Pascack Valley Regional High School District

Pascack Hills High School, Montvale, New Jersey
Pascack Valley High School, Hillsdale, New Jersey

Course Name: Chemistry

Born On: August, 2015
Revised On: August, 2020
Revised On: August, 2022
Current Version: August 2023
Board Approved: 8/28/2023

New Jersey Curricular Mandates for Science Instruction

Disabled & LGBT:
18A:35-4.35 - History of disabled and LGBT persons included in middle and high school curriculum. A board of education shall include instruction on the political, economic, and social contributions of persons with disabilities and lesbian, gay, bisexual, and transgender people, in an appropriate place in the curriculum of middle school and high school students as part of the district's implementation of the New Jersey Student Learning Standards.

Diversity, Equity, and Inclusion (DEI):
C.18A:35-4.36a - Curriculum to include instruction on diversity and inclusion. 1. a. Beginning in the 2021-2022 school year, each school district shall incorporate instruction on diversity and inclusion in an appropriate place in the curriculum of students in grades kindergarten through 12 as part of the district's implementation of the New Jersey Student Learning Standards. b. The instruction shall: (1) highlight and promote diversity, including economic diversity, equity, inclusion, tolerance, and belonging in connection with gender and sexual orientation, race and ethnicity, disabilities, and religious tolerance; (2) examine the impact that unconscious bias and economic disparities have at both an individual level and on society as a whole; and (3) encourage safe, welcoming, and inclusive environments for all students regardless of race or ethnicity, sexual and gender identities, mental and physical disabilities, and religious beliefs. c. The Commissioner of Education shall provide school districts with sample learning activities and resources designed to promote diversity and inclusion.

Amistad Law:
N.J.S.A. 18A 52:16A-88 Every board of education shall incorporate the information regarding the contributions of African Americans to our country in an appropriate place in the curriculum of elementary and secondary school students.

Climate Change:
2020 NJSLS-Science: 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.

Dissection Law
N.J.S.A. 18A:35-4.25 and N.J.S.A. 18A:35-4.24 authorizes parents or guardians to assert the right of their children to refuse to dissect, vivisect, incubate, capture or otherwise harm or destroy animals or any parts thereof as part of a course of instruction.

Chemistry

Unit 1: Electrons, Atomic Structure, and the Periodic Table

Time Allotted: Approximately 2-3 Weeks

New Jersey Student Learning Standards (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.

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

HS-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.

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

Science & Engineering Practices

Developing and Using Models

- Use a model to predict the relationships between systems or between components of a system.

Constructing Explanations and Designing Solutions

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Obtaining, Evaluating, and Communicating Information

- 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).

Connections to Nature of Science

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.
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

PS1.B: Chemical Reactions

- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

ESS1.A: The Universe and Its Stars

- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
- 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.
- 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

Cross-Cutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

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.
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

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.

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.	elements are produced when certain massive stars achieve a supernova stage and explode. **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)*	**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. • Science assumes the universe is a vast single system in which basic laws are consistent.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
• How can a model be used to represent matter at the atomic scale? • What are the merits and limitations of a model used to represent an atom? • What determines the "behavior" of electrons? • What can be predicted about similarities and differences in subatomic structure of elements? • How can the periodic table be used to help with making predictions about chemical and physical properties? • How can physical evidence be used to make predictions about elements and the subatomic structure?	• Evaluate merits and limitations of different models of the atom. • Construct explanations about elemental properties based on atomic properties such as atomic radius, ionization energy and electronegativity • Analyze atomic property data to organize elements in a model that allow for predictions of physical properties to be made. • Construct an explanation about atomic structure from data collected electromagnetic spectrum data from and known electron configurations. • Use a model of an atom based on evidence to illustrate how subatomic	• Use a computer model to evaluate relationships between changes in subatomic structure and elemental identification. • Evaluate the merits and limitations of a computer model showing subatomic structure of an atom of a representative element. • Graph trends of atomic properties of elements. • Conduct a flame test on salt solution to identify metals. • Analyze hot gas spectra to identify elemental composition using emission spectra. • Organize periodic table of mystery elements • Use computer model to collect and analyze electromagnetic spectrum data to identify the components of a star	• Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports about associating atomic structure to physical properties of elements. • Debate/discussions about representations of atomic structure • Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test • Assessment of written and verbal mastery of unit-specific vocabulary.

	particles are involved with the exchange of energy. ● Construct and revise and explanation about the atomic structure of unknown elements based on physical properties Boundaries limited to: - Atomic models of electron configurations that do not include f-block - Electron configurations model (if-applied) without exceptions. - Periodic trends only for physical properties, chemical properties, atomic radius, first ionization energy and electronegativity.	*Scientist Spotlight*: • **Dr. Krystal Vasquez** – The struggles of inaccessibility for physically disabled scientists. - NPR Podcast w/ Dr. Vasquez - "Excluded from the Lab" by Dr. Vasquez • **John Dalton** – Colorblind scientist who worked in Atomic Theory.	● Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches. ● Chemistry Benchmark #1
Resources/Materials	- Phet simulation ; Build an atom, Wave on a String and Isotopes and Atomic Mass - Explore Learning; Element builder, Periodic Trends& Electron Configurations - CK12 - PLIX - Bohr's Atomic Model - Classroom Lab: Spectral Analysis - Classroom Lab: Periodic Table Sequencing Activity - AACT ; Flame Test Classroom Demonstration/Lab - AACT: Periodic Trends Simulation - Glencoe: Mystery Element Virtual Lab - Three Levels of Representation in Chemistry		
ELA Companion Standards	**RST.11-12.1** - Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **RST.9-10.7** - Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **WHST.11-12.7** - Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.11-12.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific		

	task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. **WHST.11-12.9** - Draw evidence from informational texts to support analysis, reflection, and research. **WHST.9-12.2** - Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
Interdisciplinary Connections	***English Language Arts*** **SL.9-10.1**. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. **SL.9-10.4**. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. ***Mathematics*** **HSN-Q.A.1** - Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** - Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** - Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **MP.4** - Model with mathematics.
Career Readiness, Life Literacies, and Key Skills	**9.4.12.CI.1**: Demonstrate the ability to reflect, analyze, and use creative skills and ideas **9.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice. **9.4.12.CT.2**: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. **9.4.12.IML.3**: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions **9.4.12.TL.2**: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. **9.2.12.CAP.8**: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension tests, drug tests) used by employers in various industry sectors. **Career Readiness, Life Literacies, and Key Skills Practices** ● Act as a responsible and contributing community member and employee ● Demonstrate creativity and innovation. ● Utilize critical thinking to make sense of problems and persevere in solving them. ● Use technology to enhance productivity, increase collaboration, and communicate effectively.

	● Work productively in teams while using cultural/global competence.
Computer Science and Design Thinking	**8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. **8.2.12.ED.5**: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). **8.2.12.ETW.4**: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints

Modifications

Multi-Lingual Learners	Special Education	At-Risk	Gifted and Talented
● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	● Provide adequate scaffolds for concept development and note-taking. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions ● Sit where they learn best (for example, near the teacher)	● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.

	• Use an alarm or cues to help with time management • Work with a partner		

Chemistry
Unit 2: Nuclear Chemistry
Time Allotted: Approximately 3-4 Weeks
New Jersey Student Learning Standards (NJSLS)
HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. **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. **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. **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 that eventually reaches Earth in the form of radiation. **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. **HS-ESS1-3**: Communicate scientific ideas about the way stars, over their life cycle, produce elements.

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Using Mathematics and Computational Thinking • Use mathematical representations of phenomena to support claims. **Developing and Using Models** • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. **Constructing Explanations and Designing Solutions** • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**PS1.B: Chemical Reactions** • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. **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. **ESS1.A: The Universe and Its Stars** • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	**Energy and Matter** • The total amount of energy and matter in closed systems is conserved. • Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. **Cause and Effect** • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Obtaining, Evaluating, and Communicating Information

- Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.
- 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).

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.

- 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.
- 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.

PS4.B: Electromagnetic Radiation

- 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.
- 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)*

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.

