HILLSBOROUGH TOWNSHIP SCHOOL DISTRICT

SCIENCE CURRICULUM

CHEMISTRY

AUGUST 2021

Chemistry
Course Overview

Chemistry is the study of matter and its interactions. In the chemistry course, students use investigations, simulations, and models to make sense of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. The course provides a comprehensive first year experience at both the College Prep and Honors level. The course topic survey includes: data analysis, changes of matter, atomic structure, electrons in atoms, periodic properties, types of compounds, nomenclature, types of bonding, chemical reactions, mole concept, stoichiometry, states of matter, solutions, energy changes in chemical reactions, reaction rates and equilibrium, as well as redox reactions, and electrochemistry at the Honor level. The program incorporates features for strong math support and problem solving development. Much emphasis is given to the lab component of the course.

Throughout the survey, students explore many disciplinary core ideas. Chemical reactions, including rates of reactions and energy changes, can be understood by students in terms of the collisions of molecules and the rearrangements of atoms. Students use the periodic table as a tool to explain and predict the properties of elements. Students develop an understanding that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students develop an understanding that energy, at both the macroscopic and the atomic scales, can be accounted for as motions of particles or as energy associated with the configurations (relative positions) of particles. Students also apply an understanding of the process of optimization and engineering design to chemical reaction systems.

The crosscutting concepts of patterns, cause and effect, scale, proportion, and quantity, systems and system models, interdependence of science, engineering, and technology, and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas.

In the Chemistry course performance expectations, students are expected to demonstrate grade-appropriate proficiency in the practices of science and engineering by asking questions and defining problems; developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas.

The Chemistry curriculum meets the requirements of the New Jersey Student Learning Standards for Science and helps to prepare students to meet and exceed the standards assessed by the NJDOE state assessments through higher order application of various skills required for complete understanding of chemistry.

Unit Title:	**Time Frame/Pacing**
Introduction to Chemistry	~3-5 Days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:
'Close enough' - Said no chemist ever!
Measurement and Uncertainty

Anchoring Question:
- What are some common ways to measure objects?
- What tools are used to measure objects/substances?
- What is important to remember while measuring to get an accurate measurement?
- How would you get the most precise measurement?
- What are base units for length, mass, time, temperature?
- How does adding a prefix change a unit?
- Why would we use scientific notation to represent numbers?
- How is dimensional analysis used for unit conversion?

Essential Questions:
- What strategies are important in order to get an accurate measurement?

Enduring Understandings

- There are many ways to represent a number.
- Scientific notation is a way to express really large and really small numbers.
- Dimensional analysis is the most generally accepted way to show conversions between units.
- Every measurement includes some degree of uncertainty.
- The precision of a measurement is limited by the graduations on the instrument.
- When performing calculations with measurements, the answer is limited by the precision of the measurements involved in the calculation.

NJ Standards/NGSS Performance Expectations Taught and Assessed
Students who demonstrate understanding can:

- HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

3-Dimensional Learning Components		
Science and Engineering Practices	**Disciplinary Core Ideas (DCI)**	**Crosscutting Concepts**
Analyzing and Interpreting Data • Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. **Using Mathematics and Computational Thinking** • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m^3, acre-feet, etc.). **Obtaining, Evaluating, and Communicating Information** • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).	This unit provides scaffolding for the mathematics involved in following DCI: **PS1.B: Chemical Reactions** • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Scale, Proportion, and Quantity** • Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). **Patterns** • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.

Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking
Math • MP.2 Reason abstractly and quantitatively. • MP.4 Model with mathematics. • HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in

formulas; choose and interpret the scale and the origin in graphs and data displays.

- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.
- HSA.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

ELA

- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Computer Science and Design Thinking

- 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.

Career Readiness, Life Literacies, and Key Skills

- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

Social-Emotional Learning Competencies

- **Self Management:** Recognize the skills needed to establish and achieve personal and educational goals.
- **Social Awareness:** Demonstrate an awareness for the expectations for social interactions in a variety of settings.
- **Relationship Skills:** Utilize positive communication and social skills to interact effectively with others.

Learning Targets	Investigations/Resources	Formative Assessment

Students identify and describe the relevant components in the mathematical representations: • The mathematical representations may include numerical calculations, graphs, or other pictorial depictions of quantitative information.	Suggested activities: 'Close enough - Said no chemist ever!' article from University of Waterloo Suggested CK-12 "Chemistry For High School": PLIX-Accuracy and Precision Significant Figures tutorial by University of Waterloo ChemTour: Dimensional Analysis Lab: Thickness of Al foil EdPuzzle videos • Use dimensional analysis for problem solving. • Utilize a measuring device and express the measure to the correct number of significant figures. • Calculate percent error. • Distinguish between accuracy and precision. • Identify sources of experimental error. • Represent decimal numbers with scientific notation. • Perform calculations using scientific notation units and significant figures. • Convert between units of measurement.	Q/A Whiteboarding Practice WS Exit tickets cK-12 adaptive practice

Instructional Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate

- Copy of notes provided on Google Classroom or a hard copy, as needed
- Extension activities for gifted students
- Extra time, as allotted
- "Chunking" of information or breaking down larger projects.
- Rewording of instructions or providing clarification.
- Preferential seating in the classroom.
- Any accommodation/modifications outlined in a student's IEP/504

Common Assessment(s)	Assessment Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504)
• Quiz	• Extra time as allotted • Rewording of questions as needed • Use of a calculator • Any accommodation/modifications outlined in a student's IEP/504

Unit Title:	**Time Frame/Pacing**
Gas Laws	11 Days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:
The Balloon - Red Bull Stratos

Anchoring Question:
- Why do mylar helium filled balloons filled inside the store then transported, seem to deflate in the winter and get "extra firm" in the summer?
- Why shouldn't you over inflate a life raft if your ship is going to be in tropical water?
- Why is it that deep sea fish die when brought to the surface quickly?
- Why is it that when a person drinks a nice cold carbonated beverage (like soda) they burp?
- What caused the egg to go into the bottle?
- Why shouldn't a person hold their breath when resurfacing from scuba diving?

Essential Questions:
- How does the kinetic molecular theory account for the behavior of gases?
- How are mathematical relationships used to predict the behavior of gases?

Enduring Understandings

- Gas particles move independently and are far apart relative to each other. The behavior of gases can be explained by the kinetic molecular theory. The kinetic molecular theory can be used to explain the relationship between pressure and volume, volume and temperature, pressure and temperature, and the number of particles in a gas sample.
- Differences in the physical properties of solids, liquids, and gases are explained by the ways in which the atoms, ions, or molecules of the substances are arranged, and by the strength of the forces of attraction between the atoms, ions, or molecules.

NJ Standards/NGSS Performance Expectations Taught and Assessed
Students who demonstrate understanding can:

- 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.
- 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 component(s) and energy flows in and out of the system are known.

- 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).

3-Dimensional Learning Components

Science and Engineering Practices	Disciplinary Core Ideas (DCI)	Crosscutting Concepts
Developing and Using Models • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems. **Planning and Carrying Out Investigations** • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. • Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.	**PS2.B: Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary to HS-PS1-1), (secondary to HS-PS1-3) **PS3.A: Definitions of Energy** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. **PS3.B: Conservation of Energy and Energy Transfer** • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**Energy and Matter** • The total amount of energy and matter in closed systems is conserved. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. • Systems can be designed for greater or lesser stability. • Feedback (negative or positive) can stabilize or destabilize a system.

• Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.	• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. • The availability of energy limits what can occur in any system.	• Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking

Math
- MP.2 Reason abstractly and quantitatively.
- MP.4 Model with mathematics.
- HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context.
- HSA.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

ELA
- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Computer Science and Design Thinking
- 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.

Career Readiness, Life Literacies, and Key Skills
• 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data. • 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces. • 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.
Social-Emotional Learning Competencies
• **Self Management:** Recognize the skills needed to establish and achieve personal and educational goals. • **Social Awareness:** Demonstrate an awareness for the expectations for social interactions in a variety of settings. • **Relationship Skills:** Utilize positive communication and social skills to interact effectively with others.

Learning Targets	Investigations/Resources	Formative Assessment
Students identify and 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 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	Suggested activities: Bell Jar Lab Can Crush demo or video Modeling Air Pressure Activity Hot Air Balloon model • Utilize the kinetic molecular theory to account for the behavior of gases. • Converting units of pressure, Celsius temperature to Kelvin, and justify the necessity of Kelvin scale. • Apply mathematical relationships between temperature, volume, and pressure.	Creating a model of a phenomenon Q/A Whiteboarding Practice WS Exit tickets cK-12 adaptive practice

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.		

Instructional Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate:
• Copy of notes provided on Google Classroom or a hard copy, as needed • Extension activities for gifted students • Extra time, as allotted • "Chunking" of information or breaking down larger projects. • Rewording of instructions or providing clarification. • Preferential seating in the classroom. • Any accommodation/modifications outlined in a student's IEP/504

Common Assessment(s)	**Assessment Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504)**
• CP Gases • H Unit Test	• Extra time as allotted • Rewording of questions as needed • Use of a calculator • Any accommodation/modifications outlined in a student's IEP/504

Unit Title:	**Time Frame/Pacing**
Atomic Structure	8 days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:
- Why does a balloon rubbed on your hair stick to the wall?

