Science Department
Chemistry Curriculum

Developed By: Christine Polk
Effective Date: Fall 2019, Revised July 2021 Climate Change

Standards in Action: Climate Change Earth's climate is now changing faster than at any point in the history of modern civilization, primarily as a result of human activities. Global climate change has already resulted in a wide range of impacts across New Jersey and in many sectors of its economy. The addition of academic standards that focus on climate change is important so that all students will have a basic understanding of the climate system, including the natural and human-caused factors that affect it. The underpinnings of climate change span across physical, life, as well as Earth and space sciences. The goal is for students to understand climate science as a way to inform decisions that improve quality of life for themselves, their community, and globally and to know how engineering solutions can allow us to mitigate impacts, adapt practices, and build resilient systems. The topic of climate change can easily be integrated into science classes. At each grade level in which systems thinking, managing uncertainty, and building arguments based on multiple lines of data are included, there are opportunities for students to develop essential knowledge and skills that will help them understand the impacts of climate change on humans, animals, and the environment. For example, in the earlier grades, students can use data from first hand investigations of the school-yard habitat to justify recommendations for design improvements to the school-yard habitat for plants, animals, and humans. In the middle grades, students use resources from New Jersey Department of Environmental Protection, the National Oceanic and Atmospheric Administration (NOAA), and National Aeronautics and Space Administration (NASA), to inform their actions as they engage in designing, testing, and modifying an engineered solution to mitigate the impact of climate change on their community. In high school, students can construct models they develop of a proposed solution to mitigate the negative health effects of unusually high summer temperatures resulting from heat islands in cities across the globe and share in the appropriate setting. (NJDOE, Standards Draft Approval, 2020)

Scope and Sequence

Days	Unit	Topics	Standards
25	1 Atomic Origins	• Elements from stars • Atomic structure • Nuclear reactions • Electron configurations • Periodic trends	PS 1-8 ESS 1-3 ESS 1-1 ESS 1-2 ESS 1-6 PS 1-1
24	2 Bonds	• Bond types • Ionic bonds • Covalent bonds • Electrical forces (IFs)	PS 1-2 PS 1-3 PS 2-6 ETS 1-3 ETS 1-4

45	3 Reactions	• Balancing • Types • Moles and dimensional analysis • Composition and formulas • Stoichiometry • Gas laws • Reaction rate • Reversible reactions	PS 1-7 PS 1-4 PS 1-5 PS 1-6 ETS 1-2
30	4 Energy	• Energy transfer and specific heat • Phase changes • Thermochemistry • Water properties • Solubility and concentration • Photosynthesis and cellular respiration • Real-world issues: ○ EPA regulations ○ Mineral resources	PS 3-4 ESS 2-5 ESS 3-2 ETS 1-3 LS 1-5 LS 1-7 LS 1-6
20	5 Human Impact: Chemistry of Sustainability *Climate Change Connection	• Carbon cycle • Climate change causes • Climate change solutions	ESS 2-4 ESS 2-6 ETS 1-1 ETS 1-2 ETS 1-3 ETS 1-4

Unit 1	
Atomic Origins	
Summary and Rationale	
This unit focuses on the origins of chemistry. Chemical evidence supports the Big Bang theory, and chemical methods are used to determine the composition of matter in the universe. The life cycle of stars includes production of the elements as well as the production of energy that reaches Earth as radiation. Equations for nuclear reactions help describe how elements are made in stars, and the decay of radioactive elements in meteorites and ancient Earth materials indicate the age of the Earth and the universe. Atomic structure is a component of nuclear equations. Electron configurations of different elements are the basis for chemical analysis of matter in the universe. The periodic table reflects the atomic structure of the elements, allowing it to be used to predict properties of elements.	
Recommended Pacing	
25 days	
Standards	
HS-ESS1 Earth's Place in the Universe	
ESS 1-1	Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the the sun's core to release energy that eventually reaches Earth in the form of radiation. [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, and non-cyclic variations over centuries.] [Assessment does not include details of the atomic and subatomic processes involved with the sun's nuclear fusion.]
ESS 1-2	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. [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 the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]
ESS 1-3	Communicate scientific ideas about the way stars, over their life cycle, produce elements. [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.] [Details of the many different nucleosynthesis pathways for stars of different masses are not assessed.]
ESS 1-6	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. [Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]
PS 1-8	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. [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 is limited to alpha, beta, and gamma radioactive decays.]
PS 1-1	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. [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 is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8) • Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) **Planning and Carrying Out Investigations** 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 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. (HS-PS1-3) **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9–12 level builds on K–8 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. • Use mathematical representations of phenomena to support claims. (HS-PS1-7) **Constructing Explanations and Designing Solutions** 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. • Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) • Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)	**PS1.A: Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2) • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3), *(secondary to HS-PS2-6)* • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4) **PS1.B: Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5) • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6) • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7) **PS1.C: Nuclear Processes** • Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8) **PS2.B: Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary to HS-PS1-1), (secondary to HS-PS1-3)* **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary to HS-PS1-6)*	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5) **Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8) • The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6) - - - - - - - - - - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