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.
- Science assumes the universe is a vast single system in which basic laws are consistent.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
• How do nuclear reactions affect life on earth? • Where does matter come from? • How did the elements form? • How can half-life be used to make predictions? • How can materials be used to protect from types of radiation? • What role should nuclear energy play to meet future energy demands?	- Apply scientific ideas, principles, and/or evidence to provide an explanation of nuclear decay - Use mathematical representations of half-life to describe and/or support claims and/or explanations. - Develop a model based on evidence and scientific understanding to illustrate the atomic changes in a nuclear reaction.	- Explore models and perform mathematical representation using half-life. - Manipulate different models to explore atomic changes that occur as a result of nuclear change. - Discuss models that represent the differences between fission and fusion. - Develop a model of star cycle that explains the role of the fusion process and nuclear	• Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports • Develop models based on evidence 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.

• When and how are inferences and experimental observations used in science?	- 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. - Communicate scientific ideas about the way stars, over their life cycles, produce elements. - Communicate scientific ideas related to observations and inferences to evaluate two theories about the origin of the universe. - 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. Boundaries limited to: - Mathematical applications for half-life is limited to general applications and predictions. - Element spectral analysis is limited to qualitative analysis.	reactions that explain the formation of elements. - Debate the pros and cons of nuclear energy. - Carry out an investigation to explore the potential for various materials to be used to shield alpha, beta or gamma radiation. - Students will observe visible spectra of known elements and identify an unknown element or combination of elements by visible spectra. - Distinguish between data collected from empirical observations and inference, which may or may not arise from data to compare and contrast the Steady State and Big Bang theories for the origin of our universe. *Scientist Spotlights:* • **Lloyd Albert Quarterman** – African American Chemist who worked on the Manhattan Project • **Lise Meinter** – Jewish, female scientist who discovered nuclear fission. • **Katherine Way** – American, female scientist who worked on the Manhattan Project & established the Nuclear Data	• Student designs, conducts and communicates findings to answer a question about the effectiveness of a specific material to shield from alpha, Beta or gamma radiation. • Communicate scientific ideas in both orally and graphically to describe the way stars, over their life cycles, produce elements. • Communicate scientific ideas orally using manipulatives related to observations and inferences to evaluate two theories about the origin of the universe. • Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test • Assessment of written and verbal mastery of unit-specific vocabulary. • Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches.

		Project. • **Marie Curie** – Female scientist who discovered radium and polonium & made major contributions towards finding treatments for cancer.	
Resources/Materials	- Vernier lab: Radiation shielding lab - Explore Learning: Half-life, Nuclear Decay & Star Spectra - CK12 Plix: Types of Radioactive Decay - Classroom Lab: Penny Half-life Lab - NASA: Supernova Chemistry & Evidence is Clear! (Origin of Everything - 1955) - Youtube: Life Cycle of Stars - The Chemistry of Stars - DOE: NUCLEAR 101: How Does a Nuclear Reactor Work? - NJDEP: WHAT IS THE RELATIONSHIP BETWEEN RADIOACTIVITY AND RADON? - Science News for Students (Current events & articles related to radiation exposure) - Three Levels of Representation in Chemistry		
ELA Companion Standards	**RST.11-12.1** - Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **RST.9-10.7** - Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **WHST.11-12.7** - Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.11-12.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. **WHST.11-12.9** - Draw evidence from informational texts to support analysis, reflection, and research. **WHST.9-12.2** - Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.		
Interdisciplinary Connections	***English Language Arts***		

	SL.9-10.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. **SL.9-10.2**. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source. **SL.9-10.3**. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any false reasoning or distorted evidence. **SL.9-10.4**. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. **SL.9-10.5**. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest. ***Mathematics*** **HSN-Q.A.1** - Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** - Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** - Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **MP.2** Reason abstractly and quantitatively. **MP.4** - Model with mathematics.
Career Readiness, Life Literacies, and Key Skills	**9.4.12.CI.1**: Demonstrate the ability to reflect, analyze, and use creative skills and ideas **9.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice. **9.4.12.CT.2**: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. **9.4.12.IML.3**: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions **9.4.12.TL.2**: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. **9.1.12.CFR.2**: Summarize causes important to you and compare organizations you seek to support to other organizations with similar missions. **9.1.12.CFR.3**: Research companies with corporate governance policies supporting the common good and human rights. **9.2.12.CAP.7**: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest. **9.2.12.CAP.8**: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension tests, drug tests) used by employers in various industry sectors.

	Career Readiness, Life Literacies, and Key Skills Practices ● Act as a responsible and contributing community member and employee ● Consider the environmental, social, and economic impacts of decisions. ● Demonstrate creativity and innovation. ● Utilize critical thinking to make sense of problems and persevere in solving them. ● Model integrity, ethical leadership, and effective management. ● Use technology to enhance productivity, increase collaboration, and communicate effectively. ● Work productively in teams while using cultural/global competence.
Computer Science and Design Thinking	**8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. **8.2.12.ED.5**: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). **8.2.12.ETW.4**: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints

Modifications

Multi-Lingual Learners	Special Education	At-Risk	Gifted and Talented
● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	● Provide adequate scaffolds for concept development and note-taking. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a	● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.

	quiet room with few distractions ● Sit where they learn best (for example, near the teacher) ● Use an alarm or cues to help with time management ● Work with a partner		

Chemistry

Unit 3: Matter, Measurement, Energy & the Mole

Time Allotted: Approximately 3-4 Weeks

New Jersey Student Learning Standards (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.
HS-PS1-7 Use mathematical representation to support the claim that atoms and therefore mass are conserved during a chemical reaction.
HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
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.
HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Constructing Explanations and Designing Solutions ● Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ● Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence,	**PS1.A: Structure and Properties of Matter** ● Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. ● The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. **PS1.B: Chemical Reactions** ● The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**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. **Energy and Matter** ● The total amount of energy and matter in closed systems is conserved.

prioritized criteria, and tradeoff considerations.

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to support claims.

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

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.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence.
- Science disciplines share common rules of evidence used to evaluate explanations about natural systems.
- Science includes the process of coordinating patterns of evidence with current theory.

PS1.B: Chemical Reactions

- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

PS3.B: Conservation of Energy and Energy Transfer

- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- 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).

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

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.

ESS2.A: Earth Materials and Systems

- 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.

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.

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*)

- Energy drives the cycling of matter within and between systems.

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

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.

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.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
● How should data be collected to measure matter? ● How can a particulate model assist in explaining scientific phenomena? ● In what ways can units be used in problems-solving questions about scientific phenomena? ● How can the periodic table be used to help with making predictions about chemical and physical properties? ● What can we learn and/or predict about Earth systems from the composition of matter?	- Plan and conduct an investigation to demonstrate the kinetic molecular theory. - Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence that evaluates choices of measurement equipment used when conducting an experiment. - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence: 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. - Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to explain the role of thermal convection in the movement of Earth's materials.	- POGIL Activity, “What’s in a Name?” - Classroom Visualizations of Kinetic Molecular Theory Activity - Gro-Dino Measurement lab with graphing and/or developing experimental design both individually and collaboratively to investigate the effect of salt concentration of soaking solution on polymer expansion properties. - Evaluate multiple sources of information to develop reasoning for how thermal convection causes Earth's materials to move. - Organize periodic table of mystery elements - Demonstration of various quantities of a mole. - Develop a computer model to evaluate the relationship between mass and counting particles. - Send-a-problem (Cooperative Learning Strategy) for Mole Concept Problem-solving. *Scientist Spotlight*: • Arthur Holmes: Harnessing	● Develop a table, using the three levels of representations of chemistry to relate the Kinetic Molecular Theory to what happens to water molecules during heating. ● Organize information about Earth’s interior from multiple sources using a “jot chart”. ● Develop a model of Earth's interior layers based on research of multiple sources. ● Employ math representations using the mole concept to successfully make predictions about matter on the atomic scale ● Employ math representations on collected data to quantify the atomic particles used in a chemical reaction. ● Demonstrate a model (math or computational) that allows for counting of individual unseen articles simply by weighing a larger portion. ● Predict common formulas of ionic compounds using the periodic table model.

