Summit Public Schools

Chemistry Curriculum
Chemistry CPA
Grade 10

Unit 1: Study of Matter Using Experimental Methods

Unit 1:

Content Statement:
This chemistry unit introduces students to the fundamental concepts and practices of chemistry. Students will learn how matter is classified, describe its physical states and properties, and distinguish between physical and chemical changes. Through hands-on laboratory investigations, students will develop skills in laboratory safety, procedures, data collection, analysis, and scientific communication. The unit also emphasizes scientific measurement, including significant figures, scientific notation, qualitative and quantitative observations, and dimensional analysis for unit conversions. Overall, students will build a foundation in understanding matter, conducting scientific investigations, and communicating evidence-based conclusions.

Learning Objectives
Students will be able to:

- Precisely follow a multi-step laboratory procedure to record qualitative observations and quantitative data, using this experimental evidence to categorize unknown samples of matter as elements, compounds, homogeneous mixtures, or heterogeneous mixtures.

- Utilize the periodic table as a model to predict the relative physical and chemical properties of elements based on outermost electron patterns, and analyze molecular geometry and Lewis structures to predict molecular polarity and the resulting intermolecular forces
- Observe chemical and physical processes in the laboratory, distinguish between them by citing specific textual and experimental evidence (such as gas production, temperature change, or precipitate formation), and draft clear informative descriptions of their findings.
- Translate quantitative information regarding chemical quantities and reactions between symbolic formulas, visual models, and mathematical equations, performing dimensional analysis calculations while consistently attending to precision through the correct use of SI base units, scientific notation, and significant figures.
- Determine the meanings of and explain the distinctions between elements and compounds, describing how elements represent single-atom species with periodic trends, whereas compounds represent chemically bonded combinations of elements with entirely unique macroscopic behaviors and properties
- Construct explanations based on astronomical and composition-of-matter evidence showing how light elements were synthesized during the Big Bang, and communicate scientific ideas detailing how stars produce heavier elements throughout their life cycles.
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
- Use a model to predict the relationships between systems or between components of a system.
- 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.
- Use mathematical representations of phenomena to support claims.
- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- 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.
- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.
- 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.

Essential Questions *What provocative questions will foster inquiry, understanding, and*	**Enduring Understandings** *What will students understand about the big ideas?*

transfer of learning?	
• How do scientists use observations, measurements, and evidence to define, understand, and classify matter? • How does the structure of matter determine its properties and behavior? • How can we determine whether a change in matter is physical or chemical? • How do scientists represent, measure, and communicate information about matter accurately? • Why is it important to differentiate between elements and compounds? • What is the source of elements, and what does that mean about the history of the universe?	Students will understand that… **Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.(HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5) **Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8) • The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6) **Structure and Function** • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESSS2-5)
New Jersey Student Learning Standards *What student learning standards will be addressed?*	**Assessments** *How will students be assessed and evaluated on their learning?*
Content Area Standards: HS-PS1-1. Matter and its Interactions: 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. Matter and its Interactions: Construct and revise an explanation for the outcome of a simple chemical reaction based on the	**Formative Assessments** • *Safety & Equipment Stations Lab Practical*: Set up stations where students identify pieces of lab equipment, correct a safety violation in a mock setup, and/or demonstrate proper technique. • *Classification Card Sort:* Separate class into small groups and hand out cards with chemical formulas, element names, and mixture descriptions to physically sort into elements, compounds, homogeneous, and heterogeneous categories. • *Whiteboard Property Challenge:* Read a scenario (e.g., iron rusting or ice melting) and have groups quickly write whether it is a physical or chemical change and hold up their boards.

outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. HS-PS1-3. Matter and its Interactions: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. HS-PS1-4 Matter and its Interactions: 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-PS2-6 Motion and Stability: Forces and Interactions Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. HS-ESS2-1 Earth's Systems Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. HS-ESS2-3 Earth's Systems Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. HS-ESS1-6 Earth's Place in the Universe Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.	• *Exit Ticket on States of Matter:* Ask students to draw the molecular arrangement of a solid versus a gas and write one sentence explaining how particle attraction drives those differences. • *Modeling Matter Density Packet:* Assign students into groups of two to complete the density practice problems and then compare results to another group in class. • At Home Activity: ice cube melting experiment • Activity: determining density graphically • Identification of Laboratory Equipment and their Uses • Lab: Mixture Separation • Lab: Using Google Sheets for Density Determination • Lab: Observing a Chemical Reaction • Lab: Measure for Measure • Chemistry and Cooking Project • Pre and Post lab experiment assignments and assessments **Benchmark/Summative Assessments:** Unit Tests (Unit Tests and quizzes with multiple choice, short answer, calculations and open-ended questions). **Alternative Assessments:** Project or formal lab report

Interdisciplinary Standards: ELA/Literacy RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as used in scientific or technical contexts. RST.9-10.5 Analyze the structure of relationships among concepts in a text, including relationships among key terms. RST.9-10.7 Translate quantitative or technical information expressed in words into visual form and information expressed visually or mathematically into words. RST.9-10.9 Compare and contrast findings presented in a text with those from other sources, including their own experiments. RST.9-10.10 By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently. WHST.9-12.2 Write informative/explanatory texts, including scientific procedures, experiments, and technical processes. WHST.9-12.4 Produce clear and coherent writing appropriate to task, purpose, and audience. WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. Mathematics MP.2 Reason abstractly and quantitatively.	

MP.6 Attend to Precision Career Readiness, Life Literacies and Key Skills Standards: 9.1.12.FP.5 Evaluate how behavioral bias (e.g., overconfidence, confirmation, recency, loss aversion, etc.) affects decision-making. 9.3.ST.2 (STEM - Technical Data): *Use technology to acquire, manipulate, analyze and report data.* 9.3.ST.3 (STEM - Safety Standards): *Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.* 9.3.ST.6 (STEM - Technical Skills): *Demonstrate technical skills needed in a chosen STEM field.* 9.3.ST-SM.4 (STEM - Critical Thinking & Research Data): *Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.* 9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving. Computer Science and Design Thinking Standards: 8.1.12.DA.1 Create interactive data visualizations using software tools to help others better understand real world phenomena. 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.	

Differentiation & Modification *How will instruction be differentiated to meet students' needs?*	**Instructional Resources** *What texts and resources will be utilized in this unit?*
List those that are applicable for this unit. Supports for English Language Learners Intervention Strategies Modifications Chart **Resources for Differentiation and Modification** Colorín Colorado – Science Instruction for ELLs American Chemical Society (ACS) – Chemistry Education Resources Khan Academy – Chemistry PhET Interactive Simulations American Association of Chemistry Teachers (AACT) ACS ChemMatters Chemistry LibreTexts POGIL – Process Oriented Guided Inquiry Learning ExploreLearning Gizmos ACS Reactions – Chemistry for Life Colorín Colorado – ELL Resource Collections RSC Chemistry Literacy and Language Support	**Required:** ● Wilbraham, A. C., Staley, D. D., Matta, M. S., & Waterman, E. L. (2005). *Prentice Hall chemistry*. Pearson Prentice Hall ● New Jersey State Science Standards **Recommended:** ● NJ Department of Education (NJDOE) — NJSLS-S standards, curriculum guidance, and instructional resources. NJDOE Science Standards & Resources ● American Association of Chemistry Teachers (AACT) — Chemistry lessons, labs, demonstrations, safety, measurement, matter, properties, and separation activities. AACT Classroom Resources ● American Chemical Society (ACS) — Chemistry content, laboratory safety, periodic table resources, element discovery, and real-world applications. ACS High School Chemistry Resources ● PhET Interactive Simulations — Interactive simulations for atoms, elements, states of matter, particle behavior, and physical/chemical concepts. PhET Interactive Simulations ● New Jersey Science Teachers Association (NJSTA) — NJ-specific teaching resources, NJSLS connections, phenomena, and science instructional materials. NJSTA Resource Center ● OpenSciEd — Phenomenon-based, inquiry-centered instructional materials aligned with three-dimensional science learning. OpenSciEd ● ACS ChemMatters — Short, accessible readings connecting chemistry concepts to real-world applications, technology, Earth, and society. ChemMatters ● NJDOE Earth & Space Science Resources — Standards and instructional guidance for Earth's layers, composition, and Earth-system concepts. NJDOE Earth & Space Science Standards

Instructional Focus *What lessons and content should be included in this unit?* *Lessons may need to be adjusted, added, or skipped based on student assessments results and demonstrated skills.*

- Review laboratory techniques, identification of different types of equipment, and safety.
- Explain laboratory expectations and procedures.
- Distinguish between elements, compounds, heterogeneous, and homogeneous mixtures
- Explain that properties of elements found in compounds have completely different properties from those found in elemental form
- Recognize and interpret symbols for elements and formulas for compounds
- Describe the ways in which elements are assigned names and symbols, and some ways in which new elements have been discovered.
- General differences in the physical properties of solids, liquids, and gases are explained by the ways in which the atoms, ions, or molecules of the substances ar arranged, and by the strength of the forces of attraction between the atoms, ions, or molecules.
- Distinguish between chemical and physical properties and changes
- Review physical separation techniques
- Explain evidence of chemical changes
  - There is a vast history of discovering elements that continues with laboratory work today
  - Change numbers from scientific notation to standard notation and vice versa
  - Determine the number of significant figures in a measurement
  - Distinguish between qualitative and quantitative measurements and observations
  - Record and interpret data appropriately
  - Use dimensional analysis to convert between units of measurement

Supports for English Language Learners

Sensory Supports	Graphic Supports	Interactive Supports
Real-life objects	Charts	In pairs or partners
Manipulatives	Graphic Organizers	In triads or small groups
Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group

Magazines & Newspapers	Timelines	Structures
Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodations	**Interventions**	**Modifications**
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Unit 2: Atomic Structure and Nuclear Chemistry

Unit 2:
Content Statement: *This unit explores the development and refinement of modern atomic theory through benchmark experiments and the scientific process. Students examine the properties of protons, neutrons, and electrons and apply these concepts to atomic number, mass number, isotopes, and ionic charge. The*

unit then extends into nuclear chemistry, including the formation of elements in stars, nuclear reactions, alpha, beta, and gamma radiation, nuclear stability, half-life, and radioactive dating. Students learn to write and balance nuclear equations and use the Band of Stability to predict nuclear stability. The unit also compares nuclear fission and fusion and examines the advantages and challenges of nuclear power as a present and future energy source. Applications of nuclear chemistry in medicine, including diagnosis and treatment of disease, are explored, along with the sources of heat within Earth's interior and their connection to nuclear processes.