Interdisciplinary Connections

NJSLSA.R1	Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
NJSLSA.R2	Determine the central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
RI.11-12.1 RI.9-10.1	Accurately cite strong and thorough textual evidence, (e.g., via discussion, written response, etc.), to support analysis of what the text says explicitly as well as inferentially, including determining where the text leaves matters uncertain.

NJSLSA.W1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
Integration of Technology	
8.1	All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and create and communicate knowledge.
8.2	All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
Career Readiness, Life Literacies and Key Skills	
9.1.12.CFR.3	Research companies with corporate governance policies supporting the common good and human rights.
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
9.4.12.CT.1	Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).
9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2).
9.4.12.IML.6	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 (e.g., NJSLSA.SL5).
9.4.12.IML.7	Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change (e.g., NJSLSA.W1, 7.1.AL.PRSNT.4).
American Association for the Advancement of Science: http://www.aaas.org/programs American Chemical Society: http://www.acs.org/content/acs/en/education.html Concord Consortium: Virtual Simulations: http://concord.org/ International Technology and Engineering Educators Association: http://www.iteaconnect.org/ National Earth Science Teachers Association: http://www.nestanet.org/php/index.php National Science Digital Library: https://nsdl.oercommons.org/ National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx North American Association for Environmental Education: http://www.naaee.net/ Phet: Interactive Simulations https://phet.colorado.edu/	

Science NetLinks: http://www.aaas.org/program/science-netlinks

Tier 1 Modifications and Accommodations

Including special education students, Multilingual Language Learners (MLLs), students at risk of school failure, gifted and talented students, and students with 504 plans;

Teachers can choose from any of the suggested modifications that follow based upon teaching style, instructional method and needs of individual students.

General Modifications for students struggling to learn:

- Focus on building relationships in the classroom.
- Control the stressors for the student and manage alternate pathways for completion of assignments.
- Provide feedback utilizing a growth mindset and praise what is done correctly based upon effort, attitude and strategy.
- Boost engagement with material by providing opportunities of differentiation, group work and alternative assignments/assessments where appropriate.

MLL

- Provide additional wait time for student responses to questions to allow students the ability to undergo the process of translation between languages, composition of response and attempted response.
- Simplification of sentence structure and repetition of questions/sentences exactly as stated before trying to rephrase to allow MLL students to hear the sentence and try to comprehend it.
- Rephrase idioms and teach their meanings as when learning a new language, translations are often very literal. IE "Take a stab at it." Ensure students understand what is meant.
- Use directed reading activities. Ensure preview of text before assigned/read, provide pre-reading questions about the main idea and offer help utilizing key words.
- Allow the use of Google Translate where appropriate.
- Utilize bilingual reading texts provided by the STC program.