	- Plan 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. - Create and/or revise a computational model or simulation to demonstrate how particle counting is accomplished by weighing. - Use math representations employing the mole concept to demonstrate the relationship between various units and quantities of atomic particles. - Construct an explanation that communicates how the outermost electrons states of atoms can be used to predict formulas of ionic compounds. Boundaries limited to: - Evaluating measuring tools without the benefit of statistical analysis such as Standard-Deviation. - Analysis and problem-solving limited to known substances with given composition. - No calculations will be required to be applied to the Kinetic Molecular Theory	the Mechanics of Mantle Convection to the Theory of Continental Drift	● Collect and report data with correct accuracy from classroom scientific equipment for length, mass, volume, and density. ● Discuss measurements, units in terms of experimental design when developing a scientific argument. ● Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test ● Assessment of written and verbal mastery of unit-specific vocabulary. ● Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches.
Resources/Materials	- Explore Learning: Moles, Measuring Volume, Temperature and Particle Motion - Edpuzzle: How a Barometer Works. - POGIL: Particle Connections - What's in a Name?		

	- Classroom Lab: Counting by Weighing - Classroom Investigation: Visualizations of Kinetic Molecular Theory Activity - Modeling Earth's Layers: How Can Thermal Convection Cause Earth's Materials to Move? - Inferred Properties of Earth's Interior - Earth's Interior Jot Chart - Flinn: Gro-Dino Measurement Lab (Example) & Mole Lab - Coding Project: Using a Computer Model to Count by Weighing - Three Levels of Representation in Chemistry - Phet: States of Matter Basics
ELA Companion Standards	**RST.11-12.1** - Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **RST.9-10.7** - Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **WHST.11-12.7** - Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.11-12.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. **WHST.11-12.9** - Draw evidence from informational texts to support analysis, reflection, and research. **WHST.9-12.2** - Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
Interdisciplinary Connections	***English Language Arts*** **SL.9-10.1**. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. **SL.9-10.4**. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. ***Mathematics*** **HSN-Q.A.1** - Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** - Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** - Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **MP.4** - Model with mathematics.

Career Readiness, Life Literacies, and Key Skills	**9.4.12.CI.1**: Demonstrate the ability to reflect, analyze, and use creative skills and ideas **9.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice. **9.4.12.CT.2**: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. **9.4.12.IML.3**: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions **9.4.12.TL.2**: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. **9.2.12.CAP.7**: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest. **9.2.12.CAP.8**: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension tests, drug tests) used by employers in various industry sectors. **Career Readiness, Life Literacies, and Key Skills Practices** ● Act as a responsible and contributing community member and employee ● Demonstrate creativity and innovation. ● Utilize critical thinking to make sense of problems and persevere in solving them. ● Use technology to enhance productivity, increase collaboration, and communicate effectively. ● Work productively in teams while using cultural/global competence.
Computer Science and Design Thinking	**8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. **8.2.12.ED.5**: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). **8.2.12.ETW.4**: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints

Modifications

Multi-Lingual Learners	Special Education	At-Risk	Gifted and Talented
● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity.	● Provide adequate scaffolds for concept development and note-taking. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and	● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to	● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature.

● Assign a native language partner.	differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions ● Sit where they learn best (for example, near the teacher) ● Use an alarm or cues to help with time management ● Work with a partner	improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Provide AP Chem options for problem-solving.

Chemistry
Unit 4: Compounds, Bonding and Molecular Structure
Time Allotted: Approximately 3-4 Weeks
New Jersey Student Learning Standards (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. **HS-PS2-6** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. **HS-ESS2-5** Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. **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. **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. **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.

Science & Engineering Practices

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Obtaining, Evaluating, and Communicating Information

- Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Asking Questions and Defining Problems

- Analyze complex real-world problems by specifying criteria and constraints for successful solutions.

Constructing Explanations and Designing Solutions

- Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

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

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)*

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.

ETS1.A: Defining and Delimiting Engineering Problems

- 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.
- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

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.

Cross-Cutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.
- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology 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.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- What can we learn and/or predict from the composition of matter? - How do we predict the properties of substances? - How can a model be used to represent matter at the atomic scale? - How can an atomic-scale model be used to make predictions about the physical and chemical properties of matter? - How can the understanding of properties drive the design of materials?	- Apply techniques of percent composition to make predictions about natural resource availability and cost. - Evaluate a solution associated with natural resource extraction through mining - Use and relate computer models, physical models and Lewis Dot structures to provide information about molecular geometry and/or predict polarity - Plan and conduct an investigation to evaluate how the molecular shape of a molecule impacts its chemical and/or physical properties - Apply scientific reasoning, theory, and/or models to link evidence to the claims that certain gaseous molecules act as greenhouse gases. Boundaries limited to: - Covalent bond type and without description such as bond length. - Bond angles are limited to relative description as opposed to absolute degree values. - Discussion of ionic bonding/compounds is solely based on electron transfer and does not include structure or	- Name compounds and access SDS to develop hazard awareness - Manipulate the Breaking Chemical Bond simulation to evaluate changes in intramolecular bond energy. - Natural resources; natural resources; evaluating ore lab - Manipulate models (computer or physical) to evaluate molecular shapes and predict polarity. - Design of molecular mimic, including identification of its molecular geometry features that contribute to its function. - Use/develop various models to both predict shapes of various covalent molecules and strength of polarity - Carry out various tasks to investigate the properties of water. - Plan and carry out investigation on how to alter the properties of water to best perform a task - Complete Heating it Up Tutorial; Use Molecular Interactions model to investigate the global warming potential of various	● Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports ● Performance task assessment to predict molecular geometry and polarity of a simple molecule. ● Employ math representations on collected data to quantify the components of a mixture. ● Debate/discussions about representations of molecular structure and function. ● Carry out experiments to evaluate how physical changes such as temperature or concentration affect the properties of water. ● Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test ● Assessment of written and verbal mastery of unit-

	crystal packing. - Alloy bonding is solely descriptive. - Bond formation described without discussion of overlapping orbitals; therefore not tied to electron configuration and hybridization.	gases. *Scientist Spotlight*: • **Dorothy Crowfoot Hodgkin:** x-ray crystallography and molecular structure. • **Bettye Washing Greene**: An industrial Chemist and Inventor who Lit a Path for Innovation.	specific vocabulary. • Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches.
Resources/Materials	- Beyond Benign: Chemical Hazard Awareness - Phet: Molecular Shapes, Molecular Shapes Basics & Molecule Polarity - Classroom Lab: Molecular Geometry - Classroom Activity: Water Olympics - Concord Consortium; Breaking a Chemical Bond - Teach Engineering: Molecular Molecules and 3D Printing (CAD) - Classroom Lab: Natural Resources; Evaluating Ore Samples (Wards' Classroom Mineral Collection) - Oreo Percent Composition Performance Task - Heating it Up; The Chemistry of the Greenhouse Effect ; Molecular Interactions with Electromagnetic Radiation learning tool. - Three Levels of Representation in Chemistry		
ELA Companion Standards	**RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task,		

	purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. **WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research.
Interdisciplinary Connections	***English Language Arts*** **SL.9-10.1**. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. **SL.9-10.2**. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source. **SL.9-10.3**. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any false reasoning or distorted evidence. **SL.9-10.4**. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. **SL.9-10.5**. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest. ***Mathematics*** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
Career Readiness, Life Literacies, and Key Skills	**9.4.12.CI.1**: Demonstrate the ability to reflect, analyze, and use creative skills and ideas **9.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice. **9.4.12.CT.2**: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. **9.4.12.IML.3**: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions **9.4.12.TL.2**: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. **9.2.12.CAP.7**: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest. **9.2.12.CAP.8**: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension tests, drug tests) used by employers in various industry sectors. **Career Readiness, Life Literacies, and Key Skills Practices**

	● Act as a responsible and contributing community member and employee ● Consider the environmental, social, and economic impacts of decisions. ● Demonstrate creativity and innovation. ● Utilize critical thinking to make sense of problems and persevere in solving them. ● Model integrity, ethical leadership, and effective management. ● Use technology to enhance productivity, increase collaboration, and communicate effectively. ● Work productively in teams while using cultural/global competence.
Computer Science and Design Thinking	**8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. **8.2.12.ED.5**: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). **8.2.12.ETW.4**: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints

Modifications

Multi-Lingual Learners	Special Education	At-Risk	Gifted and Talented
● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	● Provide adequate scaffolds for concept development and note-taking. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions	● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.

