PUBLIC SCHOOLS OF EDISON TOWNSHIP

OFFICE OF CURRICULUM AND INSTRUCTION

# CHEMISTRY

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|---|---|
| Length of Course: | Term |
| Elective/Required: | Required |
| Schools: | High School |
| Eligibility: | Grade 10 |
| Credit Value: | 6 Credits |
| Date Approved: | August 17, 2021 |

# TABLE OF CONTENTS



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

## Statement of Purpose

**Introduction:** Chemistry investigates matter and energy and ways in which these two quantities interact. Over a course of study in chemistry, students should be able to recognize how both matter and energy are both quantified (measured) and qualified (observed) in a variety of contexts.

The units are presented so that students have multiple opportunities to explore matter and energy. In each unit, students will develop and explain models and theoretical frameworks that have evolved over time. They will also have opportunities to explain emergent theories and/or use modern and original data to investigate novel explanations for historical positions. The units are designed so that there are conceptual “bridges” that tie ideas from one unit to the next.

A lab-based/inquiry chemistry course is structured so that students actively engage in scientific and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas. The learning experiences provided for students should engage them with fundamental questions about the world and with how scientists have investigated and found answers to those questions. Students will have the opportunity to carry out scientific investigations and engineering design projects related to the disciplinary core ideas in physical sciences.

This curriculum guide was updated in 2020 and is designed to accompany existing course materials. This guide was updated further in the Summer 2021 to reflect the NJSLS-S/NGSS changes in the climate change language.

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## Course Objectives

The student will be able to:

Physical Science

- NJSLS:HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

- NJSLS:HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

- NJSLS:HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

- NJSLS:HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

- NJSLS:HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

- NJSLS:HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

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

- NJSLS:HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

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

- NJSLS: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.

- NJSLS: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.

- NJSLS: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).

- NJSLS:HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
- NJSLS:HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other

- NJSLS:HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

Earth and Space Sciences

- NJSLS:HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation.
- NJSLS:HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.
- NJSLS:HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.
- NJSLS:HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
- NJSLS:HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.
- NJSLS:HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.
- NJSLS:HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.
- NJSLS:HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
- NJSLS:HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
- NJSLS:HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- NJSLS:HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
- NJSLS:HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
- NJSLS:HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.
- NJSLS:HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and [changes in] climate change have influenced human activity.
- NJSLS:HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
- NJSLS:HS-ESS3-3. Create a computational simulation to illustrate the relationship among management of natural resources, the sustainability of human populations, and biodiversity.
- NJSLS:HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.

- NJSLS:HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

- NJSLS:HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change).

Engineering Design

- NJSLS:HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

- NJSLS:HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

- NJSLS:HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

- NJSLS:HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Career Readiness, Life Literacies, and Key Skills

- NJSLS:9.4.12.CI2. Identify career pathways that highlight personal talents, skills, and abilities.

- NJSLS:9.4.12.CT1-4. Collaborate with individuals with diverse experiences to aid in the problem-solving process, particularly for global issues where diverse solutions are needed.

- NJSLS:9.4.12.DC1-2,7. Explain the beneficial and harmful effects that intellectual property laws can have on the creation and sharing of content. Compare and contrast international differences in copyright laws and ethics. Evaluate the influence of digital communities on the nature, content and responsibilities of careers, and other aspects of society.

- NJSLS:9.4.12.GCA1. Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others.

- NJSLS:9.4.12.IML2,5-8. Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources. Evaluate, synthesize, and apply information on climate change from various sources appropriately. Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender, and age diversity. Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change. Evaluate media sources for point of view, bias, and motivations.

- NJSLS:9.4.12.TL2,5-8. Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

*Bolded standards should be covered or integrated at teacher's discretion as appropriate.

## Pacing Guide

| Chemistry Honors | Chemistry Level 1 | Chemistry Level 2 |
|---|---|---|
| **First Quarter Topics:**<br>--Matter and Measurement<br>-Atoms and Molecules<br>-Models of the Atom<br>(Climate Change)<br>-Nuclear Chemistry<br>(Earth Science)<br>-Periodic Table | **First Quarter Topics**<br>-Matter<br>-Atoms and Molecules<br>-Models of the Atom<br>(Climate Change)<br>-Nuclear Chemistry<br>(Earth Science)<br>-Periodic Table | **First Quarter Topics**<br>-Matter<br>-Atoms and Molecules<br>-Models of the Atom<br>(Climate Change)<br>-Nuclear Chemistry<br>(Earth Science)<br>-Periodic Table |
| **Second Quarter Topics**<br>-Chemical Bonding<br>-Chemical Reactions<br>-Stoichiometry | **Second Quarter Topics**<br>-Chemical Bonding<br>-Intermolecular Forces and Water<br>(Earth Science)<br>-States of Matter<br>-Chemical Reactions | **Second Quarter Topics**<br>-Chemical Bonding<br>-Intermolecular Forces and Water<br>(Earth Science)<br>-States of Matter<br>-Chemical Reactions |
| **Third Quarter Topics**<br>-Chemical Nature of Gases<br>-Intermolecular Forces and Water<br>(Earth Science)<br>-States of Matter<br>-Solutions and Colligative Properties | **Third Quarter Topics**<br>-Chemical Nature of Gases<br>-Stoichiometry<br>-Solutions and Colligative Properties | **Third Quarter Topics**<br>-Stoichiometry<br>-Solutions and Colligative Properties<br>-Chemical Nature of Gases |
| **Fourth Quarter Topics**<br>-Thermochemistry<br>(Climate Change)<br>-Kinetics and Equilibrium<br>-Acids and Bases<br>-Electrochemistry | **Fourth Quarter Topics**<br>-Thermochemistry<br>(Climate Change)<br>-Kinetics and Equilibrium<br>-Acids and Bases<br>-Electrochemistry | **Fourth Quarter Topics**<br>-Thermochemistry<br>(Climate Change)<br>-Kinetics and Equilibrium<br>-Acids and Bases<br>-Electrochemistry |

