type of energy and type of particle released during alpha, beta, and gamma radioactive decay, and any change from one element to another

that can occur due to the process. (Balanced nuclear equations, not including positron emission and electron capture)
- Interpret a Band of Stability graph to determine whether an isotope is unstable or not

Evidence of Learning

☑ **Formative Assessment -** Teachers will choose the most appropriate formative assessment strategy in order to assess students' understanding of the above objectives prior to a summative assessment and inform future instruction.

☑ **Summative Assessment -** Students will complete the three dimensional performance tasks listed below to demonstrate their proficiency in achieving mastery of the unit performance expectations and objectives. The focus is on having students apply their understanding of disciplinary core ideas and cross cutting concepts in the context of engaging in a science or engineering practice. The format or method in which these tasks are carried out are chosen by the teacher based on student needs and how best to demonstrate three-dimensional science proficiency; including but not limited to constructing models, designing and conducting investigations, constructing explanations for natural phenomena, or analyzing and interpreting data. Teachers - see "Integrating Science Practices Into Assessment Tasks" under resources for more examples.

☑ **Alternative Assessment -** During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students via differentiation and/or accommodations in process and product in order to provide an alternative modality for students to demonstrate three-dimensional science proficiency.

☑ **Benchmark -** Students will complete the common assessment(s) listed below to demonstrate their three-dimensional science proficiency. Students apply their understanding of disciplinary core ideas and cross cutting concepts as well as engage in science and engineering practices in order to solve a problem or explain a natural phenomenon.

Assessment Statement for Science Curriculum

The assessment plan includes teacher-designed formative and summative assessments, including common assessments, self-assessments, and performance tasks aligned with the NJSLS-S and the NJSLS-S for Climate Change. During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students. Accommodations

Sample Performance Tasks

- Construct an explanation for what causes the differences in natural abundance of the elements and how a star can function as a nuclear reactor **[HS-ESS1-3, HS-PS1-2]**
- Students carry out an investigation to obtain information about the differences in the structure of an atom and how that causes elements to have isotopes (Build an Atom pHet Sim) **[HS-PS1-1, HS-PS1-3]**
- Students carry out an investigation to obtain information about the nuclear structure of an isotope and the effect that has on stability and natural abundance (Build an Atom pHet Sim) **[HS-PS1-1, HS-PS2-6]**
- Develop a model based on evidence to illustrate that the total number of neutrons plus protons does not change in any nuclear process and the total amount of energy and matter is conserved. **[HS-PS1-7, HS-PS1-8]**
- Use mathematics and computational thinking to show the stability of decay rate of unstable nuclei. **[HS-PS1-8]**
- Communicate (or critique) evidence and reasoning about the relative risks and benefits of various nuclear technologies in order to support or argue against the development of a stronger nuclear power program in the United States. **[HS-PS1-8, HS-PS2-6, HS-ESS3-1, HS-ESS3-4]**
- Interpret data about the problems associated with the generation and disposal of sources of ionizing radiation that are encountered by a typical United States citizen in order to evaluate proposed solutions. **[HS-ETS1-3]**

Resources
Core Text: Inspire Chemistry ISBN: 978-0-07-688442-1 Unit 1, Module 3 - The Structure of the Atom Unit 5, Module 23 - Nuclear Chemistry **Suggested Resources:** *teachers may choose any resources they feel address the above objectives. Not all may be used.* ● PhET- Build an atom ● ChemMatters article- Where do elements Come From? chemmatters-oct2009-origin-chem-elem (1) ● Launch lab - How can the effects of electric charges be observed? ● Isotope POGIL ● Beanium Lab - Isotope Abundance ● Song- https://www.youtube.com/watch?v=me06I9GDM_k ● Twizzlers decay lab ● Pennies decay lab ● M&Ms/Skittles decay lab ● Flinn lab on radiation exposure ● PhET: radioactive decay ● Cloud chamber demo ● Charge of an alpha particle (Quick demo, p.775) ● Case studies from NCCSTS ● Radioisotope Infographic Project ● Radon Gas Activity ● An Atomic Assault (case study to introduce alpha, beta, and gamma) ● Gizmos (atomic structure, isotopes, average atomic mass, half-life, nuclear decay, nuclear reactions) ● Possible Connections - Energy.gov; ● NASA Climate Change Resources ● Climate.Gov ● Integrating Science Practices Into Assessment Tasks

Unit 3: Electrons and Light	
Content Area: Science	
Course & Grade Level: Chemistry, 10-12	
Summary and Rationale	
In this unit students move from the nucleus to the space surrounding it. They see how scientists used the study of light to move between models (Bohr and Schrodinger) to describe the arrangement and energy of the electrons. Students use these models and the periodic table to predict the pattern for electron configurations and determine an element's valence electrons and possible ionic charge from the configuration. The concepts of the energy and stability in an atom is dependent on this electron organization and lays the foundation for more advanced topics in chemical bonding and reactivity. This knowledge can be practically applied to explain phenomena such as colored flames, glowing orange metals, and atomic spectra seen in stars. Students will also relate the fact that energy is transferred as electromagnetic radiation to help explain the greenhouse gas effect and the impact humans have on this phenomenon. The cross-cutting concepts of patterns, cause and effect and scale, proportion and quantity are highlighted in this unit. Moreover, students continue to be presented with opportunities to develop all of the science and engineering practices.	
Recommended Pacing	
14 days	
NGSS Standards/Performance Expectations	
HS-PS1-1	**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** *{Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.} [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]*
HS-PS1-2	**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.** *{Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.} [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]*
HS-PS2-6	**Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. (Structure and Function)** *{Clarification statement: Emphasis is on the attractive and repulsive forces that determine the functioning of material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.} [Assessment boundary- Assessment is limited to providing molecular structures of specific designed materials.]*

HS-PS4-1	**Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** **(Cause and Effect)** *{Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.} [Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]*
HS-PS4-3	**Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.** **(Systems and System Models)** *{Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.} [Assessment Boundary: Assessment does not include using quantum theory.]*
HS-PS4-4	**Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.** **(Cause and Effect)** *{Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.} [Assessment Boundary: Assessment is limited to qualitative descriptions.]*
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity.** *[Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]*
HS-ESS3-6	**Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity** (i.e., climate change). *[Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]*
New Jersey Student Learning Standards for English Language Arts Companion Standards	
CPI #	**Cumulative Progress Indicator (CPI)**
NJSLSA.W1.	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
RI.9-10.8	Describe and evaluate the argument and specific claims in a text, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and reasoning.
NJSLSA.W5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

NJSLSA.R10	Read and comprehend complex literary and informational texts independently and proficiently with scaffolding as needed.
NJSLSA.R1	Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
NJSLSA.W7	Conduct short as well as more sustained research projects, utilizing an inquiry-based research process, based on focused questions, demonstrating understanding of the subject under investigation.
NJSLSA.W8	Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.
NJSLSA.W9	Draw evidence from literary or informational texts to support analysis, reflection, and research. .
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1	Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2	Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.2.12.C.4	Analyze how economic conditions and societal changes influence employment trends and future education.
9.2.12.C.3	Identify transferable career skills and design alternate career plans.
9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately.
New Jersey Student Learning Standards for Computer Science and Design Thinking	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1.2.DA.1	Collect and present data, including climate change data, in various visual formats.
8.1.2.DA.3	Identify and describe patterns in data visualizations.
8.1.2.DA.4:	Make predictions based on data using charts or graphs.
8.1.5.DA.1	Collect, organize, and display data in order to highlight relationships or support a claim.
8.1.5.DA.4	Organize and present climate change data visually to highlight relationships or support a claim.
8.1.5.DA.5	Propose cause and effect relationships, predict outcomes, or communicate ideas using data.
8.1.12.DA.5	Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.
8.2.5.ED.2	Collaborate with peers to collect information, brainstorm to solve a problem, and evaluate all possible solutions to provide the best results with supporting sketches or models.
8.2.12.ETW.3	Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation, and propose an innovative sustainable solution.
Interdisciplinary Standards	
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.
N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling

N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Phenomenon

- An Indonesian volcano has bright blue flames and bright blue "lava" flows. (in addition to the normal red ones)
    - The lava is blue because it has high concentrations of sulfur in it. The sulfur, when burning, emits a blue color. This ties to the core idea that elements have different electron configurations and when excited, electrons gain quantized amounts of energy which is then emitted upon returning to the ground state.(HS.PS4B.4)
- Hot metals give off orange light when hot.
- We can tell what stars are made of based on the light they emit
- Meteors appear as different colors (red, yellow, green blue, etc.) as they pass through the night sky during meteor showers

Unit Enduring Understandings

- Chemical and physical properties of materials can be explained by the structure of the atom, specifically the electron arrangement
- Elements can be identified by their unique atomic spectra.
- Electrons are arranged systematically in an atom following a set of rules.
- Light exhibits both wave-like and particle-like behaviors
- The electromagnetic spectrum encompasses various forms of light with different wavelengths and energies.
- Human activity has impacted changes in climate and other Earth systems.

Unit Essential Questions

- How can energy be both a wave and a particle?
- How do substances give off unique colors of light?
- To what extent are the physical and chemical properties of matter related to electron configuration?
- How are the relationships between Earth's systems being affected due to human activity?

Objectives

We are learning to/that:

- 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. **[PS4-3-4.B]**
- 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. **[PS4-4-4.B]**
- The arrangement of electrons in atoms can be expressed through orbital notations, electron configurations, and electron dot structures.