Anchoring Questions:
- What is the purpose of models? How do they evolve?

Essential Questions:
- What do you think makes up the nucleus of the atom?
- How does the structure of atoms affect their function and properties?
- How is the relative mass of atoms determined?
- How and why has the model of the atom changed?

Enduring Understandings

- All matter is made of atoms.
- There is a limited number of types of atoms.
- These are the elements.
- They differ from each other in their subatomic structure.
- The periodic table can be used to determine the number of protons in any given atom.
- A fundamental force that holds the nucleus of an atom together is the strong force.
- Electrostatic forces keep the electrons around the nucleus.

NJ Standards/NGSS Performance Expectations Taught and Assessed
Students who demonstrate understanding can:

- 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.

3-Dimensional Learning Components

Science and Engineering Practices	**Disciplinary Core Ideas (DCI)**	**Crosscutting Concepts**

Developing and Using Models • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. **Ask questions** • That arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. • That arise from examining models or a theory, to clarify and/or seek additional information and relationships. • To clarify and refine a model, an explanation, or an engineering problem.	**PS1.A: Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. • The repeating patterns of this table reflect patterns of outer electron states. **PS2.B: Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary to HS-PS1-1), (secondary to HS-PS1-3)	Patterns • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Stability and Change • Much of science deals with constructing explanations of how things change and how they remain stable.

Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking
Math • MP.2 Reason abstractly and quantitatively. (HS-PS1-5) • MP.4 Model with mathematics. • HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. • HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ELA
- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Computer Science and Design Thinking
- 8.2.12.C.4 Explain and identify interdependent systems and their functions.

Career Readiness, Life Literacies, and Key Skills

- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

Social-Emotional Learning Competencies

- **Self Management:** Recognize the skills needed to establish and achieve personal and educational goals.
- **Social Awareness:** Demonstrate an awareness for the expectations for social interactions in a variety of settings.
- **Relationship Skills:** Utilize positive communication and social skills to interact effectively with others.

Learning Targets	Investigations/Resources	Formative Assessment
Students identify and describe the components of the model that are relevant for their predictions, including: • Elements and their arrangement in the periodic table;	Suggested activities: pHet Simulation: Isotopes and Atomic Structure Suggested CK-12 “Chemistry For High School”: 4.15 Atomic Nucleus 4.16 Atomic Number 4.17 Mass Number	Creating a model of a phenomenon Q/A Whiteboarding Practice WS Exit tickets cK-12 adaptive practice

• A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons; • Electrons in the outermost energy level of atoms (i.e., valence electrons); and • The number of protons in each element.	4.18 Isotope 4.19 Atomic Mass Unit Lab: Golden Penny + CER EdPuzzle videos Timeline of the Atom Card sort • Distinguish between electrons, protons, and neutrons in terms of relative mass, charge, and location in the atom. • Determine the mass number and atomic number of an atom given its symbol. • List the number of protons, neutrons, and electrons in an atom, or given the number of protons and neutrons determine the atomic number and mass number. • Define isotopes. • Describe weighted average. • Given isotope abundance, calculate average atomic mass. <u>Additional for honors:</u> • Interpret the mass spec data for elements	
Students identify and describe the following relationships between components in the given model, including: • The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons. • Elements in the periodic table are arranged by the numbers of protons in atoms.	• Utilize the periodic table to determine atomic number and mass number of an atom.	

Instructional Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate

- Copy of notes provided on Google Classroom or a hard copy, as needed
- Extension activities for gifted students

- Extra time, as allotted
- "Chunking" of information or breaking down larger projects.
- Rewording of instructions or providing clarification.
- Preferential seating in the classroom.
- Any accommodation/modifications outlined in a student's IEP/504

Common Assessment(s)	**Assessment Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate:**
• CP Atomic Structure • H Unit Test	• Extra time as allotted • Rewording of questions as needed • Use of a calculator • Any accommodation/modifications outlined in a student's IEP/504

Unit Title:	**Time Frame/Pacing**
Electron Configuration and Light	15 days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:

- Why is the spectrum of hydrogen so different from sunlight?
- How is the color produced in a neon sign?
- What is the difference between a red laser and a green laser?
- Why is it that when you look through a piece of cobalt glass the red numbers on the clock seem to disappear?

Anchoring Questions:

- How do you think an increase in the number of electrons would impact the emission spectrum of an atom?
- How does energy affect the excitation of electrons?

Essential Questions:

- How are electrons arranged within an atom?

Enduring Understandings

- The interaction of electromagnetic energy with the atom is the key to unlocking the electronic structure of the atom.
- Each element has a characteristic emission and absorption spectrum. These can be used to identify components in mixtures both here on Earth and in the stars.

NJ Standards/NGSS Performance Expectations Taught and Assessed
Students who demonstrate understanding can:

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

3-Dimensional Learning Components

Science and Engineering Practices	Disciplinary Core Ideas (DCI)	Crosscutting Concepts
Using Mathematics and Computational Thinking • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m^3 , acre-feet, etc.). **Engaging in Argument from Evidence** • Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.	**PS1.A: Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. **PS2.B Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary to HS-PS1-1), (secondary to HS-PS1-3) **PS4.B Electromagnetic Radiation** • Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) • When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Systems can be designed to cause a desired effect. **Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. **Stability and Change** • Systems can be designed for greater or lesser stability.

	electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary) **PS4.A: Wave Properties** • The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1) **PS3.A: Definitions of Energy** • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2), (HS-PS3-3) **ESS1.A: The Universe and Its Stars** • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	

Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking

Math

- MP.2 Reason abstractly and quantitatively. (HS-PS1-5)
- MP.4 Model with mathematics. HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ELA

- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Computer Science and Design Thinking

- 8.2.12.C.4 Explain and identify interdependent systems and their functions.

Career Readiness, Life Literacies, and Key Skills

- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

Social-Emotional Learning Competencies

- **Self Management:** Recognize the skills needed to establish and achieve personal and educational goals.
- **Social Awareness:** Demonstrate an awareness for the expectations for social interactions in a variety of settings.
- **Relationship Skills:** Utilize positive communication and social skills to interact effectively with others.

Learning Targets	Investigations/Resources	Formative Assessment
Students identify and describe the following relationships between components in the given model, including: • The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons. • Elements in the periodic table are arranged by the numbers of protons in atoms.	Suggested activities: Prism Glasses/Cobalt Glass Activity/Blue Light glasses Bohr simulation Lab: Flame Test Lab: Spectroscopes Modeling: Photons Visible Light POGIL	Creating a model of a phenomenon Q/A Whiteboarding Practice WS Exit tickets cK-12 adaptive practice

	EdPuzzle videos EMR POGIL Electron Configurations POGIL Electron Configurations from the PT inquiry Lab: Fluorescent objects • Identify on a waveform picture the crest and trough of a wave. • Identify amplitude as a wave's height from origin to a crest. • Define wavelength as the shortest distance between equivalent points on a continuous wave. • Define frequency as the number of waves that pass a given point per second as measured in Hertz. • Relate the speed of light to the frequency and the wavelength. • Distinguish between atomic emission spectra (line spectra) and continuous spectra. • Write electron configurations using the periodic table	
Students develop models in which they identify and describe the relevant components, including: • All the components of the system and the surroundings, as well as energy flows between the system and the surroundings; • Clearly depicting both a macroscopic and a molecular/atomic-level representation of the system; and • Depicting the forms in which energy is manifested at two different scales: a) Macroscopic , such as motion, sound,	• Draw Bohr models of the atom (up to atomic number 20) • Relate the different electron transitions qualitatively to wavelength and frequency of emitted light. • Describe how visible light is made.	

light, thermal energy, potential energy or energy in fields; and b) Molecular/atomic, such as motions (kinetic energy) of particles (e.g., nuclei and electrons), the relative positions of particles in fields (potential energy), and energy in fields.		
Students describe the relationships between components in their models, including: • Changes in the relative position of objects in gravitational, magnetic or electrostatic fields can affect the energy of the fields (e.g., charged objects moving away from each other change the field energy). • Thermal energy includes both the kinetic and potential energy of particle vibrations in solids or molecules and the kinetic energy of freely moving particles (e.g., inert gas atoms, molecules) in liquids and gases. • The total energy of the system and surroundings is conserved at a macroscopic and molecular/atomic level. • As one form of energy increases, others must decrease by the same amount as energy is transferred among and between objects and fields. Students use their models to show that in closed systems the energy is conserved on both the macroscopic and molecular/atomic scales so that as one form of energy changes, the total system energy remains constant, as evidenced by the other forms of energy changing by the same amount or changes only by the amount of energy that is transferred into	• Relate the relative energy of a type of electromagnetic radiation to its position in the electromagnetic spectrum. • Define a photon as a quantum of electromagnetic radiation. <u>Additional for honors:</u> • Calculate wavelength, frequency, and energy, Bohr model of the hydrogen atom • Orbital notations, noble gas abbreviations, electron configurations including f-block elements	

or out of the system. Students use their 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 on both the macroscopic and microscopic scales.		