G/T

Utilize differentiation in the areas of acceleration, enrichment, and grouping. Examples include, but are not limited to:

- interdisciplinary and problem-based assignments with planned scope and sequence
- advance, accelerated, or compacted content
- abstract and advanced higher-level thinking
- allowance for individual student interests
- assignments geared to development in areas of affect, creativity, cognition, and research skills
- complex, in-depth assignments
- diverse enrichment that broadens learning
- variety in types of resources
- internships, mentorships and independent study where applicable

504/IEP

Modifications and accommodations must be aligned to stated plan and uphold expectations of the plan lawfully. Every student requires a different set of accommodations based upon need. Examples specific to science practice include, but are not limited to:

- Note taker or lab assistant
- Group lab assignments
- Use of scribe
- Adjustable tables and lab equipment within reach

- Classrooms, labs and field trips in accessible locations
- Additional time and separate room for test taking
- Additional time for in-class assignments
- Additional time in lab
- Visual and tactile instructional demonstrations
- Computer with voice output, spelling and grammar checker
- Seating in the front of the class
- Tactile drawings and graphs, and three-dimensional models
- Assignments in electronic format
- Large-print handouts, lab signs and equipment labels
- TV monitor connected to microscope to enlarge images
- Computer equipped to enlarge screen characters and images
- Auditory lab warning signals
- Adaptive lab equipment (talking calculators, talking thermometers, light probes, tactile timers)
- Staples on sticks to indicate units of measurement
- Visual warning system for lab emergencies

Career Readiness, Life Literacies, and Key Skills NJSLS

Please select all standards that apply to this unit of study:

- ❑ Act as a responsible and contributing citizen and employee.
- ❑ Apply appropriate academic and technical skills.
- ❑ Attend to personal health and financial well being.
- ❑ Communicate clearly and effectively and with reason.
- ❑ Consider the environmental social and economic impacts of decisions.
- ❑ Demonstrate creativity and innovation.
- ❑ Employ valid and reliable research strategies.
- ❑ Utilize critical thinking to make sense of problems and persevere in solving them.
- ❑ Model integrity, ethical leadership, and effective management.
- ❑ Plan education and career paths aligned to personal goals.
- ❑ Use technology to enhance productivity.
- ❑ Work productively in teams while using cultural global competence.

Suggestions on integrating these standards can be found at: https://www.nj.gov/education/standards/clicks/

LINKS TO CAREERS:

https://www.mendeley.com/careers/article/top-10-chemistry-jobs/

Unit 2	
Bonds	
Summary and Rationale	
The periodic table organizes the elements according to the underlying atomic structure that gives rise to the properties of elements. This unit focuses on how the atomic structure of elements can be used to predict the type and strength of bonds that can form between atoms of the same or different elements. Bond type and molecular structure, in turn, are used to predict properties of materials, and to design materials for a particular function.	
Recommended Pacing	
24 days	
Standards	
PS 1-3	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. [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 does not include Raoult's law calculations of vapor pressure.]
PS 2-6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* [Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically 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 is limited to provided molecular structures of specific designed materials.]
ETS 1-3	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.
ETS 1-4	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.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical and empirical 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. (HS-PS2-5) **Analyzing and Interpreting Data** Analyzing data in 9–12 builds on K–8 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. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1) **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9–12 level builds on K–8 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. • Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Constructing Explanations and Designing Solutions** 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. • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) - ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Theories and laws provide explanations in science. (HS-PS2-1),(HS-PS2-4) • Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)	**PS1.A: Structure and Properties of Matter** • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (secondary to HS-PS2-6) **PS2.A: Forces and Motion** • Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1) • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2) • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3) **PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4),(HS-PS2-5) • 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. (HS-PS2-6),*(secondary to HS-PS1-1)*,*(secondary to HS-PS1-3)* **PS3.A: Definitions of Energy** • "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. *(secondary to HS-PS2-5)* **ETS1.A: Defining and Delimiting an Engineering Problem** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. *(secondary to HS-PS2-3)* **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary to HS-PS2-3)*	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1), (HS-PS2-5) • Systems can be designed to cause a desired effect. (HS-PS2-3) **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2) **Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)

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9.4.12.CT.1	Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).
9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
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American Association for the Advancement of Science: http://www.aaas.org/programs American Chemical Society: http://www.acs.org/content/acs/en/education.html Concord Consortium: Virtual Simulations: http://concord.org/ International Technology and Engineering Educators Association: http://www.iteaconnect.org/ National Earth Science Teachers Association: http://www.nestanet.org/php/index.php	