● Use mathematics and computational thinking to identify and describe the relationships between frequency, wavelength, energy, and color of visible light (if applicable). (calculations using the various formulas involving these variables may or may not be done) ● 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 ● Explain the difference between a continuous spectra and a line spectra. ● Understand that electrons exist in quantized energy levels and can jump up or down to the next level depending on energy lost or gained. ● When electrons transition between energy levels, they emit or absorb specific wavelengths of light, producing unique atomic emission spectra for each element. ● Understand that human activity directly affects the amount of greenhouse gasses in the atmosphere and the extent is still being determined. ● Write orbital notations and electron dot structures for any given element. (Elements #1-36, and anything in the p block.) ● understand that the Aufbau principle, Pauli exclusion principle, and Hund's rule govern how the electron configurations of elements are written ● Construct a Bohr model for any given atom. ● Determine the number of valence electrons based on electron configurations. ● Analyze and use evidence from computation representation to describe how human activity correlates to the amount greenhouse houses in the atmosphere
Evidence of Learning
☑ **Formative Assessment -** Teachers will choose the most appropriate formative assessment strategy in order to assess students' understanding of the above objectives prior to a summative assessment and inform future instruction.
☑ **Summative Assessment -** Students will complete the three dimensional performance tasks listed below to demonstrate their proficiency in achieving mastery of the unit performance expectations and objectives. The focus is on having students apply their understanding of disciplinary core ideas and cross cutting concepts in the context of engaging in a science or engineering practice. The format or method in which these tasks are carried out are chosen by the teacher based on student needs and how best to demonstrate three-dimensional science proficiency; including but not limited to constructing models, designing and conducting investigations, constructing explanations for natural phenomena, or analyzing and interpreting data. Teachers - see "Integrating Science Practices Into Assessment Tasks" under resources for more examples.
☑ **Alternative Assessment -** During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that not only adhere to 504 and IEP requirements but reflect good teaching practices that benefit any and all students. Alternative assessments are individualized for the needs of all students via differentiation and/or accommodations in process and product in order to provide an alternative modality for students to demonstrate three-dimensional science proficiency.
☑ **Benchmark -** Students will complete the common assessment(s) listed below to demonstrate their three-dimensional science proficiency. Students apply their understanding of disciplinary core ideas and cross cutting concepts as well as engage in science and engineering practices in order to solve a problem or explain a natural phenomenon.
<u>Assessment Statement for Science Curriculum</u> The assessment plan includes teacher-designed formative and summative assessments, including common assessments, self-assessments, and performance tasks aligned with the NJSLS-S and the NJSLS-S for Climate

Change. During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students. Accommodations
Sample Performance Tasks:
• Critique models used to describe the electron transitions that occur to produce the light seen caused by energy passing through a given gaseous element sample.**[HS-PS1-1, HS-PS4-4]** • Develop questions to carry out an investigation to gather evidence to construct an atomic level explanation for what causes the flames and lava to appear blue in color **[HS-PS1-1]** • Analyze and interpret an EM chart and equations (speed of light and Planck's) to determine the pattern between energy, frequency, wavelength (color) of light **[HS-PS4-1, HS-PS4-3]** • Evaluate the data from the flame test lab to explain that atoms of each element emit and absorb characteristic energies and frequencies of light and these characteristics allow identification of the presence of an element even in microscopic quantities **[HS-PS1-1, HS-PS2-6, HS-PS4-3]** • Carry out an investigation (POGIL) to understand how the structure of the atom's electrons determines its periodic table placement and how it interacts with other atoms to form bonds and its properties **[HS-PS1-1, HS-PS1-2]** • Students use mathematics and computational thinking to illustrate the relationship between the amount of greenhouse gasses in the atmosphere and changes in impacted environmental systems. **[HS-ESS3-1, HS-ESS3-6]**
Resources
Core Text: Inspire Chemistry ISBN: 978-0-07-688442-1 Module 4 - Electrons in Atoms **Suggested Resources:** *teachers may choose any resources they feel address the above objectives. Not all may be used.* • Blue Lava Video from online textbook • Flame Test Lab (used as investigation) • Electron Energy & Light POGIL • Emission Tubes & Spectrometers • Electron Configuration POGIL • Energy and the electron (Modeling activity from AACT) • Gizmos (e- configurations, Bohr model, photoelectric effect) • Pivot Interactive (gas emission spectra, flame test) • NASA Climate Change Resources • Climate.Gov

Unit 4: The Periodic Table and Metals	
Content Area: Science	
Course & Grade Level: Chemistry, 10-12	
Summary and Rationale	
By making real world connections to the everyday use of materials such as metals and their alloys, students study chemical concepts of elemental periodicity and classification. Students will use the periodic table as a tool to explain and predict the properties of elements. Students build an understanding of periodicity and how the arrangement of an atom's electrons determines its position in the periodic table of the elements. Alloys illustrate on a molecular level how structure is aligned to function. The crosscutting concepts of *energy and matter*; *scale, proportion, and quantity*; and *stability and change* are called out as organizing concepts for this unit. Students are expected to demonstrate proficiency in *developing and using models*; *constructing explanations and designing solutions; and obtaining, evaluating, and communicating information*; and they are expected to use these practices to demonstrate an understanding of how scientists use the periodic table to predict chemical reactivity. The unit lends itself well to learning about the environmental impact of metal extraction, use, and disposal. By discussing sustainable practices and recycling efforts, students will develop a sense of responsibility towards resource management and environmental preservation.	
Recommended Pacing	
10 days	
NGSS Standards/Performance Expectations	
HS-PS1-1	**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** *{Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.} [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]*
HS-PS1-2	**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.** *{Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.} [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]*
HS-PS2-6	**Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. (Structure and Function)** *{Clarification statement: Emphasis is on the attractive and repulsive forces that determine the functioning of material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.} [Assessment boundary- Assessment is limited to providing molecular structures of specific designed materials.]*

HS-ETS1-3	**Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.** *{Clarification Statement: Emphasis is placed on safety in the laboratory as well as the environmental impact of our actions.}*
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity.** *[Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]*
HS-ESS3-2	**Evaluate completing design solutions for developing, managing, utilizing energy and mineral resources based on cost-benefit ratios** *Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.*
New Jersey Student Learning Standards for English Language Arts Companion Standards	
CPI #	**Cumulative Progress Indicator (CPI)**
W.9-10.1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
NJSLSA.W5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.
NJSLSA.W9	Draw evidence from literary or informational texts to support analysis, reflection, and research.
NJSLSA.R1	Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
NJSLSA.W1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1	Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2	Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.2.12.C.4	Analyze how economic conditions and societal changes influence employment trends and future education.
9.2.12.C.3	Identify transferable career skills and design alternate career plans.

9.4.12.IML.7	Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately.
New Jersey Student Learning Standards for Computer Science and Design Thinking	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1.2.DA.3	Identify and describe patterns in data visualizations.
8.1.2.DA.4	Make predictions based on data using charts or graphs.
8.1.5.DA.1	Collect, organize, and display data in order to highlight relationships or support a claim.
8.15.DA.5	Propose cause and effect relationships, predict outcomes, or communicate ideas using data.
8.2.5.ED.2	Collaborate with peers to collect information, brainstorm to solve a problem, and evaluate all possible solutions to provide the best results with supporting sketches or models.
8.2.12.ETW.3	Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation, and propose an innovative sustainable solution.
Interdisciplinary Standards	
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.
N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling
N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Phenomenon

- Most metals are usually found in the form of ore, not a pure substance.
- We can wear “precious metals” as jewelry but not other metals.
- When Magnesium metal is burned, a new substance is formed that is different than the original metal
- When alkali metals are thrown in a large body of water, a large explosion occurs. We must keep alkali metals stored in kerosene
- Ancient civilizations utilized metal alloys for various applications

Unit Enduring Understandings

- Understanding interactions among elements allows individuals to predict changes in natural and designed systems.
- Understanding of regularities and patterns in the periodic table allow for predictions of interactions among the elements.
- The properties of elements determine their use and the manipulation of them allows us to achieve desired properties
- Earth has a limited amount of natural resources that we need to conserve

Unit Essential Questions

- Is there more than one accurate way to organize the elements in a useful manner?
- How can the chemical and physical properties of matter be explained? What determines these properties?
- How can matter be modified to make it more useful?
- If nature ALWAYS conserves, then why are we RUNNING OUT of some of our most valuable resources?

