

Pascack Valley Regional High School District

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

Course Name: Honors Chemistry

Born On: August, 2026
Board Approval: 8/24/26

New Jersey Curricular Mandates for Science Instruction

Disabled & LGBT:

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

Diversity, Equity, and Inclusion (DEI):

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

Amistad Law:

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

Climate Change:

2026 NJSL-Science: Earth's climate is now changing faster than at any point in the history of modern civilization, primarily as a result of human activities. Global climate change has already resulted in a wide range of impacts across New Jersey and in many sectors of its economy. The addition of academic standards that focus on climate change is important so that all students will have a basic understanding of the climate system, including the natural and human-caused factors that affect it. The underpinnings of climate change span across physical, life, as well as Earth and space sciences. The goal is for students to understand climate science as a way to inform decisions that improve quality of life for themselves, their community, and globally and to know how engineering solutions can allow us to mitigate impacts, adapt practices, and build resilient systems.

Dissection Law

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

Honors Chemistry		
Unit Title	Approx # of weeks	Months
<i>Benchmark #1</i>		
Atomic Structure, Nuclear Energy, the EM Spectrum and the Periodic Table	6-8 Weeks	August - October
Compounds, Bonding and Molecular Structure	4-5 weeks	October- November
Moles and Reactions	4-5 weeks	November - December
<i>Benchmark #2</i>		
Thermochemistry and Thermodynamics	5-6 weeks	January - February
Environmental Chemistry, Gases, Climate Change	4-6 weeks	February - March
Equilibrium and Kinetics	3-4 weeks	April - May
Acids and Bases	2-3 weeks	May-June
<i>Benchmark #3</i>		

Honors Chemistry		
Unit 1: Atomic Structure, Nuclear Energy, the EM Spectrum and the Periodic Table		
Related Phenomena: 1. Stellar Alchemy and Earth's Elements 2. Reactivity of Alkali Metals 3. Dating of Fossils		
Pacing: Approximately 6-8 Weeks		
New Jersey Student Learning Standards (NJSL)		
HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. HS-PS1-8: Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. HS-PS4-4: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. HS-ESS1-2: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. HS-ESS1-3: Communicate scientific ideas about the way stars, over their life cycle, produce elements. HS-ESS3-2: Evaluate competing design solutions for developing, conserving, managing, and utilizing energy and mineral resources based on the associated economic, social, environmental, and geopolitical costs and risks, as well as benefits.		
Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Developing and Using Models - Use a model to predict the relationships between systems or between components of a system. Constructing Explanations and Designing Solutions - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the	PS1.A: Structure and Properties of Matter - Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. - The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.	Patterns - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Energy and Matter - Energy cannot be created or destroyed—only moved between one place and another place,

natural world operate today as they did in the past and will continue to do so in the future. Obtaining, Evaluating, and Communicating Information - Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). <i>Connections to Nature of Science</i> Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena - A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	PS1.B: Chemical Reactions - The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. PS1.C: Nuclear Processes - Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. ESS1.A: The Universe and Its Stars - The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. - The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. - Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. PS4.B: Electromagnetic Radiation - Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. <i>(secondary)</i> - When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.	between objects and/or fields, or between systems. - In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. - Cause and effect 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. ----- <i>Connections to Engineering, Technology, and Applications of Science</i> Interdependence of Science, Engineering, and Technology - Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. ----- <i>Connections to Nature of Science</i> Scientific Knowledge Assumes an Order and Consistency in Natural Systems - Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. - Science assumes the universe is a vast single system in which basic laws are consistent.	
Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How can a model be used to represent matter at the atomic scale? - How has the model of the	Student will be able to: Evaluate the merits and limitations of different models of the atom.	Use a computer model to evaluate relationships between changes in subatomic structure and	Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by