## UNIT 1: ATOMS AND THEIR ELECTRONS, NJSLS:HS-PS1-1, NJSLS:HS-ESS1-3,4

**Essential Question:** "How can one explain the structure and properties of matter?"

**Performance Expectations:** (Students who demonstrate understanding can:)

NJSLS:HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

NJSLS:HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.

NJSLS:HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)
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.

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
|---|---|---|---|---|
| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS1.A: Structure and Properties of Matter**<br><br>Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.<br><br>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. | **Developing and Using Models**<br><br>From the given model, students identify and describe the components of the model that are relevant for their predictions, including:<br>● Elements and their arrangement in the periodic table<br>● A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons<br>● Electrons in the outermost energy level of atoms (i.e., valence electrons)<br>● The number of protons in each element.<br><br>Students identify and describe the following relationships between components in the given model, including<br>● The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons | **Patterns**<br><br>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.<br><br>Students predict the following patterns of properties:<br>● The number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements<br>● The number and charges in stable ions that form from atoms in a group of the periodic table<br>● 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. | Periodic Table Lab<br><br>Periodic Trends Lab<br><br>Periodic Trends Computer Activities<br><br>Periodic Trends Project | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

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| | • Elements in the periodic table are arranged by the numbers of protons in atoms. | The relative sizes of atoms both across a row and down a group in the periodic table. | | |

**Common Core Standards Alignment**

| ELA/Literacy | Mathematics | Technology | Career Ready Practice |
|---|---|---|---|
| RST.9-10.7<br>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. | MP.4<br>Model with mathematics. | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP2.<br>Apply appropriate academic and technical skills<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

| Resources | Instructional Adjustments |
|---|---|
| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices<br><br>Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021)<br><br>Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings.<br><br>[Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.] |

## UNIT 2: ELECTRONS AND CHEMICAL REACTIONS, NJSLS:HS-PS1-2

**Essential Questions:** "How do substances combine or change (react) to make new substances?" "How does one characterize and explain these reactions and make predictions about them?"

**Performance Expectations:** (Students who demonstrate understanding can:)

NJSLS:HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

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.

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
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| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS1.A: Structure and Properties of Matter**<br><br>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.<br><br>**PS1.B: Chemical Reactions**<br><br>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. | **Constructing Explanations and Designing Solutions**<br><br>Students construct an explanation of the outcome of the given reaction, including:<br>● The idea that the total number of atoms of each element in the reactant and products is the same<br>● 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<br>● 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 | **Patterns**<br><br>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. | Types of chemical reactions lab<br><br>Single Replacement Lab<br><br>Balancing Chemical Reactions Activity | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

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| | ● 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).<br><br>Students identify and describe the evidence to construct the explanation, including<br>● Identification of the products and reactants, including their chemical formulas and the arrangement of their outermost (valence) electrons<br>● Identification that the number and types of atoms are the same both before and after a reaction<br>● Identification of the numbers and types of bonds (i.e., ionic, covalent) in both the reactants and the products<br>● The patterns of reactivity (e.g., the high reactivity of alkali metals) at the macroscopic level as determined by using the periodic table<br>● 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.<br><br>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. | | | |

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| | Given new evidence or context, students construct a revised or expanded explanation about the outcome of a chemical reaction and justify the revision. | | | |

**Common Core Standards Alignment**

| ELA/Literacy | Mathematics | Technology | Career Ready Practice |
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| WHST.9-12.5<br>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. | HSN-Q.A.1<br>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<br>HSN-Q.A.3<br>Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

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| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices<br><br>Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021)<br><br>Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings.<br><br>[Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.] |

## UNIT 3: FORCES WITHIN PARTICLES, NJSLS:HS-PS1-3, NJSLS:HS-ESS2-5,6,7

**Essential Question:** "How do particles combine to form the variety of matter one observes?"
**Performance Expectations:** (Students who demonstrate understanding can:)

NJSLS:HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles

NJSLS:HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

NJSLS:HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

NJSLS:HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

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
Students construct an explanation for how energy flowing into and out of Earth's systems explain changes in climate.