Objectives

We are learning to/that:

- 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. **[PS1-1.1.A]**
- Classify selected elements as metals, nonmetals, or metalloids based on direct laboratory observations of their chemical and physical properties.
- Obtain, evaluate, and communicate information about appropriate methods of resource conservation/management.
- Analyze and interpret supply and demand data to estimate the lifetime of a given resource, accounting for the uncertainty involved in such estimates.
- Students analyze and interpret data from the periodic table to construct explanations of the patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of the outermost electrons and determine the typical reactivity of an atom.
- Students analyze and interpret data from the periodic table to construct explanations for following patterns of properties:
    - the number and charges in stable ions that form from atoms in a group of the periodic table
    - the trend in reactivity and electronegativity of atoms down a group and across a row in the periodic table, based on attractions of valence electrons to the nucleus
    - the relative sizes of atoms both across a row and down a group in the periodic table.
    - ionization energy both across a row and down a group on the periodic table.
    - ionic radii both across a row and down a group on the periodic table.
- Students construct an explanation that describes the causal relationship between the observable macroscopic patterns of reactivity of elements in the periodic table and the patterns of outermost electrons for each atom and its relative electronegativity.
- Explain metals' properties of malleability and conductivity using an atomic level model of metallic bonding.
- Describe the variations in metal and alloy properties and how they are exploited for practical uses.
- Use the periodic table to: (a) predict physical and chemical properties of an element; (b) write formulas for various compounds; (c) identify elements by their atomic masses and atomic numbers; (d) locate periods and groups (families) of elements; and (e) locate metals, nonmetals and metalloids.
- Design and be able to justify a student-generated periodic table given properties of a set of elements or objects/sketches.
- Argue from evidence to classify selected elements as metals, nonmetals, or metalloids based on direct observations of their chemical and physical properties.
- Given certain properties of an unknown element, determine what the element is.

Evidence of Learning

☑ **Formative Assessment -** Teachers will choose the most appropriate formative assessment strategy in order to assess students' understanding of the above objectives prior to a summative assessment and inform future instruction.

☑ **Summative Assessment -** Students will complete the three dimensional performance tasks listed below to demonstrate their proficiency in achieving mastery of the unit performance expectations and objectives. The focus is on having students apply their understanding of disciplinary core ideas and cross cutting concepts in the context of engaging in a science or engineering practice. The format or method in which these tasks are carried out are chosen by the teacher based on student needs and how best to demonstrate three-dimensional science proficiency; including but not limited to constructing models, designing and conducting investigations, constructing explanations for natural phenomena, or analyzing and interpreting data. Teachers - see "Integrating Science Practices Into Assessment Tasks" under resources for more examples.

☑ **Alternative Assessment -** During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students via differentiation and/or accommodations in process and product in order to provide an alternative modality for students to demonstrate three-dimensional science proficiency.

☑ **Benchmark -** Students will complete the common assessment(s) listed below to demonstrate their three-dimensional science proficiency. Students apply their understanding of disciplinary core ideas and cross cutting concepts as well as engage in science and engineering practices in order to solve a problem or explain a natural phenomenon.

Assessment Statement for Science Curriculum

The assessment plan includes teacher-designed formative and summative assessments, including common assessments, self-assessments, and performance tasks aligned with the NJSLS-S and the NJSLS-S for Climate Change. During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students. Accommodations

Sample Performance Task

- 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. **[HS-PS1-1, HS-PS1-2]**
- Develop a model to explain the structure, properties, and transformations of matter by observing patterns in an atomic and molecular structure. **[HS-PS1-1, HS-PS2-6]**
- Analyze and interpret data, to determine patterns of trends found on the periodic table such as properties that help to distinguish between metals, nonmetals, and metalloids. **[HS-PS1-1, HS-PS2-6]**
- Obtain, evaluate, and communicate information about how the lack of different natural resources in specific areas has had an affect on the human activity in that specific region **[HS-ESS3-1, HS-ETS1-3, HS-ESS3-2]**

Resources

Core Text: Inspire Chemistry ISBN: 978-0-07-688442-1

Module 5 and Module 6- Lesson 4

Suggested Resources: *teachers may choose any resources they feel address the above objectives. Not all may be used.*

- Forged (clips on YouTube- alloys)
- Hunting the Elements (NOVA)- Mendeleev, bronze bell and periodic table table sections
- TedEd- the periodic table
- Alien cards periodic table (arranging creatures into groups and periods)
- Element cards periodic table (arranging "unknown" elements based on properties)
- Alien periodic table (logic puzzle using trends, properties)
- Secrets of the Samurai Sword (NOVA special)
- Metals/Nonmetals/Metalloids Lab
- Gold penny lab (alloys)

- Gizmos (Periodic Trends)
- Criminal concerns around the theft of catalytic converters (There's Big Money In Stolen Catalytic Converters)
- NASA Climate Change Resources
- Climate.Gov

Unit 5: Chemical Bonding

Content Area: Science	
Course & Grade Level: Chemistry, 10-12	
Summary and Rationale	
This unit aims to deepen students' understanding of the substructure of atoms and how they interact and bond to form molecules and compounds. Students will explore the different types of chemical bonds and the forces that hold molecules and formula units together, enabling them to better comprehend the properties and behaviors of different substances and mechanisms for chemical reactions. They will explain bonding through the patterns in outermost electrons, periodic trends, stability, and chemical properties. Students use investigations, simulations, and models to make sense of the strength of electrical forces between particles to provide more mechanistic explanations of the properties of substances. This leads to a broader study of other intermolecular forces and the influence on phenomena such as boiling point, surface tension, and solubility. Students build on their prior knowledge of atomic structure and bonding to learn how to write chemical formulas and to name compounds according to certain conventions. The crosscutting concepts of *patterns, energy and matter*, and *stability and change* are the organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in *developing and using models*, *planning and conducting investigations*, *using mathematical thinking*, and *constructing explanations and designing solutions*.	
Recommended Pacing	
24 days	
NGSS Standards/Performance Expectations	
HS-PS1-1	**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** *{Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.} [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]*
HS-PS1-2	**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.** *{Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.} [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]*
HS-PS1-3	**Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (Patterns)** *{Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances*

	could include the melting point and boiling point, vapor pressure, and surface tension.} [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]
HS-PS1-4	**Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. (Energy and Matter)** *{Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.} [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]*
HS-PS1-7	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. (Energy and Matter)** *{Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.} [Assessment Boundary: Assessment does not include complex chemical reactions.]*
HS-PS2-4	**Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.** *[Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]*
HS-PS2-6	**Communicate scientific and technical information in multiple formats about why the molecular-level structure is important in the functioning of designed materials.** *{Clarification statement: Emphasis is on the attractive and repulsive forces that determine the functioning of material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.} [Assessment boundary- Assessment is limited to providing molecular structures of specific designed materials.]*
HS-PS3-1	**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 components and energy flows in and out of the system are known** . *[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]*
HS-PS3-2	**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 (objects) and energy associated with the relative positions of particles (objects).** *[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]*
	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when

HS-PS3-4	**two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics)**. *[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]*
HS-PS3-5	**Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.** *[Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: Assessment is limited to systems containing two objects.]*
HS-ETS1-1	**Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.** *{Clarification Statement: Emphasis should be placed on students rationalizing why the problem is a major global issue, and describing both quantitatively and qualitatively the extent and depth of the problem and its consequences to society and the natural world based on research including primary sources. Students should also define the process or system boundaries and the components of the process or system as well as define the criteria and constraints.}*
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity.** *[Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]*
HS-ESS3-6	**Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity** (i.e., climate change). *[Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]*
New Jersey Student Learning Standards for English Language Arts Companion Standards	
CPI #	**Cumulative Progress Indicator (CPI)**
NJSLSA.R10	Read and comprehend complex literary and informational texts independently and proficiently with scaffolding as needed.
NJSLSA.R1	Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

NJSLSA.W8	Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.
W.9-10.8.	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1	Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2	Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.2.12.C.4	Analyze how economic conditions and societal changes influence employment trends and future education.
9.2.12.C.3	Identify transferable career skills and design alternate career plans.
9.4.5.GCA.1	Analyze how culture shapes individual and community perspectives and points of view
9.1.12.EG.6	Analyze the rights and responsibilities of buyers and sellers under consumer protection laws.
New Jersey Student Learning Standards for Computer Science and Design Thinking	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1.2.DA.1	Collect and present data, including climate change data, in various visual formats.
8.1.5.DA.1	Collect, organize, and display data in order to highlight relationships or support a claim.
8.1.5.DA.4	Organize and present climate change data visually to highlight relationships or support a claim.
8.1.5.DA.5	Propose cause and effect relationships, predict outcomes, or communicate ideas using data.
8.2.12.ETW.3	Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation, and propose an innovative sustainable solution.
Interdisciplinary Standards	
G-MG.A.1	Use geometric shapes, their measures, and their properties to describe objects
A-SSE.A.1	Interpret expressions that represent a quantity in terms of context
Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.
Instructional Focus	
Unit Phenomenon	
• Some water samples conduct electricity while others do not. • Two inedible elements combine to form the common edible substance (table salt).	

- Environmental agencies track increasing numbers of fish kills occurring across the country due to contaminated water
- Water doesn't fall through the screen.
- Geckos can walk up smooth surfaces.
- Water striders can walk on water.
- Concrete bridges/sidewalks crack in the winter.
- Alcohol evaporates in your hand and feels cold.
- Ice cubes float in water.
- Water in outer space forms spheres and can't be wrung out of a towel. (STEMonstrations via NASA)

Unit Enduring Understandings

- Chemical elements don't always exist alone
- Structure and function are often related
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms **[PS1-3-1.A]**
- Understanding of regularities and patterns in the periodic table allow for predictions of interactions among the elements.
- The properties of a material are related to the type and energy of the bonds.
- 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 **[PS1-4-1.A]**
- The naming of chemicals and formulas depends on the regularities and patterns inherent in the periodic table.
- Chemical formulas are shorthand for describing compounds.
- The formation of ionic compounds in Earth's systems can have lasting effects.
- The transfer of energy in and out of systems has an effect on the behavior of a substance's particles and the interaction between systems.