National Science Digital Library: https://nsdl.oercommons.org/
National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx
North American Association for Environmental Education: http://www.naaee.net/
Phet: Interactive Simulations https://phet.colorado.edu/
Science NetLinks: http://www.aaas.org/program/science-netlinks

www.acs.org/content/acs/en/education/resources/highschool/chemmatters.html

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MLL

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- Rephrase idioms and teach their meanings as when learning a new language, translations are often very literal. IE “Take a stab at it.” Ensure students understand what is meant.
- Use directed reading activities. Ensure preview of text before assigned/read, provide pre-reading questions about the main idea and offer help utilizing key words.
- Allow the use of Google Translate where appropriate.
- Utilize bilingual reading texts provided by the STC program.

G/T

Utilize differentiation in the areas of acceleration, enrichment, and grouping. Examples include, but are not limited to:

- interdisciplinary and problem-based assignments with planned scope and sequence
- advance, accelerated, or compacted content
- abstract and advanced higher-level thinking
- allowance for individual student interests
- assignments geared to development in areas of affect, creativity, cognition, and research skills
- complex, in-depth assignments
- diverse enrichment that broadens learning
- variety in types of resources
- internships, mentorships and independent study where applicable

504/IEP

Modifications and accommodations must be aligned to stated plan and uphold expectations of the plan lawfully. Every student requires a different set of accommodations based upon need. Examples specific to science practice include, but are not limited to:

- Note taker or lab assistant

- Group lab assignments
- Use of scribe
- Adjustable tables and lab equipment within reach
- Classrooms, labs and field trips in accessible locations
- Additional time and separate room for test taking
- Additional time for in-class assignments
- Additional time in lab
- Visual and tactile instructional demonstrations
- Computer with voice output, spelling and grammar checker
- Seating in the front of the class
- Tactile drawings and graphs, and three-dimensional models
- Assignments in electronic format
- Large-print handouts, lab signs and equipment labels
- TV monitor connected to microscope to enlarge images
- Computer equipped to enlarge screen characters and images
- Auditory lab warning signals
- Adaptive lab equipment (talking calculators, talking thermometers, light probes, tactile timers)
- Staples on sticks to indicate units of measurement
- Visual warning system for lab emergencies

Career Readiness, Life Literacies, and Key Skills NJSLS

Please select all standards that apply to this unit of study:

- ❏ Act as a responsible and contributing citizen and employee.
- ❏ Apply appropriate academic and technical skills.
- ❏ Attend to personal health and financial well being.
- ❏ Communicate clearly and effectively and with reason.
- ❏ Consider the environmental social and economic impacts of decisions.
- ❏ Demonstrate creativity and innovation.
- ❏ Employ valid and reliable research strategies.
- ❏ Utilize critical thinking to make sense of problems and persevere in solving them.
- ❏ Model integrity, ethical leadership, and effective management.
- ❏ Plan education and career paths aligned to personal goals.
- ❏ Use technology to enhance productivity.
- ❏ Work productively in teams while using cultural global competence.

Suggestions on integrating these standards can be found at: https://www.nj.gov/education/standards/clicks/

LINKS TO CAREERS:

https://www.mendeley.com/careers/article/top-10-chemistry-jobs/

Unit 3	
Reactions	
Summary and Rationale	
Atoms, and therefore mass, are conserved in chemical reactions. The mole concept makes quantitative analysis of reactants and products possible. Rates of reactions, and properties of gases, are affected by temperature and concentration, and can be understood in terms of Kinetic Molecular (collision) theory. Reversible chemical reactions can be manipulated to produce more products or more reactants by changing reaction conditions.	
Recommended Pacing	
45 days	
Standards	
PS 1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment does not include complex chemical reactions.]
PS 1-4	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. [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 does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]
PS 1-5	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. [Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [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.]
PS 1-6	Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* [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 is limited to specifying the change in only one variable at a time. Assessment does not

	include calculating equilibrium constants and concentrations.]
ETS 1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

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

Planning and Carrying Out Investigations
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 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. (HS-PS1-3)

Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 9–12 level builds on K–8 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.