atom changed over time? - What are the merits and limitations of a model used to represent an atom? - What determines the “behavior” of electrons? - What can be predicted about similarities and differences in subatomic structure of elements? - How can the periodic table be used to help with making predictions about chemical and physical properties? - How can physical evidence be used to make predictions about elements and the subatomic structure? - How can radio waves be used to provide information about the internal structure of the body? - How do stars produce the elements found in the periodic table, and what evidence supports this process? - How does the observation of redshift in the spectra of distant galaxies provide evidence for the expansion of the universe? - How do nuclear reactions affect life on earth? - How can half-life be used to	- Evaluate the merits and limitations of the Bohr and cloud models of the atom. - Construct explanations about elemental properties based on atomic properties such as atomic radius, ionization energy and electronegativity - Analyze atomic property data to organize elements in a model that allow for predictions of physical properties to be made. - Construct an explanation of atomic structure from data collected from electromagnetic spectra and known electron configurations. - Apply scientific ideas, principles, and/or evidence to provide an explanation of how MRI can use waves to provide information about human tissues. - Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. - Apply scientific ideas, principles, and/or evidence to provide an explanation of	elemental identification. - Analyze the data generated by a simulation of half-life decay, using pennies being flipped in a box, to determine the validity of the concepts of half-life. - Evaluate the merits and limitations of a computer model showing the subatomic structure of an atom of a representative element. Video - Analyze the history of the atomic models video - Evaluate the s, p, and d blocks of the periodic table using Electron Battleship - Organize periodic table of mystery elements AACT: Periodic Trends Simulation - Graph trends of atomic properties of elements. (Classroom Lab: Periodic Table Sequencing Activity - Conduct a flame test on salt solution to identify metals. AACT Flame Test Classroom Demonstration/Lab NASA Big Bang Timeline - Analyze hot gas spectra to identify elemental composition using emission spectra. Classroom Lab: Spectral Analysis.	submitting Lab Reports about associating atomic structure to physical properties of elements. - Debate/discussions about representations of atomic structure - Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test - Assessment of written and verbal mastery of unit-specific vocabulary. - Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches. - LinkIt! Form A (benchmark) <u>Alternative Assessment Options:</u> Claim-Evidence-Reasoning (CER): Develop a scientific argument evaluating the role of nuclear energy in meeting future global energy demands by analyzing scientific evidence related to nuclear reactions, radiation risks, environmental impacts,
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make predictions? • Can ionizing radiation be harmful and beneficial simultaneously? • How can materials be used to protect from types of radiation? • What role should nuclear energy play to meet future energy demands? • When and how are inferences and experimental observations used in science?	nuclear decay (include alpha, beta, gamma and electron capture) • Evaluate documentation about treatments such as gamma knife therapy to determine risk/benefit of ionizing radiation treatment • Use mathematical representations of half-life to describe and/or support claims and/or explanations • Use a model of an atom based on evidence to illustrate how subatomic particles are involved with the exchange of energy. • Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation. • Develop a model and compare/contrast the fission and fusion process • Construct and revise and explanation about the atomic structure of unknown elements based on physical properties	• Apply mathematical principles and relations of frequency and wavelength in via worksheet • Compare and contrast CT and MRI regarding waves, information, and ionizing radiation • Glencoe: Mystery Element Virtual Lab • Use computer model to collect and analyze electromagnetic spectrum data to identify the components of a star via the YouTube videos, Life Cycle of Stars, The Chemistry of Stars, and Star Spectra • Distinguish between data collected from empirical observations and inference to compare and contrast the Steady State and Big Bang theories for the origin of our universe. • Explore models and perform mathematical representation using half-life. Vernier lab: Radiation shielding lab • Explore Learning: Half-life. • Classroom Lab: Penny Half-life Lab • Manipulate different models to explore atomic changes that occur because of nuclear	sustainability, and economic trade-offs. • Performance Task: Analyze multiple sources of evidence—including atomic structure, emission spectra, periodic trends, and isotope data—to identify an unknown element, justify its placement on the periodic table, and predict its physical and chemical properties using scientific reasoning. • Engineering Design Challenge: Design, optimize, and defend a radiation shielding system for a specific application (e.g., deep-space exploration, nuclear medicine, or nuclear power generation). Evaluate multiple materials based on effectiveness, cost, mass, sustainability, and engineering constraints while supporting design decisions with scientific evidence. • Scientific Research Presentation: Develop and deliver a professional-quality scientific presentation or multimedia product explaining how atomic structure, spectroscopy, or stellar nucleosynthesis
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		change. ● Explore the fission process with PhET Fission ● Discuss models that represent the differences between fission and fusion. Fission Fusion Mini Position Paper ● Develop a model of star cycle that explains the role of the fusion process and nuclear reactions that explain the formation of elements. ● CER on risk/benefit of ionizing radiation therapy ● Debate the cost/risk/benefit of nuclear energy. DOE Link ● Carry out an investigation to explore the potential for various materials to be used to shield alpha, beta, or gamma radiation. <i>Scientist Spotlights:</i> ● Dr. Krystal Vasquez – The struggles of inaccessibility for physically disabled scientists. - NPR Podcast w/ Dr. Vasquez “Excluded from the Lab” by Dr. Vasquez ● John Dalton – Colorblind scientist who worked in Atomic Theory. ● Lloyd Albert Quarterman – African	provides evidence for the composition and evolution of matter in the universe. Incorporate peer-reviewed scientific sources, quantitative data, and appropriate scientific models to support conclusions.
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		American Chemist who worked on the Manhattan Project ● Lise Meitner – Jewish, female scientist who discovered nuclear fission. ● Katherine Way – American, female scientist who worked on the Manhattan Project & established the Nuclear Data Project. ● Marie Curie – Female scientist who discovered radium and polonium & made major contributions towards finding treatments for cancer.	
Interdisciplinary Connections	<u>English Language Arts</u> RI.MF.9–10.6. Analyze, integrate, and evaluate multiple interpretations (e.g., charts, graphs, diagrams, videos) of a single text or text/s presented in different formats (visually, quantitatively) as well as in words to address a question or solve a problem. RI.AA.9–10.7. Describe and evaluate the argument and specific claims in an informational text, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and reasoning. SL.II.9–10.2. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source. SL.PI.9–10.4. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. <u>Mathematics</u> N.Q.A.1 - Use units to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.A.2 - Define appropriate quantities for the purpose of descriptive modeling. N.Q.A.3 - Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. S.ID.B.6 – Represent data on two quantitative variables on a scatter plot and describe how the variables are related. F.LE.A.1 – Distinguish between situations that can be modeled with linear functions and with exponential functions <u>Social Studies</u> 6.2.12.HistoryCC.5.b - Analyze how scientific and technological innovations have influenced society, the environment, and the global economy through investigations of atomic theory, nuclear technology, and energy production.		