Unit Essential Questions

- Why do elements form compounds?
- If all atoms are composed of the same fundamental building blocks, how is it that different atoms can behave chemically in vastly different ways?
- How can a chemical formula be derived from the name of a compound or vice versa?
- What effect does the presence of ionic compounds have on different environments?
- What forces exist between molecules?

Objectives

We are learning to/that:

- 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. **[PS1-1-2.B, PS1-3-2.B, PS2-6-2.B]**
- Understand how evidence at the bulk scale can be used to infer evidence about the atomic scale.
- State the "octet rule" and the importance of the noble-gas configuration in the formation of ions.
- Distinguish between anions and cations and their formation.
- Differentiate between ionic and molecular compounds, and between formula units and molecules.
- Explain why a systematic method of naming chemical compounds is necessary.
- Identify characteristics of molecular and ionic substances.
- Define lattice energy.
- Name and describe the weak attractive forces that hold molecules together.

- Explain why and how certain atoms bond with each other in ionic compounds using words and models based on patterns of the periodic table relating to valence electrons and attraction between ions
- Determine the number of valence electrons based on electron configurations or position on periodic table.
- Develop and use models such as electron dot structures for the representative elements to show cation formation from metals and anion formation from nonmetals.
- Predict the charge of an ion based on its' number or valence electrons and placement on periodic table
- Given specific elements, predict the ratio they will bond in to form an ionic compound
- Given ions, including polyatomic ions, form ionic compounds and name them.
- Given the name of an ionic compound, write its chemical formula.
- Analyze and interpret data from the periodic table identify a compound as having either ionic or covalent bonds.
- Construct an explanation for the electrical conductivity of molten and aqueous solutions of ionic compounds.
- Analyze and interpret data to differentiate between polar covalent, nonpolar covalent, and ionic bonds using electronegativity differences as well as location of elements on the periodic table.
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (only to include hydrogen bonds, dipole-dipole, and dispersion forces)
- Compare and contrast the energy and formation of intermolecular attractions.
- Students engage in argument from evidence to describe the phenomenon under investigation, which includes the following idea: the relationship between the measurable properties (e.g. melting point, boiling point, vapor pressure, surface tension) of a substance and the strength of the electrical forces between the particles of the substance.
- Students plan and carry out an investigation that requires them to describe the data that will be collected and the evidence to be derived from the data, including bulk properties of a substance (e.g. melting point, boiling point, volatility, surface tension) that would allow inferences to be made about the strength of electrical forces between the particles and the transfer of energy

Evidence of Learning

☑ **Formative Assessment -** Teachers will choose the most appropriate formative assessment strategy in order to assess students' understanding of the above objectives prior to a summative assessment and inform future instruction.

☑ **Summative Assessment -** Students will complete the three dimensional performance tasks listed below to demonstrate their proficiency in achieving mastery of the unit performance expectations and objectives. The focus is on having students apply their understanding of disciplinary core ideas and cross cutting concepts in the context of engaging in a science or engineering practice. The format or method in which these tasks are carried out are chosen by the teacher based on student needs and how best to demonstrate three-dimensional science proficiency; including but not limited to constructing models, designing and conducting investigations, constructing explanations for natural phenomena, or analyzing and interpreting data. Teachers - see "Integrating Science Practices Into Assessment Tasks" under resources for more examples.

☑ **Alternative Assessment -** During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students via differentiation and/or accommodations in process and product in order to provide an alternative modality for students to demonstrate three-dimensional science proficiency.

☑ **Benchmark -** Students will complete the common assessment(s) listed below to demonstrate their three-dimensional science proficiency. Students apply their understanding of disciplinary core ideas and cross cutting concepts as well as engage in science and engineering practices in order to solve a problem or explain a natural phenomenon.

Assessment Statement for Science Curriculum

The assessment plan includes teacher-designed formative and summative assessments, including common assessments, self-assessments, and performance tasks aligned with the NJSLS-S and the NJSLS-S for Climate Change. During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students. Accommodations

Sample Performance Task:

- Conduct an investigation of the characteristics of ionic and covalent compounds to understand how evidence at the bulk scale can be used to infer evidence about the atomic scale. **[HS-PS1-3, HS-PS2-6]**
- Identify the pattern of ionic charge, size and lattice energies and explain how they are dependent on electrostatic forces between atoms. **[HS-PS1-1, HS-PS2-4]**
- Construct and revise an explanation for the outcome of a simple synthesis chemical reaction to form an ionic or covalent compound based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. **[HS-PS1-2, HS-PS1-7]**
- Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical (intermolecular) forces between particles **[HS-PS1-3, HS-PS2-4]**
- Develop and use a model of two atoms interacting to illustrate the forces between them and the changes in energy of the objects due to the interaction during bond formation or intermolecular attraction **[HS-PS3-1, HS-PS3-2, HS-PS3-4, HS-PS3-5]**
- 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 **[HS-PS1-4]**
- Using mathematics and computational thinking, construct an explanation for how technology has affected the availability of natural resources within earth's systems, making the distinction between causal and correlational relationships **[HS-ESS3-6] [HS-ESS3-1]**
- Analyze and interpret data to identify patterns in the levels of dissolved compounds (ionic compounds) in natural waterways as a result of human activity and the overall impact on the relationships between earth systems **[HS-ESS3-6, HS-ESS3-1, HS-ETS1-1]**

Resources

Core Text: Inspire Chemistry ISBN: 978-0-07-688442-1

- Module 6 - Ionic Compounds and Metals (Lessons 1-3)
- Module 7 - Covalent Bonding

Suggested Resources: *teachers may choose any resources they feel address the above objectives. Not all may be used.*

- Naming Ionic Compounds POGIL
- Polyatomic Ion POGIL
- Ionic Bonding and Ionic Formulas (ChemThink in SimBucket)
- Tooth and notch cards (also online at http://www.chemfiles.com/flash/formulas.html)
- Balancing ions simulation (http://www.chemfiles.com/flash/formulas.html)
- Poisoned Water (NOVA - to talk about ions in water)
- Foul Water lab
- Solubility lab (ionic vs. covalent; polarity)
- Diaper lab (use sodium polyacrylate to distinguish between ionic and covalent compounds)
- Ionic vs. Covalent compounds properties lab
- Materials sort (separate bag of common “stuff” based on properties)
- Water Testing lab (ion testing)
- Gizmos (Ionic bonds)

- heavy metal and compound contaminants in NJ waterways (White Paper: Recontamination of Mitigation Sites in the Meadowlands)
- States of Matter PhET simulation
- Water stations (properties of water)
- Pivot Interactive (surface tension and intermolecular forces, temperature during phase changes)
- Gizmos (phase changes, temperature and particle motion, sticky molecules)
- STEMonstrations via NASA (https://www.nasa.gov/stemonstrations)
- NASA Climate Change Resources
- Climate.Gov

Unit 6: Chemical Reactions	
Content Area: Science	
Course & Grade Level: Chemistry, 10-12	
Summary and Rationale	
Understanding chemical reactions is at the core of chemistry and is essential for comprehending various natural phenomena and human-made processes. Students will explore the rearrangement of atoms, the breaking and forming of bonds, and the role of energy in transforming reactants into products, thereby gaining insights into the driving forces behind chemical change. The unit emphasizes the principle of conservation of mass and students will conduct experiments,analyze data, and balance chemical equations to observe and verify this fundamental law. Students will use knowledge of outermost electron states of atoms, trends in the periodic table, and patterns of chemical properties to predict and explain the outcomes of different types of chemical reactions. Chemical reactions can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students should also be able to write a rigorous explanation of the outcome of simple chemical reactions, using data from their own investigations, models, and simulations. Students then explore the impact of various factors (temperature and concentration) on reaction rates and deepen their understanding of particle interactions. The unit will highlight the practical applications of chemical reactions, including industrial processes, environmental issues, and biological transformations. Students will recognize the importance of chemical reactions in everyday life and their impact on various aspects of society and the environment. The crosscutting concepts of *patterns, energy and matter*, and *stability and change* are the organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in *developing and using models*, *planning and conducting investigations*, *using mathematical thinking*, and *constructing explanations and designing solutions*.	
Recommended Pacing	
25 days	
NGSS Standards/Performance Expectations	
HS-PS1-1	**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms**. *{Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.} [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]*
HS-PS1-2	**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties**. *{Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.} [Assessment*

	Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]
HS-PS1-4	**Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. (Energy and Matter)** *{Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.} [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]*
HS-PS1-5	**Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. (Patterns)** *{Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.} [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]*
HS-PS1-6	**Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. (Stability and Change)** *{Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.} [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]*
HS-PS1-7	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. (Energy and Matter)** *{Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.} [Assessment Boundary: Assessment does not include complex chemical reactions.]*
HS-PS2-6	**Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. (Structure and Function)** *{Clarification statement: Emphasis is on the attractive and repulsive forces that determine the functioning of material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.} [Assessment boundary- Assessment is limited to providing molecular structures of specific designed materials.]*
HS-PS3-5	**Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.** *[Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: Assessment is limited to systems containing two objects.]*

HS-ESS3-4	**Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.** (**Stability and Change**) *[Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]*
New Jersey Student Learning Standards for English Language Arts Companion Standards	
CPI #	**Cumulative Progress Indicator (CPI)**
W.9-10.7	Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
RI.9-10.8	Describe and evaluate the argument and specific claims in a text, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and reasoning.
NJSLSA.W5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.
NJSLSA.W9	Draw evidence from literary or informational texts to support analysis, reflection, and research.
NJSLSA.R1	Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
SL.9-10.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest.
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1	Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2	Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.2.12.C.4	Analyze how economic conditions and societal changes influence employment trends and future education.
9.2.12.C.3	Identify transferable career skills and design alternate career plans.
New Jersey Student Learning Standards for Computer Science and Design Thinking	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1.2.DA.1	Collect and present data, including climate change data, in various visual formats.
8.1.5.DA.5	Propose cause and effect relationships, predict outcomes, or communicate ideas using data.
8.1.12.DA.6	Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process.
8.2.5.ED.2	Collaborate with peers to collect information, brainstorm to solve a problem, and evaluate all possible solutions to provide the best results with supporting sketches or models.
8.2.12.ETW.3	Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation, and propose an innovative sustainable solution.