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

Constructing Explanations and Designing Solutions
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.

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)
- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2)
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3), *(secondary to HS-PS2-6)*
- A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)

PS1.B: Chemical Reactions

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5)
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7)

PS1.C: Nuclear Processes

- Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8)

PS2.B: Types of Interactions

- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary to HS-PS1-1), (secondary to HS-PS1-3)*

ETS1.C: Optimizing the Design Solution

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary to HS-PS1-6)*

Crosscutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)

Energy and Matter

- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)
- The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)
- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4)

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

Connections to other DCIs in this grade-band:

Career Readiness, Life Literacies and Key Skills	
9.1.12.CFR.3	Research companies with corporate governance policies supporting the common good and human rights.

9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
9.4.12.CT.1	Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).
9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
9.4.12.IML.5	Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2).
9.4.12.IML.6	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 (e.g., NJSLSA.SL5).
9.4.12.IML.7	Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change (e.g., NJSLSA.W1, 7.1.AL.PRSNT.4).

Instructional Focus

Enduring Understandings:	**Essential Questions:**
The total amount of energy and matter in a chemical reaction system is conserved. The amount of energy in a chemical reaction can be described in terms of collisions of molecules and rearrangement of atoms into new molecules. A stable molecule has less energy than the same set of atoms separated.	Why do we balance equations for chemical reactions? Why is energy released (or absorbed) in reactions? What determines how fast a reaction occurs? How can the amount of product formed by a reaction be controlled?

Evidence of Learning (Assessments)

Multiple formative assessments
Laboratory write ups
Unit assessment: Bonds

Objectives (SLO)

Students will know:	Students will be able to:
The fact that atoms are conserved, together with the knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. There are patterns of chemical reactivity that help predict the products of a reaction. Balanced equations show proportional relationships between reactants and products at atomic and macroscopic scales. Analysis of units is a powerful calculation technique. Stoichiometry relates the proportional relationships between reactants and products to the masses of reactants and products. Gases respond to changing conditions in predictable, proportional ways. 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 rearrangement 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. Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Patterns in the effects of changing the temperature or concentration of the reacting particles can be used to provide evidence for causality in the rate at which a reaction occurs. Much of science deals with constructing explanations of how things change and how they remain stable. 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. 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 may be needed.	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. 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. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Suggested Resources/Technology Tools

American Association for the Advancement of Science: http://www.aaas.org/programs
American Chemical Society: http://www.acs.org/content/acs/en/education.html
Concord Consortium: Virtual Simulations: http://concord.org/
International Technology and Engineering Educators Association: http://www.iteaconnect.org/
National Earth Science Teachers Association: http://www.nestanet.org/php/index.php
National Science Digital Library: https://nsdl.oercommons.org/

National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx
North American Association for Environmental Education: http://www.naaee.net/
Phet: Interactive Simulations https://phet.colorado.edu/
Science NetLinks: http://www.aaas.org/program/science-netlinks

Tier 1 Modifications and Accommodations

Including special education students, Multilingual Language Learners (MLLs), students at risk of school failure, gifted and talented students, and students with 504 plans;

Teachers can choose from any of the suggested modifications that follow based upon teaching style, instructional method and needs of individual students.

General Modifications for students struggling to learn:

- Focus on building relationships in the classroom.
- Control the stressors for the student and manage alternate pathways for completion of assignments.
- Provide feedback utilizing a growth mindset and praise what is done correctly based upon effort, attitude and strategy.
- Boost engagement with material by providing opportunities of differentiation, group work and alternative assignments/assessments where appropriate.

MLL

- Provide additional wait time for student responses to questions to allow students the ability to undergo the process of translation between languages, composition of response and attempted response.
- Simplification of sentence structure and repetition of questions/sentences exactly as stated before trying to rephrase to allow MLL students to hear the sentence and try to comprehend it.
- Rephrase idioms and teach their meanings as when learning a new language, translations are often very literal. IE “Take a stab at it.” Ensure students understand what is meant.
- Use directed reading activities. Ensure preview of text before assigned/read, provide pre-reading questions about the main idea and offer help utilizing key words.
- Allow the use of Google Translate where appropriate.
- Utilize bilingual reading texts provided by the STC program.