Students construct an explanation for the properties of water and how this affects Earth and its inhabitants.

Students construct an explanation or model for how carbon cycles through the Earth.

Students construct a way to minimize waste and maximize the cost-benefit ratios related to utilizing energy and material resources.

Students organize data(e.g., with graphs) from global climate models (e.g., computational simulations) and climate observations overtime that relate to the effect of climate change on the physical parameters or chemical composition of the atmosphere, geosphere, hydrosphere, or cryosphere.

Students construct an explanation and computational representation for how human activity affects the Earth and its systems.

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
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| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS1.A: Structure and Properties of Matter**<br><br>The structure and interactions of matter at the bulk | **Planning and Carrying Out Investigations**<br><br>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 | **Patterns**<br><br>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: | Model Building Activity<br><br>Intermolecular Forces Activity<br><br>GAK | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
|---|---|---|---|---|
| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| scale are determined by electrical forces within and between atoms. | electrical forces between the particles of the substance.<br><br>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.<br>In the investigation plan, students Include:<br>● A rationale for the choice of substances to compare and a description of the composition of those substances at the atomic molecular scale.<br>● A description of how the data will be collected, the number of trials, and the experimental set up and equipment required.<br>● Students describe how the data will be collected, the number of trials, the experimental setup, and the equipment required.\<br><br>Students collect and record data — quantitative and/or qualitative — on the bulk properties of substances.<br><br>Students evaluate their investigation, including evaluation of<br>● Assessing the accuracy and precision of the data collected, as well as the limitations of the investigation<br>● The ability of the data to provide the evidence required.<br>● If necessary, students refine the plan to produce more accurate precise, & useful data. | ● 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).<br>● 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<br>● The patterns of interactions between particles at the molecular scale are reflected in the patterns of behavior at the macroscopic scale.<br>● 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. | | |

**Common Core Standards Alignment**

| ELA/Literacy | Mathematics | Technology | Career Ready Practice |
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| RST.11-12.1<br>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<br>WHST.9-12.7<br>Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.<br>WHST.11-12.8<br>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.<br>WHST.9-12.9<br>Draw evidence from informational texts to support analysis, reflection, and research. | HSN-Q.A.1<br>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<br>HSN-Q.A.3<br>Choose a level of accuracy appropriate to limitations on measurement when reporting quantities | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

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| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices<br><br>Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021)<br><br>Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings.<br><br>[Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.] |

## UNIT 4: REACTIONS AND ENERGY, NJSLS:HS-PS1-4

**Essential Questions:** "What is energy?" How does energy change within a chemical system?"

**Performance Expectations:** (Students who demonstrate understanding can:)

NJSLS:HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
|---|---|---|---|---|
| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS1.A: Structure and Properties of Matter**<br><br>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.<br><br>**PS1.B: Chemical Reactions**<br><br>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. | **Developing and Using Models**<br><br>Students use evidence to develop a model in which they identify and describe the relevant components, including<br>● The chemical reaction, the system, and the surroundings under study<br>● The bonds that are broken during the course of the reaction<br>● The bonds that are formed during the course of the reaction<br>● The energy transfer between the systems and their components or the system and surroundings<br>● The transformation of potential energy from the chemical system interactions to kinetic energy in the surrounding (or vice versa) by molecular collisions; and the relative potential energies of the reactants and the products<br>Students use the developed model to illustrate:<br>● The energy change within the system is accounted for by the | **Energy and Matter**<br><br>In the model, students include and describe the relationships between components, including:<br>● The net change of energy within the system is the result of bonds that are broken and formed during the reaction (Note: This does not include calculating the total bond energy changes.);<br>● The energy transfer between system and surroundings by molecular collisions<br>● The total energy change of the chemical reaction system is matched by an equal but opposite change of energy in the surroundings (Note: This does not include calculating the total bond energy changes.) The release or absorption of energy | Hess's Law Activity<br><br>Energy Diagrams<br><br>Bond Energy Computer Simulation | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

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| | change in the bond energies of the reactants and products.<br><br>(Note: This does not include calculating the total bond energy changes.)<br>● Breaking bonds requires an input of energy from the system or surroundings, and forming bonds releases energy to the system and the surroundings.<br>● The energy transfer between systems and surroundings is the difference in energy between the bond energies of the reactants and the products.<br>● The overall energy of the system and surroundings is unchanged (conserved) during the reaction.<br>● Energy transfer occurs during molecular collisions.<br>● The relative total potential energies of the reactants and products can be accounted for by the changes in bond energy. | depends on whether the relative potential energies of the reactants and products decrease or increase. | | |