Interdisciplinary Standards	
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.
N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling
A-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
A-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Phenomenon

- When you “burn” fat and “lose weight”, the mass just seemingly disappears.
- Bridge ‘stalactites’ form over the Millstone River
- Your bike rusts if you leave it outside for long
- The statue of liberty used to be copper colored but now it’s green
- What happens to food when you cook it?
- Convergence of two rivers produces a white river.
- Gates of Hell burning hole in Turkmenistan
- Environmental Clean-up through specific chemical reactions (i.e. industrial spills, acid/base reactions)

Unit Enduring Understandings

- Understanding of regularities and patterns in the periodic table allow for predictions of interactions among the elements.
- Types and levels of organization provide useful ways of thinking about chemical reactions.
- Scientists use a common language to communicate chemical information
- Chemical reactions occur naturally (in the environment and biologically) or are engineered (industrial products).
- A chemical equation needs verification through experimentation and observation.
- The law of conservation of Energy and matter applies to chemical reactions.
- Chemical reactions can have desired and undesirable products and we can use technology to influence the level of impact

Unit Essential Questions

- What information do chemical equations convey about matter, energy, and their changes?
- To what extent are all chemical reactions the same?
- How do we know how atoms and molecules combine in reactions if we cannot see them?
- How is a symbol system used to make the understanding/interpretation of chemical reactions uniform among scientists?
- Why is it important to be able to predict the products of different chemical reactions?

- To what extent do temperature, surface area, concentration of reactant, and pressure affect reaction rates?

Objectives

We are learning to/that:

- 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. **[PS1-4-1.B, PS1-5.1.B]**
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. **[PS1-2-1.B, PS1-7-1.B]**
- Identify all of the components of a balanced chemical equation. (reactants, products, super and subscripts, coefficients, state symbols, the arrow and conditions of the reaction)
- Classify a reaction as combination, decomposition, single-replacement, double-replacement, or combustion.
- Construct an explanation of the difference between chemical and physical changes through examples of various reactions.
- Identify evidence that a chemical reaction has occurred (gas, precipitate, water forms, heat or light given off, color change)
- Distinguish between exothermic and endothermic reactions based on observable changes.
- Interpret the law of conservation of matter in chemical reactions and in terms of resources.
- Construct an explanation of the outcome for a given reaction, including:
    - The idea that the total number of atoms of each element in the reactant and products is the same
    - The numbers and types of bonds (i.e., ionic, covalent) that each atom forms, as determined by the outermost (valence) electron states and the electronegativity
    - The outermost (valence) electron state of the atoms that make up both the reactants and the products of the reaction is based on their position in the periodic table;
    - A discussion of how the patterns of attraction allow the prediction of the type of reaction that occurs (e.g., formation of ionic compounds, combustion of hydrocarbons).
- Use models such as a potential energy diagram to determine whether a reaction is endothermic or exothermic.
- Engage in argument from evidence to justify the products of chemical reactions
- Analyze and interpret data such as the activity series of metals to predict the products of single-replacement reactions.
- Experimentally test, compare and rank the reactivities of selected elements and apply to a practical situation.
- Write balanced chemical equations.
- Identify spectator ions in the process of writing net ionic equations.
- Construct an explanation for how the rate of a chemical reaction is influenced by temperature, particle size of reactants, concentration, and/or the nature of the reactants using the collision theory.

Evidence of Learning

☑ **Formative Assessment -** Teachers will choose the most appropriate formative assessment strategy in order to assess students' understanding of the above objectives prior to a summative assessment and inform future instruction.

☑ **Summative Assessment -** Students will complete the three dimensional performance tasks listed below to demonstrate their proficiency in achieving mastery of the unit performance expectations and objectives. The focus is on having students apply their understanding of disciplinary core ideas and cross cutting concepts in the context of engaging in a science or engineering practice. The format or method in which these tasks are carried out are chosen by the teacher based on student needs and how best to demonstrate three-dimensional science proficiency; including but not limited to constructing models, designing and conducting investigations, constructing explanations for natural phenomena, or analyzing and interpreting data. Teachers - see "Integrating Science Practices Into Assessment Tasks" under resources for more examples.

☑ **Alternative Assessment -** During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students via differentiation and/or accommodations in process and product in order to provide an alternative modality for students to demonstrate three-dimensional science proficiency.

☑ **Benchmark -** Students will complete the common assessment(s) listed below to demonstrate their three-dimensional science proficiency. Students apply their understanding of disciplinary core ideas and cross cutting concepts as well as engage in science and engineering practices in order to solve a problem or explain a natural phenomenon.

Assessment Statement for Science Curriculum

The assessment plan includes teacher-designed formative and summative assessments, including common assessments, self-assessments, and performance tasks aligned with the NJSLS-S and the NJSLS-S for Climate Change. During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students. Accommodations

Sample Performance Tasks

- Plan and Conduct an investigation to show that the number of atoms or number of moles is unchanged after a chemical reaction where a specific mass of reactant is converted to product) support the claim that atoms, and therefore mass, are conserved in a chemical system. **[HS-PS1-2, HS-PS1-7]**
- Conduct an investigation to collect data to identify patterns in the outcomes of single replacement reactions. **[HS-PS1-2]**
- Develop a model to explain the structure, properties, and transformations of matter by observing patterns in an atomic and molecular structure. [**HS-PS1-1, HS-ESS2-5, HS-PS2-6]**
- Develop and use a model based on predictable patterns of properties to explain the structure and interaction of matter at the bulk scale that is determined by electrical forces within and between atoms. [**HS-PS1-1, HS-PS1-2, HS-PS3-5]**
- Argue from evidence to support the predicted products of a reaction based on studied patterns of chemical reactions. [**HS-PS1-2]**
- Develop and use models to clearly depict both a macroscopic and a molecular/atomic-level representation of a chemical system. **[HS-PS1-4]**
- Identify and describe evidence of the pattern that results from increasing temperature and/or concentration and the effect on reaction rate and amount of product [**HS-PS1-5, HS-PS1-6]**
- Engage in argument from evidence to evaluate the tradeoffs of choosing chemical reactions that contribute to the stability of a system. **[HS-ESS3-4, HS-PS1-6]**

Resources

Core Text: Inspire Chemistry ISBN: 978-0-07-688442-1

- Module 8

Suggested Resources: *teachers may choose any resources they feel address the above objectives. Not all may be used.*

- Single replacement online lab (Greenbowe)
- Tiger simulations site
- pHet Balancing Equation Simulation
- Jefferson labs balancing equations game
- steel wool demo (or lab)
- Copper labs (from ChemComm)

- Types of Chemical Reactions POGIL
- Gizmos(chemical changes, balancing equations, chemical equations, reaction energy)
- Pivot Interactive (Double replacement, mass changes burning steel wool, copper and silver nitrate)
- NASA Climate Change Resources
- Climate.Gov

Unit 7: The Mole, Stoichiometry, and Solutions	
Content Area: Science	
Course & Grade Level: Chemistry, 10-12	
Summary and Rationale	
This unit focuses on mathematical thinking as it applies to chemical reactions. The “mole” is the central counting unit for quantifying chemical reactions, enabling students to relate macroscopic quantities to the sub-microscopic world of atoms and molecules. The mole concept and stoichiometry are used to show proportional relationships between masses of reactants and products. Students gain an understanding of the use of dimensional analysis to perform mass to mole conversions that demonstrate how mass is conserved during chemical reactions. Students construct mole ratios from balanced equations and transition into stoichiometric calculations that allow them to make quantitative predictions about the outcomes of reactions, optimize yields, and limit waste. Focus is on students’ use of mathematics to demonstrate their thinking about proportional relationships among masses of reactants and products and to make connections between the atomic and macroscopic world. Students will also apply this mathematical thinking to solutions, including concentration calculations, dilutions, solution formation, and solubility. Students will conduct an investigation to determine factors that affect solvation and learn how to make a solution with a particular molarity, as well as dilute that solution. Students *develop and use models*, *plan and carry out investigations*, *analyze and interpret data,* and *engage in argument from evidence* to make sense of matter as a quantitative property of a system—a property that depends on the interactions of matter within that system.	
Recommended Pacing	
25 days	
NGSS Standards/Performance Expectations	
HS-PS1-1	**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** *{Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.} [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]*
HS-PS1-2	**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.** *{Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.} [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]*
HS-PS1-3	**Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (Patterns)** *{Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.} [Assessment Boundary: Assessment does not include Raoult’s law calculations of vapor pressure.]*
	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. (Energy and Matter) *{Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy*

HS-PS1-4	*change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.} [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]*
HS-PS1-5	**Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. (Patterns)** *{Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.} [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]*
HS-PS1-6	**Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. (Stability and Change)** *{Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.} [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]*
HS-PS1-7	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. (Energy and Matter)** *{Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.} [Assessment Boundary: Assessment does not include complex chemical reactions.]*
HS-ESS3-6	**Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity** (i.e., climate change). *[Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]*
New Jersey Student Learning Standards for English Language Arts Companion Standards	
CPI #	**Cumulative Progress Indicator (CPI)**
NJSLSA.W7	Conduct short as well as more sustained research projects, utilizing an inquiry-based research process, based on focused questions, demonstrating understanding of the subject under investigation.
W.9-10.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, trying a new approach, or consulting a style manual (such as MLA or APA Style), focusing on addressing what is most significant for a specific purpose and audience.
W.9-10.9	Draw evidence from literary or nonfiction informational texts to support analysis, reflection, and research.