	• Sit where they learn best (for example, near the teacher) • Use an alarm or cues to help with time management • Work with a partner		

Chemistry
Unit 5: Chemical Reactions
Time Allotted: Approximately 5-6 Weeks
New Jersey Student Learning Standards (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. **HS-PS1-7** Use mathematical representation to support the claim that atoms and therefore mass are conserved during a chemical reaction. **HS-ESS3-2** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Constructing Explanations and Designing Solutions • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Using Mathematics and Computational Thinking** • Use mathematical representations of phenomena to support claims.	**PS1.A: Structure and Properties of Matter** • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. **PS1.B: Chemical Reactions** • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. **ESS3.A: Natural Resources** • All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.	**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. **Energy and Matter** • The total amount of energy and matter in closed systems is conserved. - *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. • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. • Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. • Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.

Engaging in Argument from Evidence • 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).	**ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*	- *Connections to Engineering, Technology, and Applications of Science* **Influence of Science, Engineering, and Technology on Society and the Natural World** • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. • Analysis of costs and benefits is a critical aspect of decisions about technology.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How can a model be used to represent chemical reactions? - How can products of chemical reactions be predicted? - How can prediction be made using the Law of Conservation of Matter? - How should data be collected to measure chemical reactions?	- Construct and/or revise an explanation using evidence that differentiates chemical and physical changes in matter. - Use math representations to explain/validate the Law of Conservation of Matter during chemical reactions. - Develop and/or use particulate models, such as balanced chemical equations to demonstrate how mass is conserved during a chemical reaction. - 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) to predict whether a chemical reaction between	- Carry out various tasks to investigate properties of substances and to determine types of evidence that can be used to indicate a chemical change has occurred. - Use/develop various models such as the Balancing Equation simulation to discover/demonstrate how chemical equations represent that mass is conserved during a chemical reaction. - Develop an activity series for metals from evidence collected from an experiment. - Plan and conduct an investigation individually and collaboratively to produce data that evaluates the potential for solutions of two ionic compounds to react and form a precipitate. - Plan and carry out an	● Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports ● Use/apply various models to demonstrate understanding of chemical change ● Support a claim with evidence to evaluate a chemical reaction at both the particulate and macroscopic levels. ● Employ math representations to demonstrate how the Law of Conservation of Mass applies to chemical reactions. ● Carry out experiments to employ a chemical reaction to solve a problem or answer a question. ● Assessment of skills such as

	two substances is likely or not, as if so predict the products of the reaction. - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence to evaluate recycling solutions over extraction of metals from ore. - Use math representations, based on balanced equations to make quantitative predictions about chemical reactions. Boundaries limited to: - Five types of major reactions without discussion of oxidation and reduction (electron transfer) - Focus on predicting products from single and double replacement reactions. - Net ionic equation models excluded.	investigation to employ a chemical reaction to isolate a metal resource from a natural ore. *Scientist Spotlight*: • **Dr. Carolyn Bertozzi** - She is the inventor of "bioorthogonal chemistry", a class of chemical reactions compatible with living systems that enable molecular imaging and drug targeting	Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test ● Assessment of written and verbal mastery of unit-specific vocabulary. ● Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches. ● Chemistry Benchmark #2
Resources/Materials	- Classroom Lab: Evidence for Chemical Change - Concord Consortium: Baggie Chemistry - Phet: Balancing Equations Simulation & Reactant,Products & Leftovers - Beyond Benign (Green Chemistry): Reactions Lab - CK12: Balancing Chemical Equations - Classroom Lab: Developing an Activity Series - Teach Engineering: If You're Not Part of the Solution, You're Part of the Precipitate! - Flinn Kit: Copper Mining Lab - Recycling of Materials (Video) - Teach Engineering: Create Silver Nanoparticles - POGIL: Limiting Reactants - Flinn: Stoichiometry of Self-inflating Balloon		

	- Three Levels of Representation in Chemistry
ELA Companion Standards	**RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. **WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research.
Interdisciplinary Connections	***English Language Arts*** **SL.9-10.1**. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. **SL.9-10.2**. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source. **SL.9-10.4**. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. ***Mathematics*** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
Career Readiness, Life Literacies,	**9.4.12.CI.1**: Demonstrate the ability to reflect, analyze, and use creative skills and ideas

and Key Skills	**9.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice. **9.4.12.CT.2**: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. **9.4.12.IML.3**: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions **9.4.12.TL.2**: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. **9.1.12.CFR.3**: Research companies with corporate governance policies supporting the common good and human rights. **9.2.12.CAP.7**: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest. **9.2.12.CAP.8**: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension tests, drug tests) used by employers in various industry sectors. **Career Readiness, Life Literacies, and Key Skills Practices** ● Act as a responsible and contributing community member and employee ● Consider the environmental, social, and economic impacts of decisions. ● Demonstrate creativity and innovation. ● Utilize critical thinking to make sense of problems and persevere in solving them. ● Model integrity, ethical leadership, and effective management. ● Use technology to enhance productivity, increase collaboration, and communicate effectively. ● Work productively in teams while using cultural/global competence.
Computer Science and Design Thinking	**8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. **8.2.12.ED.1**: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers. **8.2.12.ED.2**: Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback. **8.2.12.ED.3**: Evaluate several models of the same type of product and make recommendations for a new design based on a cost benefit analysis. **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. **8.2.12.ED.5**: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). **8.2.12.ED.6**: Analyze the effects of changing resources when designing a specific product or system (e.g., materials, energy, tools, capital, labor).

	8.2.12.ETW.4: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints		
Modifications			
Multi-Lingual Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	● Provide adequate scaffolds for concept development and note-taking. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions ● Sit where they learn best (for example, near the teacher) ● Use an alarm or cues to help with time management ● Work with a partner	● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.

Chemistry

Unit 6: Intermolecular Forces, States of Matter & Phase Changes

Time Allotted: Approximately 2-3 Weeks

New Jersey Student Learning Standards (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.

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

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

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

Science & Engineering Practices

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Obtaining, Evaluating, and Communicating Information

- Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

Constructing Explanations and Designing Solutions

- Construct 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

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

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

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.
- 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.

PS3.A: Definitions of Energy

- "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. *(secondary)*

ESS3.A: Natural Resources

- Resource availability has guided the development of human society.

ESS3.B: Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.