Instructional Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate

- Copy of notes provided on Google Classroom or a hard copy, as needed
- Extension activities for gifted students
- Extra time, as allotted
- "Chunking" of information or breaking down larger projects.
- Rewording of instructions or providing clarification.
- Preferential seating in the classroom.

Common Assessment(s)	**Assessment Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) when appropriate:**
• CP Light • H Unit Test	• Extra time as allotted • Rewording of questions as needed • Use of a calculator • Any accommodation/modifications outlined in a student's IEP/504

Unit Title:	**Time Frame/Pacing**
Trends of the Periodic Table	16 days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:

- Reactivity of alkali metals in water
- Different elements have different properties. (Example: Gold is very unreactive while sodium is highly reactive)

Anchoring Questions/Activity:

- How and why do you organize items in everyday life?
- Demonstration of reactivity of metals with water:
- Why is potassium more reactive than sodium?
- Why is sodium more reactive than magnesium?

Essential Questions:

- How can you create an organizational chart to assist in understanding?
- How is the periodic table organized?
- How does the arrangement of electrons in an atom determine its chemical behavior?

Enduring Understandings

- The periodicity of the chemical and physical properties of the elements depends on the underlying electronic structure of the atom.
- Important distinguishments between metals and nonmetals are in the number of valence electrons, conductivity, magnitude of ionization energy and type of ions formed.
- The periodic table reflects this periodicity and therefore serves as a valuable tool to predict and explain the properties of elements.

NJ Standards/NGSS Performance Expectations Taught and Assessed
Students who demonstrate understanding can:

- 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.
- 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.

3-Dimensional Learning Components

Science and Engineering Practices	Disciplinary Core Ideas (DCI)	Crosscutting Concepts
Developing and Using Models • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. **Analyzing and Interpreting Data** • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. • Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.	**PS1.A: Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1), (HS-PS1-2) **PS2.B Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary to HS-PS1-1), (secondary to HS-PS1-3) • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4)	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Empirical evidence is needed to identify patterns. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. • Systems can be designed for greater or lesser stability.

Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking
Math • MP.2 Reason abstractly and quantitatively. • MP.4 Model with mathematics. • HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. • HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. • HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. • HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context. • HSA.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. **ELA** • RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1) • WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. • WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. • SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. **Computer Science and Design Thinking** • 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.
Career Readiness, Life Literacies, and Key Skills
• 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data. • 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces. • 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.
Social-Emotional Learning Competencies

- **Self Management:** Recognize the skills needed to establish and achieve personal and educational goals.
- **Social Awareness:** Demonstrate an awareness for the expectations for social interactions in a variety of settings.
- **Relationship Skills:** Utilize positive communication and social skills to interact effectively with others.

Learning Targets	Investigations/Resources	Formative Assessment
From the given model, students identify and describe the components of the model that are relevant for their predictions, including: • Elements and their arrangement in the periodic table; • A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons; • Electrons in the outermost energy level of atoms (i.e., valence electrons); and • The number of protons in each element. Students use the periodic table to predict the patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons that determine the typical reactivity of an atom. Students predict the 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 outermost (valence) electrons to the nucleus;	Suggested activities: Introduction of the phenomenon- Lab Demo: Alkali metals in water. Periodic Table coloring or digital coloring activity. Drawing the model -20 Bohr worksheet Question worksheet on 20 Bohr Modeling Atomic Radius Periodic Trends POGIL Coulombic Attraction POGIL Videos Simulations CER on Reactivity of Alkali metals Kinesthetic Coulomb's law/shielding activity Merry Men • Identify periods as horizontal rows of the periodic table. • Identify groups as vertical columns of the periodic table. • Relate atomic number to number of protons in a nucleus. • Relate group number for representative elements to number of valence electrons in the atom. • Relate the period number of energy levels occupied for an atom. • Using your periodic table, locate all of the following: metals, nonmetals, metalloids, representative elements, transition elements, and the following groups: noble	Creating a model of a phenomenon Q/A Whiteboarding Practice WS Exit tickets cK-12 adaptive practice

• The relative sizes of atoms both across a row and down a group in the periodic table. • The patterns of reactivity (e.g., the high reactivity of alkali metals) at the macroscopic level as determined by using the periodic table. In the explanation, students describe 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.	gases, alkali metals, alkaline earth metals, and halogens. • Draw Bohr models for the atoms (and ions). • Identify group and periodic trends observed for size of atoms (atomic radii). • Account for size trends in terms of nuclear charge, electrostatic attraction, energy level of the electrons. • Utilize size trends along with your periodic table to predict which two atoms is larger. • Differentiate between inner core electrons and valence electrons. • Describe shielding effect. • Define ions and how they are made. Additional for honors: • Use photoelectron spectroscopy to identify an element. • Given an element, illustrate the predict the PES spectrum. • Calculate the ionization energy in J/atom.	

Instructional Modifications and/or Accommodations (EL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate
• Copy of notes provided on Google Classroom or a hard copy, as needed • Extension activities for gifted students • Extra time, as allotted • "Chunking" of information or breaking down larger projects. • Rewording of instructions or providing clarification. • Preferential seating in the classroom.

Common Assessment(s)	**Assessment Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) when appropriate:**
• CP Trends • H Unit Test	• Extra time as allotted • Rewording of questions as needed

	• Use of a calculator • Any accommodation/modifications outlined in a student's IEP/504

Unit Title:	**Time Frame/Pacing**
Bonding	26 days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:
- Conductivity of salt vs. sugar solutions.
- Sodium chloride is safe to eat, but chlorine and sodium are both toxic.
- Frying pans are made of metal and baking dishes are often made of glass or ceramic.
- Electrical wires are made of copper and not carbon fiber.

Anchoring Question:
- Why do mixtures have different properties? Why do different materials have different properties?
- Why do some things dissolve, conduct, and melt and some don't?
- Can you smell a natural gas leak without an additive?

Essential Questions:
- Why do elements combine to form compounds?
- Why do elements combine in the specific ways that they do?
- How might the valence electrons of sodium (Na) and chlorine (Cl) interact to create the bond in NaCl?
- How are chemical compounds represented with words and formulas?

Enduring Understandings

- Atoms will combine to form various molecular and ionic compounds thereby, lowering the energy state and becoming a more stable entity.
- The manner in which they combine can be predicted based on their outermost electronic structure which can be inferred from the periodic table.

NJ Standards/NGSS Performance Expectations Taught and Assessed
Students who demonstrate understanding can:

- 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.
- 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.
- 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.

- 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.
- 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.

3-Dimensional Learning Components

Science and Engineering Practices	Disciplinary Core Ideas (DCI)	Crosscutting Concepts
Developing and Using Models • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. **Using Mathematics and Computational Thinking** • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. **Planning and Carrying Out Investigations** • Plan an investigation or test a design individually and collaboratively to produce	**PS1.A Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1) • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary to HS-PS1-1), (secondary to HS-PS1-3) • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart (HS-PS1-4) **PS2.B Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Systems can be designed to cause a desired effect. **Structure and function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Select appropriate tools to collect, record, analyze, and evaluate data. **Constructing Explanations and Designing Solutions** • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.	models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) • Attraction and repulsion between electrical charges at the atomic scale explain the structure, properties, and transformation of matter, as well as the contact forces between material objects. **PS3.C: Relationship Between Energy and Forces** • When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)	

Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking
Math • MP.2 Reason abstractly and quantitatively. • MP.4 Model with mathematics. • HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. • HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. • HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. • HSA.SSE.A.1 Interpret expressions that represent a quantity in terms of its context. • HSA.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. • HSA.CED.A.1 Create equations and inequalities in one variable and use them to solve problems. • HSA.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. • HSA.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. • HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. • HSS-IS.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots). **ELA** • RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. • RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. • RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. • WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. • WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. • WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. **Computer Science and Design Thinking**

- 8.2.12.C.4 Explain and identify interdependent systems and their functions.

Career Readiness, Life Literacies, and Key Skills

- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

Social-Emotional Learning Competencies

- **Self Management:** Recognize the skills needed to establish and achieve personal and educational goals.
- **Social Awareness:** Demonstrate an awareness for the expectations for social interactions in a variety of settings.
- **Relationship Skills:** Utilize positive communication and social skills to interact effectively with others.