G/T

Utilize differentiation in the areas of acceleration, enrichment, and grouping. Examples include, but are not limited to:

- interdisciplinary and problem-based assignments with planned scope and sequence
- advance, accelerated, or compacted content
- abstract and advanced higher-level thinking
- allowance for individual student interests
- assignments geared to development in areas of affect, creativity, cognition, and research skills
- complex, in-depth assignments
- diverse enrichment that broadens learning
- variety in types of resources
- internships, mentorships and independent study where applicable

504/IEP

Modifications and accommodations must be aligned to stated plan and uphold expectations of the plan lawfully. Every student requires a different set of accommodations based upon need. Examples specific to science practice include, but are not limited to:

- Note taker or lab assistant
- Group lab assignments
- Use of scribe
- Adjustable tables and lab equipment within reach

- Classrooms, labs and field trips in accessible locations
- Additional time and separate room for test taking
- Additional time for in-class assignments
- Additional time in lab
- Visual and tactile instructional demonstrations
- Computer with voice output, spelling and grammar checker
- Seating in the front of the class
- Tactile drawings and graphs, and three-dimensional models
- Assignments in electronic format
- Large-print handouts, lab signs and equipment labels
- TV monitor connected to microscope to enlarge images
- Computer equipped to enlarge screen characters and images
- Auditory lab warning signals
- Adaptive lab equipment (talking calculators, talking thermometers, light probes, tactile timers)
- Staples on sticks to indicate units of measurement
- Visual warning system for lab emergencies

Career Readiness, Life Literacies, and Key Skills NJSLS

Please select all standards that apply to this unit of study:

- ❏ Act as a responsible and contributing citizen and employee.
- ❏ Apply appropriate academic and technical skills.
- ❏ Attend to personal health and financial well being.
- ❏ Communicate clearly and effectively and with reason.
- ❏ Consider the environmental social and economic impacts of decisions.
- ❏ Demonstrate creativity and innovation.
- ❏ Employ valid and reliable research strategies.
- ❏ Utilize critical thinking to make sense of problems and persevere in solving them.
- ❏ Model integrity, ethical leadership, and effective management.
- ❏ Plan education and career paths aligned to personal goals.
- ❏ Use technology to enhance productivity.
- ❏ Work productively in teams while using cultural global competence.

Suggestions on integrating these standards can be found at: https://www.nj.gov/education/standards/clicks/

LINKS TO CAREERS:

https://www.mendeley.com/careers/article/top-10-chemistry-jobs/

Unit 4	
Energy	
Summary and Rationale	
Energy is a quantitative property that depends on the motion and interactions of matter and radiation in a system. The total change of energy in any system is equal to the total energy transferred into or out of the system. A system can be global (weather, hydrologic cycles), a reaction that releases or absorbs energy, or as simple as two water samples at different temperatures mixed together. Energy from the sun is converted through photosynthesis to energy that organisms use to form macromolecules such as proteins and nucleic acids.	
Recommended Pacing	
30 days	
Standards	
PS 3-4	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). [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 is limited to investigations based on materials and tools provided to students.]
ESS 2-5	Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]
ESS 3-2	Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]
ETS 1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. [See Three-Dimensional Teaching and Learning Section for

	examples].
LS 1-5	Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment does not include specific biochemical steps.]
LS 1-6	Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Emphasis is on using evidence from models and simulations to support explanations.] [Assessment does not include the details of the specific chemical reactions or identification of macromolecules.]
LS 1-7	Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy. [Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment should not include identification of the steps or specific processes involved in cellular respiration.]

Science and Engineering Practices

Developing and Using Models
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 components in the natural and designed world(s).

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS1-1)

Using Mathematical and Computational Thinking
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.

- Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4)

Constructing Explanations and Designing Solutions
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.