NJSLSA.SL4	Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.
NJSLSA.SL5	Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1	Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2	Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.2.12.C.4	Analyze how economic conditions and societal changes influence employment trends and future education.
9.2.12.C.3	Identify transferable career skills and design alternate career plans.
New Jersey Student Learning Standards for Computer Science and Design Thinking	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1.2.DA.1	Collect and present data, including climate change data, in various visual formats.
8.1.2.DA.3	Identify and describe patterns in data visualizations.
8.1.5.DA.1	Collect, organize, and display data in order to highlight relationships or support a claim.
8.1.5.DA.5	Propose cause and effect relationships, predict outcomes, or communicate ideas using data.
8.1.12.DA.5	Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.
8.1.12.DA.6	Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process.
8.2.5.ED.2	Collaborate with peers to collect information, brainstorm to solve a problem, and evaluate all possible solutions to provide the best results with supporting sketches or models.
8.2.12.ETW.3	Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation, and propose an innovative sustainable solution.
Interdisciplinary Standards	
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.
N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A-SSE.A.1	Interpret expressions that represent a quantity in terms of context
A-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
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.
A-REI.D.10	Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).

Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Phenomena

- Chemistry of Airbags
- Taste something that terrible, why is it bad? Baking/Cooking - recipe without measurements
- Ocean acidification
- Forest fire /stoichiometry for forest litter
- Coal dust/methane mine explosions
- Instant “freeze” solid (supersaturated solution of sodium acetate)
- Humans can’t taste salt unless its dissolved in our saliva

Unit Enduring Understandings

- Quantities of all reactants are not always completely consumed.
- Chemical formulas can provide much information about the amount of chemicals that can be used or produced during a reaction.
- The mole is an important unit of measurement that aids in the quantification of matter.
- Changes in systems can be quantified.
- Solutions can be described in both qualitative (unsaturated, saturated and supersaturated) and quantitative (molarity) terms.

Unit Essential Questions

- To what extent is it advantageous to look at chemical composition in terms of moles instead of mass?
- To what extent can you determine which reactant will be used up first?
- How can we quantify changes in chemical systems?
- To what extent do temperature, surface area, and concentration affect solubility?

Objectives:

We are learning to/that:

- The mole (Avogadro’s number) is the main unit for quantifying atomic level particles.
- Dimensional analysis is a mathematical tool used for conversion problems.
- Understand that the mathematical representations (e.g. stoichiometric calculations to show that the number of atoms or number of moles is unchanged after a chemical reaction where a specific mass of reactant is converted to product) support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
- Students understand that the mass of a substance can be used to determine the number of atoms, molecules, or ions using moles and mole relationships (e.g., macroscopic to atomic molecular scale conversion using the number of moles and Avogadro’s number).
- Distinguish between the terms gram atomic mass, gram molecular mass, gram formula mass, and molar mass.
- Distinguish between an empirical and a molecular formula.
- Use mathematics and computational thinking to calculate the molar mass of all components of the reaction.

- Analyze and interpret a balanced chemical equation in terms of interacting moles, representative particles, and masses
- Use mathematics and computational thinking to convert among measurements of mass, and number of particles using the mole.
- Construct mole ratios from balanced chemical equations for use as conversion factors in stoichiometric problems.
- Use mathematics and computational thinking to perform stoichiometric calculations with balanced equations using moles, mass, and representative particles.
- Interpret the meaning of the result of a stoichiometric calculation in words.
- Based on the limiting reagent, use mathematics and computational thinking to calculate the maximum amount of product(s) produced and the amount of any unreacted excess reagent.
- Given information from which any two of the following may be determined, calculate the third: theoretical yield, actual yield, and percentage yield.
- Students construct an explanation to describe how the mass of a substance can be used to determine the number of atoms, molecules, or ions using moles and mole relationships (e.g., macroscopic to atomic molecular scale conversion using the number of moles and Avogadro's number).
- Quantitatively identify the limit to how much of a solute can dissolve in a given solvent
- Explain that solubility is a ratio that stays constant (as long as T stays constant), even when the mass of solvent increases
- Differentiate between a saturated, unsaturated, or supersaturated solution based off of lab observations
- Understand how temperature change can affect the solubility of solute in a solution.
- Define the following terms, giving an example of each: solution, aqueous solution, solute, solvent, molarity, molality
- Analyze and interpret data from solubility curves or experimental data to determine solution concentration.
- Use mathematics and computational thinking to perform molarity calculations and calculations based on solubility graphs.
- Construct an explanation for how the rate of a solvation is influenced by temperature, surface area, concentration, using the collision theory.

Evidence of Learning

☑ **Formative Assessment -** Teachers will choose the most appropriate formative assessment strategy in order to assess students' understanding of the above objectives prior to a summative assessment and inform future instruction.

☑ **Summative Assessment -** Students will complete the three dimensional performance tasks listed below to demonstrate their proficiency in achieving mastery of the unit performance expectations and objectives. The focus is on having students apply their understanding of disciplinary core ideas and cross cutting concepts in the context of engaging in a science or engineering practice. The format or method in which these tasks are carried out are chosen by the teacher based on student needs and how best to demonstrate three-dimensional science proficiency; including but not limited to constructing models, designing and conducting investigations, constructing explanations for natural phenomena, or analyzing and interpreting data. Teachers - see "Integrating Science Practices Into Assessment Tasks" under resources for more examples.

☑ **Alternative Assessment -** During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students via differentiation and/or accommodations in process and product in order to provide an alternative modality for students to demonstrate three-dimensional science proficiency.

- ☑ **Benchmark -** Students will complete the common assessment(s) listed below to demonstrate their three-dimensional science proficiency. Students apply their understanding of disciplinary core ideas and cross cutting concepts as well as engage in science and engineering practices in order to solve a problem or explain a natural phenomenon.

<u>Assessment Statement for Science Curriculum</u>

The assessment plan includes teacher-designed formative and summative assessments, including common assessments, self-assessments, and performance tasks aligned with the NJSLS-S and the NJSLS-S for Climate Change. During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students. Accommodations

Sample Performance Tasks

- Plan and Conduct an investigation to (e.g. stoichiometric calculations to show that the number of atoms or number of moles is unchanged after a chemical reaction where a specific mass of reactant is converted to product) support the claim that atoms, and therefore mass, are conserved in a chemical system. **[HS-PS1-1 , HS-PS1-2, HS-PS1-7, HS-PS1-6]**
- Students develop and use models to clearly depict both a macroscopic and a molecular/atomic-level representation of a chemical system. **[HS-PS1-4]**
- Students use mathematics and computational thinking to model the relationships between human activity and Earth's systems. **[HS-ESS3-6]**
- Plan and Conduct an investigation to gather evidence of the effect of stirring, surface area, and temperature on the rate of solvation in a solution. [**HS-PS1-5, HS-PS1-3]**
- Design and optimize a solution that would produce increased or decreased amounts of products at equilibrium by manipulating reaction conditions .[**HS-PS1-5, HS-PS1-6, HS-ESS3-6]**

Resources

Core Text: Inspire Chemistry ISBN: 978-0-07-688442-1

Modules 9, 10, 13, and 16

Suggested Resources: *teachers may choose any resources they feel address the above objectives. Not all may be used.*

- supersaturation lab
- Solubility POGIL
- factors affecting solvation lab
- PhET (concentration, molarity)
- TedEd- The Mole
- Gizmos (limiting reactants, stoichiometry, solubility and temperature)
- Pivot Interactive (limiting reactants, percent yield)
- Airbag lab
- NASA Climate Change Resources
- Climate.Gov