Cross-Cutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.
- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

- -

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.	**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.	*Connections to Engineering, Technology, and Applications of Science* **Influence of Science, Engineering, and Technology on Society and the Natural World** • Modern civilization depends on major technological systems.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How can the substructures of atoms explain the observable properties of substances? - How can the understanding of properties drive the design of materials? - What makes water's properties essential to life on our planet? - How are humans impacted during natural hazards as a result of water's properties?	- 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. - 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. - Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. - Plan and conduct an investigation of the properties of water and its effects on Earth materials	- Use computer simulations and physical models to make predictions about intermolecular forces in substances. - Plan and conduct an investigation of substances (ie. simple alcohols) to investigate how physical properties such as boiling points are affected by the quantity and strength of intermolecular forces. - Plan and conduct an investigation to evaluate how human activity disrupts soil structure, which impacts the soil's ability to absorb water and increases problems of stormwater runoff and erosion. - Apply scientific principles and evidence to evaluate how biomimicry has been used to drive the design of adhesive	• Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports • Use/apply various models to demonstrate understanding of intermolecular forces. • Support a claim with evidence to evaluate the relationship between physical properties of substances and substructure of atoms. • Support a claim with evidence to evaluate how the properties of water impact natural systems. • Debate/discussions about material design choices in terms of relating physical properties with intermolecular forces. • Assessment of skills such as Problem Solving, Creating

	and surface processes. Boundaries limited to: - Identification and discussion of intermolecular bond-type without the idea of polarizability. - Phase diagrams are used solely as a tool for interpreting various models of phase change. - No calculations will be required to be applied to the Kinetic Molecular Theory	materials. *Scientist Spotlight*: • **John Cornforth** – an Australian-British chemist whose life and career were shaped by a hearing disorder that left him profoundly deaf by the age of 20.	and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test • Assessment of written and verbal mastery of unit-specific vocabulary. • Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches.
Resources/Materials	- Phet: Atomic Interactions - POGIL: Intermolecular Forces - Vernier Lab: Evaporation and Intermolecular Forces - Explore Learning: Sticky Molecules Simulation - Edpuzzle: Vapor Pressure and Boiling - Concord Consortium: Boiling Point of Nonpolar and Polar Substance - Data Nuggets: Sticky situations: Big and small animals with sticky feet - Garden Practicum: Soil Lesson Plans - Three Levels of Representation in Chemistry		
ELA Companion Standards	**RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.		

	WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. **WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research.
Interdisciplinary Connections	***English Language Arts*** **SL.9-10.1**. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. **SL.9-10.2**. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source. **SL.9-10.3**. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any false reasoning or distorted evidence. **SL.9-10.4**. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. **SL.9-10.5**. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest. ***Mathematics*** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
Career Readiness, Life Literacies, and Key Skills	**9.4.12.CI.1**: Demonstrate the ability to reflect, analyze, and use creative skills and ideas **9.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice. **9.4.12.CT.2**: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. **9.4.12.IML.3**: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions **9.4.12.TL.2**: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. **9.2.12.CAP.7**: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest. **9.2.12.CAP.8**: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension

	tests, drug tests) used by employers in various industry sectors. **Career Readiness, Life Literacies, and Key Skills Practices** ● Act as a responsible and contributing community member and employee ● Consider the environmental, social, and economic impacts of decisions. ● Demonstrate creativity and innovation. ● Utilize critical thinking to make sense of problems and persevere in solving them. ● Model integrity, ethical leadership, and effective management. ● Use technology to enhance productivity, increase collaboration, and communicate effectively. ● Work productively in teams while using cultural/global competence.
Computer Science and Design Thinking	**8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. **8.2.12.ED.5**: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). **8.2.12.ETW.4**: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints

Modifications

Multi-Lingual Learners	Special Education	At-Risk	Gifted and Talented
● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	● Provide adequate scaffolds for concept development and note-taking. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions ● Sit where they learn best (for	● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.

	example, near the teacher) • Use an alarm or cues to help with time management • Work with a partner		

Chemistry
Unit 7: Gas Laws and Atmosphere
Time Allotted: Approximately 3-4 Weeks
New Jersey Student Learning Standards (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. **HS-PS1-7.** Use mathematical representation to support the claim that atoms and therefore mass are conserved during a chemical reaction. **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. **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. **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. **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.

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Constructing Explanations and Designing Solutions • Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. • Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. • Evaluate a solution to a complex real-world problem,	**PS1.B: Chemical Reactions** • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. • 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. **ETS1.A: Defining and Delimiting Engineering Problems** • 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. • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. **Energy and Matter** • The total amount of energy and matter in closed systems is conserved. **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs

based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Using Mathematics and Computational Thinking

- Use mathematical representations of phenomena to support claims.
- Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

Asking Questions and Defining Problems

- Analyze complex real-world problems by specifying criteria and constraints for successful solutions.

addressed through engineering. These global challenges also may have manifestations in local communities.

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

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.

ESS2.D: Weather and Climate

- Current models predict that, although future regional climate changes will be complex and varied, 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. *(secondary)*

ESS3.D: Global Climate Change

- 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.

analyzed and described using models.

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.

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology 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.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How can predictions about gas behavior be made? - How are humans impacting Earth's atmosphere? - How can the understanding of properties of gases drive design choices? - How can gaseous products of chemical reactions be predicted? - How can predictions be made using the Law of Conservation of Matter?	- Use math representations to support quantitative claims about gaseous reactants and products in a chemical reaction. - Use math representations to support claims about physical changes of gaseous substances. - Analyze an atmospheric dataset to explore the impact of humans on Earth's atmosphere and identify	- Use a computer simulation to model and predict gas behavior. - Utilize a spreadsheet to manage large dataset to investigate daily and seasonal influences on carbon dioxide and ozone in the atmosphere. - Plan and conduct an investigation that involves quantitative predictions of gaseous substances as a product of a chemical	● Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports ● Math representations used to make quantitative predictions about closed gaseous systems. ● Math representations used to support quantitative predictions about gaseous chemicals involved in a

	specific criteria and constraints associated with the data when considering a solution. - Use both scientific knowledge and supporting evidence to explain observations related to a data set - Design and evaluate a solution to where gases are employed to solve a problem. - Use a computer model to explore how Earth's atmosphere affects the energy balance between incoming and outgoing radiation. Boundaries limited to: - Applications and discussions about Ideal gases only. Real gas applications limited to discussions in context of error in laboratory data when appropriate. - Limited applications of Ideal gas law with pressure units of either atmosphere or kilopascal - Focus on mathematical developing understanding of relationships predicted through graph models to equations.	reaction. - Use a computer simulation to model and predict impact of greenhouse gases on Earth's energy budget. - Air Bag Design Challenge *Scientist Spotlight*: • **Eunice Foot** – amateur scientists from the mid-1800s whose experiments foreshadowed the discovery of Earth's Greenhouse effect.	chemical reaction. ● Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. ● Use multiple lines of evidence to support how variations in the flow of energy into and out of Earth's systems result in climate changes. ● Analyze and discuss design decisions based on learned concepts related to systems that rely on gaseous products. ● Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test ● Assessment of written and verbal mastery of unit-specific vocabulary. ● Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches.
Resources/Materials	- Teach Engineering: Understanding Air Through Data Analysis - Vernier Lab: Behavior of Gas		

	- Phet Simulations: Introduction to Gases ,Gas Properties, Greenhouse Effect - Explore Learning: Boyles' Law & Charles' Law & Ideal Gas Law - Flinn: Micromole Rocket - Pasco: Air Bag Module - Classroom Lab: Determining Mass of CO_2 from a Chemical Reaction - Data Nuggets: The Ground has Gas! - MyNASA Data: Earth System: Matter and Energy Cycles - Greenhouse Gases; A Closer Look (IR Windows Learning Tool) - Concord Consortium: Greenhouse gases - Carbon Footprint Calculator - Three Levels of Representation in Chemistry
ELA Companion Standards	**RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **WHST.9-12.1** Write arguments focused on discipline-specific content. **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
Interdisciplinary Connections	***English Language Arts*** **SL.9-10.1**. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. **SL.9-10.2**. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source. **SL.9-10.3**. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any false reasoning or distorted evidence. **SL.9-10.4**. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. **SL.9-10.5**. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest. ***Mathematics*** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics.

	HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. **HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. **HSF-BF.A.1** Write a function that describes a relationship between two quantities. **HSF-IF.B.5** Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. **HSS-ID.A.1** Represent data with plots on the real number line. **HSS-ID.B.6** Represent data on two quantitative variables on a scatter plot, and describe how those variables are related.
Career Readiness, Life Literacies, and Key Skills	**9.4.12.CI.1**: Demonstrate the ability to reflect, analyze, and use creative skills and ideas **9.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice. **9.4.12.CT.2**: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. **9.4.12.IML.3**: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions **9.4.12.TL.2**: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. **9.1.12.CFR.2**: Summarize causes important to you and compare organizations you seek to support to other organizations with similar missions. **9.1.12.CFR.3**: Research companies with corporate governance policies supporting the common good and human rights. **9.2.12.CAP.7**: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest. **9.2.12.CAP.8**: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension tests, drug tests) used by employers in various industry sectors. **Career Readiness, Life Literacies, and Key Skills Practices** ● Act as a responsible and contributing community member and employee ● Consider the environmental, social, and economic impacts of decisions.