Learning Objectives

Students will be able to:

- Analyze historical scientific texts describing indirect experimental evidence—specifically Thomson's cathode ray tube and Rutherford's gold foil experiment—to infer the existence, mass, and charges of unseen subatomic particles (protons, neutrons, and electrons) and defend why these discoveries necessitated a new atomic model
- Construct a written scientific explanation tracing how cosmological and physical evidence—including stellar emission light spectra, galaxy motion, and the relative composition of matter in the universe—transformed atomic theory from Dalton's indivisible billiard ball model to a nucleus-centered stellar and primordial nucleosynthesis model.
- Evaluate the claims, reasoning, and spectroscopic evidence (such as discrete atomic hydrogen emission lines) that exposed the mathematical and physical limitations of classical planetary models (Bohr model) and justified the transition to the modern, probability-based quantum mechanical model.
- Communicate scientific ideas using visual charts and nucleosynthesis models to explain how nuclear fusion inside stellar cores during stars' lifecycles synthesized heavier elements, and contrast this stellar lifecycle origin with the primordial synthesis of light elements during the Big Bang.
- Construct and analyze graphical models of the "band of stability" to explain how the ratio of protons to neutrons dictates nuclear stability (the balance of strong nuclear forces vs. electrostatic repulsions) and predict the specific type of nuclear decay (alpha, beta, or gamma emission) an unstable nuclide must undergo to achieve a stable ground state
- Gather and critically evaluate multiple digital resources to draft a comparison between high-energy ionizing radiation (including alpha particles, beta particles, gamma rays, and high-frequency EM waves) and low-energy non-ionizing radiation (such as radio waves or visible light) based on wavelength, frequency, energy levels, and molecular mechanisms of biological interaction.
- Develop a system model of a nuclear fission reactor to explain how controlled nuclear chain reactions release thermal energy, and perform an opportunity-cost or risk-benefit analysis evaluating safety systems, radioactive waste disposal hazards, and environmental impacts against localized economic benefits
- Research, synthesize, and present a technical project illustrating how key concepts in nuclear rate of decay (half-lives) and specific radioisotope properties have been engineered to optimize grid power generation, calculate the ages of ancient Earth materials, and develop targeted medical diagnostic and therapeutic technologies.

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
- Use a model to predict the relationships between systems or between components of a system.
- 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.
- Use mathematical representations of phenomena to support claims.
- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- 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.
- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.
- 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.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
• How do we know what we cannot see? • How has scientific evidence transformed our understanding of the atom and the universe? • Is there evidence that exists that suggests our current model of the atom is not sufficient? • Where did all the elements on Earth originate? • Why are some nuclei stable while others release radiation?	Students will understand that… **Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5) **Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8) • The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4)

• Are all forms of radiation harmful? • How can nuclear reactions be both a source of tremendous energy and a potential risk? • How has our understanding of nuclear science changed the way we produce energy, study Earth's history, and treat disease?	• Energy cannot be created or destroyed-only moved between one place and another place, between objects and/or fields, or between systems (HS-ESS1-2) • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3) **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6) • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1) **Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2- 6) • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1) • 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. (HS-PS4-4) Systems can be designed to cause a desired effect. (HS-PS4-5)
New Jersey Student Learning Standards *What student learning standards will be addressed?*	**Assessments** *How will students be assessed and evaluated on their learning?*
Content Area Standards: HS-PS1-1. Matter and its Interactions: 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. Matter and its Interactions:	**Formative Assessments** • *Exit Ticket:* Students complete a quick prompt contrasting the mass, charge, and location of protons, neutrons, and electrons. • *Whiteboard Modeling (Band of Stability)*: Students use a band of stability chart and mini-whiteboards and predict whether an unstable isotope undergoes alpha or beta decay. • *Gizmo or PhET Simulation Check*: Students manipulate virtual atoms to discover how changing neutrons impacts the mass number without altering the atomic numbers

Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. HS-PS1-3 Matter and its Interactions: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. HS-PS1-4 Matter and its Interactions: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. HS-PS1-8 Matter and its Interactions: 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. Interdisciplinary Standards: ELA/Literacy ● RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. ● RST.9-10.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text. ● RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as used in scientific or technical contexts. ● RST.9-10.5 Analyze the structure of relationships among concepts in a text, including relationships among key terms.	● Activity: create a timeline showing the significant developments of atomic theory. ● Lab: Candium (use candy to demonstrate how an average atomic mass is calculated) ● Lab: Radioactive Decay with Pennies ● Activity: 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. ● Activity: Class debate on nuclear power ● Activity: Calculate annual nuclear radiation exposure from different environmental sources ● Pre and Post lab experiment assignments and assessments **Benchmark/Summative Assessments:** Unit Tests (Unit Tests and quizzes with multiple choice, short answer, calculations and open-ended questions). **Alternative Assessments:** Project or formal lab report

• RST.9-10.7 Translate quantitative or technical information expressed in words into visual form and information expressed visually or mathematically into words. • RST.9-10.9 Compare and contrast findings presented in a text with those from other sources, including their own experiments. • RST.9-10.10 By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently. • WHST.9-12.2 Write informative/explanatory texts, including scientific procedures, experiments, and technical processes. • WHST.9-12.4 Produce clear and coherent writing appropriate to task, purpose, and audience. • WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. Career Readiness, Life Literacies and Key Skills Standards: • 9.1.12.FP.5 Evaluate how behavioral bias (e.g., overconfidence, confirmation, recency, loss aversion, etc.) affects decision-making. • 9.3.ST.2 (STEM - Technical Data): *Use technology to acquire, manipulate, analyze and report data.* • 9.3.ST.3 (STEM - Safety Standards): *Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.* • 9.3.ST.6 (STEM - Technical Skills): *Demonstrate technical skills needed in a chosen STEM field.* • 9.3.ST-SM.4 (STEM - Critical Thinking & Research Data): *Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.* • 9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving.	

Computer Science and Design Thinking Standards: ● 8.1.12.DA.1 Create interactive data visualizations using software tools to help others better understand real world phenomena. ● 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.	
Differentiation & Modification *How will instruction be differentiated to meet students' needs?*	**Instructional Resources** *What texts and resources will be utilized in this unit?*
List those that are applicable for this unit. Supports for English Language Learners Intervention Strategies Modifications Chart **Resources for Differentiation and Modification** Colorín Colorado – Science Instruction for ELLs American Chemical Society (ACS) – Chemistry Education Resources Khan Academy – Chemistry PhET Interactive Simulations American Association of Chemistry Teachers (AACT) ACS ChemMatters Chemistry LibreTexts POGIL – Process Oriented Guided Inquiry Learning ExploreLearning Gizmos ACS Reactions – Chemistry for Life Colorín Colorado – ELL Resource Collections RSC Chemistry Literacy and Language Support	**Required:** ● Wilbraham, A. C., Staley, D. D., Matta, M. S., & Waterman, E. L. (2005). *Prentice Hall chemistry*. Pearson Prentice Hall ● New Jersey State Science Standards **Recommended:** ● NJ Department of Education (NJDOE) — NJSLS-S standards, curriculum guidance, and instructional resources. NJDOE Science Standards & Resources ● American Association of Chemistry Teachers (AACT) — Chemistry lessons, labs, demonstrations, safety, measurement, matter, properties, and separation activities. AACT Classroom Resources ● American Chemical Society (ACS) — Chemistry content, laboratory safety, periodic table resources, element discovery, and real-world applications. ACS High School Chemistry Resources ● PhET Interactive Simulations — Interactive simulations for atoms, elements, states of matter, particle behavior, and physical/chemical concepts. PhET Interactive Simulations ● New Jersey Science Teachers Association (NJSTA) — NJ-specific teaching resources, NJSLS connections, phenomena, and science instructional materials.

	[NJSTA Resource Center] ● OpenSciEd — Phenomenon-based, inquiry-centered instructional materials aligned with three-dimensional science learning. [OpenSciEd] ● ACS ChemMatters — Short, accessible readings connecting chemistry concepts to real-world applications, technology, Earth, and society. [ChemMatters] ● NJDOE Earth & Space Science Resources — Standards and instructional guidance for Earth's layers, composition, and Earth-system concepts. [NJDOE Earth & Space Science Standards]

Instructional Focus

What lessons and content should be included in this unit?

Lessons may need to be adjusted, added, or skipped based on student assessments results and demonstrated skills.

- Development and refinement of modern atomic theory with a focus on benchmark experiments and the scientific process.
- Distinguish between protons, electrons and neutrons in terms of their location, mass and charge.
- Apply these ideas to the terms mass number, atomic number, isotopes, and charge.
- Explain the formation of elements in stars.
- Define nuclear reactions and identify the three different types of radiation that can be given off; alpha, beta and gamma radiation.
- Write and balance nuclear reactions to show the conservation of energy.
- Explain the Band of Stability and use it to predict the stability of different nuclei
- Calculate the amount of nuclear material remaining using half-life.
- Use radioactive dating to determine the age of objects found on Earth and relate to history of Earth's development
- Compare and contrast fission and fusion.
- Describe the pro's and con's of nuclear power; including its role as an energy source for the future.
- Explain how nuclear power is used in different fields of medicine and the treatment of illnesses.
- Describe the sources of heat in the Earth's interior

Supports for English Language Learners

Sensory Supports	Graphic Supports	Interactive Supports
Real-life objects	Charts	In pairs or partners
Manipulatives	Graphic Organizers	In triads or small groups
Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group
Magazines & Newspapers	Timelines	Structures
Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies

Accommodations	Interventions	Modifications
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Unit 3: Periodicity and Atomic Spectrum

Unit 3:

Content Statement:
This unit explores the relationship between light, energy, and the behavior of electrons in atoms, tracing how experimental evidence led to the development of the quantum mechanical model. Students investigate wavelength, frequency, and the electromagnetic spectrum, as well as the properties of light, quantum theory, the wave model of the atom, and the photoelectric effect and its role in the development of modern technologies. Through experimentation and historical evidence, students examine how scientists determined the organization of electrons and how electron configurations explain the structure and properties of the periodic table. The unit also examines the development of the periodic table from its earliest forms to the modern organization and focuses on predicting periodic trends, including atomic radius, ionization energy, electronegativity, chemical reactivity, and metallic character. Students apply their understanding of light and atomic structure to analyze stellar spectra and determine the composition of stars.