Unit 8: Gas Laws & The Atmosphere	
Content Area: Science	
Course & Grade Level: Chemistry, 10-12	
Summary and Rationale	
Earth's atmosphere forms the foundation for studying gas behavior. In this unit of study, students use investigations, simulations, and models to make sense of the substructure of atoms and to provide more mechanistic explanations of the properties of gasses. The nature of gasses can be understood by students in terms of the collisions of molecules and the spatial arrangement of atoms. This unit starts with a close examination of gasses—their properties (especially in contrast to solids and liquids), gas law calculations (for one set of conditions, or changing conditions), and gas stoichiometry. An understanding of the kinetic molecular theory allows students to delve deeper into the behavior of gasses. Students will study the gas laws and learn to use mathematical formulas to make predictions about how gasses behave under varying conditions such as temperature and pressure. The unit delves into the composition and properties of Earth's atmosphere, including the roles of gasses like nitrogen, oxygen, carbon dioxide, and water vapor. Students will investigate the impact of human activities on atmospheric composition and global climate. This fosters an understanding of the challenges posed by greenhouse gasses, air pollution, and the need for sustainable practices moving forward. The crosscutting concept of structure and function is called out as the framework for understanding the disciplinary core ideas.	
Recommended Pacing	
10 days	
NGSS Standards/Performance Expectations	
HS-ETS1-4	**Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.** *{Clarification Statement: Emphasis is on students identifying the scientific principle(s) and/or relationship(s) being used by the model and identifying which variables can be changed by the user to evaluate the proposed solutions, tradeoffs, or other decisions. Emphasis is also placed on students identifying the model's limitations and the possible negative consequences of solutions that outweigh the benefits.}*
HS-PS1-7	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. (Energy and Matter)** *{Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.} [Assessment Boundary: Assessment does not include complex chemical reactions.]*
HS-PS1-3	**Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (Patterns)** *{Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.} [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]*
	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. (Structure and Function) *{Clarification*

HS-PS2-6	*statement: Emphasis is on the attractive and repulsive forces that determine the functioning of material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.} [Assessment boundary- Assessment is limited to providing molecular structures of specific designed materials.]*
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity.** *[Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]*
HS-ESS3-6	**Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity** (i.e., climate change). *[Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]*
New Jersey Student Learning Standards for English Language Arts Companion Standards	
CPI #	**Cumulative Progress Indicator (CPI)**
NJSLSA.W7	Conduct short as well as more sustained research projects, utilizing an inquiry-based research process, based on focused questions, demonstrating understanding of the subject under investigation.
NJSLSA.SL5	Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1	Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2	Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.2.12.C.4	Analyze how economic conditions and societal changes influence employment trends and future education.
9.2.12.C.3	Identify transferable career skills and design alternate career plans.
New Jersey Student Learning Standards for Computer Science and Design Thinking	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1.2.DA.1	Collect and present data, including climate change data, in various visual formats.

8.1.2.DA.3	Identify and describe patterns in data visualizations.
8.1.2.DA.4	Make predictions based on data using charts or graphs.
8.1.5.DA.1	Collect, organize, and display data in order to highlight relationships or support a claim.
8.1.5.DA.4	Organize and present climate change data visually to highlight relationships or support a claim.
8.1.5.DA.5	Propose cause and effect relationships, predict outcomes, or communicate ideas using data.
8.1.12.DA.5	Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.
8.1.12.DA.6	Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process.
8.2.5.ED.2	Collaborate with peers to collect information, brainstorm to solve a problem, and evaluate all possible solutions to provide the best results with supporting sketches or models.
8.2.12.ETW.3	Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation, and propose an innovative sustainable solution.
Interdisciplinary Standards	
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.
N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A-SSE.A.1	Interpret expressions that represent a quantity in terms of context
A-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
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.
A-REI.D.10	Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).
Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Phenomena

- Shelters can be well-insulated using pine boughs.
- Tires go flat in the winter.
- Your ears pop when you go underground in the subway or up in an airplane.
- Imploding gas tanker
- At altitudes above 3,000 feet, preparation of food may require changes in time, temperature or recipe
- hot air balloons

Unit Enduring Understandings

- The kinetic molecular theory conceptually describes the physical behavior of gasses.

- All gasses do not follow the KMT.
- The gas laws (mathematical formulas) can predict, analyze and explain many everyday occurrences involving gasses.
- The understanding of the movement of particles can be applied to changes in Earth's systems.

Unit Essential Questions

- How does the composition of the Earth's atmosphere affect its properties and behavior?
- Is the solar radiation that reaches the Earth's surface good or bad for the atmosphere?
- To what extent can air pollution be controlled?
- How do molecules of a gas respond to changes in their surroundings?
- To what extent can the pressure, volume, and temperature of a gas be utilized within gas laws?
- In what way does the inter-relationship of the variables of pressure, volume, temperature and moles predict the behavior of gasses?

Objectives

We are learning to/that:

- Describe the relationship between the four gas variables: temperature, pressure, volume, and moles.
- State the conditions under which gasses behave most ideally.
- Explain why real gasses deviate from the gas laws
- Describe the composition of the Earth's atmosphere.
- Describe air pressure and the units of measurement.
- Account for the gas laws in terms of the Kinetic Molecular Theory of gasses.
- Describe the interrelationships among amount (moles), temperature, volume, and pressure of a gas. Provide one practical example of each relationship.
- Define, and apply in appropriate situations the terms molar volume, standard temperature and pressure (STP), Kelvin temperature, and absolute zero.
- Identify the behavior of an ideal gas and explain why real gasses deviate from the gas laws.
- Compare the various components of solar radiation and relate them to the earth's energy balance.
- Describe the greenhouse effect, its natural incidence and causes, and the significance of industrial contributions.
- Explain how differing heat capacities and reflectivities of various locations influence the local climate.
- List the major categories of air pollutants and discuss the relative contributions of various human and natural factors.
- Distinguish between primary and secondary sources of air pollution.
- Describe general strategies for controlling pollution.
- Explain the chemical reactions responsible for photochemical smog.
- Describe the causes and impacts of atmospheric ozone depletion.
- Calculate pressure, temperature, moles, and volume changes in a gas using various gas laws.
- Investigate the relationship between pressure, temperature, moles, and volume changes in a gas in the laboratory to demonstrate that:
    - The spacing of the particles of the chosen substances can change as a result of the experimental procedure even if the identity of the particles does not change.
    - The patterns of interactions between particles at the molecular scale are reflected in the patterns of behavior at the macroscopic scale.
- Students evaluate Carbon Dioxide Investigation, including evaluation of: Assessing the accuracy and precision of the data collected, concentration of carbon dioxide found in ambient, exhaled and combustion air.
- Interpret data tables and graphs of carbon dioxide concentrations over the past hundred years, and then make predictions for the future.

- Generate a gas and dissolve it in water, creating a solution similar to acid rain. Use chemical indicators to evaluate the acidity of the solution.
- Kinetic molecular theory explains the gas behavior (not to include Dalton's law, Graham's law, nor air pressure)

Evidence of Learning

☑ **Formative Assessment -** Teachers will choose the most appropriate formative assessment strategy in order to assess students' understanding of the above objectives prior to a summative assessment and inform future instruction.

☑ **Summative Assessment -** Students will complete the three dimensional performance tasks listed below to demonstrate their proficiency in achieving mastery of the unit performance expectations and objectives. The focus is on having students apply their understanding of disciplinary core ideas and cross cutting concepts in the context of engaging in a science or engineering practice. The format or method in which these tasks are carried out are chosen by the teacher based on student needs and how best to demonstrate three-dimensional science proficiency; including but not limited to constructing models, designing and conducting investigations, constructing explanations for natural phenomena, or analyzing and interpreting data. Teachers - see "Integrating Science Practices Into Assessment Tasks" under resources for more examples.

☑ **Alternative Assessment -** During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students via differentiation and/or accommodations in process and product in order to provide an alternative modality for students to demonstrate three-dimensional science proficiency.

☑ **Benchmark -** Students will complete the common assessment(s) listed below to demonstrate their three-dimensional science proficiency. Students apply their understanding of disciplinary core ideas and cross cutting concepts as well as engage in science and engineering practices in order to solve a problem or explain a natural phenomenon.

Assessment Statement for Science Curriculum

The assessment plan includes teacher-designed formative and summative assessments, including common assessments, self-assessments, and performance tasks aligned with the NJSLS-S and the NJSLS-S for Climate Change. During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students. Accommodations

Sample Performance Tasks:

- Construct particle models to demonstrate the effect of changing various factors (P,T,V,n) on the behavior and interactions of the particles within a system **[HS-ETS1-4]**
- Students plan and conduct an investigation to determine the relationship between the variables of a gas. **[HS-ETS1-4] [HS-PS1-3]**
- Use computational representations to illustrate the relationships among the variables of a gas in the atmosphere, the behavior of the gas, and the effect of human activity on these relationships within Earth's systems **[HS-ESS3-6]**

Resources

Core Text: Inspire Chemistry ISBN: 978-0-07-688442-1
Module 12 (lesson 1 & 3)

Suggested Resources:

- Expanding marshmallow in a plunger (individual student demo)
- Cartesian diver
- Gas Variable Balloon Investigation
- Labs with gas syringes

- Gas Variable POGIL
- AACT Gas Law Simulation
- PHeT (Gases intro and gas properties, the greenhouse effect)
- Gizmos (Boyle's and Charles' Law)
- Can crushing demo
- Can stuck to the wall demo (neoprene donut)
- Toilet plunger demos
- Shop vac a student in a trash bag
- NASA Climate Change Resources
- Climate.Gov