Learning Targets	Investigations/Resources	Formative Assessment
Students identify and describe the following relationships between components in the given model, including: • The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons. Presented with chemical formulas of known binary ionic compounds, students will analyze, interpret and synthesize information and construct explanations to identify the patterns to account for the bonding ratios.	Suggested activities Lab: Properties of Ionic and Covalent Compounds Ionic bonding simulation and questions EdPuzzle videos Covalent bonding simulation and questions Molecular geometry simulation and questions Molecular geometry models lab VSEPR magnet activity Kinesthetic "who do you bond with" activity Developing naming patterns/rules card sort • Distinguish between ionic and covalent bonding in terms of what occurs with electrons. • Explain the octet rule. • Describe the formation of an ionic bond. • Infer number of valence electrons from periodic table.	Creating a model of a phenomenon Q/A Whiteboarding Practice WS Exit tickets cK-12 adaptive practice

	• Draw Lewis dot structure of atoms. • Relate ionic charge to type of atom and number of valence electrons.	
Students use the periodic table to predict the patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons that determine the typical reactivity of an atom.	• Account for physical properties of ionic compounds. • Describe an ionic crystalline solid. • Indicate formation of ionic bonding by illustrating Lewis Dot structure and the movement of valence electrons. • Explain how the octet rule is satisfied in the formation of an ionic compound.	
Students predict the following patterns of properties: • The number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements; • 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 outermost (valence) electrons to the nucleus; and • The relative sizes of atoms both across a row and down a group in the periodic table.	• Define electronegativity. • Account for group and period trend observed or electronegativity as related to that observed for atomic radii. • Determine bond character (polar, nonpolar, or ionic) based on difference of electronegativity. • Describe the formation of a covalent bond. • Use the periodic table to infer the number of valence electrons and to draw Lewis structures of covalent compounds that satisfy the octet rule. • Distinguish between single, double, and triple bonds. • Draw Lewis structures of polyatomic ions.	
Students clearly define the system of the interacting objects that is mathematically represented. • Based on the given mathematical models, students describe that the ratio between gravitational and electric forces between objects with a given charge and mass is a pattern that is independent of distance.	• Determine the number of electron domains associated with an atom. • Relate the number of electron domains with an atom to bonding geometry. • Using Lewis structures, identify molecular shape as either linear, angular, trigonal	

	planar, bent, trigonal pyramid, and tetrahedral geometries. Additional for honors: • Use electron configurations to explain the trend in electron affinity for main group elements. • Compare lattice energies between different ionic compounds and how they relate to observable properties such as melting point and boiling point • List atoms that accommodate fewer than an octet of electrons (H, Be, B). • Predict the shape for molecules with 5 and 6 electron domains. • Compare potential energy diagrams to distinguish between different types of covalent bonds. • Students will identify regions of sigma and pi bonding and evaluate the effect on the 3-dimensional character of the molecule (including rotation around sigma bonds and planarity of molecules and isomers). • Students will use the concept of resonance to explain the bond length in polyatomic ions and molecules.	

Instructional Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate

- Copy of notes provided on Google Classroom or a hard copy, as needed
- Extension activities for gifted students
- Extra time, as allotted
- "Chunking" of information or breaking down larger projects.
- Rewording of instructions or providing clarification.
- Preferential seating in the classroom.

Common Assessment(s)	Assessment Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504)
• CER: Ionic and molecular compound properties • H Unit Test	• Extra time as allotted • Rewording of questions as needed • Use of a calculator • Any accommodation/modifications outlined in a student's IEP/504

Unit Title:	**Time Frame/Pacing**
Intermolecular Forces	17 days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:

- Washable markers are different from permanent markers.
- You drink milk and not water when you eat something spicy.
- When you are in the shower or going for a swim your hair gets wet and it takes a while to dry but when a duck is swimming her feathers stay dry and don't get wet.
- There are different recycling codes that you see everywhere, what do they mean?

Anchoring Questions:

- Why do some things melt more easily than others?
- What determines how hard it is to clean something?
- Why are molecules attracted to each other?
- What influences the strength of the attraction of molecules?
- What are polymers and how can knowledge of their structures help in the design process?
- How are properties of matter related to atomic structure? To what extent is understanding the predictability of changes in matter useful?
- What are the advantages of a natural dye versus a synthetic one?

Essential Questions:

- How do liquids and solids behave and why?
- What determines the phase that a given substance exists in?

Enduring Understandings

- The strength of Coulombic forces of attraction on the particulate level is what determines the macroscopic properties of a substance. These properties include state of matter, boiling point, melting point, surface tension, solubility, material strength, elasticity, and many others.

NJ Standards/NGSS Performance Expectations Taught and Assessed
Students who demonstrate understanding can:

- 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.

- 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.
- HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of 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.

3-Dimensional Learning Components

Science and Engineering Practices	Disciplinary Core Ideas (DCI)	Crosscutting Concepts
Developing and Using Models • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems. **Planning and Carrying Out Investigations** • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider	**PS1.A Structure and Properties of Matter** • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3), (secondary to HS-PS2-6) **PS2.B Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary to HS-PS1-1), (secondary to HS-PS1-3)	**Cause and effect** • Systems can be designed to cause a desired effect. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. **Structure and function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. **Obtaining, Evaluating, and Communicating Information** • Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. • Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. • Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. • Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed		

process or system) in multiple formats (i.e., orally, graphically, textually, mathematically). **Constructing Explanations and Designing Solutions** • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.		

Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking
Math • HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. • HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. • HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **ELA** • 9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. • WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical

processes.

- WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest

Computer Science and Design Thinking

- 8.1.12.DA.1 Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change

Career Readiness, Life Literacies, and Key Skills

- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

Social-Emotional Learning Competencies

- **Self Management:** Recognize the skills needed to establish and achieve personal and educational goals.
- **Social Awareness:** Demonstrate an awareness for the expectations for social interactions in a variety of settings.
- **Relationship Skills:** Utilize positive communication and social skills to interact effectively with others.

Learning Targets	Investigations/Resources	Formative Assessment
• Students 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.	Suggested activities: Demonstration: Evaporation Race (water, ethanol, acetone) IMF Lab IMF Kinesthetic card activity Lab Properties of Polymers Lab: Diaper gel Properties of Ionic and covalent bonding Lab Slime and Ink Polarity Lab ChemMatters Articles: • Sticky Solutions	Creating a model of a phenomenon Q/A Whiteboarding Practice WS Exit tickets cK-12 adaptive practice

	• Hot Peppers Muy Caliente • Ice Cream Chemistry • Paintball Chemistry Kinesthetic Activity: Melting Point and Boiling Point. Antarctica vs Death Valley Digital Card Sort Videos: • Solubility of NaCl • Surface Tension on the ISS Flinn Dyeing Fabric Lab • Describe and compare intermolecular forces and chemical bonds • Account for trends in boiling points that occur for the covalent hydrides of the elements in Groups 4A, 5A, 6A, and 7A. • Account for trends in boiling points that occur for in noble gases and in alkanes (methane, ethane, etc).	
• Students develop an investigation plan and 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 and boiling point, volatility, surface tension) that would allow inferences to be made about the strength of electrical forces between particles.	• Describe hydrogen bonding as unusually strong dipole-dipole interactions that occur among molecules in which hydrogen is bonded to a highly electronegative atom (N, F, O). • Describe London dispersion forces as relatively weak forces that exist among noble gas atoms and nonpolar molecules as a result of short-lived induced dipole. • Define viscosity as a measure of a liquid's resistance to flow. • Predict viscosity based on intermolecular forces. • Account for surface tension in water.	

	• Differentiate between cohesion and adhesion. • Attribute water's formation of a concave meniscus to adhesive forces exceeding cohesive forces.	
Students 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 January 2015 Page 7 of 121 patterns of behavior at the macroscopic scale. iv. 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.	• Apply kinetic molecular theory to properties of liquids and solids. • Relate the increase of London dispersion forces with size of atom to the higher polarizability of larger atoms.	
Students correctly use the given mathematical formulas to predict the gravitational force between	Students will be able to model the interactions between polar and non polar molecules and identify	

objects or predict the electrostatic force between charged objects.	the type of force between them. • Determine polarity of bond based on differences in electronegativity. • Classify molecules as polar or nonpolar based on Lewis structure, molecular shape, and bond polarity. • Define dipole-dipole attraction as an electrostatic attraction that occurs when molecules with dipoles orient themselves to maximize the (+) - (-) interactions. • Describe dipole-dipole forces as about 1% as strong as covalent or ionic bonds.	
Based on the given mathematical models, students describe that the ratio between gravitational and electric forces between objects with a given charge and mass is a pattern that is independent of distance.	Students will be to develop a model to show the dissociation of ionic compounds in a polar solvent and construct an explanation to describe the interaction between an ionic compound and a polar solvent. • Describe ion-dipole interaction. • Write dissociation equations. • Describe the process of hydration of an ionic compound.	
Students describe the relationship between the material's function and its macroscopic properties (e.g., material strength, conductivity, reactivity, state of matter, durability) and each of the following: • Molecular level structure of the material. • Intermolecular forces and polarity of molecules. • The ability of electrons to move relatively freely in metals. Students describe the effects that attractive and repulsive electrical forces between molecules have on the arrangement (structure) of the chosen	Students will obtain, synthesize evidence from their investigation and engage in argument to determine the forces at work.	

designed material(s) of molecules (e.g., solids, liquids, gases, network solid, polymers). Students describe that, for all materials, electrostatic forces on the atomic and molecular scale results in contact forces (e.g., friction, normal forces, stickiness) on the macroscopic scale.		
Using the model, students describe the cause and effect relationships on a qualitative level between forces produced by electric or magnetic fields and the change of energy of the objects in the system.	Students will predict, obtain, synthesize evidence from their investigation and engage in argument to determine the forces at work. <u>Additional for honors:</u> • Polarity of molecules with 5 and 6 electron domains	

Instructional Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate

- Copy of notes provided on Google Classroom or a hard copy, as needed
- Extension activities for gifted students
- Extra time, as allotted
- "Chunking" of information or breaking down larger projects.
- Rewording of instructions or providing clarification.
- Preferential seating in the classroom.
- Any accommodation/modifications outlined in a student's IEP/504

Common Assessment(s)	**Assessment Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504)**
• CP IMFs • H Unit Test	• Extra time as allotted • Rewording of questions as needed • Use of a calculator • Any accommodation/modifications outlined in a student's IEP/504

Unit Title:	**Time Frame/Pacing**
Reactions	14 days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:
- Sinkholes form and stone deteriorates due to environmental factors.
- The Statue of Liberty has copper on the outside and iron as inner support and as time goes by, copper starts to react with air and form a patina.
- Explosions and roasting marshmallows have much in common.
- Cutting raw onions makes you cry.
- Bridges, such as the George Washington Bridge, must be painted every so often.
- Burn magnesium with a Bunsen burner to form magnesium oxide (demonstration or student activity).
- Why do we get a new substance when burning a pure element?
- By the end of this task set students will determine whether the white solid product is ionic or covalent.