**Common Core Standards Alignment**

| ELA/Literacy | Mathematics | Technology | Career Ready Practice |
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| SL.11-12.5<br>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. | MP.4<br>Model with mathematics. | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings. |
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| Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021)<br><br>Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.] |

# UNIT 5: REACTION RATES, NJSLS:HS-PS1-5

**Essential Question:** "How can the rate of a chemical reaction be controlled?"

**Performance Expectations:** (Students who demonstrate understanding can:)

NJSLS:HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)
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

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
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| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS1.B: Chemical Reactions**<br><br>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. | **Constructing Explanations and Designing Solutions**<br><br>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.<br><br>Students use and describe the following chain of reasoning that integrates evidence, facts, and scientific principles to construct the explanation:<br>● Molecules that collide can break bonds and form new bonds, producing new molecules.<br>● 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.<br>● Since temperature is a measure of average kinetic energy, a | **Patterns**<br><br>Students identify and describe evidence to construct the explanation, including:<br>● 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<br>● Evidence of a pattern that increases in temperature usually increase the reaction rate, and vice versa | Equilibrium Activity<br><br>Le Chatelier's Activity<br><br>Clock Reactions<br><br>Equilibrium Simulations | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

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| | higher temperature means that molecular collisions will, on average, be more likely to break bonds and form new bonds.<br>● 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.<br>● 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. | | | |

**Common Core Standards Alignment**

| ELA/Literacy | Mathematics | Technology | Career Ready Practice |
|---|---|---|---|
| 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<br>WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. | MP.2 Reason abstractly and quantitatively.<br>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<br>HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

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| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices<br><br>Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021)<br><br>Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings.<br><br>[Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.] |

# UNIT 6: EQUILIBRIUM, NJSLS:HS-PS1-6

**Essential Questions:** "What is meant by dynamic equilibrium?" "What happens when a system at equilibrium is disturbed?"

**Performance Expectations:** (Students who demonstrate understanding can:)

NJSLS:HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
|---|---|---|---|---|
| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS1.B: Chemical Reactions**<br><br>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.<br><br>**ETS1.C: Optimizing the Design Solution**<br><br>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. | **Constructing Explanations and Designing Solutions**<br><br>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.<br><br>Students systematically evaluate the proposed refinements to the design of the given chemical system. The potential refinements are evaluated by comparing the redesign to the list of criteria (i.e., increased product) and constraints (e.g., energy required, availability of resources).<br>Students refine the given designed system by making tradeoffs that would optimize the designed system | **Stability and Change**<br><br>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<br><br>● How, at a molecular level, a stress involving a change to one component of an equilibrium system affects other components | Equilibrium Activities<br><br>Color Change Activity<br><br>Equilibrium Simulation | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

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| | to increase the amount of product, and describe the reasoning behind design decisions. | • 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;<br>• 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. | | |

**Common Core Standards Alignment**

| ELA/Literacy | Mathematics | Technology | Career Ready Practice |
|---|---|---|---|
| WHST.9-12.7<br>Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. | MP.2<br>Reason abstractly and quantitatively | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings. |
|---|---|
| Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021)<br><br>Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.] |

# UNIT 7: CONSERVING MATTER, NJSLS:HS-PS1-7

**Essential Questions:** "How can the mass of a sample of an element or compound be related to the individual number of atoms or molecules contained in the sample?" "How do the individual particles composing an atom contribute to its mass?"

**Performance Expectations:** (Students who demonstrate understanding can:)

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

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

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

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
|---|---|---|---|---|
| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS1.B: Chemical Reactions**<br><br>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. | **Using Mathematics and Computational Thinking**<br><br>Students identify and describe the relevant components in the mathematical representations<br>● Quantities of reactants and products of a chemical reaction in terms of atoms, moles, and mass<br>● Molar mass of all components of the reaction<br>● Use of balanced chemical equation(s)<br>● Identification of the claim that atoms, and therefore mass, are conserved during a chemical reaction.<br><br>The mathematical representations may include numerical calculations, graphs, or other pictorial depictions of quantitative information<br>Students use the mole to convert between the atomic and macroscopic scale in the analysis. | **Energy and Matter and Scientific Knowledge Assumes an Order and Consistency in Natural Systems**<br><br>Students identify the claim to be supported: that atoms, and therefore mass, are conserved during a chemical reaction. | Law of Conservation of Mass Activity<br><br>Rocket Activity<br><br>Chemical Company Activity | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

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| | Given a chemical reaction, students use the mathematical representations to:<br><br>• Predict the relative number of atoms in the reactants versus the products at the atomic molecular scale<br>• Calculate the mass of any component of a reaction, given any other component.<br><br>Students 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.<br><br>Students describe how the mass of a substance can be used to determine the number of atoms, molecules, or ions using moles and mole relationships (e.g., macroscopic to atomic molecular scale conversion using the number of moles and Avogadro's number). | | | |

**Common Core Standards Alignment**

| ELA/Literacy | Mathematics | Technology | Career Ready Practice |
|---|---|---|---|
| RST.9-10.7<br>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. | MP.2<br>Reason abstractly and quantitatively. | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

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| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices<br><br>Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021)<br><br>Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings.<br><br>[Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the |

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| Gizmos | atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.] |

## UNIT 8: NUCLEAR CHEMISTRY, NJSLS:HS-PS1-8, NJSLS:HS-ESS1-1,5,6, NJSLS:HS-ETS1-1,2,3,4

**Essential Questions:** “What kind of changes do nuclei undergo during nuclear reactions?” “How do nuclear reactions produce energy and how can that energy be used?”