Learning Objectives
Students will be able to:
- Construct and evaluate scientific models of electromagnetic radiation to analyze wave-particle duality, using textual and mathematical evidence to explain how light acts as a continuous wave during propagation but as discrete photon packets during matter interactions (such as the photoelectric effect)
- Calculate and translate quantitative relationships between energy, frequency, and wavelength to explain how quantized electronic transition states within Bohr and quantum mechanical atomic models generate discrete emission line spectra
- Use the periodic table as a predictive model to analyze how the structural layout of electron configurations and electrostatic nuclear pull generate repeating patterns of elemental properties, including atomic radius, ionization energy, electronegativity, chemical reactivity, and metallic character
- Compare and contrast historical scientific discoveries to construct an explanation tracing how early chemical models of periodic organization and planetary arrangements of the atom failed to account for anomalous spectroscopic data, necessitating a transition to modern, probability-based quantum models
- Research, evaluate, and argue how the physical laws governing quantum electronic behaviors (such as the photoelectric effect) are engineered into everyday technologies, and analyze the resulting social, economic, and environmental trade-offs of these technological system

- Interpret stellar absorption and emission spectra to identify the presence of specific elements, and construct an evidence-based explanation outlining how star lifecycles and the Big Bang synthesized the elements that comprise the physical matter of the universe.
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
- Use a model to predict the relationships between systems or between components of a system.
- 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.
- Use mathematical representations of phenomena to support claims.
- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- 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.
- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.
- 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.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
• How can something behave as both a continuous wave and a discrete particle, and how does this duality challenge our understanding of reality? • How can a beam of light serve as an invisible bridge to reveal the internal structure of an atom? • How does the invisible architecture of an element's electrons dictate the tangible physical and chemical properties of our world? • How do unexpected "surprises" or failures in existing scientific theories force us to rethink the laws of nature? • How has human mastery over the behavior of unseen electrons shaped the landscape of modern technology?	Students will understand that… **Systems and System Models** • Electromagnetic radiation is a complex system that cannot be fully explained by a single classical model; instead, it exhibits a dual nature where it behaves as a continuous wave when propagating through space but as discrete wave-packets or particle-like quanta of energy (photons) when interacting with matter. **Energy and Matter: Flows, Cycles, and Conservation** • Matter and energy are fundamentally linked at the atomic scale; when electrons within an atom absorb or release discrete, quantized packets of electromagnetic energy, they transition between defined orbital energy levels,

• How can a light signature traveling across billions of miles of empty space tell us what the stars are made of, and what does that reveal about our own origin?	emitting or absorbing specific wavelengths of light that create a unique, element-specific spectral fingerprint **Patterns/Structure and Function** • Repeating patterns of chemical and physical properties are determined by structural electronic configurations—specifically the number of electrons in an atom's outermost energy level—and the electrostatic "nuclear pull" exerted by the nucleus on those electrons **Stability and Change** • Scientific models are dynamic, human-designed tools that adapt, evolve, or are completely redesigned when technological advancements and systematic investigations yield anomalous evidence that contradicts previous explanations • 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. **Influence of Engineering, Technology, and Science on Society and the Natural World** • Understanding the quantum mechanical behaviors of electrons—such as the photoelectric effect—enables engineers to design technologies that solve modern problems, allowing us to capture solar energy, automate processes, and engineer advanced computing and imaging systems **Scale, Proportion, and Quantity** • The origin of all elements on Earth is fundamentally linked to cosmic history; primordial nucleosynthesis during the Big Bang synthesized light elements, whereas heavier elements are manufactured by nuclear fusion inside stellar cores and released throughout the universe over the lifecycles of stars
New Jersey Student Learning Standards *What student learning standards will be addressed?*	**Assessments** *How will students be assessed and evaluated on their learning?*
Content Area Standards:	**Formative Assessments**

HS-PS1-1. Matter and its Interactions: 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. Matter and its Interactions: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. HS-PS1-3. Matter and its Interactions: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. HS-PS1-4 Matter and its Interactions: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. HS-PS1-5 Matter and Its Interactions: 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 Matter and Its Interactions: 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 Matter and Its Interactions:	• *Spectral Analysis Activity*: Students use spectroscopes to view gas discharge tubes and identify unknown elements by matching emission lines to a reference chart. • *Periodic Trend Prediction Whiteboard Session*: Small groups sketch and justify arrows for atomic radius and ionization energy changes across periods and groups. • *Photoelectric Effect Exit Ticket:* Students sketch incoming photons ejecting electrons from a metal plate and explain why changing light intensity versus frequency affects electron emission differently • Lab: Colorful Flames and Calculation of an Atomic Emission Spectrum • Lab: Electron Configuration • Lab: Periodic Trends • Pre and Post lab experiment assignments and assessments **Benchmark/Summative Assessments:** Unit Tests (Unit Tests and quizzes with multiple choice, short answer, calculations and open-ended questions). **Alternative Assessments:** Project or formal lab report

Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. HS-PS1-8 Matter and Its Interactions: 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-PS4-3 Waves and Their Applications in Technologies for Information Transfer: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. HS-PS4-4 Waves and Their Applications in Technologies for Information Transfer: 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-PS4-5 Waves and Their Applications in Technologies for Information Transfer: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. Interdisciplinary Standards: ELA/Literacy • RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.	

• RST.9-10.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text. • RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as used in scientific or technical contexts. • RST.9-10.5 Analyze the structure of relationships among concepts in a text, including relationships among key terms. • RST.9-10.7 Translate quantitative or technical information expressed in words into visual form and information expressed visually or mathematically into words. • RST.9-10.9 Compare and contrast findings presented in a text with those from other sources, including their own experiments. • RST.9-10.10 By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently. • WHST.9-12.2 Write informative/explanatory texts, including scientific procedures, experiments, and technical processes. • WHST.9-12.4 Produce clear and coherent writing appropriate to task, purpose, and audience. • WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. Career Readiness, Life Literacies and Key Skills Standards: • 9.1.12.FP.5 Evaluate how behavioral bias (e.g., overconfidence, confirmation, recency, loss aversion, etc.) affects decision-making. • 9.3.ST.2 (STEM - Technical Data): *Use technology to acquire, manipulate, analyze and report data.* • 9.3.ST.3 (STEM - Safety Standards): *Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.*	

• 9.3.ST.6 (STEM - Technical Skills): *Demonstrate technical skills needed in a chosen STEM field.* • 9.3.ST-SM.4 (STEM - Critical Thinking & Research Data): *Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.* • 9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving. Computer Science and Design Thinking Standards: • 8.1.12.DA.1 Create interactive data visualizations using software tools to help others better understand real world phenomena. • 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.	
Differentiation & Modification *How will instruction be differentiated to meet students' needs?*	**Instructional Resources** *What texts and resources will be utilized in this unit?*
List those that are applicable for this unit. Supports for English Language Learners Intervention Strategies Modifications Chart **Resources for Differentiation and Modification**	**Required:** • Wilbraham, A. C., Staley, D. D., Matta, M. S., & Waterman, E. L. (2005). *Prentice Hall chemistry*. Pearson Prentice Hall • New Jersey State Science Standards **Recommended:** • NJ Department of Education (NJDOE) — NJSLS-S standards, curriculum

Colorín Colorado – Science Instruction for ELLs American Chemical Society (ACS) – Chemistry Education Resources Khan Academy – Chemistry PhET Interactive Simulations American Association of Chemistry Teachers (AACT) ACS ChemMatters Chemistry LibreTexts POGIL – Process Oriented Guided Inquiry Learning ExploreLearning Gizmos ACS Reactions – Chemistry for Life Colorín Colorado – ELL Resource Collections RSC Chemistry Literacy and Language Support	guidance, and instructional resources. NJDOE Science Standards & Resources ● American Association of Chemistry Teachers (AACT) — Chemistry lessons, labs, demonstrations, safety, measurement, matter, properties, and separation activities. AACT Classroom Resources ● American Chemical Society (ACS) — Chemistry content, laboratory safety, periodic table resources, element discovery, and real-world applications. ACS High School Chemistry Resources ● PhET Interactive Simulations — Interactive simulations for atoms, elements, states of matter, particle behavior, and physical/chemical concepts. PhET Interactive Simulations ● New Jersey Science Teachers Association (NJSTA) — NJ-specific teaching resources, NJSLS connections, phenomena, and science instructional materials. NJSTA Resource Center ● OpenSciEd — Phenomenon-based, inquiry-centered instructional materials aligned with three-dimensional science learning. OpenSciEd ● ACS ChemMatters — Short, accessible readings connecting chemistry concepts to real-world applications, technology, Earth, and society. ChemMatters ● NJDOE Earth & Space Science Resources — Standards and instructional guidance for Earth's layers, composition, and Earth-system concepts. NJDOE Earth & Space Science Standards

Instructional Focus

What lessons and content should be included in this unit?

Lessons may need to be adjusted, added, or skipped based on student assessments results and demonstrated skills.

- Determine how wavelength and frequency can be used to determine the properties of different forms of electromagnetic radiation.
- Explain how the study of light led to the discovery of the quantum mechanical model of the atom.
- Describe the discovery of the organization of electrons in atoms in the context of experimentation
- Review the properties of light and quantum theory and the wave model of the atom.
- Explain the photoelectric effect and how it led to the development of many technological tools we use today.
- Relate the organization of electrons (configurations) to the properties of atoms and the arrangement of the periodic table.
- Describe the development of the first periodic table and compare it to the one we use today.

- Explain and predict periodic properties and trends such as: atomic radii, ionization energies, electronegativity, chemical reactivity, metallic character
- Determine the composition of stars by analyzing the spectra of light emitted.