	● Demonstrate creativity and innovation. ● Utilize critical thinking to make sense of problems and persevere in solving them. ● Model integrity, ethical leadership, and effective management. ● Use technology to enhance productivity, increase collaboration, and communicate effectively. ● Work productively in teams while using cultural/global competence.
Computer Science and Design Thinking	**8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. **8.2.12.ED.5**: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). **8.2.12.ETW.4**: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints

Modifications			
Multi-Lingual Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	● Provide adequate scaffolds for concept development and note-taking. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions ● Sit where they learn best (for example, near the teacher)	● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.

	• Use an alarm or cues to help with time management • Work with a partner		

Chemistry
Unit 8: Solution Chemistry
Time Allotted: Approximately 3-4 Weeks
New Jersey Student Learning Standards (NJSLS)
HS-PS1-2 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. **HS-ESS2-5** Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes **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.

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Constructing Explanations and Designing Solutions • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Planning and Carrying Out Investigations** • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. **Analyzing and Interpreting Data** • Analyze data using computational models in order to make valid and reliable scientific claims. - *Connections to Nature of Science*	**PS1.A: Structure and Properties of Matter** • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. **PS1.B: Chemical Reactions** • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. **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.	**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. **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. **Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time.

Scientific Investigations Use a Variety of Methods • Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • New technologies advance scientific knowledge. **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based on empirical evidence. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**ESS3.D: Global Climate Change** • 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.	Some system changes are irreversible.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How can a model be used to represent or predict the solvation process? - Why are electrolytes important? - How can the composition of a solution be quantified? - What can we predict about solutions? - How can the substructures of atoms explain the potential for solvation in a given solvent? - How can one explain the structure, properties, and interactions of matter?	- Relate the concepts of intermolecular forces to solvation and solubility. - Use math representations to quantify the composition of and make predictions about a solution. - Use a model to differentiate among saturated, unsaturated, and supersaturated solutions. - Develop and/or use particulate models, such as balanced and/or net ionic chemical equations to demonstrate the solvation process and make predictions about chemical change. - Use both scientific knowledge and supporting evidence to explain observations related to electrolytic strength. Boundaries limited to: - No requirement to interpret net	- Use computer simulations and physical models to make predictions about the role of intermolecular on the potential for a substance to dissolve in a polar or nonpolar solvent. - Plan and carry out an experimental investigation to create a solubility curve for a given substance. - Plan and carry out an experimental investigation to differentiate between saturated, supersaturated and unsaturated solutions. - Analyze monthly satellite data of the North Atlantic in order to make valid and reliable scientific claims about how the water cycle affects ocean salinity and how climate change has impacted the cycle and the effected	• Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports • Employ math representations to make quantitative predictions about solutions and solubility.. • Support a claim with evidence to predict the products of chemical change from the reaction of two ionic solutions. • Debate/discussions about a dataset used as evidence to support a claim. • Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit

	ionic equations from balanced chemical equations. - Units of concentration are limited to Molarity and g/100mL H_2O - Concept of colligative properties may be addressed without any calculations required.	ecosystems. - Plan and carry out an experimental investigation to identify a set of unknown solutions by mixing them and looking for precipitates. - Conduct research about solutions that impact life on this planet.	Test ● Assessment of written and verbal mastery of unit-specific vocabulary. ● Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches.
Resources/Materials	- Classroom lab; Solubility of a Salt - Classroom lab; Are We Saturated Yet? - Vernier lab; Conductivity of Ionic Solutions - AACT; Preparing Solutions Simulation - Phet: Concentration, Molarity & Beer's Law Lab (*G/T & HONORS*) - MyNASA Data: Inferring Relationships Among Sea Surface Salinity & Other Variables in the North Atlantic - Teach Engineering; Kidney Stone Crystallization - Three Levels of Representation in Chemistry		
ELA Companion Standards	**WHST.9-12.1** Write arguments focused on discipline-specific content. **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. **RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.		
Interdisciplinary Connections	***English Language Arts*** **SL.9-10.1**. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. **SL.9-10.4**. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. ***Mathematics*** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics.		

	HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. **HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. **HSF-BF.A.1** Write a function that describes a relationship between two quantities. **HSF-IF.B.5** Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. **HSS-ID.A.1** Represent data with plots on the real number line. **HSS-ID.B.6** Represent data on two quantitative variables on a scatter plot, and describe how those variables are related.
Career Readiness, Life Literacies, and Key Skills	**9.4.12.CI.1**: Demonstrate the ability to reflect, analyze, and use creative skills and ideas **9.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice. **9.4.12.CT.2**: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. **9.4.12.IML.3**: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions **9.4.12.TL.2**: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. **9.2.12.CAP.7**: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest. **Career Readiness, Life Literacies, and Key Skills Practices** ● Act as a responsible and contributing community member and employee ● Consider the environmental, social, and economic impacts of decisions. ● Demonstrate creativity and innovation. ● Utilize critical thinking to make sense of problems and persevere in solving them. ● Model integrity, ethical leadership, and effective management. ● Use technology to enhance productivity, increase collaboration, and communicate effectively. ● Work productively in teams while using cultural/global competence.
Computer Science and Design	**8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different

Thinking	interpretations of real-world phenomena. **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. **8.2.12.ED.5**: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). **8.2.12.ETW.4**: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints

Modifications

Multi-Lingual Learners	Special Education	At-Risk	Gifted and Talented
● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	● Provide adequate scaffolds for concept development and note-taking. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions ● Sit where they learn best (for example, near the teacher) ● Use an alarm or cues to help with time management ● Work with a partner	● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.

Chemistry
Unit 9: Thermochemistry and Climate Change
Time Allotted: Approximately 5-6 Weeks
New Jersey Student Learning Standards (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. **HS-PS3-1** Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known **HS-PS3-2** Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). **HS-PS3-3** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. **HS-PS3-4** Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). **HS-ESS2-2** Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems. **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. **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.

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Developing and Using Models • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. • Use a model to provide mechanistic accounts of phenomena. **Using Mathematics and Computational Thinking** • Create a computational model or simulation of a phenomenon, designed device, process, or system.	**PS1.A: Structure and Properties of Matter** • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart . **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. **PS3.A: Definitions of Energy** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. **Systems and System Models** • Models can be used to predict the behavior of a system, but these predictions have limited

Constructing Explanations and Designing Solutions

- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Analyzing and Interpreting Data

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

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science arguments are strengthened by multiple lines of evidence supporting a single explanation.
- Science knowledge is based on empirical evidence.

Scientific Investigations Use a Variety of Methods

- Science investigations use diverse methods and do not always use the same set of procedures to obtain data.
- New technologies advance scientific knowledge.

- 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.
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

PS3.B: Conservation of Energy and Energy Transfer

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.
- 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).

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

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)*

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

precision and reliability due to the assumptions and approximations inherent in models.

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system.
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

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.