	Visual and Performing Arts 1.5.12.prof.Cr1a - Use multiple approaches to develop scientific visualizations that communicate complex ideas such as atomic structure, electromagnetic radiation, or stellar nucleosynthesis to a scientific audience.		
Career Readiness, Life Literacies, and Key Skills	9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice. 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. 9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills. 9.1.12.PB.2: Prioritize financial decisions by considering alternatives and possible consequences		
Computer Science and Design Thinking	8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. 8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). 8.2.12.ETW.4: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints		
Modifications			
Multi-Lingual Learners	Students with Special Needs/504s	At-Risk	Gifted and Talented
● Provide illustrated vocabulary guides for atomic structure, periodic trends, electromagnetic radiation, and nuclear chemistry. ● Use labeled diagrams, atomic models, periodic tables, and visual simulations to reinforce scientific concepts. ● Pre-teach key academic and scientific vocabulary using sentence frames and word banks for CER writing and laboratory investigations. ● Pair students with peers for collaborative analysis of emission spectra, periodic trends, and atomic models.	● Provide guided notes, graphic organizers, and partially completed atomic models or periodic trend graphs. ● Break multi-step laboratory investigations and mathematical calculations into smaller, manageable tasks with frequent teacher check-ins. ● Allow extended time for assessments, graphing activities, and laboratory reports as indicated by student accommodations. ● Provide alternative methods for demonstrating understanding, including oral explanations, digital presentations, or physical models.	● Reinforce foundational concepts using hands-on atomic models, color-coded periodic tables, and guided practice before independent work. ● Provide scaffolded problem-solving templates for periodic trends, half-life calculations, and electromagnetic spectrum relationships. ● Incorporate frequent formative assessments (exit tickets, whiteboard responses, think-pair-share) to monitor understanding and provide timely intervention. ● Connect concepts to real-world applications such as medical	● Investigate advanced applications of spectroscopy, stellar nucleosynthesis, or nuclear chemistry through independent research. ● Analyze authentic scientific data from NASA, the Department of Energy, or peer-reviewed publications to support scientific claims. ● Design and defend an engineering solution addressing radiation shielding, nuclear energy production, or space exploration using scientific evidence. ● Compare historical and modern atomic models, evaluating how new evidence has refined

● Provide translated or simplified directions for laboratory investigations and engineering design challenges when appropriate. ● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	● Utilize interactive simulations (PhET, ExploreLearning, or similar) to reinforce abstract concepts such as atomic structure, radioactive decay, and electromagnetic radiation. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions ● Sit where they learn best (for example, near the teacher) Suggested Activities: Mendeleev's Activity and Mendeleev's cards Nuclear Disasters Rutherford's Gold Foil Experiment	imaging, nuclear energy, forensic science, and astronomy to increase engagement. ● Offer small-group instruction and targeted review sessions for mathematical and conceptual skills. ● Incorporate student choice ● Invite parents, neighbors, friends, the school principal, and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	scientific understanding over time. ● Extend learning through AP Chemistry-level problems involving isotope abundance, electron configurations, or quantitative analysis of periodic trends. ● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving
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Honors Chemistry	
Unit 2: Compounds, Bonding and Molecular Structure	
Related Phenomena: 1. The Frosting of a Window 2. Drug Design and Bodily Activity – Using an Epipen 3. The dancing droplets of alcohol and water	
Pacing: 4-5 weeks	
New Jersey Student Learning Standards (NJSLS)	
HS-PS1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.	