Supports for English Language Learners		
Sensory Supports	**Graphic Supports**	**Interactive Supports**
Real-life objects	Charts	In pairs or partners
Manipulatives	Graphic Organizers	In triads or small groups
Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group
Magazines & Newspapers	Timelines	Structures
Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodations	**Interventions**	**Modifications**
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials

Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Unit 4: Bonding and Chemical Reactions

Unit 4:
Content Statement: *This unit explores how the arrangement of electrons determines how atoms bond and interact to form compounds. Students investigate ion formation and distinguish between ionic, covalent, metallic, and network covalent bonding, connecting bonding patterns to the periodic table and the physical properties of different types of matter. Students learn to write and name ionic and binary molecular compounds, construct Lewis structures, identify intermolecular forces, determine molecular geometry and polarity, and relate molecular structure to the properties of substances. The unit also introduces chemical reactions, including combination, decomposition, combustion, single replacement, double replacement, acid-base, and redox reactions. Students practice predicting products, writing chemical formulas, and balancing chemical equations while developing an understanding of how matter is rearranged during chemical change.* **Learning Objectives** *Students will be able to:* ● Explain how an element's unique atomic number defines its identity and placement on the periodic table, utilizing structural electron configurations to predict repeating periodic trends like atomic radii and reactivity. ● Construct a scientific explanation demonstrating why elements in the same column share similar chemical reactivities, using their outermost valence electron configurations, to predict how they transfer or share electrons to form stable configurations. ● Develop potential energy system models to illustrate that breaking a chemical bond always requires an input of energy (endothermic), whereas forming a chemical bond releases potential energy to the surroundings (exothermic) based on changes in total bond energy. ● Translate between systematic names, symbolic chemical formulas, and visual molecular structures to accurately identify and communicate the exact

ratios and arrangement of atoms in ionic and covalent compounds.
- Plan and carry out investigations to gather bulk-scale data—such as melting points, vapor pressures, and physical states —to infer the relative strength of microscopic electrical forces (ionic, covalent, metallic, or intermolecular forces) between particles.
- Construct and manipulate symbolic system models (such as Lewis dot diagrams, orbital filling representations, and 3D VSEPR molecular geometries) to visually communicate how valence electrons are shared or transferred during ionic and covalent bond formation
- Explain how underlying bond polarity and charge distributions cause macroscopic solubility ("like dissolves like") and electrical conductivity, contrasting the movement of charges in electrolyte aqueous solutions with non-electrolytes.
- Construct mathematical representations using the mole concept to show that mass and atoms are conserved during chemical reactions , utilizing stoichiometry calculations (such as mass-to-mass conversions, limiting reagents, and percent yields) to calculate qualitative reactant-to-product quantities
- Predict and write balanced chemical equations for chemical reactions by applying periodic trends, valence electron configurations, and the Law of Conservation of Mass, classifying the reaction types to systematically predict product outcomes
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
- Use a model to predict the relationships between systems or between components of a system.
- 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.
- Use mathematical representations of phenomena to support claims.
- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- 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.
- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.
- 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.

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
• How does the internal structure of an atom dictate its position and the repeating patterns found on the periodic table?	Students will understand that… **Patterns**

- Why do elements in the same column share similar chemical properties, and how do their outer electron states drive reactivity? - Why does a stable molecule possess lower energy than its separated component atoms? - How can we use the language of Chemistry to refer to substances by name or by formula? - How do microscopic attractions and repulsions between electric charges explain macroscopic contact forces and material transformations? - How can we visually represent what is happening when a bond forms? - What determines the properties of substances, such as solubility in water and electrical conductivity? - How can we represent a chemical reaction both quantitatively and qualitatively? - How can the conservation of atoms and periodic trends be used to accurately describe and predict the outcomes of chemical reactions?	- 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. - An element's unique atomic number (proton count) defines its specific identity and coordinate position on the periodic table, while the repeating periodic patterns of elemental properties (trends) are structured by the systematic filling of quantized electron shells - Because atomic mass is completely conserved during chemical reactions, we can use outermost electron states and recurring periodic trends to predict reaction products, ensuring that every atom present in the reactant systems is accounted for in the newly rearranged product molecules **Structure and Function** - Elements grouped within the same vertical column of the periodic table share identical configurations of valence electrons in their outermost energy levels; these outer electron states are the primary drivers of chemical reactivity, dictating how atoms exchange or share electrons to establish stable octets **Energy and Matter: Flows, Cycles, and Conservation** - The formation of a chemical bond is an energetically favorable process because attractive electrostatic forces draw atoms into stable, low-energy configurations; consequently, a bonded molecule exists at a lower potential energy state than its isolated component atoms, releasing the excess energy to its surroundings. **Systems and System Models** - Chemistry utilizes a highly structured, standardized symbolic nomenclature system to represent the precise identity, ratio, and arrangement of bonded atoms, translating microscopic structures into a universal scientific language. - Because atomic interactions cannot be directly observed, scientists use abstract system models (such as Lewis dot structures, orbital configurations, and molecular geometries) to visually track, simplify, and communicate how valence electrons are shared, transferred, or delocalized during bond formation. **Cause and Effect** - The solubility and conductivity of materials are caused by their underlying molecular configurations; polar structures dissolve in polar solvents like water via electrostatic attractions, and electrical current is

	conducted only when a substance's bond structure permits the free movement of charged particles (ions or delocalized electrons). **Scale, Proportion, and Quantity** • Macroscopic material behaviors, contact forces, and phase transformations are physical consequences of scale, determined entirely by the cumulative strength and behavior of microscopic electromagnetic attractions (covalent, ionic, or intermolecular forces) and repulsions occurring between individual atoms, ions, or molecules. • A chemical reaction is described qualitatively by identifying state changes and molecular rearrangements in balanced equations, and represented quantitatively through stoichiometry, using the mole concept to calculate precise particle, mass, and yield proportions • **Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8) • The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6) • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1)
New Jersey Student Learning Standards *What student learning standards will be addressed?*	**Assessments** *How will students be assessed and evaluated on their learning?*
Content Area Standards: HS-PS1-1. Matter and its Interactions: 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.	**Formative Assessments** • *Whiteboard Modeling*: Students draw electron configurations turning into ions and hold up mini-whiteboards for instant checks. • *Exit Tickets*: Students write the Stock system name for a random chemical formula before leaving class.

HS-PS1-2. Matter and its Interactions: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. HS-PS1-3. Matter and its Interactions: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. HS-PS1-4 Matter and its Interactions: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. HS-PS1-5 Matter and Its Interactions: 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 Matter and Its Interactions: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. HS-PS1-4 Matter and its Interactions: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. HS-PS1-5 Matter and Its Interactions:	● *Concept Sorts*: Students group cut-out strips of chemical properties into ionic, molecular, metallic, or network covalent categories. ● *Periodic Table Trends Check*: Students highlight regions on a blank periodic table to predict bonding types based on electronegativity differences ● Sample Assessments: ● Lab: Identify an Unknown Metal ● Lab: Lewis Structures and Molecular Geometry ● Lab: Types of Solids ● Lab: Types of Chemical Reactions ● Demonstrations for types of chemical reactions and post demo quiz ● Pre and Post lab experiment assignments and assessments **Benchmark/Summative Assessments:** Unit Tests (Unit Tests and quizzes with multiple choice, short answer, calculations and open-ended questions). **Alternative Assessments:** Project or formal lab report

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 Matter and Its Interactions: 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 Matter and Its Interactions: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Interdisciplinary Standards: ELA/Literacy ● RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. ● RST.9-10.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text. ● RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as used in scientific or technical contexts. ● RST.9-10.5 Analyze the structure of relationships among concepts in a text, including relationships among key terms. ● RST.9-10.7 Translate quantitative or technical information expressed in words into visual form and information expressed visually or mathematically into words. ● RST.9-10.9 Compare and contrast findings presented in a text with those from other sources, including their own experiments.	

• RST.9-10.10 By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently. • WHST.9-12.2 Write informative/explanatory texts, including scientific procedures, experiments, and technical processes. • WHST.9-12.4 Produce clear and coherent writing appropriate to task, purpose, and audience. • WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. Career Readiness, Life Literacies and Key Skills Standards: • 9.1.12.FP.5 Evaluate how behavioral bias (e.g., overconfidence, confirmation, recency, loss aversion, etc.) affects decision-making. • 9.3.ST.2 (STEM - Technical Data): *Use technology to acquire, manipulate, analyze and report data.* • 9.3.ST.3 (STEM - Safety Standards): *Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.* • 9.3.ST.6 (STEM - Technical Skills): *Demonstrate technical skills needed in a chosen STEM field.* • 9.3.ST-SM.4 (STEM - Critical Thinking & Research Data): *Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.* • 9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving.	

Computer Science and Design Thinking Standards: ● 8.1.12.DA.1 Create interactive data visualizations using software tools to help others better understand real world phenomena. ● 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.	
Differentiation & Modification *How will instruction be differentiated to meet students' needs?*	**Instructional Resources** *What texts and resources will be utilized in this unit?*
List those that are applicable for this unit. Supports for English Language Learners Intervention Strategies Modifications Chart Other Resources for DIfferentiation and Modification Colorín Colorado – Science Instruction for ELLs American Chemical Society (ACS) – Chemistry Education Resources Khan Academy – Chemistry PhET Interactive Simulations American Association of Chemistry Teachers (AACT) ACS ChemMatters Chemistry LibreTexts POGIL – Process Oriented Guided Inquiry Learning ExploreLearning Gizmos	**Required:** ● Wilbraham, A. C., Staley, D. D., Matta, M. S., & Waterman, E. L. (2005). *Prentice Hall chemistry*. Pearson Prentice Hall ● New Jersey State Science Standards **Recommended:** ● NJ Department of Education (NJDOE) — NJSLS-S standards, curriculum guidance, and instructional resources. NJDOE Science Standards & Resources ● American Association of Chemistry Teachers (AACT) — Chemistry lessons, labs, demonstrations, safety, measurement, matter, properties, and separation activities. AACT Classroom Resources ● American Chemical Society (ACS) — Chemistry content, laboratory safety, periodic table resources, element discovery, and real-world applications. ACS High School Chemistry Resources ● PhET Interactive Simulations — Interactive simulations for atoms, elements,

ACS Reactions – Chemistry for Life Colorín Colorado – ELL Resource Collections RSC Chemistry Literacy and Language Support	states of matter, particle behavior, and physical/chemical concepts. PhET Interactive Simulations ● New Jersey Science Teachers Association (NJSTA) — NJ-specific teaching resources, NJSLS connections, phenomena, and science instructional materials. NJSTA Resource Center ● OpenSciEd — Phenomenon-based, inquiry-centered instructional materials aligned with three-dimensional science learning. OpenSciEd ● ACS ChemMatters — Short, accessible readings connecting chemistry concepts to real-world applications, technology, Earth, and society. ChemMatters ● NJDOE Earth & Space Science Resources — Standards and instructional guidance for Earth's layers, composition, and Earth-system concepts. NJDOE Earth & Space Science Standards

Instructional Focus

What lessons and content should be included in this unit?

Lessons may need to be adjusted, added, or skipped based on student assessments results and demonstrated skills.