**Performance Expectations:** (Students who demonstrate understanding can:)

NJSLS:HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

NJSLS:HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun’s core to release energy in the form of radiation.

NJSLS:HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

NJSLS:HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth’s formation and early history.

NJSLS:HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

NJSLS:HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

NJSLS:HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

NJSLS:HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

| Student Learning Objectives: (SLO) | | | Instructional Actions | |
|---|---|---|---|---|
| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS1.C: Nuclear Processes**<br><br>Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy.<br><br>The total number of neutrons plus protons does not change in any nuclear process.<br><br>**PS3.D: Energy in Chemical Processes and Everyday Life**<br><br>Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. | **Developing and Using Models**<br><br>Students develop models in which they identify and describe the relevant components of the models, including<br>● Identification of an element by the number of protons<br>● The number of protons and neutrons in the nucleus before and after the decay<br>● The identity of the emitted particles (i.e., alpha, beta — both electrons and positrons, and gamma)<br><br>Students develop five distinct models to illustrate the relationships between components underlying the nuclear processes of 1) fission, 2) fusion and 3) three distinct types of radioactive decay.<br><br>Students include the following features, based on evidence, in all five models:<br>● The total number of neutrons plus protons is the same both before and after the nuclear process, although the total number of protons and the total number of neutrons may be different before and after.<br><br>**Obtaining, Evaluating, and Communicating Information**<br><br>Develop a model based on evidence to illustrate the relationships between systems or between components of a system. | **Energy and Matter**<br>The scale of energy changes associated with nuclear processes, relative to the scale of energy changes associated with chemical processes.<br><br>**Energy and Matter**<br><br>In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.<br><br>The total amount of energy and matter in closed systems is conserved.<br><br>**Cause and Effect**<br><br>The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. | Nuclear Decay Activity<br><br>Conservation of Mass vs Matter Activity<br><br>Nucleus of an Atom Activity<br><br>Life Cycle of a Star Project/Webquest | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

**Common Core Standards Alignment**

| **ELA/Literacy** | **Mathematics** | **Technology** | **Career Ready Practice** |
|---|---|---|---|
| RST.9-10.7<br>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<br>RST.11-12.1<br>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 | MP.2<br>Reason abstractly and quantitatively.<br>MP.4 Model with mathematics.<br>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<br>HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.<br>HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities<br>HSA-SSE.A.1<br>Interpret expressions that represent a quantity in terms of its context.<br>HSA-CED.A.2<br>Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.<br>HSA-CED.A.4<br>Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings. |
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| Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021)<br><br>Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]<br>**Instructional Adjustments:**<br>Modifications, student difficulties, possible misunderstandings.<br><br>[Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, |

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| | and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.] |

## UNIT 9: SCIENTIFIC COMMUNICATION, NJSLS:HS-PS2-6, NJSLS:HS-ESS3-1,2,3,4,5,6

**Essential Questions:** “What underlying forces explain the variety of interactions observed?” “Why are some physical systems more stable than others?”

**Performance Expectations:** (Students who demonstrate understanding can:)

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

NJSLS:HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and [changes in] climate change have influenced human activity.

NJSLS:HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

NJSLS:HS-ESS3-3. Create a computational simulation to illustrate the relationship among management of natural resources, the sustainability of human populations, and biodiversity.

NJSLS:HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.

NJSLS:HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

NJSLS:HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change).

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

Develop a model that describes the relationship between the material’s function and its macroscopic properties.

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
|---|---|---|---|---|
| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS2.B: Type of Interactions**<br><br>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.<br><br>**ESS3.A: Natural Resources**<br>All forms of energy production and other resource extraction have associated economic, social, environmental, and | **Obtaining, Evaluating, and Communication Information**<br><br>Students identify and communicate the evidence for why molecular level structure is important in the functioning of designed materials, including:<br>● How the structure and properties of matter and the types of interactions of matter at the atomic scale determine the function of the chosen designed material(s); and<br>● How the material’s properties make it suitable for use in its designed function. | **Structure and Function**<br><br>Students explicitly identify the molecular structure of the chosen designed material(s) (using a representation appropriate to the specific type of communication — e.g., geometric shapes for drugs and receptors, ball and stick models for long-chained molecules). | Molecular Models<br><br>Conductivity of Materials<br><br>Intermolecular Forces | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