Anchoring Questions:
- Why are some items plated with silver or gold rather than solid silver or gold?
- Why might an artist choose to electroplate a sculpture?
- What is rust and what causes it?
- Why do you think that food spoilage (chemical change) takes place more slowly in a refrigerator?
- In what form are the reactants prepared in fireworks?
- A pad of steel wool rusts out much faster than the hull of a steel ship. Why?
- What is the difference between aluminum and gold?
- Why has the value of aluminum decreased over the years?

Essential Questions:
- Why do substances react to form new products?
- What are the indications that a chemical reaction has occurred?
- How are chemical reactions classified?
- How is the outcome of a chemical reaction predicted?
- What factors affect the rates of chemical reactions and how do they affect it?

Enduring Understandings

- Atoms are conserved in chemical reactions.

• Recognizing the patterns for various reaction types allows for the prediction of the products of a reaction.
NJ Standards/NGSS Performance Expectations Taught and Assessed **Students who demonstrate understanding can:**
• 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. • 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.
3-Dimensional Learning Components

Science and Engineering Practices	Disciplinary Core Ideas (DCI)	Crosscutting Concepts
Developing and Using Models • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems. **Planning and Carrying Out Investigations** • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models,	**PS1.A: Structure and Properties of Matter** • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-2) **PS 1.B Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-5) • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. **Cause and effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Systems can be designed to cause a desired effect. • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller

supporting explanations for phenomena, or testing solutions to problems. • Select appropriate tools to collect, record, analyze, and evaluate data **Analyzing and Interpreting Data** • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	describe and predict chemical reactions. (HS-PS1-2) **ETS1.A: Defining and Delimiting an Engineering Problem** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS3-3) **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others	scale mechanisms within the system.

	(trade-offs) may be needed. (secondary to HS-PS1-6) **ESS1.C The History of Planet Earth** • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.	

Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking

Math

- MP.2 Reason abstractly and quantitatively. (HS-PS1-5) MP.4 Model with mathematics.
- HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ELA

- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2), (HS-PS1- 5)
- WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Computer Science and Design Thinking

- 8.1.12.DA.1 Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change

Career Readiness, Life Literacies, and Key Skills

- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

Social-Emotional Learning Competencies

- **Self Management:** Recognize the skills needed to establish and achieve personal and educational goals.
- **Social Awareness:** Demonstrate an awareness for the expectations for social interactions in a variety of settings.
- **Relationship Skills:** Utilize positive communication and social skills to interact effectively with others.

Learning Targets	Investigations/Resources	Formative Assessment
Students construct an explanation of the outcome of the 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; and • 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).	Suggested activities: Demonstration: Burning of Magnesiums Finding Patterns for types of reactions card sort Activity Series Lab Double Replacement Lab Silver nitrate and copper wire lab Synthesis and Decomposition of ZnI_2 lab Production of an Unknown Gas Lab (H_2) Types of Reactions Card Sort Kinesthetic: Types of reaction relay race • Interpret a chemical equation. List the reactants, products, and physical state in a given reaction. • State what it means for an equation to be balanced and relate to the law of conservation of mass.	Creating a model of a phenomenon Q/A Whiteboarding Practice WS Exit tickets cK-12 adaptive practice

Students identify and describe the evidence to construct the explanation, including: • Identification of the products and reactants, including their chemical formulas and the arrangement of their outermost (valence) electrons; • Identification that the number and types of atoms are the same both before and after a reaction; • Identification of the numbers and types of bonds (i.e., ionic, covalent) in both the reactants and the products; • The patterns of reactivity (e.g., the high reactivity of alkali metals) at the macroscopic level as determined by using the periodic table; and • The outermost (valence) electron configuration and the relative electronegativity of the atoms that make up both the reactants and the products of the reaction based on their position in the periodic table. Students describe their reasoning that connects the evidence, along with the assumption that theories and laws that describe their natural world operate today as they did in the past and will continue to do so in the future, to construct an explanation for how the patterns of outermost electrons and the electronegativity of elements can be used to predict the number and types of bonds each element forms. In the explanation, students describe the causal relationship between the observable	• Distinguish subscripts and coefficients in chemical equations. • Use the correct symbol for the physical state of each substance involved in chemical equations. • Identify elements that occur as diatomic molecules. • Write balanced equations given names and/or formulas for reactants and products. • Classify a given reaction as one of these five types: single replacement, double replacement, decomposition, synthesis, combustion. • Predict products of synthesis reactions between two elements. • Predict products of decomposition reactions of binary compounds. • Predict products of hydrocarbon combustion reactions. • Utilize an activity series of metals and halogens to predict whether or not a given reaction will occur. • Predict products of single replacement reactions. • Write possible products of double replacement reactions. • Apply solubility rules to double replacement reactions to determine which product, if any, forms a solid precipitate. • Predict reactivity of double displacement reactions based on the following driving forces - formation of water, solid precipitate, or evolution of a gas. • Provide indicators that a chemical reaction has occurred.	

macroscopic patterns of reactivity of elements in the periodic table and the patterns of outermost electrons for each atom and its relative electronegativity. Given new evidence or context, students construct a revised or expanded explanation about the outcome of a chemical reaction and justify the revision.	Additional for honors: ● Provide complete and net ionic equations for double and single replacement reactions. ● Balance reactions using the half-reaction method. ● Sketch a voltaic cell labeling each part of the half cell, the direction of electron flow, and what occurs at each electrode in the half cell. (Electrochemistry mini-unit)	

Instructional Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate

- Copy of notes provided on Google Classroom or a hard copy, as needed
- Extension activities for gifted students
- Extra time, as allotted
- "Chunking" of information or breaking down larger projects.
- Rewording of instructions or providing clarification.
- Preferential seating in the classroom.
- Any accommodation/modifications outlined in a student's IEP/504

Common Assessment(s)	Assessment Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate
● CP Reactions ● H Unit Test	● Extra time as allotted ● Rewording of questions as needed ● Use of a calculator ● Any accommodation/modifications outlined in a student's IEP/504

Unit Title:	**Time Frame/Pacing**
The Mole	~11 days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:
- Which has more particles, 10 g of water and 10 g of aluminum?

Anchoring Activity:
- What is a mole?

Essential Questions:
- How is the mass of a molecule related to measurable quantities?
- How is mass related to the composition of chemical substances?
- How are the properties of gases influenced by the quantity of particles?

Enduring Understandings

- The mole is the link between the macroscopic and particulate world.
- The ideal gas law helps us obtain a snapshot of the properties of an ideal gas by using the relationship PV=nRT.

NJ Standards/NGSS Performance Expectations Taught and Assessed
Students who demonstrate understanding can:

- 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.
- HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

3-Dimensional Learning Components

Science and Engineering Practices	Disciplinary Core Ideas (DCI)	Crosscutting Concepts
Using Mathematics and Computational Thinking	**PS1.A: Structure and Properties of Matter** • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with	**Scale and Proportions** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

• Apply techniques of algebra and functions to represent and solve scientific and engineering problems. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m^3 , acre-feet, etc.). **Obtaining, Evaluating, and Communicating Information** • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).	similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-2) **PS 1.B Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-5)	• Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). • Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking

Math
- MP.2 Reason abstractly and quantitatively. (HS-PS1-5)
- MP.4 Model with mathematics.
- HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ELA

- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2), (HS-PS1-5)
- WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Computer Science and Design Thinking

- 8.2.12.B.4 The influence of technology on history. Investigate a technology used in a given period of history, e.g., stone age, industrial revolution or information age, and identify their impact and how they may have changed to meet human needs and wants.
- 8.2.12.C.3 The application of engineering design. Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).

Career Readiness, Life Literacies, and Key Skills

- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

Social-Emotional Learning Competencies

- **Self Management:** Recognize the skills needed to establish and achieve personal and educational goals.
- **Social Awareness:** Demonstrate an awareness for the expectations for social interactions in a variety of settings.
- **Relationship Skills:** Utilize positive communication and social skills to interact effectively with others.