- Describe ion formation based on electron configuration
- Distinguish between ionic and covalent bonds in terms of electron behavior as well as the properties of compounds that contain each type.
- Recognize patterns of bonding from the periodic table.
- Describe metallic bonding and how it affects the properties of metals
- Write chemical formulas for ionic and binary molecular compounds
- Name (using the Stock system) ionic and binary molecular compounds
- Create Lewis structures for a variety of molecular compounds and polyatomic ions
- Describe and name the forces that hold molecules together
- Determine molecular geometry for molecular compounds
- Determine molecular polarity and describe its effect on the properties of a sample of matter
- Categorize matter as ionic, molecular, metallic, or network covalent
- Classify chemical reactions as combination, decomposition, combustion, single replacement, or double replacement, acid-base or redox reactions
- Predict the products for different types of chemical reactions and balance chemical equations

Supports for English Language Learners		
Sensory Supports	**Graphic Supports**	**Interactive Supports**
Real-life objects	Charts	In pairs or partners
Manipulatives	Graphic Organizers	In triads or small groups
Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group
Magazines & Newspapers	Timelines	Structures
Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodations	**Interventions**	**Modifications**
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Unit 5: Calculations in Chemistry

Unit 5:
Content Statement: *This unit develops students' ability to use the mole as a fundamental counting unit in chemistry and apply quantitative relationships to chemical substances and reactions. Students practice multi-step conversions among mass, volume, density, moles, and representative particles while applying appropriate precision and accuracy when reporting measurements. Using balanced chemical equations, students apply stoichiometry to determine the amounts of reactants and products, identify limiting reactants, and calculate theoretical and percent yields. Students also determine empirical and molecular formulas and calculate percent composition from experimental and chemical data. Throughout the unit, students examine the conservation and transfer of energy in closed systems and use balanced chemical equations to represent the conservation of energy during chemical reactions* **Learning Objectives** *Students will be able to:* ● Can convert between the macroscopic mass of a substance, its equivalent chemical moles, and its constituent particles to calculate percent composition and mathematically determine its empirical and molecular formulas. ● Write and utilize balanced chemical equations as mathematical algorithms to calculate quantitative mass-to-mass yields of reactants and products

during chemical transformations, demonstrating that total mass and atoms are conserved.

- Identify the limiting and excess reagents in a multi-reactant system to calculate the theoretical product yield and determine the percent yield based on experimental outputs.
- Determine and report calculated chemical quantities to an appropriate level of accuracy by applying the rules of significant figures, scientific notation, and dimensional unit prefixes to reflect laboratory measurement limitations
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
- Use a model to predict the relationships between systems or between components of a system.
- 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.
- Use mathematical representations of phenomena to support claims.
- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
- 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.
- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.
- 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.
-

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
• How can the interpretation or manipulation of quantitative data be used to determine the chemical composition of a substance? • How are balanced chemical equations used to calculate quantities of substances in chemical reactions? • Why is it important that we are able to determine a limiting reactant?	Students will understand that… **Cause and Effect** • Limiting reactant is critical because it acts as the primary constraint on a reaction system, dictating the maximum theoretical yield of products and allowing scientists and industries to calculate efficiency losses (percent yield) to optimize chemical processes. **Scale**

• How can you choose a level of accuracy that is appropriate to limitations on measurement when reporting quantities?	• Quantitative analytical data—such as relative mass measurements—can be systematically converted and manipulated via the mole concept to determine the exact proportional ratio of constituent atoms in a chemical substance, revealing its empirical and molecular chemical composition • The appropriate level of accuracy reported in calculated chemical quantities is strictly limited by the precision boundaries of laboratory measurement instruments; expressing data with correct significant figures is necessary to prevent the misleading representation of scientific precision **Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5) **Energy and Matter: Flows, Cycles, and Conservation** Balanced chemical equations establish the exact molar proportions of reactants and products required to satisfy the Law of Conservation of Mass; these stoichiometric ratios act as mathematical conversion pathways to calculate mass-to-mass yields in a reaction system **Energy and Matter** • The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)
New Jersey Student Learning Standards *What student learning standards will be addressed?*	**Assessments** *How will students be assessed and evaluated on their learning?*
[Content Area Standards:]() **Content Area Standards:**	**Formative Assessments** • *Gizmo or PhET Simulation Check*: Balancing chemical equations and types of reactions. • *Exit Ticket:* Students perform a brief calculation to identify the limiting reagent for a reaction scenario displayed on the board.

HS-PS1-1. Matter and its Interactions: 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. Matter and its Interactions: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. HS-PS1-3. Matter and its Interactions: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. HS-PS1-4 Matter and its Interactions: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. HS-PS1-5 Matter and Its Interactions: 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 Matter and Its Interactions: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. HS-PS1-4 Matter and its Interactions:	• Lab: Limiting Reactant and Percent Yield • Lab: Determine Empirical and Molecular Formula • Lab: Decomposition of Baking Soda • Lab: Determine percent of sugar in a piece of gum • Pre and Post lab experiment assignments and assessments **Benchmark/Summative Assessments:** Unit Tests (Unit Tests and quizzes with multiple choice, short answer, calculations and open-ended questions). **Alternative Assessments:** Projects

Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. HS-PS1-5 Matter and Its Interactions: 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 Matter and Its Interactions: 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 Matter and Its Interactions: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Interdisciplinary Standards: ELA/Literacy • RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. • RST.9-10.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text. • RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as used in scientific or technical contexts. • RST.9-10.5 Analyze the structure of relationships among concepts in a text, including relationships among key terms.	

- RST.9-10.7 Translate quantitative or technical information expressed in words into visual form and information expressed visually or mathematically into words. - RST.9-10.9 Compare and contrast findings presented in a text with those from other sources, including their own experiments. - RST.9-10.10 By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently. - WHST.9-12.2 Write informative/explanatory texts, including scientific procedures, experiments, and technical processes. - WHST.9-12.4 Produce clear and coherent writing appropriate to task, purpose, and audience. - WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. Career Readiness, Life Literacies and Key Skills Standards: 9.1.12.FP.5 Evaluate how behavioral bias (e.g., overconfidence, confirmation, recency, loss aversion, etc.) affects decision-making. 9.3.ST.2 (STEM - Technical Data): *Use technology to acquire, manipulate, analyze and report data.* 9.3.ST.3 (STEM - Safety Standards): *Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.* 9.3.ST.6 (STEM - Technical Skills): *Demonstrate technical skills needed in a chosen STEM field.* 9.3.ST-SM.4 (STEM - Critical Thinking & Research Data): *Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.* 9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving.	

<table>
<tr><td>

Computer Science and Design Thinking Standards:

- 8.1.12.DA.1 Create interactive data visualizations using software tools to help others better understand real world phenomena.
- 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.
-

</td><td></td></tr>
<tr><th>Differentiation & Modification
How will instruction be differentiated to meet students' needs?</th><th>Instructional Resources
What texts and resources will be utilized in this unit?</th></tr>
<tr><td>

List those that are applicable for this unit.

Supports for English Language Learners
Intervention Strategies
Modifications Chart

Resources for Differentiation and Modification

Colorín Colorado – Science Instruction for ELLs
American Chemical Society (ACS) – Chemistry Education Resources
Khan Academy – Chemistry
PhET Interactive Simulations
American Association of Chemistry Teachers (AACT)
ACS ChemMatters
Chemistry LibreTexts
POGIL – Process Oriented Guided Inquiry Learning
ExploreLearning Gizmos
ACS Reactions – Chemistry for Life
Colorín Colorado – ELL Resource Collections
RSC Chemistry Literacy and Language Support

</td><td>

Required:

- Wilbraham, A. C., Staley, D. D., Matta, M. S., & Waterman, E. L. (2005). *Prentice Hall chemistry*. Pearson Prentice Hall
- New Jersey State Science Standards

Recommended:

- NJ Department of Education (NJDOE) — NJSLS-S standards, curriculum guidance, and instructional resources.
NJDOE Science Standards & Resources
- American Association of Chemistry Teachers (AACT) — Chemistry lessons, labs, demonstrations, safety, measurement, matter, properties, and separation activities.
AACT Classroom Resources
- American Chemical Society (ACS) — Chemistry content, laboratory safety, periodic table resources, element discovery, and real-world applications.
ACS High School Chemistry Resources
- PhET Interactive Simulations — Interactive simulations for atoms, elements, states of matter, particle behavior, and physical/chemical concepts.
PhET Interactive Simulations
- New Jersey Science Teachers Association (NJSTA) — NJ-specific teaching resources, NJSLS connections, phenomena, and science instructional materials.

</td></tr>
</table>

	[NJSTA Resource Center] ● OpenSciEd — Phenomenon-based, inquiry-centered instructional materials aligned with three-dimensional science learning. [OpenSciEd] ● ACS ChemMatters — Short, accessible readings connecting chemistry concepts to real-world applications, technology, Earth, and society. [ChemMatters] ● NJDOE Earth & Space Science Resources — Standards and instructional guidance for Earth's layers, composition, and Earth-system concepts. [NJDOE Earth & Space Science Standards]

Instructional Focus

What lessons and content should be included in this unit?

Lessons may need to be adjusted, added, or skipped based on student assessments results and demonstrated skills.

- Review the definition of a mole and its uses
- Perform multi-step problems to convert between units of mass, volume, representative particles and density
- Practice describing and calculating the continuous transfer of energy in a closed system.
- Using a balanced equation and stoichiometry to calculate the amount of reactants and products present in a chemical reaction.
- Determine the limiting reactant and use to calculate the amount of product that would be produced
- Determine the empirical and molecular formula of a compound
- Calculate theoretical yield and percent yield
- Calculate the percent composition for a sample of material
- Use balanced chemical equations to show the conservation of energy throughout a reaction
- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities

Supports for English Language Learners

Sensory Supports	Graphic Supports	Interactive Supports
Real-life objects	Charts	In pairs or partners

Manipulatives	Graphic Organizers	In triads or small groups
Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group
Magazines & Newspapers	Timelines	Structures
Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodations	**Interventions**	**Modifications**
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Unit 6: Phases of Matter and Aqueous Solutions

Unit 6:

Content Statement:

This unit explores the behavior of matter in different phases and the interactions of particles in gases, solids, and aqueous solutions. Students will investigate changes of state, pressure, temperature, phase diagrams, vapor pressure, and the properties of solids. They will use the Kinetic Molecular Theory and the gas laws to predict gas behavior, including applications to stoichiometry, partial pressure, and diffusion. Students also examine changes in Earth's atmosphere and the role of chemical reactions in carbon dioxide production.

The unit then focuses on water and aqueous solutions, including water's properties, the water cycle, solubility, electrolytes, concentration, molarity, and dilution. Students use solubility curves and "like dissolves like" to predict solubility and explore acid-base reactions, pH, and titrations.