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| geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.<br><br>**ESS3.D: Global Climate Change**<br>Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. | 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.<br><br>**Using Mathematics and Computational Thinking**<br>Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.<br>● Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. | 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:<br>● Molecular level structure of the material;<br>● Intermolecular forces and polarity of molecules; and<br>● The ability of electrons to move relatively freely in metals.<br><br>Students describe the effects that attractive and repulsive electrical forces between molecules have on the arrangement (structure) of the chosen designed material(s) of molecules (e.g., solids, liquids, gases, network solid, polymers). | | |

**Common Core Standards Alignment**

| ELA/Literacy | Mathematics | Technology | Career Ready Practice |
|---|---|---|---|
| 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.<br>WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. | HSN-Q.A.1<br>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<br>HSN-Q.A.2<br>Define appropriate quantities for the purpose of descriptive modeling | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

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| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices<br><br>Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021) | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings.<br><br>[Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically |

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| Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.] |

## UNIT 10: ENERGY FLOW, NJSLS:HS-PS3-1, NJSLS:HS-ESS2-1,2,3,4

**Essential Question:** "How is energy transferred between states of matter?"

**Performance Expectations:** (Students who demonstrate understanding can:)

NJSLS: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.

NJSLS:HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

NJSLS:HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

NJSLS:HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

NJSLS:HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

Develop representations to explain the flow of energy in and out of a system
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| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
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| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS3.A: Definitions of Energy**<br><br>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.<br><br>**PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total | **Using Mathematics and Computational Thinking**<br><br>Students identify and describe the components to be computationally modeled, including:<br>● 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);<br>● 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 | **Systems and System Models**<br><br>Students 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.<br><br>Students use the computational model to predict the maximum possible change in the energy of one component of the system for a given set of energy flows.<br><br>Students identify and describe the limitations of the computational model, based on the assumptions that were made in creating the algebraic | Calorimetry<br><br>Potential Energy Diagrams<br><br>Exothermic/Endothermic Activity | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

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| 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. Mathematical expressions, which quantify 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. | description to calculate the total initial energy of the system;<br>● The energy flows in or out of the system, including a quantification in an algebraic description with flow into the system defined as positive; and<br>● The final energies of the system components, including a quantification in an algebraic description to calculate the total final energy of the system.<br>● Students use the algebraic descriptions of the initial and final energy state of the system, along with the energy flows to 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.<br>**Developing and Using Models**<br>**Planning and Carrying Out Investigations**<br>● models. 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. | descriptions of energy changes and flows in the system.<br><br>**Structure and function**<br>**Stability and Change**<br><br>**Systems and System Models**<br>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. | | |

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
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| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **ESS2.A: Earth Materials and Systems**<br><br>The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.<br><br>**ESS2.A: Earth Materials and Systems**<br><br>Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.<br><br>Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.<br><br>Current models predict that, although future regional climate changes will be complex and varied, | **Engaging in Argument from Evidence**<br>Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.<br>● Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).<br><br>**Analyzing and Interpreting Data**<br>Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.<br>● Analyze data using computational models in order to make valid and reliable scientific claims. | | | |

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| average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere.<br><br>**ESS2.C: The Roles of Water in Earth's Surface Processes**<br>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.<br><br>**ESS2.D: Weather and Climate**<br>The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation | | | | |

| Common Core Standards Alignment | | | |
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| **ELA/Literacy** | **Mathematics** | **Technology** | **Career Ready Practice** |
| SL.11-12.5<br>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.<br>RST.11-12.7<br>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.<br>RST.11-12.8<br>Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information<br>WHST.9-12.2<br>Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes<br>WHST.9-12.7<br>Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.<br>SL.11-12.5<br>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. | MP.2<br>Reason abstractly and quantitatively.<br>MP.4<br>Model with mathematics.<br>HSN-Q.A.1<br>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<br>HSN-Q.A.2<br>Define appropriate quantities for the purpose of descriptive modeling.<br>HSN-Q.A.3<br>Choose a level of accuracy appropriate to limitations on measurement when reporting quantities | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

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| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices<br><br>Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021) | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings.<br><br>[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the |

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| Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.] |

# UNIT 11: THERMOCHEMISTRY, NJSLS:HS-PS3-3, 3-4

**Essential Questions:** "How is energy transferred between objects or systems?"

**Performance Expectations:** (Students who demonstrate understanding can:)

NJSLS: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.

NJSLS: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).

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

Use representations to explain the changes in thermal energy of a system.

Design, build and evaluate a device that converts one form of energy into another.