Learning Targets	Investigations/Resources	Formative Assessment
Identify and describe the relevant components in the mathematical representations:	Suggested Activities: Team Activity: Determining Number By Mass Team Activity: The Mole POGIL: The Mole and Molar Mass	Q/A Whiteboarding Practice WS Exit Tickets

• Quantities of reactants and products of a chemical reaction in terms of atoms, moles, and mass; • Molar mass of all components of the reaction; The mathematical representations may include numerical calculations, graphs, or other pictorial depictions of quantitative information. Students identify the claim to be supported: that atoms, and therefore mass, are conserved during a chemical reaction.	ChemQuest: Intro to Moles Activity: Molecules in a sip of water Activity: Molecules of wax in a drawing Activity: Formula Units of chalk in your name Flinn: which sample has the most particles? • Explain how chemists count atoms and molecules using mass. • Explain the meaning of Avogadro's number. • Define the mole. • Utilize the ideal gas law in calculations (Additional for honors: verify molar volume, determine gas density at various temperatures, determine moles of a gas in a sample)	Do nows cK-12 adaptive practice
Use the mole to convert between the atomic and macroscopic scale in the analysis. Given a chemical reaction, use the mathematical representations to • Predict the relative number of atoms in the reactants versus the products at the atomic molecular scale; and • Calculate the mass of any component of a reaction, given any other component.	• Perform calculations to convert moles to individual particles and vice versa. • Determine molar mass of atoms. • Convert mass to moles and vice versa. • Use dimensional analysis for problem solving.	
• Describe how 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. • Describe how the mass of a substance can	• Utilize a measuring device and express the measure to the correct number of significant figures. • Calculate percent error. • Distinguish between accuracy and precision. • Identify sources of experimental error. • Represent decimal numbers with scientific notation.	

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).	• Perform calculations using scientific notation units and significant figures. • Convert between units of measurement. Additional for honors: • Use dimensional analysis to calculate the number of particles, ions, atoms, etc. in a given sample. • Calculate the percent composition by mass for elements in a compound. • Calculating empirical and molecular formulas.	

Instructional Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate

- Copy of notes provided on Google Classroom or a hard copy, as needed
- Extension activities for gifted students
- Extra time, as allotted
- "Chunking" of information or breaking down larger projects.
- Rewording of instructions or providing clarification.
- Preferential seating in the classroom.
- Any accommodation/modifications outlined in a student's IEP/504

Common Assessment(s)	**Assessment Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) when appropriate:**
• CP Mole • H Unit Test	• Extra time as allotted • Rewording of questions as needed • Use of a calculator • Any accommodation/modifications outlined in a student's IEP/504

Unit Title:	Time Frame/Pacing
Stoichiometry	21 days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:

- Different cars emit different amounts of air pollution, the ratios of reactants influences the amount of pollutants produced
- An airbag is designed in such a way that an exact quantity of nitrogen must be produced in an instant.

Anchoring Question:

- How are atoms cycled in earth's systems, where does the matter go?
- How many atoms are in a soda can?
- How much product is made from any one reaction and where did it come from?
- How do we make water safe to drink?

Essential Question:

- How are the quantities of reactants and products in a chemical reaction interrelated?

Enduring Understandings

- A balanced chemical equation describes the relative number of each type of reactant and product involved in a chemical reaction.
- That relationship, along with a knowledge of the masses of the elements, enables the mathematical computation of the relative masses of reactants and products involved in a chemical reaction.

NJ Standards/NGSS Performance Expectations Taught and Assessed
Students who demonstrate understanding can:

- 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.
- 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.
- HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

3-Dimensional Learning Components

Science and Engineering Practices	Disciplinary Core Ideas (DCI)	Crosscutting Concepts

Using Mathematics and Computational Thinking • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m^3, acre-feet, etc.). **Obtaining, Evaluating, and Communicating Information** • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).	**PS1.B Chemical Reactions** • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2), (HS-PS1-7)	**Scale and Proportions** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking		
Math • MP.2 Reason abstractly and quantitatively. • MP.4 Model with mathematics. • HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. • HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. • HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.		

ELA

- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Computer Science and Design thinking

- 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.

Career Readiness, Life Literacies, and Key Skills

- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

Social-Emotional Learning Competencies

- **Self Management:** Recognize the skills needed to establish and achieve personal and educational goals.
- **Social Awareness:** Demonstrate an understanding of the need for mutual respect when viewpoints differ.
- **Responsible Decision-**Making: Evaluate personal, ethical, safety, and civic impact of decisions.
- **Relationship Skills:** Identify who, when, shwere, or how to seek help for oneself or others when needed.

Learning Targets	Investigations/Resources	Formative Assessment
Students identify and describe the relevant components in the mathematical representations:	Suggested Activities: Mole ratio introduction demo or lab activity	Q/A Whiteboarding

• Quantities of reactants and products of a chemical reaction in terms of atoms, moles, and • Molar mass of all components of the reaction; • Use of balanced chemical equation(s); and • Identification of the claim that atoms, and therefore mass, are conserved during a chemical reaction.	Conversion worksheet Kinesthetic: Human stoichiometry AlkaSeltzer Rocket Lab Airbag Lab Limiting Reagent Lab Can you determine the mole ratio for a chemical reaction? Thermite Activity • Determine the limiting reactant. • Calculate percent yield for reactions. • Use dimensional analysis for problem solving.	Practice WS Exit tickets cK-12 adaptive practice
Students describe mathematically 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).	• Determine mole relationships from balanced chemical equations.	
Students will be able to mathematically model given a chemical reaction, use the mathematical representations to calculate the mass of any component of a reaction, given any other component. Students use the mole to convert between the atomic and macroscopic scale in the analysis.	• Calculate the mass relationships between substances in chemical reactions. Example calculations: Mole to mole Mass to mole Mole to mass Mass to Mass	
Students will be able to describe how the mathematical representations (e.g stoichiometric calculations to a specific mass of reactant is converted to product) support the claim that atoms,	<u>Additional for honors:</u> • Calculate how much of an excess reactant is left over.	

and therefore mass, are conserved during a chemical reaction.		

Instructional Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate
• Copy of notes provided on Google Classroom or a hard copy, as needed • Extension activities for gifted students • Extra time, as allotted • "Chunking" of information or breaking down larger projects. • Rewording of instructions or providing clarification. • Preferential seating in the classroom. • Any accommodation/modifications outlined in a student's IEP/504

Common Assessment(s)	**Assessment Modifications and/or Accommodations** **(ELL, Special Education, Gifted, At-Risk of Failure, 504) when appropriate:**
• CPStoichiometry • H Unit Test	• Extra time as allotted • Rewording of questions as needed • Use of a calculator • Any accommodation/modifications outlined in a student's IEP/504

Unit Title:	Time Frame/Pacing
Solutions	~ 9 days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:
- Iced Tea Challenge
- Concentration of sugar in a soda can
- Concentration of salt in the ocean
- What makes the salinity of the ocean different then the salinity of contact solution?

Anchoring Question:
- What makes one solution different from another solution?

Essential Question:
- How can you dilute a solution?
- How can you differentiate between the concentration of different solutions?
- What is the relationship between temperature and solubility of a substance?

Enduring Understandings

- Atoms are conserved in chemical reactions.
- Factors such as temperature and concentration will affect the rate at which dissolving will occur.
- Many of these reactions occur in solution due to the added freedom of the particles.
- The mole is the link between the macroscopic and particulate world.
- Solution concentration is a measure of the amount of solute in a solvent and can be expressed in different ways.

NJ Standards/NGSS Performance Expectations Taught and Assessed
Students who demonstrate understanding can:

- 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.
- 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.

3-Dimensional Learning Components

Science and Engineering Practices	Disciplinary Core Ideas (DCI)	Crosscutting Concepts
Developing and Using Models • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems. **Using Mathematics and Computational Thinking** • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. • Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or	**PS1.A Structure and Properties of Matter** • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3), (secondary to HS-PS2-6)	**Cause and effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Systems can be designed to cause a desired effect. **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. • Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m^3, acre-feet, etc.). **Obtaining, Evaluating, and Communicating Information** • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).		

Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking

Math

- HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; ch oose and interpret the scale and the origin in graphs and data displays.
- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ELA

- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1)
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2), (HS-PS1- 5)
- WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance

understanding of findings, reasoning, and evidence and to add interest.

Computer Science and Design Thinking

- 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.