Learning Objectives:

- Use the Kinetic Molecular Theory to explain how changes in temperature (average kinetic energy) and pressure affect the spacing, motion, and macroscopic properties of solids, liquids, and gases.
- analyze vapor pressure curves and phase diagrams to explain how substances with differing molecular structures and intermolecular forces can exist in different physical states at identical ambient temperatures and pressures
- Can use the Kinetic Molecular Theory to explain how changes in temperature (average kinetic energy) and pressure affect the spacing, motion, and macroscopic properties of solids, liquids, and gases
- Can evaluate geoscience data to construct an evidence-based argument tracing how the composition of Earth's atmosphere has changed over geological time and analyze how human technology impacts atmospheric stability.
- Can explain how the polar covalent molecular structure of water drives its ability to form hydrogen bonds, and trace how these microscopic forces cause its unique bulk macroscopic behaviors.
- Model the steps of the water cycle to explain how phase transitions (evaporation, condensation) and geological filtration act as physical purification techniques,comparing these natural mechanisms to engineered water treatment designs.
- Construct a microscopic model illustrating how solvent molecules hydrate and dissociate solute particles, and use mathematical formulas to calculate solution concentrations (molarity) and dilutions.
- Can predict whether a substance will be soluble or insoluble in water by analyzing its molecular geometry, polarity, and potential intermolecular forces, and cite experimental observations to justify my predictions.
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)
- Use mathematical representations of phenomena to support claims. (HS-PS1-7)

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)
- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (HS-PS1-6)
- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
• What factors affect the properties of the different states of matter? • How can matter exist at different states at the same temperature and pressure? • Has the composition of our atmosphere remained consistent over time? • Why is water a unique chemical substance? • What steps of the water cycle are natural purification techniques? • What happens to a substance when it dissolves? • Why are some substances soluble in water and others aren't?	Students will understand that… **Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5) **Cause and Effect** • The macroscopic physical properties of the solid, liquid, and gas phases (such as shape, density, viscosity, and compressibility) are caused by a dynamic competition between the average kinetic energy of the particles, which is directly proportional to Kelvin temperature, and the electrostatic intermolecular attractions holding those particles together. • Solubility is caused by the rule of electrostatic compatibility ("like dissolves like"); polar water molecules form strong electrostatic attractions with ionic or polar solutes to overcome their cohesive forces, but cannot form compatible attractions with nonpolar solutes, which remain insoluble **Energy and Matter** • The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Structure and Function**

	- At any given temperature and pressure, the physical state of a substance is determined by its molecular structure; substances with strong electrostatic attractions (such as ionic networks or polar molecules with strong intermolecular forces) remain bound as solids or liquids, whereas substances with weak attractions exist as gases. - Water possesses highly anomalous bulk physical properties—such as an exceptionally high boiling point, high specific heat capacity, and expansion upon freezing—which are structural consequences of its polar covalent geometry and its ability to form extensive, cohesive hydrogen bond networks - **Stability and Change** - Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6) - Earth's atmosphere is a dynamic, evolving system whose chemical composition has undergone massive transitions over geological time scales—driven by planetary outgassing, the biological evolution of photosynthetic life, and modern human technology—influencing global climate stability **System and System Models** - The water cycle operates as a planetary purification system where phase changes—specifically evaporation and condensation—and lithospheric filtration leverage gravitational and thermal systems to separate pure water from dissolved chemical salts, biological contaminants, and suspended particulates. - When a solute dissolves, the solution process involves a systemic rearrangement of matter where solute-solute and solvent-solvent attractions are overcome, and new solvent-solute electrostatic interactions are established, resulting in the uniform dispersal of solute particles (ions or molecules) throughout the solvent
New Jersey Student Learning Standards *What student learning standards will be addressed?*	**Assessments** *How will students be assessed and evaluated on their learning?*

Content Area Standards: HS-PS1-1. Matter and its Interactions: 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. Matter and its Interactions: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. HS-PS1-3. Matter and its Interactions: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. HS-PS1-4 Matter and its Interactions: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. HS-PS1-5 Matter and Its Interactions: 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 Matter and Its Interactions: 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 Matter and Its Interactions:	**Formative Assessments** ● *Gizmo or PhET Simulation Check*: Investigating properties of solids, liquids and gases ● *Exit Ticket:* Students label a phase diagram and answer questions ● *Exit Ticket:* Students look at unlabeled graphs and identify whether they represent Boyle's, Charles's, or Gay-Lussac's law ● Investigation of Gas Properties Lab ● Volume of the Room Lab ● Collecting Gas over Water Lab ● Creating a Heating and Cooling Curve for Lauric Acid Lab. ● Developing the Kelvin Temperature Scale Lab ● Beer's Law Lab ● Titration Lab ● Demonstrations: surface tension, atmospheric pressure, chromatography...etc ● Activity: What is Oobleck? **Benchmark/Summative Assessments:** Unit Tests (Unit Tests and quizzes with multiple choice, short answer, calculations and open-ended questions). **Alternative Assessments:** Projects

Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. HS-LS2-3: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. Interdisciplinary Standards: ELA/Literacy ● RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. ● RST.9-10.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text. ● RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as used in scientific or technical contexts. ● RST.9-10.5 Analyze the structure of relationships among concepts in a text, including relationships among key terms. ● RST.9-10.7 Translate quantitative or technical information expressed in words into visual form and information expressed visually or mathematically into words. ● RST.9-10.9 Compare and contrast findings presented in a text with those from other sources, including their own experiments. ● RST.9-10.10 By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently. ● WHST.9-12.2 Write informative/explanatory texts, including scientific procedures, experiments, and technical processes. ● WHST.9-12.4 Produce clear and coherent writing appropriate to task, purpose, and audience.	

- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. Career Readiness, Life Literacies and Key Skills Standards: - 9.1.12.FP.5 Evaluate how behavioral bias (e.g., overconfidence, confirmation, recency, loss aversion, etc.) affects decision-making. - 9.3.ST.2 (STEM - Technical Data): *Use technology to acquire, manipulate, analyze and report data.* - 9.3.ST.3 (STEM - Safety Standards): *Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.* - 9.3.ST.6 (STEM - Technical Skills): *Demonstrate technical skills needed in a chosen STEM field.* - 9.3.ST-SM.4 (STEM - Critical Thinking & Research Data): *Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.* - 9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving. Computer Science and Design Thinking Standards: - 8.1.12.DA.1 Create interactive data visualizations using software tools to help others better understand real world phenomena. - 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.	

Differentiation & Modification *How will instruction be differentiated to meet students' needs?*	**Instructional Resources** *What texts and resources will be utilized in this unit?*
List those that are applicable for this unit. Supports for English Language Learners Intervention Strategies Modifications Chart **Resources for Differentiation and Modification** Colorín Colorado – Science Instruction for ELLs American Chemical Society (ACS) – Chemistry Education Resources Khan Academy – Chemistry PhET Interactive Simulations American Association of Chemistry Teachers (AACT) ACS ChemMatters Chemistry LibreTexts POGIL – Process Oriented Guided Inquiry Learning ExploreLearning Gizmos ACS Reactions – Chemistry for Life Colorín Colorado – ELL Resource Collections RSC Chemistry Literacy and Language Support	**Required:** ● Wilbraham, A. C., Staley, D. D., Matta, M. S., & Waterman, E. L. (2005). *Prentice Hall chemistry*. Pearson Prentice Hall ● New Jersey State Science Standards **Recommended:** ● NJ Department of Education (NJDOE) — NJSLS-S standards, curriculum guidance, and instructional resources. NJDOE Science Standards & Resources ● American Association of Chemistry Teachers (AACT) — Chemistry lessons, labs, demonstrations, safety, measurement, matter, properties, and separation activities. AACT Classroom Resources ● American Chemical Society (ACS) — Chemistry content, laboratory safety, periodic table resources, element discovery, and real-world applications. ACS High School Chemistry Resources ● PhET Interactive Simulations — Interactive simulations for atoms, elements, states of matter, particle behavior, and physical/chemical concepts. PhET Interactive Simulations ● New Jersey Science Teachers Association (NJSTA) — NJ-specific teaching resources, NJSLS connections, phenomena, and science instructional materials. NJSTA Resource Center ● OpenSciEd — Phenomenon-based, inquiry-centered instructional materials aligned with three-dimensional science learning. OpenSciEd ● ACS ChemMatters — Short, accessible readings connecting chemistry concepts to real-world applications, technology, Earth, and society. ChemMatters ● NJDOE Earth & Space Science Resources — Standards and instructional guidance for Earth's layers, composition, and Earth-system concepts. NJDOE Earth & Space Science Standards

Instructional Focus

What lessons and content should be included in this unit?

Lessons may need to be adjusted, added, or skipped based on student assessments results and demonstrated skills.

Changes of State

- Define Atmospheric pressure, how to measure, identifying units for pressure and how to convert between them.
- Define the Kelvin Temperature scale and Absolute Zero
- Review different states of matter, changes of state and phase diagrams.
- Distinguish between boiling and evaporation.
- Explain vapor pressure and reading vapor pressure curves
- Describe the organization and forces between particles in the solid phase.
- Identify and define an allotrope and amorphous solids.

Properties of Gases

- Define Kinetic Molecular Theory and how it describes the behavior of gases.
- Derive graphically and define Boyles, Charles's and Gay-Lussac's law.
- Use the combined gas law and ideal gas law to predict changes of gas behavior. Compare and contrast ideal and real gases.
- Apply the Ideal Gas Law to Reaction Stoichiometry.
- Use Dalton's law to calculate partial pressures. Predict Relative Rates of Diffusion Using Graham's Law
- Explain how the composition of the Earth's atmosphere has changed over time due to human activity
- Review the different chemical reactions involved in the production of carbon dioxide in our atmosphere

Reactions in Aqueous Solutions

- Describe properties of water.
- Review the water cycle and the amount of fresh water found on Earth
- Describe the process by which solutes dissolve in solvents.
- Identify what factors affect the rate of dissolution.
- Use the "like dissolves like" rule to predict the solubility of one substance in another.
- Describe the factors that affect solubility including pressure, temperature and nature of components.
- Distinguish between strong and weak electrolytes.
- Review how to read a solubility curve and determine if a solution is saturated, unsaturated or supersaturated.
- Calculate the concentration of solution; Molarity. Distinguish between a dilute and concentrated solution and how to calculate concentration of a diluted solution.
- Describe Acid Base reactions, pH scale and titrations.