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
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| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS3.A: Definitions of Energy**<br>● At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.<br><br>**PS3.B: Conservation of Energy and Energy Transfer**<br>● Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.<br>● 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). | **Planning and Carrying Out Investigations**<br>Students 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).<br>Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including:<br>● 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 | **Systems and System Models**<br>In the investigation plan, students describe:<br>● How a nearly closed system will be constructed, including the boundaries and initial conditions of the system;<br>● The data that will be collected, including masses of components and initial and final temperatures; and<br>● The experimental procedure, including how the data will be collected, the number of trials, the experimental setup, and equipment required.<br>**Energy and Matter**<br>● 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. | Calorimetry<br><br>Hess's Law<br><br>Battery Lab | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

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| **PS3.D: Energy in Chemical Processes**<br>Although energy cannot be destroyed, it can be converted to less useful forms<br>— for example, to thermal energy in the surrounding environment. | interaction of the hot and cold components; and the heat capacity of the components in the system (obtained from scientific literature).<br><br>Students collect and record data that can be used to calculate the change in thermal energy of each of the two components of the system.<br><br>Students evaluate their investigation, including:<br>● The accuracy and precision of the data collected, as well as the limitations of the investigation; and<br>● The ability of the data to provide the evidence required.<br><br>If necessary, students refine the plan to produce more accurate, precise, and useful data that address the experimental question.<br><br>Students 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.<br><br>**Constructing Explanations and Designing Solutions**<br><br>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. | | | |

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| | • Design and evaluate a device that converts one type of energy to another. | | | |

**Common Core Standards Alignment**

| ELA/Literacy | Mathematics | Technology | Career Ready Practice |
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| RST.11-12.1<br>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.<br>WHST.9-12.7<br>Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.<br>WHST.11-12.8<br>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.<br>WHST.9-12.9<br>Draw evidence from informational texts to support analysis, reflection, and research. | MP.2<br>Reason abstractly and quantitatively.<br>MP.4<br>Model with mathematics.<br>HSN-Q.A.1<br>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.<br>HSN-Q.A.2<br>Define appropriate quantities for the purpose of descriptive modeling.<br>HSN-Q.A.3<br>Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

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| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices<br><br>Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021)<br><br>Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings.<br><br>[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.] |

# UNIT 12: WAVES, NJSLS:HS-PS4-1

**Essential Questions:** "What is light?" "What other forms of electromagnetic radiate are there?"

**Performance Expectations:** (Students who demonstrate understanding can:)

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

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

Develop a model to explain the inverse relationship between wavelength and frequency

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
|---|---|---|---|---|
| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS4.A: Wave Properties**<br><br>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 | **Using Mathematical Computational Thinking**<br><br>Students identify and describe the relevant components in the mathematical representations:<br>● The relationships between frequency, wavelength, and speed of waves traveling in various specified media. | **Cause and Effect**<br><br>The relationship between wavelength and frequency are inversely proportional. | Spectroscopes<br><br>Discharge tubes | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

**Common Core Standards Alignment**

| **ELA/Literacy** | **Mathematics** | **Technology** | **Career Ready Practice** |
|---|---|---|---|
| RST.11-12.7<br>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. | MP.2<br>Reason abstractly and quantitatively.<br>MP.4<br>Model with mathematics. HSA-SSE.A.1<br>Interpret expressions that represent a quantity in terms of its context.)<br>HSA-SSE.B.3<br>Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.<br>HSA.CED.A.4<br>Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings. |
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| Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021)<br><br>Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | [Clarification Statement: Examples of data could include electromagnetic radiation traveling in space.[Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.] |

## UNIT 13: ELECTROMAGNETIC RADIATION, NJSLS:HS-PS4-3, NJSLS:HS-ESS1-2

**Essential Question:** "What are the characteristic properties and behaviors of waves?"

**Performance Expectations:** (Students who demonstrate understanding can:)

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

NJSLS:HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

Develop a model to explain the inverse relationship between wavelength and frequency

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
|---|---|---|---|---|
| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS4.A: Wave Properties**<br><br>[From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) | **Engaging in Argument from Evidence**<br><br>Students identify the given explanation that is to be supported by the claims, evidence, and reasoning to be evaluated, and that includes the following idea: Electromagnetic radiation can be described either by a wave model or a particle model, and for some situations one model is more useful than the other.<br><br>Students evaluate the phenomenon of the photoelectric effect to determine how it supports the argument that electromagnetic radiation can be described by a particle model. | **Systems and System Models Models (e.g., physical, mathematical, and computer models) can be used to simulate systems and interactions — including energy, matter and information flows — within and between systems at different scales.**<br><br>Simulations that describe and model photoelectric effect. | Spectroscopes<br><br>Discharge tubes<br><br>Flame Test | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

## UNIT 13: ELECTROMAGNETIC RADIATION, NJSLS:HS-PS4-3, NJSLS:HS-ESS1-2(CONT.)

| Common Core Standards Alignment | | | |
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| **ELA/Literacy** | **Mathematics** | **Technology** | **Career Ready Practice** |
| RST.9-10.8<br>Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem<br>RST.11-12.1<br>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<br>RST.11-12.8<br>Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information | MP.2<br>Reason abstractly and quantitatively<br>HSA-SSE.A.1<br>Interpret expressions that represent a quantity in terms of its context<br>HSA-SSE.B.3<br>Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.<br>HSA.CED.A.4<br>Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

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| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices<br><br>Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021)<br><br>Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | **Instructional Adjustments:**<br>Modifications, student difficulties, possible misunderstandings.<br><br>[Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [Assessment Boundary: Assessment does not include using quantum theory.] |

## UNIT 14: RADIATION AND MATTER, NJSLS:HS-PS4-4, NJSLS:HS-ESS1-2

**Essential Questions:** “How is frequency related to wavelength?” “How is radiant energy from different parts of the electromagnetic spectrum used?”