Unit 9: Reaction Rates and Equilibrium	
Content Area: Science	
Course & Grade Level: Chemistry, 10-12	
Summary and Rationale	
This unit focuses on the dynamic nature of chemical reactions and aims to deepen students' understanding of the factors that drive reactions and how they reach a state of balance. Students explore the impact of various factors (temperature, concentration, catalysts) on reaction rates and deepen their understanding of particle interactions. Students explore the concept of equilibrium through investigation and use the results to develop an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs and on equilibrium of the system. Then the concept of reversible reactions is used to explain chemical equilibrium. Equilibrium constants are used to summarize the ratios of reactants and products for a particular equilibrium reaction. Le Chatelier's principle is used to predict the effects of changing environmental conditions of a system at equilibrium. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. The crosscutting concepts of energy and matter, and stability and change are the organizing concepts for these disciplinary core ideas.	
Recommended Pacing	
10 days	
NGSS Standards/Performance Expectations	
HS-PS1-5	**Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. (Patterns)** *{Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.} [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]*
HS-PS1-6	**Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. (Stability and Change)** *{Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.} [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]*
HS-ESS3-6	**Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity** (i.e., climate change). *[Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]*
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity.** *[Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater),*

	regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]
New Jersey Student Learning Standards for English Language Arts Companion Standards	
CPI #	**Cumulative Progress Indicator (CPI)**
NJSLSA.W7	Conduct short as well as more sustained research projects, utilizing an inquiry-based research process, based on focused questions, demonstrating understanding of the subject under investigation.
NJSLSA.W9	Draw evidence from literary or informational texts to support analysis, reflection, and research.
NJSLSA.R1	Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
RI.9-10.8	Describe and evaluate the argument and specific claims in a text, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and reasoning.
NJSLSA.SL5	Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.
New Jersey Student Learning Standards for Career Readiness, Life Literacies and Key Skills	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1	Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
8.2	Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
9.2.12.C.4	Analyze how economic conditions and societal changes influence employment trends and future education.
9.2.12.C.3	Identify transferable career skills and design alternate career plans.
New Jersey Student Learning Standards for Computer Science and Design Thinking	
CPI #	**Cumulative Progress Indicator (CPI)**
8.1.2.DA.1	Collect and present data, including climate change data, in various visual formats.
8.1.2.DA.3	Identify and describe patterns in data visualizations.
8.1.2.DA.4	Make predictions based on data using charts or graphs.
8.1.5.DA.1	Collect, organize, and display data in order to highlight relationships or support a claim.
8.1.5.DA.4	Organize and present climate change data visually to highlight relationships or support a claim.
8.1.5.DA.5	Propose cause and effect relationships, predict outcomes, or communicate ideas using data.
8.1.12.DA.6	Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process
Interdisciplinary Standards	
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.

N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling
N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
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.
Standard 6.1 U.S. History: America in the World	All students will acquire the knowledge and skills to think analytically about how past and present interactions of people, cultures, and the environment shape the American heritage. Such knowledge and skills enable students to make informed decisions that reflect fundamental rights and core democratic values as productive citizens in local, national, and global communities.
Standard 6.2 World History: Global Studies	All students will acquire the knowledge and skills to think analytically and systematically about how past interactions of people, cultures, and the environment affect issues across time and cultures. Such knowledge and skills enable students to make informed decisions as socially and ethically responsible world citizens in the 21st century.

Instructional Focus

Unit Phenomenon

- Our blood maintains roughly the same pH despite our intake of acids and bases.
- Climate change (can talk about ocean or atmospheric phenomena)
- Glow sticks in the freezer preserves the glow for longer
- Grain mill dust explosions (also coal mine dust explosions)
- Weathering of limestone or statues increases as air pollution increases.
- Food spoils more slowly in the fridge.

Unit Enduring Understandings

- The rate of a chemical reaction is influenced by controllable outside forces.
- The rate of a chemical reaction does not determine the quantity of the product.
- Equilibrium is a physical state in which forces and changes occur in opposite and off-setting directions.
- The initial conditions of a reaction system largely determine the process and outcomes.

Unit Essential Questions

- To what extent does temperature predict the spontaneity of a reaction?
- To what extent do temperature, surface area, concentration of reactant, and pressure affect reaction rates?
- What constitutes a state of dynamic equilibrium?
- Why are reactant and product concentrations not necessarily equal at equilibrium?

Objectives:

We are learning to/that:

- 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. **[PS1-6-1.B]**
- Define reaction rate.
- List the factors which affect rates of reaction.
- Define collision theory.
- Define dynamic chemical equilibrium.
- State Le Chatelier’s Principle.
- Analyze and interpret data to predict the changes in equilibrium position due to changes in temperature, pressure and/or concentrations using Le Châtelier’s Principle.

- Students construct an explanation that includes the idea that as the kinetic energy of colliding particles increases and the number of collisions increases, the reaction rate increases.
- Students identify and describe evidence to construct an explanation, including:
  - Evidence (e.g., from a table of data) of a pattern that increases in concentration (e.g., a change in one concentration while the other concentration is held constant) increase the reaction rate, and vice versa; and
  - Evidence of a pattern that increases in temperature usually increases the reaction rate, and vice versa.
- Students use and describe the following chain of reasoning that integrates evidence, facts, and scientific principles to construct the explanation:
  - Molecules that collide can break bonds and form new bonds, producing new molecules.
  - The probability of bonds breaking in the collision depends on the kinetic energy of the collision being sufficient to break the bond, since bond breaking requires energy.
  - Since temperature is a measure of average kinetic energy, a higher temperature means that molecular collisions will, on average, be more likely to break bonds and form new bonds.
  - At a fixed concentration, molecules that are moving faster also collide more frequently, so molecules with higher kinetic energy are likely to collide more often.
  - A high concentration means that there are more molecules in a given volume and thus more particle collisions per unit of time at the same temperature.
- Students engage in argument from evidence (i.e. Le Châtelier's principle) to explain how potential changes in a component of the given chemical reaction system will increase or decrease the amounts of particular species at equilibrium.
- Students use evidence to describe the relative quantities of a product before and after changes to a given chemical reaction system (e.g., concentration increases, decreases, or stays the same), and will explicitly use Le Chatelier's principle, including:
  - How, at a molecular level, a stress involving a change to one component of an equilibrium system affects other components;
  - That changing the concentration of one of the components of the equilibrium system will change the rate of the reaction (forward or backward) in which it is a reactant, until the forward and backward rates are again equal; and
  - A description of a system at equilibrium that includes the idea that both the forward and backward reactions are occurring at the same rate, resulting in a system that appears stable at the macroscopic level.

Evidence of Learning

☑ **Formative Assessment -** Teachers will choose the most appropriate formative assessment strategy in order to assess students' understanding of the above objectives prior to a summative assessment and inform future instruction.

☑ **Summative Assessment -** Students will complete the three dimensional performance tasks listed below to demonstrate their proficiency in achieving mastery of the unit performance expectations and objectives. The focus is on having students apply their understanding of disciplinary core ideas and cross cutting concepts in the context of engaging in a science or engineering practice. The format or method in which these tasks are carried out are chosen by the teacher based on student needs and how best to demonstrate three-dimensional science proficiency; including but not limited to constructing models, designing and conducting investigations, constructing explanations for natural phenomena, or analyzing and interpreting data. Teachers - see "Integrating Science Practices Into Assessment Tasks" under resources for more examples.

☑ **Alternative Assessment -** During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students via differentiation and/or accommodations in process and product in order to provide an alternative modality for students to demonstrate three-dimensional science proficiency.

☑ **Benchmark -** Students will complete the common assessment(s) listed below to demonstrate their three-dimensional science proficiency. Students apply their understanding of disciplinary core ideas and cross cutting concepts as well as engage in science and engineering practices in order to solve a problem or explain a natural phenomenon.

Assessment Statement for Science Curriculum

The assessment plan includes teacher-designed formative and summative assessments, including common assessments, self-assessments, and performance tasks aligned with the NJSLS-S and the NJSLS-S for Climate Change. During each common, formative, and summative assessment, teachers will provide alternative assessment opportunities that adhere to 504 and IEP requirements. Alternative assessments are individualized for the needs of all students. Accommodations

Sample Performance Tasks

- Plan and carry out an investigation to change conditions of a chemical reaction and observe the effect on the reaction's rate. [**HS-PS1-5, HS-PS1-6]**
- Students identify and describe evidence of the pattern that results from increasing temperature and/or concentration and the effect on reaction rate [**HS-PS1-5, HS-PS1-6]**
- Construct an explanation of how things change and how they remain stable by refining a solution to a complex real-world problem based on scientific knowledge, student generated evidence, and prioritized criteria to demonstrate a dynamic and condition-dependent balance between a reaction and the reverse reaction. [**HS-PS1-5, HS-PS1-6]**
- Design and optimize a solution that would produce increased or decreased amounts of products at equilibrium by manipulating reaction conditions .[**HS-PS1-5, HS-PS1-6, HS-ESS3-6]**

Resources

Core Text: Inspire Chemistry ISBN: 978-0-07-688442-1

Module 13 (parts of pertinent lessons) and Module 15 (parts of pertinent lessons), and Module 16

Suggested Resources: *teachers may choose any resources they feel address the above objectives. Not all may be used.*

- supersaturation lab
- factors affecting solvation lab
- Dynamic Equilibrium Simulation Activity
- Gizmos (collision theory, equilibrium and concentration, temperature and solubility)
- PhET (concentration, molarity)
- Pivot Interactives (Reaction rate lab of HCl and Mg)
- Glow stick lab - temperature effect on reaction rate
- iodine clock reaction
- ferrous cyanide complex
- Equilibrium and Lechatelier's Principle Online Lab.
- Laboratory 1: Chemical Equilibrium
- Equilibrium Lab
- Equilibrium/Le Chatelier's Principle online lab
- NASA Climate Change Resources
- Climate.Gov