Supports for English Language Learners

Sensory Supports	Graphic Supports	Interactive Supports
Real-life objects	Charts	In pairs or partners
Manipulatives	Graphic Organizers	In triads or small groups
Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group
Magazines & Newspapers	Timelines	Structures
Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodations	**Interventions**	**Modifications**
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Unit 7: Energy in Chemical and Physical Changes

Unit 7:
Content Statement: *This unit explores the energy changes associated with chemical and physical processes. Students distinguish between systems, surroundings, and the universe and investigate exothermic and endothermic reactions using potential energy diagrams, activation energy, and enthalpy. Students apply calorimetry and specific heat calculations to determine heat transfer and calculate heats of reaction, phase changes, combustion, and dissolution using Hess's Law and standard heats of formation. The unit then introduces the laws of thermodynamics, focusing on entropy, spontaneity, and free energy. Students predict changes in entropy, calculate entropy and Gibbs free energy, and use the relationship $\Delta G = \Delta H - T\Delta S$ to determine whether chemical processes are spontaneous.* **Learning Objectives:** ● Can construct a conceptual model demonstrating that total energy is conserved in a system, and explain how the net absorption or release of energy in physical and chemical processes depends on the total bond energies of the system. ● Explain the distinction between thermal energy, heat, and temperature, using the Kinetic Molecular Theory to describe how kinetic energy flows during molecular collisions. ● Follow complex lab procedures to measure heat transfer and calculate enthalpy changes (Delta H) during changes of state and chemical reactions, applying Hess's Law to determine total heat changes ● Evaluate physical and chemical changes based on experimental evidence, and apply Le Chatelier's Principle to explain how a chemical system at equilibrium shifts in response to stress changes in temperature, concentration, or pressure. ● Use balanced chemical equations as mathematical algorithms to perform mass-to-mass stoichiometry conversions, identifying limiting and excess reagents to calculate theoretical and percent yields ● Apply collision theory to explain how changes in temperature and concentration alter reaction rates, and use experimental data to write rate laws. ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8) ● Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) ● Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the

data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

- Use mathematical representations of phenomena to support claims. (HS-PS1-7)
- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)
- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (HS-PS1-6)
- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
• What is energy? • What is the difference between heat and temperature? • What factors affect the ability of material to absorb or release heat? • Are chemical and physical changes reversible? • What factors affect the amounts of product formed in a chemical reaction? • What factors determine whether or not a chemical reaction will happen?	Students will understand that… **Cause and Effect:** • Whether a reaction occurs is determined by collision theory (colliding particles must possess sufficient kinetic energy to overcome the activation barrier and collide in a favorable spatial orientation), and is driven by thermodynamic spontaneity, which balances enthalpy changes (Delta H) and universal entropy **Scale** • Temperature is a macroscopic, scale-dependent measure of the average kinetic energy of the individual particles within a sample of matter, whereas heat is the macroscopic transfer of thermal energy from a system of higher temperature to a system of lower temperature via microscopic particle collisions • The mass of products formed in a reaction is limited by scale and proportion; it is determined by the stoichiometric mole ratios of the balanced chemical equation, the mass of the limiting reagent (which acts

	as a reaction constraint), and the system conditions that shift dynamic equilibrium **Patterns** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5) **Energy and Matter** ● The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) ● Energy drives the cycling of matter within and between systems. (HS-ESS2-3) ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) ● Energy cannot be created or destroyed-only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2) ● Energy is a quantitative property of a system that depends on the motion and interactions of matter; at the chemical level, energy is stored in the electrostatic attractions between atoms (chemical bonds), and any physical or chemical change involves a flow, transformation, or rearrangement of this energy while the total amount of universal energy remains completely conserved **Stability and Change** ● Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6) ● Physical state changes are typically reversed by simple thermal manipulations, and chemical changes are also reversible in closed systems where forward and reverse reaction rates eventually stabilize at a state of dynamic chemical equilibrium where reactant and product concentrations remain constant. **Structure and Function** ● The capacity of a material to absorb or release thermal energy is a structural property determined by its mass, specific heat capacity (which is dictated by internal bonds and intermolecular forces), and the magnitude of the temperature change. ● **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. (HS-PS3-4)

New Jersey Student Learning Standards *What student learning standards will be addressed?*	**Assessments** *How will students be assessed and evaluated on their learning?*
Content Area Standards: HS-PS1-1. Matter and its Interactions: 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. Matter and its Interactions: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. HS-PS1-3. Matter and its Interactions: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. HS-PS1-4 Matter and its Interactions: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. HS-PS1-5 Matter and Its Interactions: 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 Matter and Its Interactions:	**Formative Assessments** ● *Exit Ticket:* Ask students to write if the hand is part of the system or surroundings when holding a hot test tube ● *Whiteboard Challenge:* Give students a list of exothermic and endothermic chemical and physical processes and have them sort into two columns. ● *3-2-1 Summary Exit Ticket*: Ask students to identify three key takeaways, two compelling observations, and one remaining point of inquiry to conclude the lesson. ● *Thermodynamic Mapping Exercise:* Students construct a visual schematic linking core concepts including the system, surroundings, and universe, while utilizing directional vectors to illustrate enthalpy and heat transfers. ● *Thermodynamic Error Analysis:* Present a flawed calculation where a temperature conversion to Kelvin was omitted or the sign for an exothermic process was neglected. Students must identify and rectify the technical inaccuracy. ● Lab: Calorimetry ● Lab: Specific heat of an unknown metal ● Lab: Burning food lab ● Lab: Heats of Solution ● Activity: Specific Heat and Hurricanes ● Demonstrations for specific heat **Benchmark/Summative Assessments:** Unit Tests (Unit Tests and quizzes with multiple choice, short answer, calculations and open-ended questions). **Alternative Assessments:** Projects

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 Matter and Its Interactions: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Interdisciplinary Standards:] ELA/Literacy ● RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. ● RST.9-10.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text. ● RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as used in scientific or technical contexts. ● RST.9-10.5 Analyze the structure of relationships among concepts in a text, including relationships among key terms. ● RST.9-10.7 Translate quantitative or technical information expressed in words into visual form and information expressed visually or mathematically into words. ● RST.9-10.9 Compare and contrast findings presented in a text with those from other sources, including their own experiments. ● RST.9-10.10 By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.	

● WHST.9-12.2 Write informative/explanatory texts, including scientific procedures, experiments, and technical processes. ● WHST.9-12.4 Produce clear and coherent writing appropriate to task, purpose, and audience. ● WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. Career Readiness, Life Literacies and Key Skills Standards: ● 9.1.12.FP.5 Evaluate how behavioral bias (e.g., overconfidence, confirmation, recency, loss aversion, etc.) affects decision-making. ● 9.3.ST.2 (STEM - Technical Data): *Use technology to acquire, manipulate, analyze and report data.* ● 9.3.ST.3 (STEM - Safety Standards): *Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.* ● 9.3.ST.6 (STEM - Technical Skills): *Demonstrate technical skills needed in a chosen STEM field.* ● 9.3.ST-SM.4 (STEM - Critical Thinking & Research Data): *Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.* ● 9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving. Computer Science and Design Thinking Standards: ● 8.1.12.DA.1 Create interactive data visualizations using software tools to help others better understand real world phenomena.	

● 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.	
Differentiation & Modification *How will instruction be differentiated to meet students' needs?*	**Instructional Resources** *What texts and resources will be utilized in this unit?*
List those that are applicable for this unit. Supports for English Language Learners Intervention Strategies Modifications Chart **Resources for Differentiation and Modification** Colorín Colorado – Science Instruction for ELLs American Chemical Society (ACS) – Chemistry Education Resources Khan Academy – Chemistry PhET Interactive Simulations American Association of Chemistry Teachers (AACT) ACS ChemMatters Chemistry LibreTexts POGIL – Process Oriented Guided Inquiry Learning ExploreLearning Gizmos ACS Reactions – Chemistry for Life Colorín Colorado – ELL Resource Collections RSC Chemistry Literacy and Language Support	**Required:** ● Wilbraham, A. C., Staley, D. D., Matta, M. S., & Waterman, E. L. (2005). *Prentice Hall chemistry*. Pearson Prentice Hall ● New Jersey State Science Standards **Recommended:** ● NJ Department of Education (NJDOE) — NJSLS-S standards, curriculum guidance, and instructional resources. NJDOE Science Standards & Resources ● American Association of Chemistry Teachers (AACT) — Chemistry lessons, labs, demonstrations, safety, measurement, matter, properties, and separation activities. AACT Classroom Resources ● American Chemical Society (ACS) — Chemistry content, laboratory safety, periodic table resources, element discovery, and real-world applications. ACS High School Chemistry Resources ● PhET Interactive Simulations — Interactive simulations for atoms, elements, states of matter, particle behavior, and physical/chemical concepts. PhET Interactive Simulations ● New Jersey Science Teachers Association (NJSTA) — NJ-specific teaching resources, NJSLS connections, phenomena, and science instructional materials. NJSTA Resource Center ● OpenSciEd — Phenomenon-based, inquiry-centered instructional materials aligned with three-dimensional science learning. OpenSciEd ● ACS ChemMatters — Short, accessible readings connecting chemistry concepts to real-world applications, technology, Earth, and society. ChemMatters

	• NJDOE Earth & Space Science Resources — Standards and instructional guidance for Earth's layers, composition, and Earth-system concepts. [NJDOE Earth & Space Science Standards]

Instructional Focus

What lessons and content should be included in this unit?

Lessons may need to be adjusted, added, or skipped based on student assessments results and demonstrated skills.

Instructional Focus

Thermodynamics

- Distinguish between the system, surroundings and the universe.
- Identify exothermic and endothermic reactions
- Draw and interpret potential energy diagrams for chemical reactions.
- Identify the molar heat of reaction, activation energy, activated complex, and classify the reactions as endothermic or exothermic.
- Calculate the amount of heat (q) released during a chemical or physical change
- Identify the specific heat of an unknown metal
- Define calorimetry
- Define enthalpy of reaction
- Determine the heat of phase changes as well as heat of combustion and dissolution.
- Calculate the heat of reaction using Hess's Law or standard heat of formation
- Recognize the second Law of thermodynamics as it refers to the inevitable increase in entropy for the system and the universe for all spontaneous processes.
- Predict the relative entropies of chemical systems and calculate entropy using standard free entropy values.
- Define free energy and use its value to determine if a reaction is spontaneous.
- Perform calculations using the equation $\Delta G = \Delta H - T\Delta S$.

Supports for English Language Learners

Sensory Supports	Graphic Supports	Interactive Supports
Real-life objects	Charts	In pairs or partners
Manipulatives	Graphic Organizers	In triads or small groups

Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group
Magazines & Newspapers	Timelines	Structures
Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodations	**Interventions**	**Modifications**
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Unit 8: Kinetics and Equilibrium

Unit 8:

Content Statement:
This unit explores the energy changes associated with chemical and physical processes. Students distinguish between systems, surroundings, and the universe and investigate exothermic and endothermic reactions using potential energy diagrams, activation energy, and enthalpy. Students apply calorimetry and specific heat calculations to determine heat transfer and calculate heats of reaction, phase changes, combustion, and dissolution using Hess's Law and standard heats of formation. The unit then introduces the laws of thermodynamics, focusing on entropy, spontaneity, and free energy. Students predict changes in entropy, calculate entropy and Gibbs free energy, and use the relationship $\Delta G = \Delta H - T\Delta S$ to determine whether chemical processes are spontaneous.