**Performance Expectations:** (Students who demonstrate understanding can:)

NJSLS:HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

NJSLS:HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

**Unit Assessment:** (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

Develop a model depicting the penetration of various electromagnetic radiation.

Students construct an explanation that includes a description* of how astronomical evidence from numerous sources is used collectively to support the Big Bang theory, which states that the universe is expanding and that thus it was hotter and denser in the past, and that the entire visible universe emerged from a very tiny region and expanded.

| **Student Learning Objectives:** (SLO) | | | **Instructional Actions** | |
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| **Disciplinary Core Ideas** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Activities/Strategies** Technology Implementation/ Interdisciplinary Connections | **Assessment Check Points** |
| **PS4.B: Electromagnetic Radiation**<br><br>When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.<br><br>**ESS1.A: The Universe and Its Stars**<br><br>The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. . | **Obtaining, Evaluating, and Communicating Information**<br><br>Students use reasoning about the data presented, including the energies of the photons involved (i.e., relative wavelengths) and the probability of ionization, to analyze the validity and reliability of each claim**.**<br><br>**Obtaining, Evaluating, and Communicating Information**<br><br>Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in | **Cause and Effect**<br><br>Students describe the cause and effect of a particular wavelength of radiation on a single cell to the effect of that wavelength on the entire organism.<br><br>**Cause and Effect**<br><br>Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems.<br><br>Scientific knowledge is based on the assumption that natural laws operate today as they did in the | Sun Screen Article<br><br>Electromagnetic Penetration Simulation<br><br>Sizing up the Stars | Quizzes<br><br>Tests<br><br>Homework<br><br>Labs<br><br>Projects |

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| Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.<br><br>**ESS1.A: The Universe and Its Stars**<br><br>The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. .<br><br>Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.<br><br>**ESS1.B: Earth and the Solar System**<br>Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. | the past and will continue to do so in the future.<br><br>A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.<br><br>**Obtaining, Evaluating, and Communicating Information**<br><br>Communicate scientific ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).<br>A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.<br><br>**Developing and Using Models**<br>Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their | past and they will continue to do so in the future.<br><br>Science assumes the universe is a vast single system in which basic laws are consistent.<br><br>**Cause and Effect**<br><br>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.<br><br>**Structure and Function**<br>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.<br><br>**Stability and Change**<br>Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system chances are irreversible. | | |

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| | components in the natural and designed world(s).<br>● Use a model to provide mechanistic accounts of phenomena.<br>**Planning and Carrying Out Investigations**<br>Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical | | | |

**Common Core Standards Alignment**

| ELA/Literacy | Mathematics | Technology | Career Ready Practice |
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| RST.9-10.8<br>Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem<br>RST.11-12.1<br>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<br>RST.11-12.7<br>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.<br>RST.11-12.8<br>Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information<br>WHST.9-12.2<br>Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes | MP.2<br>Reason abstractly and quantitatively<br>MP.4<br>Model with mathematics.<br>HSN-Q.A.1<br>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.<br>HSN-Q.A.2<br>Define appropriate quantities for the purpose of descriptive modeling.<br>HSN-Q.A.3<br>Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.<br>HSA-SSE.A.1<br>Interpret expressions that represent a quantity in terms of its context.<br>HSA-CED.A.2<br>Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.<br>HSA-CED.A.4<br>Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. | 8.1.12.A.3<br>Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. | CRP4.<br>Communicate clearly and effectively and with reason.<br>CRP8.<br>Utilize critical thinking to make sense of problems and persevere in solving them. |

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| WHST.11-12.8<br>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 | | | |

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| **Resources:** Essential Materials, Supplementary Materials, Links to Best Practices<br><br>Level 2: Experience Chemistry (Pearson, 2021)<br><br>Level 1: Experience Chemistry (Pearson, 2021)<br><br>Honors: Chemistry: Matter and Change (McGraw Hill, 2017)<br><br>Discovery Techbook-Chemistry<br><br>Gizmos | **Instructional Adjustments:** Modifications, student difficulties, possible misunderstandings.<br><br>[Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. [Assessment Boundary: Assessment is limited to qualitative descriptions.]<br><br>[Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from spectra of electromagnetic radiation from stars, which matches that predicted by the Big Bang theory (3/4 hydrogen and ¼ helium).]<br><br>[Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.]<br>[Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.] |