Career Readiness, Life Literacies, and Key Skills

- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

Social-Emotional Learning Competencies

- **Social Awareness:**
  - Recognize and identify the thoughts, feelings, and perspectives of others
  - Demonstrate an understanding of the need for mutual respect when viewpoints differ
  - Demonstrate an awareness of the expectations for social interactions in a variety of settings
- **Responsible Decision-Making:**
  - Develop, implement, and model effective problem-solving and critical thinking skills
  - Identify the consequences associated with one's actions in order to make constructive choices
  - Evaluate personal, ethical, safety, and civic impact of decisions
- **Relationship Skills:**
  - Utilize positive communication and social skills to interact effectively with others

Learning Targets	Investigations/Resources	Formative Assessment
Collaboratively plan and carry out an investigation to understand molarity. Apply mathematical and graphical thinking to identify to solubility of substances including gases in water at a given temperature.	Suggested Activities: Solutions Packet Activity: Which has a higher concentration: sugar in Coke or salt in the ocean? Molarity and Dilution Calculations Making HCl and NaOH solutions lab Modeling solutions Dissociation of salt in water modeling	Q/A Whiteboarding Practice WS Exit tickets cK-12 adaptive practice

	• Define solute, solvent, solubility, soluble, insoluble, miscible, immiscible, solution. • Distinguish between saturated, unsaturated and supersaturated solutions. • Describe / illustrate the process of hydration of an ionic compound. Write dissociation equations of ionic compounds.	
Use mathematical calculations to solve for molarity using moles or grams of a substance. Students will develop a model quantitatively and qualitatively the dilution calculation.	• Express solution concentration in percent by mass and molarity. • Perform calculations involving mass, mole, and molarity. • Perform calculations involving molarity and dilutions. Additional for honors: • Calculate percent by mass for a solution • Solution stoichiometry, performing strong acid/strong base titrations.	

Instructional Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate

- Copy of notes provided on Google Classroom or a hard copy, as needed
- Extension activities for gifted students
- Extra time, as allotted
- "Chunking" of information or breaking down larger projects.
- Rewording of instructions or providing clarification.
- Preferential seating in the classroom.
- Any accommodation/modifications outlined in a student's IEP/504

Common Assessment(s)	Assessment Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) when appropriate:
• CPSolutions • H Unit Test	• Extra time as allotted • Rewording of questions as needed • Use of a calculator

	• Any accommodation/modifications outlined in a student's IEP/504

Unit Title:	**Time Frame/Pacing**
Energy and Thermodynamics	~11 days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:

- Styrofoam cups can keep liquids warm and cold
- Dissolving of calcium chloride is an exothermic process
- Dissolving of ammonium nitrate is an endothermic process
- Stainless steel pan frequently have a copper bottom
- Confectioners use marble slabs to prepare candies and fudge
- Urban areas are generally warmer than their surroundings

Anchoring Questions:

- Which cookware would you choose to fry an egg and why?
- What is the difference between heat and temperature?
- Can you make frozen Popsicles out of hot cocoa?
- Why are certain materials better insulators?
- Do the instant ice packs found in first-aid kits require refrigeration?
- Which is hotter, beach sand or the water? Concrete or asphalt?

Essential Questions:

- How is the behavior of a chemical reaction determined by the energy changes involved in the reaction?
- Where does the heat obtained from a reaction come from?
- What is the role of the catalyst in a chemical reaction?

Honors:

- How is the exothermicity of a reaction related to the bond strengths of the reactants and products?
- How are enthalpy and entropy related to reaction spontaneity?

Enduring Understandings

- Energy is neither created nor destroyed. It is only transformed from one form to another.
- Breaking a bond requires an input of energy; forming a bond releases energy.
- This is due to a change in the potential energy of the system. In chemical reactions, some bonds are broken while others are formed.

- This leads to a difference in the potential energy of the reactants versus the products.
- This difference leads to a change in the kinetic energy of the system which is then observed as a change in temperature.

NJ Standards/NGSS Performance Expectations Taught and Assessed
Students who demonstrate understanding can:

- 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.
- 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 component(s) and energy flows in and out of the system are known.
- 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 position of particles (objects).
- HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
- 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).

3-Dimensional Learning Components

Science and Engineering Practices	Disciplinary Core Ideas (DCI)	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. • Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider	**PS 1.B Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-5) • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2) **PS3.A Definitions of Energy**	**Energy and Matter** • The total amount of energy and matter in closed systems is conserved. • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that systems. • Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. • Energy drives the cycling of matter within and between systems. **Structure and function**

limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables. **Developing and Using Models** • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to	• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1), (HS-PS3-2) • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2), (HS-PS3-3) • These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) **PS3.B Conservation of Energy and Energy Transfer** • Conservation of energy means • that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)	• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

generate data to support explanations, predict phenomena, analyze systems, and/or solve problems. **Obtaining, Evaluating, and Communicating Information** • Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. • Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. • Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).	• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1), (HS-PS3-4) • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) • The availability of energy limits what can occur in any system. (HS-PS3-1) • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) **PS3.C: Relationship Between Energy and Forces** • When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5) **PS3.D Energy in Chemical Processes and Everyday Life** • Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3), (HS-PS3-4)	

	ESS2.C The Role of Water in Earth's Surface Processes • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	

Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking

Math

- MP.2 Reason abstractly and quantitatively.
- MP.4 Model with mathematics.
- HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ELA

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- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Computer Science and Design Thinking

- 8.2.12.A.1 Propose an innovation to meet future demands supported by an analysis of the potential full costs, benefits, trade-offs and risks, related to the use of the innovation.
- 8.2.12.D.1 Design and create a prototype to solve a real world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for peer review.
- 8.2.12.D.2 Write a feasibility study of a product to include: economic, market, technical, financial, and management factors, and provide recommendations for implementation.

Career Readiness, Life Literacies, and Key Skills

- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

Social-Emotional Learning Competencies

- **Self Management:** Recognize the skills needed to establish and achieve personal and educational goals.
- **Social Awareness:** Demonstrate an awareness for the expectations for social interactions in a variety of settings.
- **Relationship Skills:** Utilize positive communication and social skills to interact effectively with others.

Learning Targets	Investigations/Resources	Formative Assessment

<table>
<tr>
<td>Develop a model to identify and describe the relevant components, including:
The chemical reaction, the system, and the surroundings under study;
The bonds that are broken during the course of the reaction;
The bonds that are formed during the course of the reaction;
The energy transfer between the systems and their components or the system and
surroundings;
The transformation of potential energy from the chemical system interactions to kinetic energy in the surroundings (or vice versa) by molecular collisions; and
The relative potential energies of the reactants and the products.</td>
<td>Suggested Activities:
Modeling: Energy Transfer
POGIL: Bond Energy
Activity: Snowman
PhET simulation: Energy Transfer
POGIL: States of Matter
Engineering and Design Challenge: Hand Warmer
Endothermic/Exothermic Activity: $Ba(OH)_2$ and NH_4SCN
Interpret potential energy diagrams.
Identify reactants, products, activated complex (transition state) activation energy and heat of reaction on energy diagram.
Account for the effect of a catalyst on a chemical reaction.
Determine whether a reaction is endothermic or exothermic.
Explain the need for activation energy.</td>
<td rowspan="2">Q/A
Whiteboarding
Practice WS
Exit Tickets
Do Nows
cK-12 adaptive practice</td>
</tr>
<tr>
<td>Identify and describe the components to be computationally modeled, including:
The boundaries of the system and that the reference level for potential energy = 0 (the potential energy of the initial or final state does not have to be zero);
The initial energies of the system's components (e.g., energy in fields, thermal energy, kinetic energy, energy stored in springs — all expressed as a total amount of Joules in each component), including a quantification in an algebraic description to calculate the total initial energy of the system;
The energy flows in or out of the system,</td>
<td>Create a model to relate the change in thermal energy to the exchanges in kinetic and potential energy.
Model what occurs with matter and energy at the particulate level during a phase change. (Also in IMF unit)
Use Lewis dot diagrams to illustrate covalent compounds.
Estimate heat of reaction based on bond energies.</td>
</tr>
</table>

including a quantification in an algebraic description with flow into the system defined as positive; and • The final energies of the system components, including a quantification in an algebraic description to calculate the total final energy of the system. Create a computational model (e.g., simple computer program, spreadsheet, simulation, software package application) that is based on the principle of the conservation of energy. Use the computational model to calculate changes in the energy of one component of the system when changes in the energy of the other components and the energy flows are known. Predict the maximum possible change in the energy of one component of the system for a given set of energy flows. Identify and describe the limitations of the computational model, based on the assumptions that were made in creating the algebraic descriptions of energy changes and flowsin the system.		
Develop a model, identify and describe the relevant components, including: • All the components of the system and the surroundings, as well as energy flows between the system and the surroundings; • Clearly depicting both a macroscopic and a molecular/atomic-level representation of the system; and • Depicting the forms in which energy is manifested at two different scales:	• Model the process of dissolving and track the energy and matter flow.	