Learning Objectives:

- Use mathematical representations (stoichiometry calculations and mole ratios) to support the claim that atoms and mass are conserved during chemical transformations, identifying how limiting reactants and system conditions restrict maximum product yields.
- Apply scientific principles and evidence to explain how changing temperature or concentration alters the collision rate of reacting particles, and use experimental data to write rate laws.
- construct and analyze system models (reaction coordinate diagrams) to show that a chemical reaction requires an input of activation energy to break existing chemical bonds and initiate molecular rearrangements.
- Research and argue how engineering chemical reaction rates (such as catalytic converters in transport or enzymatic stabilization in pharmaceuticals) addresses human problems, and analyze the ethical, economic, and environmental trade-offs of these technologies.
- refine the design of a simulated chemical system by specifying precise changes in temperature, pressure, or concentration to shift the reaction pathway and optimize product yield.
- Construct a scientific explanation distinguishing between static and dynamic balance, using particle-level models to show that dynamic equilibrium involves continuous chemical transformations with stable macroscopic concentrations.
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)
- Use mathematical representations of phenomena to support claims. (HS-PS1-7)
- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2)

- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (HS-PS1-6)
- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)

Essential Questions *What provocative questions will foster inquiry, understanding, and transfer of learning?*	**Enduring Understandings** *What will students understand about the big ideas?*
• Are chemical and physical changes reversible? • What factors affect the amounts of product formed in a chemical reaction? • How can the rate of a chemical reaction be measured and changed? • What factors determine whether or not a chemical reaction will happen? • How do the rates of chemical reactions directly impact our lives? • Under what conditions can a reaction be manipulated to proceed in one particular direction? • What is the difference between static and dynamic equilibrium?	Students will understand that… **Scale** • The mass and amount of product formed in a chemical reaction are strictly limited by scale and proportion; product formation is constrained by the stoichiometry of the balanced chemical equation, the quantity of the limiting reactant, and the system conditions that restrict dynamic equilibrium shifts.. **Influence of Engineering, Technology, and Science on Society and the Natural World** • Human control over chemical reaction rates is the cornerstone of modern technology, medicine, and environmental science; accelerating rates makes industrial processes economically viable, while slowing rates preserves food, prevents material decay, and maintains biological health. • **Cause and Effect** • The rate of a chemical reaction is measured by tracking changes in reactant or product concentrations over time; this rate is altered by temperature, concentration, surface area, and catalysts, which directly change collision frequency and particle energy. **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. • 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. **Stability and Change**

<table>
<tr>
<td></td>
<td>

- A chemical system at equilibrium is dynamic and responsive; introducing external stresses (altering concentration, temperature, or pressure) disturbs this stability, causing the system to shift its reaction coordinate according to Le Chatelier's Principle to produce more reactants or products.
- Unlike static equilibrium where all motion has completely ceased, dynamic chemical equilibrium is a state of active, continuous balancing where forward and reverse chemical reactions occur at identical, non-zero rates, resulting in no net change in reactant or product concentrations.

Structure and Function

- Whether a chemical reaction occurs depends on collision theory—requiring reacting particles to collide with sufficient kinetic energy to overcome the activation barrier and collide in a favorable spatial orientation—and is driven by thermodynamic spontaneity, which balances net changes in potential bond energy and universal entropy.

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

</td>
</tr>
<tr>
<th>New Jersey Student Learning Standards
What student learning standards will be addressed?</th>
<th>Assessments
How will students be assessed and evaluated on their learning?</th>
</tr>
<tr>
<td>

Content Area Standards:

HS-PS1-1. Matter and its Interactions: 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. Matter and its Interactions: 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.

</td>
<td>

Formative Assessments

- *Whiteboard Collision Sketches:* Have small groups create a particle-level model illustrating how catalysts or increased concentration influence reaction rates.
- *Rate Law Prediction Polls:* Use digital polling tools to assess students' ability to predict rate changes based on doubling reactant concentrations in a provided rate law.
- *Graph Interpretation Check-ins:* Present a concentration-time graph and require students to determine where the velocity is maximized, justifying their answer via slope analysis.

</td>
</tr>
</table>

HS-PS1-3. Matter and its Interactions: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. HS-PS1-4 Matter and its Interactions: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. HS-PS1-5 Matter and Its Interactions: 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 Matter and Its Interactions: 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 Matter and Its Interactions: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Interdisciplinary Standards: ELA/Literacy • RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. • RST.9-10.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text.	• *Mini-Whiteboard Error Analysis:* Provide a technical description of activation energy containing a flaw; groups must collaborate to diagnose the underlying misconception. • Disturbing Equilibrium Lab • Factors that Affect Rate Lab • Iodine Clock Reaction Lab • Spontaneity Lab • Demonstrations for specific heat **Benchmark/Summative Assessments:** Unit Tests (Chapter Tests and quizzes with multiple choice, short answer, calculations and open-ended questions) **Alternative Assessments:** Projects

• RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as used in scientific or technical contexts. • RST.9-10.5 Analyze the structure of relationships among concepts in a text, including relationships among key terms. • RST.9-10.7 Translate quantitative or technical information expressed in words into visual form and information expressed visually or mathematically into words. • RST.9-10.9 Compare and contrast findings presented in a text with those from other sources, including their own experiments. • RST.9-10.10 By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently. • WHST.9-12.2 Write informative/explanatory texts, including scientific procedures, experiments, and technical processes. • WHST.9-12.4 Produce clear and coherent writing appropriate to task, purpose, and audience. • WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. Career Readiness, Life Literacies and Key Skills Standards: • 9.1.12.FP.5 Evaluate how behavioral bias (e.g., overconfidence, confirmation, recency, loss aversion, etc.) affects decision-making. • 9.3.ST.2 (STEM - Technical Data): *Use technology to acquire, manipulate, analyze and report data.* • 9.3.ST.3 (STEM - Safety Standards): *Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.* • 9.3.ST.6 (STEM - Technical Skills): *Demonstrate technical skills needed in a chosen STEM field.* • 9.3.ST-SM.4 (STEM - Critical Thinking & Research Data): *Apply critical thinking skills to review information, explain statistical*	

analysis, and to translate, interpret and summarize research and statistical data. ● 9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving. Computer Science and Design Thinking Standards: ● 8.1.12.DA.1 Create interactive data visualizations using software tools to help others better understand real world phenomena. ● 8.1.12.DA.5 Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.	
Differentiation & Modification *How will instruction be differentiated to meet students' needs?*	**Instructional Resources** *What texts and resources will be utilized in this unit?*
List those that are applicable for this unit. Supports for English Language Learners Intervention Strategies Modifications Chart **Resources for Differentiation and Modification** Colorín Colorado – Science Instruction for ELLs American Chemical Society (ACS) – Chemistry Education Resources Khan Academy – Chemistry PhET Interactive Simulations American Association of Chemistry Teachers (AACT) ACS ChemMatters Chemistry LibreTexts POGIL – Process Oriented Guided Inquiry Learning	**Required:** ● Wilbraham, A. C., Staley, D. D., Matta, M. S., & Waterman, E. L. (2005). *Prentice Hall chemistry*. Pearson Prentice Hall ● New Jersey State Science Standards **Recommended:** ● NJ Department of Education (NJDOE) — NJSLS-S standards, curriculum guidance, and instructional resources. NJDOE Science Standards & Resources ● American Association of Chemistry Teachers (AACT) — Chemistry lessons, labs, demonstrations, safety, measurement, matter, properties, and separation activities. AACT Classroom Resources ● American Chemical Society (ACS) — Chemistry content, laboratory safety, periodic table resources, element discovery, and real-world applications. ACS High School Chemistry Resources

ExploreLearning Gizmos ACS Reactions – Chemistry for Life Colorín Colorado – ELL Resource Collections RSC Chemistry Literacy and Language Support	● PhET Interactive Simulations — Interactive simulations for atoms, elements, states of matter, particle behavior, and physical/chemical concepts. PhET Interactive Simulations ● New Jersey Science Teachers Association (NJSTA) — NJ-specific teaching resources, NJSLS connections, phenomena, and science instructional materials. NJSTA Resource Center ● OpenSciEd — Phenomenon-based, inquiry-centered instructional materials aligned with three-dimensional science learning. OpenSciEd ● ACS ChemMatters — Short, accessible readings connecting chemistry concepts to real-world applications, technology, Earth, and society. ChemMatters ● NJDOE Earth & Space Science Resources — Standards and instructional guidance for Earth's layers, composition, and Earth-system concepts. NJDOE Earth & Space Science Standards

Instructional Focus

What lessons and content should be included in this unit?

Lessons may need to be adjusted, added, or skipped based on student assessments results and demonstrated skills.

Instructional Focus

Chemical Kinetics

- Interpret and express the rate of a chemical reaction.
- Identify and analyze experimentally the factors that affect the rate.
- Write rate laws for chemical reactions and calculate the values of the order and the rate constant from initial rate data.
- Interpret mechanisms

Chemical Equilibrium

- Define chemical equilibrium in terms of the rates of forward and reverse reactions.
- Apply Le Chatelier's Principle to predict the effect of stress on a system at equilibrium.
- Use the value of the equilibrium constant to determine the position of equilibrium; calculate the value of the constant using experimental data.
- Use the ICE box method to solve equilibrium problems.

Supports for English Language Learners		
Sensory Supports	**Graphic Supports**	**Interactive Supports**
Real-life objects	Charts	In pairs or partners
Manipulatives	Graphic Organizers	In triads or small groups
Pictures	Tables	In a whole group
Illustrations, diagrams & drawings	Graphs	Using cooperative group
Magazines & Newspapers	Timelines	Structures
Physical activities	Number lines	Internet / Software support
Videos & Film		In the home language
Broadcasts		With mentors
Models & Figures		

Intervention Strategies		
Accommodations	**Interventions**	**Modifications**
Allow for verbal responses	Multi-sensory techniques	Modified tasks/expectations
Repeat/confirm directions	Increase task structure (e.g. directions, checks for understanding, feedback	Differentiated materials
Permit response provided via computer or electronic device	Increase opportunities to engage in active academic responding	Individualized assessment tools based on student need
Audio Books	Utilize pre-reading strategies and activities previews, anticipatory guides, and semantic mapping	Modified assessment grading

Revised June 2026