- 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 the past and will continue to do so in the future. (HS-ESS1-2)
- Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6)

Engaging in Argument from Evidence
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 the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5)

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- 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). (HS-ESS1-3)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- 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. (HS-ESS1-2),(HS-ESS1-6)
- Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6)

Disciplinary Core Ideas

ESS1.A: The Universe and Its Stars

- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1)
- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)
- The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2)
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2),(HS-ESS1-3)

ESS1.B: Earth and the Solar System

- Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)

ESS1.C: The History of Planet Earth

- Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5)
- Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6)

ESS2.B: Plate Tectonics and Large-Scale System Interactions

- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. *(ESS2.B Grade 8 GBE) (secondary to HS-ESS1-5)*

PS1.C: Nuclear Processes

- Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. *(secondary to HS-ESS1-5), (secondary to HS-ESS1-6)*

PS3.D: Energy in Chemical Processes and Everyday Life

- Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. *(secondary to HS-ESS1-1)*

PS4.B: Electromagnetic Radiation

- Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. *(secondary to HS-ESS1-2)*

Crosscutting Concepts

Patterns

- Empirical evidence is needed to identify patterns. (HS-ESS1-5)

Scale, Proportion, and Quantity

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)
- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4)

Energy and Matter

- Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3)

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)

Connections to Engineering, Technology,
and Applications of Science

Interdependence of Science, Engineering, and Technology

- Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2),(HS-ESS1-4)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2)
- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)

Interdisciplinary Connections

NJSLSA.R1	Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
NJSLSA.R2	Determine the central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
RI.11-12.1 RI.9-10.1	Accurately cite strong and thorough textual evidence, (e.g., via discussion, written response, etc.), to support analysis of what the text says explicitly as well as inferentially, including determining where the text leaves matters uncertain.
NJSLSA.W1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
Integration of Technology	
8.1	All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and create and communicate knowledge.
8.2	All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
Career Readiness, Life Literacies and Key Skills	
9.1.12.CFR.3	Research companies with corporate governance policies supporting the common good and human rights.
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
9.4.12.CT.1	Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).
9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
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National Science Digital Library: https://nsdl.oercommons.org/
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North American Association for Environmental Education: http://www.naaee.net/
Phet: Interactive Simulations https://phet.colorado.edu/
Science NetLinks: http://www.aaas.org/program/science-netlinks

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Including special education students, Multilingual Language Learners (MLLs), students at risk of school failure, gifted and talented students, and students with 504 plans;

Teachers can choose from any of the suggested modifications that follow based upon teaching style, instructional method and needs of individual students.

General Modifications for students struggling to learn:

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- Provide feedback utilizing a growth mindset and praise what is done correctly based upon effort, attitude and strategy.
- Boost engagement with material by providing opportunities of differentiation, group work and alternative assignments/assessments where appropriate.

MLL

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- Rephrase idioms and teach their meanings as when learning a new language, translations are often very literal. IE “Take a stab at it.” Ensure students understand what is meant.
- Use directed reading activities. Ensure preview of text before assigned/read, provide pre-reading questions about the main idea and offer help utilizing key words.
- Allow the use of Google Translate where appropriate.
- Utilize bilingual reading texts provided by the STC program.

G/T

Utilize differentiation in the areas of acceleration, enrichment, and grouping. Examples include, but are not limited to:

- interdisciplinary and problem-based assignments with planned scope and sequence
- advance, accelerated, or compacted content
- abstract and advanced higher-level thinking
- allowance for individual student interests
- assignments geared to development in areas of affect, creativity, cognition, and research skills
- complex, in-depth assignments
- diverse enrichment that broadens learning

- variety in types of resources
- internships, mentorships and independent study where applicable

504/IEP

Modifications and accommodations must be aligned to stated plan and uphold expectations of the plan lawfully. Every student requires a different set of accommodations based upon need. Examples specific to science practice include, but are not limited to:

- Note taker or lab assistant
- Group lab assignments
- Use of scribe
- Adjustable tables and lab equipment within reach
- Classrooms, labs and field trips in accessible locations
- Additional time and separate room for test taking
- Additional time for in-class assignments
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- Adaptive lab equipment (talking calculators, talking thermometers, light probes, tactile timers)
- Staples on sticks to indicate units of measurement
- Visual warning system for lab emergencies

Career Readiness, Life Literacies, and Key Skills NJSLS

Please select all standards that apply to this unit of study:

- ❑ Act as a responsible and contributing citizen and employee.
- ❑ Apply appropriate academic and technical skills.
- ❑ Attend to personal health and financial well being.
- ❑ Communicate clearly and effectively and with reason.
- ❑ Consider the environmental social and economic impacts of decisions.
- ❑ Demonstrate creativity and innovation.
- ❑ Employ valid and reliable research strategies.
- ❑ Utilize critical thinking to make sense of problems and persevere in solving them.
- ❑ Model integrity, ethical leadership, and effective management.
- ❑ Plan education and career paths aligned to personal goals.
- ❑ Use technology to enhance productivity.
- ❑ Work productively in teams while using cultural global competence.

Suggestions on integrating these standards can be found at: https://www.nj.gov/education/standards/clicks/

LINKS TO CAREERS:
https://www.mendeley.com/careers/article/top-10-chemistry-jobs/

Unit 5	
Human Impact: Chemistry of Sustainability	
Summary and Rationale	
Climate change is the “major global challenge” [ETS 1-1] and “complex real-world problem” [ETS 1-3] of our day. This unit begins with an examination of the flow of energy into and out of Earth’s systems. Geochemical data can be used to describe effects on climate by different causes, over different time scales. The cycling of carbon through the hydrosphere, atmosphere, geosphere and biosphere has been affected by human activity, and can be studied empirically. Topics from previous units (energy flow, combustion reactions, properties of water, behavior of gases, etc.) are synthesized to understand climate change. Strategies from engineering are used to propose and evaluate potential solutions.	
Recommended Pacing	
20 days	
Standards	
ESS 2-4	Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate. [Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruptions, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]
ESS 2-6	Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]
ETS 1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
ETS 1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
ETS 1-3	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.
ETS 1-4	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.

Science and Engineering Practices

Developing and Using Models
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 components in the natural and designed world(s).

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-1),(HS-ESS2-3),(HS-ESS2-6)
- Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4)

Planning and Carrying Out Investigations
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 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. (HS-ESS2-5)

Analyzing and Interpreting Data
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.

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2)

Engaging in Argument from Evidence
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 the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Construct an oral and written argument or counter-arguments based on data and evidence. (HS-ESS2-7)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence. (HS-ESS2-3)
- Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (HS-ESS2-3)
- Science includes the process of coordinating patterns of evidence with current theory. (HS-ESS2-3)
- Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4)

Disciplinary Core Ideas

ESS1.B: Earth and the Solar System

- 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. *(secondary to HS-ESS2-4)*

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1),(HS-ESS2-2)
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)
- 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. (HS-ESS2-4)

ESS2.B: Plate Tectonics and Large-Scale System Interactions

- The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3)
- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)* (HS-ESS2-1)

ESS2.C: The Roles of Water in Earth's Surface Processes

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2)(HS-ESS2-4)
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6),(HS-ESS2-7)
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6),(HS-ESS2-4)

ESS2.E Biogeology

- The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS-ESS2-7)

PS4.A: Wave Properties

- Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-3)

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)

Energy and Matter

- The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6)
- Energy drives the cycling of matter within and between systems. (HS-ESS2-3)

Structure and Function

- 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. (HS-ESS2-5)

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7)
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1)
- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology

- Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS2-3)

Influence of Engineering, Technology, and Science on Society and the Natural World

- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS2-2)

Interdisciplinary Connections	
NJSLSA.R1	Read closely to determine what the text says explicitly and to make logical inferences and relevant connections from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
NJSLSA.R2	Determine the central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
RI.11-12.1 RI.9-10.1	Accurately cite strong and thorough textual evidence, (e.g., via discussion, written response, etc.), to support analysis of what the text says explicitly as well as inferentially, including determining where the text leaves matters uncertain.
NJSLSA.W1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
Integration of Technology	
8.1	All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and create and communicate knowledge.
8.2	All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
Career Readiness, Life Literacies and Key Skills	
9.1.12.CFR.3	Research companies with corporate governance policies supporting the common good and human rights.
9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
9.4.12.CT.1	Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).
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https://www.sustainablejerseyschools.com/resources/resource-library/climate-change-curriculum/

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