Connections to Engineering, Technology, and Applications of Science

	• 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. **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. **ESS3.D: Global Climate Change** • 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. **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)*	**Influence of Science, Engineering and Technology on Society and the Natural World** • Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. • 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.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How is energy in a system defined? - What are limitations when quantifying energy of a closed system? - How can models be used to evaluate energy transfer? - How are humans impacting how energy is transferred in Earth's climate system? - How can evidence be gathered to evaluate or predict human impact on	- Plan and carry out an investigation to provide evidence for and test conceptual, mathematical, physical, and empirical models of energy transfer via conduction, convection and radiation. - Develop/use a model to represent how energy is transferred between chemical bonds in the system during chemical reactions.	- Ask questions about various natural phenomena such as a morning fog that rely on observations about energy exchange. - Plan and carry out an experimental investigation that employs calorimetry to quantify the energy in a given substance or mixture. (Determine the Calories in foodstuffs) - Use or develop a model that	● Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports ● Development of scientific questions about energy and phases changes from observations that are testable and lead to a scientific investigation. ● Employ math representations to make

energy transfer on Earth?	- Make and defend a claim based on evidence about the natural world that reflects scientific knowledge about energy transfer, phase changes and intermolecular forces. - Use math representations to quantify the energy absorbed by or released from a substance using its specific heat. - Communicate scientific information or ideas in multiple formats (including orally, graphically, textually, and mathematically) to explain how energy is transferred to account for Earth's energy budget. - Apply scientific reasoning, theory, and/or climate models to link evidence to determine how reasoning and data support the explanation of climate feedback. Boundaries limited to: - No requirement for thermodynamics for determination of reaction spontaneity. - Focus on real-world applications (ie food analysis) of energy transfer in terms of calorimetry applications/ math representations. - Units of Specific Heat are limited to those including joule and calorie	explains how bond energies are exchanged during a chemical reaction. - Plan and carry out an experimental investigation to quantify the amount of energy either absorbed or released from a chemical reaction. - Develop a scientific explanation from evidence gathered from a demonstration of a heating curve as heat is slowly but constantly added to ice to explain energy transfer in a closed system. - Use a climate model and/or simulation to evaluate how changes in Earth's energy budget will impact further changes that will result in climate feedback. Scientist Spotlight: • **Winifred Burks-Houck**: An environmental organic chemist and the first woman president of the National Organization for the Professional Advancement of Black Chemists and chemical Engineers. • **Warren Washington** – atmospheric climate scientist	quantitative predictions about energy exchanged based on principles of calorimetry and specific heat. ● Support a claim with evidence to explain the transfer of energy between objects/substances. ● Construct an explanation from evidence that demonstrates understanding of climate feedback loops. ● Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test ● Assessment of written and verbal mastery of unit-specific vocabulary. ● Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches.

	- Hess's Law is not explicitly addressed, but may be used to explain energy transfer in chemical reactions (no calculations of multi-step reactions required)		
Resources/Materials	- Phet: Energy Forms and Changes , Molecules and Light - AACT : Energy Changes and Chemical Reactions Simulation - Vernier Lab: Determining the Enthalpy of a Chemical Reaction ; Energy in Food - Teach Engineering: The Reaction Exposed;The Big Chill & Heat Transfer: From Hot to Not ; Organic Solar Energy & Berries - Concord Consortium: Exploring Climate Change - Data Nuggets: The Arctic is Melting – So What? - MyNASA Data: Surface and Air Temperatures Throughout the Day - MyNASA Data: Positive Feedback - Arctic Albedo - Science News for Students (Current events & articles related to climate change research) - Three Levels of Representation in Chemistry		
ELA Companion Standards	**RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. **WHST.9-12.1** Write arguments focused on discipline-specific content. **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. **WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research.		
Interdisciplinary Connections	***English Language Arts*** **SL.9-10.1**. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. **SL.9-10.2**. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source.		

	SL.9-10.3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any false reasoning or distorted evidence. **SL.9-10.4**. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. **SL.9-10.5**. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest. ***Mathematics*** **HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. **HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. **HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. **HSF-BF.A.1** Write a function that describes a relationship between two quantities. **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
Career Readiness, Life Literacies, and Key Skills	**9.4.12.CI.1**: Demonstrate the ability to reflect, analyze, and use creative skills and ideas **9.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice. **9.4.12.CT.2**: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. **9.4.12.IML.3**: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions **9.4.12.TL.2**: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. **9.1.12.CFR.2**: Summarize causes important to you and compare organizations you seek to support to other organizations with similar missions. **9.1.12.CFR.3**: Research companies with corporate governance policies supporting the common good and human rights. **9.2.12.CAP.7**: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest. **9.2.12.CAP.8**: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension tests, drug tests) used by employers in various industry sectors.

	Career Readiness, Life Literacies, and Key Skills Practices ● Act as a responsible and contributing community member and employee ● Consider the environmental, social, and economic impacts of decisions. ● Demonstrate creativity and innovation. ● Utilize critical thinking to make sense of problems and persevere in solving them. ● Model integrity, ethical leadership, and effective management. ● Use technology to enhance productivity, increase collaboration, and communicate effectively. ● Work productively in teams while using cultural/global competence.
Computer Science and Design Thinking	**8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. **8.2.12.ED.5**: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). **8.2.12.ETW.4**: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints

Modifications

Multi-Lingual Learners	Special Education	At-Risk	Gifted and Talented
● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	● Provide adequate scaffolds for concept development and note-taking. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a	● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.

	quiet room with few distractions • Sit where they learn best (for example, near the teacher) • Use an alarm or cues to help with time management • Work with a partner		

Chemistry

Unit 10: Kinetics and Equilibrium

Time Allotted: Approximately 3-4 Weeks

New Jersey Student Learning Standards (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.

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

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.

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. **Constructing Explanations and Designing Solutions** • Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**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. **PS1.B: Chemical Reactions** • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. **PS3.A: Definitions of Energy** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. **Systems and System Models** • Models can be used to predict the behavior of a system, but

Using Mathematics and Computational Thinking • Create a computational model or simulation of a phenomenon, designed device, process, or system.	**PS3.B: Conservation of Energy and Energy Transfer** • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. • The availability of energy limits what can occur in any system. **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)*	these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. - *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.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- Why do some chemical reactions happen at different rates? - How can the rate of a reaction be increased or decreased? - Why do systems establish equilibrium? - What predictions can be made about chemical equilibrium?	- 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. - Translate among reaction energy profile representations, particulate representations, and symbolic representations	- Plan and carry out an experimental investigation to determine how changing conditions (i.e., temperature, concentration, surface area) influence the rate of a reaction. - Explain the difference between collisions that convert reactants to products and those that do not in terms of energy distributions and molecular orientation - Plan and carry out an experiment to investigate how given stresses will shift a given reaction which is at equilibrium.	• Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports • Support a claim with evidence to explain how changing conditions (i.e., temperature, concentration, surface area) influence the rate of a reaction. • Present a written/oral scientific argument to evaluate the claims, evidence, and/or reasoning behind Le Chatelier's principle to determine its merits.

	(chemical equations) of a chemical reaction occurring in the presence and absence of a catalyst. - Given a set of experimental observations regarding physical, chemical, biological, or environmental processes that are reversible, construct an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes. - Develop or use a model to explain on the molecular level what happens to a system in chemical equilibrium when a stress is applied. - Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence from investigating a reversible reaction. - Apply kinetic principles, and/or evidence to provide an explanation of phenomena that demonstrates Le Chatelier's principle.	- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims about the solubility of a compound. - Critically read "What's So Equal about Equilibrium" from ACS to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	● Debate/discussions about observations of physical, chemical, biological, or environmental processes that are explained by reversible reactions. ● Summarize an article adapted for classroom use that illustrates an example(s) of equilibrium in a natural system. ● Use math representations or a model to predict/explain the solubility of a salt. ● Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test ● Assessment of written and verbal mastery of unit-specific vocabulary. ● Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches. ● Chemistry Benchmark #3

	- Use math representations of equilibrium constants to predict the solubility of a compound. Boundaries limited to: - Equilibrium focus is on context when explaining macroscopic outcomes from reversible reactions as opposed to quantifying concentrations from math representations such as equilibrium constants. - Calculations involving equilibrium should be limited to situations at which equilibrium has been achieved and not include changing conditions. - Concepts and calculations involving rate laws are not addressed.		
Resources/Materials	- Phet: Reversible Reactions ; Reaction Rates - AACT: Predicting Shifts in Equilibrium - Classroom Lab: Le Chatelier's Principle Using Iron Complex - Flinn: Iodine Clock Challenge - ExploreLearning: Equilibrium and Concentration; Equilibrium and Pressure - ACS Chem Matters: What's so Equal about Equilibrium? - POGIL: Equilibrium and LeChatelier's Principle - Vernier: Ksp of Calcium Hydroxide - Three Levels of Representation in Chemistry		
ELA Companion Standards	**WHST.9-12.1** Write arguments focused on discipline-specific content. **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. **RST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.		
Interdisciplinary Connections	***English Language Arts***		

	SL.9-10.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. **SL.9-10.4**. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. ***Mathematics*** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. **HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. **HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
Career Readiness, Life Literacies, and Key Skills	**9.4.12.CI.1**: Demonstrate the ability to reflect, analyze, and use creative skills and ideas **9.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice. **9.4.12.CT.2**: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. **9.4.12.IML.3**: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions **9.4.12.TL.2**: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. **9.2.12.CAP.7**: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest. **Career Readiness, Life Literacies, and Key Skills Practices** ● Act as a responsible and contributing community member and employee ● Consider the environmental, social, and economic impacts of decisions. ● Demonstrate creativity and innovation. ● Utilize critical thinking to make sense of problems and persevere in solving them. ● Model integrity, ethical leadership, and effective management. ● Use technology to enhance productivity, increase collaboration, and communicate effectively.