a) Macroscopic, such as motion, sound, light, thermal energy, potential energy or energy in fields; and b) Molecular/atomic, such as motions (kinetic energy) of particles (e.g., nuclei and electrons), the relative positions of particles in fields (potential energy), and energy in fields. Describe the relationships between components in their models, including: • Changes in the relative position of objects in gravitational, magnetic or electrostatic fields can affect the energy of the fields (e.g., charged objects moving away from each other change the field energy). • Thermal energy includes both the kinetic and potential energy of particle vibrations in solids or molecules and the kinetic energy of freely moving particles (e.g., inert gas atoms, molecules) in liquids and gases. • The total energy of the system and surroundings is conserved at a macroscopic and molecular/atomic level. • Chemical energy can be considered in terms of systems of nuclei and electrons in electrostatic fields (bonds). • As one form of energy increases, others must decrease by the same amount as energy is transferred among and between objects and fields. Use models to show that in closed systems the energy is conserved on both the macroscopic and molecular/atomic scales so that as one form of energy changes, the total		

system energy remains constant, as evidenced by the other forms of energy changing by the same amount or changes only by the amount of energy that is transferred into or out of the system. 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 on both the macroscopic and microscopic scales.		
Design a device that converts one form of energy into another form of energy. Develop a plan for the device in which they: • Identify what scientific principles provide the basis for the energy conversion design; • Identify the forms of energy that will be converted from one form to another in the • designed system; • Identify losses of energy by the design system to the surrounding environment; • Describe the scientific rationale for choices of materials and structure of the device, • including how student-generated evidence influenced the design; and • Describe that this device is an example of how the application of scientific knowledge • and engineering design can increase benefits for modern civilization while decreasing • costs and risk. Describe criteria and constraints, including	• Construct explanations using mathematical thinking and develop a model to illustrate the release or absorption of energy from a chemical reaction and relate it to the changes in the total bond energy.	

quantification when appropriate for the design of the device, along with the tradeoffs implicit in these design solutions. Examples of constraints to be considered are cost and efficiency of energy conversion. Build and test the device according to the plan. Evaluate the performance of the device against the criteria and constraints. Use the results of the tests to improve the device performance by increasing the efficiency of energy conversion, keeping in mind the criteria and constraints, and noting any modifications in tradeoffs.		
Describe the purpose of the investigation, which includes the following idea, 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). Develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including: • The measurement of the reduction of temperature of the hot object and the increase in temperature of the cold object to show that the thermal energy lost by the hot object is equal to the thermal energy gained by the cold object and that the distribution of thermal energy is more uniform after the interaction of the hot and cold components; and	• Calculate heat content changes from a chemical or physical process given experimental data using the mathematical equation $q = m\,c\,\Delta T$. • Describe on a molecular level what occurs during phase changes. <u>Additional for honors:</u> • Calculate the energy involved in phase changes (heating curves) • Develop and model for determining if the entropy of a system is increasing or decreasing. • Explain the difference between enthalpy and entropy. • Predict the sign of entropy change in phase changes and chemical reactions. • Evaluate enthalpy and entropy data using the Gibbs Free Energy model and to qualitatively determine whether a reaction	

• The heat capacity of the components in the system (obtained from scientific literature). Describe: • How a nearly closed system will be constructed, including the boundaries and initial conditions of the system; • The data that will be collected, including masses of components and initial and final temperatures; and • The experimental procedure, including how the data will be collected, the number of trials, the experimental setup, and equipment required. Collect and record data that can be used to calculate the change in thermal energy of each of the two components of the system. Evaluate the investigation, including: • The accuracy and precision of the data collected, as well as the limitations of the investigation; and • The ability of the data to provide the evidence required. Refine the plan to produce more accurate, precise, and useful data that address the experimental question. Identify potential causes of the apparent loss of energy from a closed system (which should be zero in an ideal system) and adjust the design of the experiment accordingly.	will be spontaneous or not (determine reaction spontaneity from the sign of the enthalpy and entropy).	

Instructional Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) When Appropriate
• Copy of notes provided on Google Classroom or a hard copy, as needed • Extension activities for gifted students • Extra time, as allotted • “Chunking” of information or breaking down larger projects. • Rewording of instructions or providing clarification. • Preferential seating in the classroom. • Any accommodation/modifications outlined in a student's IEP/504

Common Assessment(s)	Assessment Modifications and/or Accommodations (ELL, Special Education, Gifted, At-Risk of Failure, 504) when appropriate:
• CPThermochemistry • H Unit Test	• Extra time as allotted • Rewording of questions as needed • Use of a calculator • Any accommodation/modifications outlined in a student's IEP/504

Unit Title:	**Time Frame/Pacing**
Rates and Equilibrium	~13-16 days

Phenomena/Anchoring Activity/Anchoring Question/Essential Questions

Phenomena:

- Fish tank equilibria
- pH indicator change
- Mood rings change to various colors when worn
- Color changing substances (nail polish, doll clothes, toys) will change colors based on temperature/moisture.
- Ocean acidification
- Why are hydrangea flowers different colors in different types of soil?
- Natural indicators such as turmeric and cabbage juice

Anchoring Question:

- How are enzymes related to the collision theory?
- How can you make reactions go faster?
- How do changes in population relate to equilibrium?

Essential Questions:

- What factors affect the rates of chemical reactions and how do they affect it?
- What defines chemical equilibrium?
- How do you recognize a system at equilibrium?
- How are reversible reactions affected by changes in concentration, temperature or pressure?
- How does taking an antacid relieve the discomfort that accompanies digestive problems?

Enduring Understandings

- Factors such as temperature and concentration will affect the rate at which a reaction will occur. This can be understood through viewing a reaction on the particulate level; reactants must collide in the correct orientation with sufficient energy to produce products.
- Many reactions are reversible, meaning that the products formed can react to reform reactant molecules.
- These reversible reactions tend to reach an equilibrium where the forward rate of reaction is equal to the reverse rate of reaction.
- When equilibrium is reached, both reactants and products will remain in the system with their concentrations unchanging.
- An understanding of what influences the rates of the forward and reverse reaction rates, along with Le Chatelier's Principle, allows for a prediction of how the relative amounts of reactants and products present at equilibrium changes under varying conditions of temperature and concentration.

NJ Standards/NGSS Performance Expectations Taught and Assessed
Students who demonstrate understanding can:

- 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.
- 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.

3-Dimensional Learning Components

Science and Engineering Practices	Disciplinary Core Ideas (DCI)	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.	**PS1.B Chemical Reactions** • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6) • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-5) • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2)	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. **Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Systems and System Models** • Models (e.g., physical,mathematical, computer models) can be used to simulate systems and interactions — including energy, matter, and information flows — within and between systems at different scales. **Cause and Effect** • Empirical evidence is required to differentiate between cause and

		correlation and make claims about specific causes and effects.

Interdisciplinary Connections: Math, ELA, and Computer Science and Design Thinking

Math

- MP.2 Reason abstractly and quantitatively.
- MP.4 Model with mathematics.
- HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

ELA

- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Computer Science and Design Thinking

- 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.

Career Readiness, Life Literacies, and Key Skills

- 9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

Social-Emotional Learning Competencies		
• **Self Management:** Recognize the skills needed to establish and achieve personal and educational goals. • **Social Awareness:** Demonstrate an awareness for the expectations for social interactions in a variety of settings. • **Relationship Skills:** Utilize positive communication and social skills to interact effectively with others.		
Learning Targets	**Investigations/Resources**	**Formative Assessment**
Students identify and describe potential changes in a component of the given chemical reaction system that will increase the amounts of particular species at equilibrium. 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.	Suggested activities: ChemMatters Article: What is equal about equilibrium? Straw launch lab Lab: Stressing an Equilibrium EdPuzzle videos Factors Affecting Rate of Reaction Compound Chem Infographic Ted-Ed video on collision theory Students will apply experimental data to develop a graphical model of equilibrium. • Graphically describe a reversible reaction as it approaches equilibrium given the initial and final concentrations of the reactants. • Identify the region of equilibrium for a reversible reaction on a graph of concentration of reactants present vs. time <u>Additional for honors:</u> • Interpret equilibrium constants. (K_c, K_{sp}, K_a, K_b) • Identify the direction of shift based on the reaction quotient, Q. • Calculate equilibrium constants and use ICE tables to determine equilibrium concentrations.	Q/A Whiteboarding Practice WS Exit tickets cK-12 adaptive practice

	• Quantitative analysis of the data. (ratios of volumes at equilibrium points in straw lab)	
Students describe the prioritized criteria and constraints, and quantify each when appropriate. Examples of constraints to be considered are cost, energy required to produce a product, hazardous nature and chemical properties of reactants and products, and availability of resources.	Students will plan and investigate how various stresses will affect an equilibrium. They will then construct explanations for phenomena observed (including at the particulate level using collision theory) • Apply Le Chatelier's Principle to determine the effect on equilibrium (shift right or shift left) when a "stress" is applied to the system. • Utilize collision theory to account for a shift in the equilibrium of a reaction.	
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 the 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.	Use collision theory to explain the effect of temperature, concentration, surface area, and the addition of a catalyst on rate. Additional honors topics: • Calculate average rate of reaction. • Use a graph of concentration vs. time to identify average and instantaneous rates. • Write rate laws from experimental data. • Utilize stoichiometric ratios to graph reactant/product concentrations vs time. • Calculate concentration, rate constant, or rate using the rate law. • Determine reaction order from a graph of reactant concentration and rate.	
Students will be able to plan and conduct investigation to produce data to serve as the basis for evidence in determining the factors influencing the rate of the reactions.		

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<td>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.</td>
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• CPEquilibrium & Rates • H Unit Test	• Extra time as allotted • Rewording of questions as needed • Use of a calculator • Any accommodation/modifications outlined in a student's IEP/504