	● Work productively in teams while using cultural/global competence.
Computer Science and Design Thinking	**8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. **8.2.12.ED.5**: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). **8.2.12.ETW.4**: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints

Modifications

Multi-Lingual Learners	Special Education	At-Risk	Gifted and Talented
● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	● Provide adequate scaffolds for concept development and note-taking. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions ● Sit where they learn best (for example, near the teacher) ● Use an alarm or cues to help with time management ● Work with a partner	● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.

Chemistry

Unit 11: Acids and Bases

Time Allotted: Approximately 2-3 Weeks

New Jersey Student Learning Standards (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

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

HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-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.

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.

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Constructing Explanations and Designing Solutions • Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. • Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. **Using Mathematics and Computational Thinking** • Create a computational model or simulation of a phenomenon, designed device, process, or system. • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. **Analyzing and Interpreting Data** • Analyze data using computational models in order to make valid and reliable scientific claims. -	**PS1.B: Chemical Reactions** • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. • 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. **PS3.A: Definitions of Energy** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. **PS3.B: Conservation of Energy and Energy Transfer** • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. **Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Systems and System Models** • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods

- Science investigations use diverse methods and do not always use the same set of procedures to obtain data.
- New technologies advance scientific knowledge.

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence.
- Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.

ESS3.D: Global Climate Change

- 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.

ETS1.B: Developing Possible Solutions

- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

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)*

assumptions and approximations inherent in models.

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales.

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.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How are acids and bases recognized as unique compounds? - How can chemical principles be used to explain why acids differ from each other? - How is pH used to make predictions? - How are acid and bases affected by equilibrium shift?	- Develop and/or use particulate models, such as balanced chemical equations to demonstrate how acids/bases are defined. - Use math representations to explain changes in acidity/alkalinity in terms of pH - Construct and revise an	- POGIL activity to develop definitions of acids and bases based on various models. - Investigate the properties of acids and bases by analyzing several household products. - Use a model/simulation to collect data to investigate the pH scale. - Plan and conduct an	● Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports ● Support a claim with evidence to explain how titration method is used to make predictions about a neutralization reaction.

- How are tools/techniques used to measure the strength of acids?. - How do natural systems respond to changes in pH?	explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) to differentiate between acid (or base) strength and pH. - 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) that demonstrates how acid/base strength is a result of a reversible reaction and therefore can be predicted using equilibrium constant calculations. - Use a computer model/simulation to investigate the impact of changes in ph on natural systems. - Use math representations, based on balanced equations to make quantitative predictions about neutralization reactions. Boundaries limited to: - Prediction of pH of strong acids and bases - Strong vs. Weak acids only	experiment to collect data from a neutralization reaction using titration method to determine the concentration of a strong acid. - Plan and conduct an experiment to investigate the pH ranges for a set of indicators. - Plan and conduct a research project to understand changes in pH in a natural system. (ie. natural rain pH < 7 as a result of reaction of CO_2 with atmospheric water) - Use NOAA Data in the Classroom Ocean Acidification Model to investigate how anthropogenic CO_2 atmospheric changes affect ocean water pH and coral reef systems. - Critically read "The Quest for a Clean Drink" from ACS to evaluate questions about how natural systems respond to changes in pH.	● Employ math representations on collected data to quantify acid strength. ● Use models to describe a system and define its boundaries, initial conditions, inputs, and outputs to explain a change in pH. ● Summarize an article adapted for classroom use that illustrates an example(s) of impact of pH changes in a natural system.. ● Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test ● Assessment of written and verbal mastery of unit-specific vocabulary. ● Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches.

	addressed conceptually as opposed to using math representations involving equilibrium. - Quantifying reactants/products in neutralization reactions with strong acids and strong bases only.		
Resources/Materials	- POGIL: Introduction to Acids & Bases - Teach Engineering: Basically Acidic Ink - Phet: pH Scale Basics, pH Scale & Acid Base Solution Simulation - Flinn: Microscale Acid/Base Titration - NOAA Data in the Classroom: Ocean Acidification - ACS ChemMatters: The Quest for a Clean Drink - Three Levels of Representation in Chemistry		
ELA Companion Standards	**RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. **RST.11-12.8** 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. **RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. **WHST.9-12.1** Write arguments focused on discipline-specific content. **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research.		
Interdisciplinary Connections	***English Language Arts*** **SL.9-10.1**. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. **SL.9-10.2**. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source. **SL.9-10.3**. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any false reasoning or distorted evidence.		

	SL.9-10.4. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. **SL.9-10.5**. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest. ***Mathematics*** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **HSA-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. **HSA-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. **HSA-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. **HSF-IF.C.7** Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. **HSS-ID.A.1** Represent data with plots on the real number line.
Career Readiness, Life Literacies, and Key Skills	**9.4.12.CI.1**: Demonstrate the ability to reflect, analyze, and use creative skills and ideas **9.4.12.CT.1**: Identify problem-solving strategies used in the development of an innovative product or practice. **9.4.12.CT.2**: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. **9.4.12.IML.3**: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions **9.4.12.TL.2**: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. **9.1.12.CFR.2**: Summarize causes important to you and compare organizations you seek to support to other organizations with similar missions. **9.2.12.CAP.7**: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest. **9.2.12.CAP.8**: Determine job entrance criteria (e.g., education credentials, math/writing/reading comprehension tests, drug tests) used by employers in various industry sectors. **Career Readiness, Life Literacies, and Key Skills Practices** ● Act as a responsible and contributing community member and employee ● Consider the environmental, social, and economic impacts of decisions. ● Demonstrate creativity and innovation. ● Utilize critical thinking to make sense of problems and persevere in solving them. ● Model integrity, ethical leadership, and effective management.

	• Use technology to enhance productivity, increase collaboration, and communicate effectively. • Work productively in teams while using cultural/global competence.
Computer Science and Design Thinking	**8.1.12.DA.5**: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. **8.2.12.ED.4**: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. **8.2.12.ED.5**: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). **8.2.12.ETW.4**: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints

Modifications

Multi-Lingual Learners	Special Education	At-Risk	Gifted and Talented
• Display labeled images of designs and parts. • Use body movement and gestures to further explain concepts to students. • Restate design steps aloud before project activity. • Assign a native language partner.	• Provide adequate scaffolds for concept development and note-taking. • Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. • Use color to identify and differentiate important aspects of concepts and problem-solving. • Provide an outline of lessons • Get a written list of instructions • Work or take a test in a different setting, such as a quiet room with few distractions • Sit where they learn best (for example, near the teacher) • Use an alarm or cues to help with time management • Work with a partner.	• Incorporate student choice • Invite parents, neighbors, friends, the school principal, and other community members to support classroom activities. • Provide peer mentoring to improve techniques. • Provide alternative assessments to demonstrate proficiency	• Lead the class in the deciphering of new learning. • Share understanding through peer tutoring • Evaluate concepts through scientific literature. • Provide AP Chem options for problem-solving.

Additional Resources to promote DEI:

- Structure Matters: Twenty-One Teaching Strategies to Promote Student Engagement and Cultivate Classroom Equity
- Race Matters
- Inclusive Teaching