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

HS-PS3-5: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

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

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Planning and Carrying Out Investigations - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. Obtaining, Evaluating, and Communicating Information - Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	PS1.A: Structure and Properties of Matter - The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. PS2.B: Types of Interactions - Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (<i>secondary</i>) PS3.A: Definitions of Energy - At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. ESS2.C: The Roles of Water in Earth's Surface Processes - The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.	Patterns - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Structure and Function - Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. - The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. ----- <i>Connections to Engineering, Technology, and Applications of Science</i> Influence of Science, Engineering, and Technology on Society and the Natural World - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How do the types of chemical bonds (ionic, covalent, metallic) determine the structure and properties of compounds? - How can a model be used to represent matter at the atomic scale pictorially, symbolically, and textually? - Why is precise nomenclature critical for communicating the composition and structure of chemical compounds, and how does it reflect their bonding characteristics? - How does the polarity of molecules, influenced by their bonding and structure, affect intermolecular forces and the physical properties of substances, such as boiling point and solubility? - How can the structure of a molecule help to determine its function? - How can the understanding of properties drive the design of materials?	- Use and relate computer models, physical models and Lewis Dot structures to provide information about molecular geometry and/or predict polarity. - Plan and conduct an investigation to evaluate how the shape of a molecule impacts its chemical and/or physical properties. - Model interactions of molecules in electric fields to understand how molecules can be polar and how that polarity affects its interaction with other molecules. - Explain with a specific example how the structure of a molecule (e.g. a drug) affects its function. - Understand how atomic arrangement can affect the properties of materials (allotropes). - Investigate the properties of water and how Earth's surface can be affected by it. - Apply scientific reasoning, theory, and/or models to link evidence to the claims that certain gaseous molecules act as greenhouse gases. Boundaries limited to:	- Name compounds and access SDS to develop hazard awareness POGIL: Particle Connections - What's in a Name? - Beyond Benign: Chemical Hazard Awareness - Manipulate the Breaking Chemical Bond simulation to evaluate changes in intramolecular bond energy. Phet: Molecular Shapes, Molecular Shapes Basics & Molecule Polarity - Concord Consortium; Breaking a Chemical Bond - Natural resources; natural resources; evaluating ore lab Classroom Lab: Natural Resources; Evaluating Ore Samples (Wards' Classroom Mineral Collection) Oreo Percent Composition Performance Task - Manipulate models (computer or physical) to evaluate molecular shapes and predict polarity. Teach Engineering: Molecular Molecules and 3D Printing (CAD) and PhET Molecule Shapes AACT The Discovery of Fullerenes - Allotropes of	- Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports - Performance task assessment to predict molecular geometry and polarity of a simple molecule. - Employ math representations on collected data to quantify the components of a mixture. - Debate/discussions about representations of molecular structure and function. - Carry out experiments to evaluate how physical changes such as temperature or concentration affect the properties of water. - Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test - Assessment of written and verbal mastery of unit-specific vocabulary. - Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure,

	- Alloy bonding is solely descriptive. - Predominant bond type need not be calculated with electronegativity values - Bond angles are limited to relative description as opposed to absolute degree values. - Discussion of ionic bonding/compounds is solely based on electron transfer and does not include structure or crystal packing. - Bond formation is described without discussion of overlapping orbitals; therefore, it is not tied to electron configuration and hybridization. - VSEPR Theory includes 2, 3, 4, 5 and 6 electron domains	Carbon ● Create a database of typical molecular models, representative of all of the different types of shapes in the VSEPR system. ● Design of a molecular mimic, including identification of its molecular geometry features that contribute to its function such as with a pharmaceutical as in The Most Prescribed Drugs in the World; use a chemical structure drawing tool such as Pubchem ● Use/develop various models to both predict shapes of various covalent molecules and strength of polarity Classroom Lab: Molecular Geometry ● Conduct an experiment to determine the percent composition and the empirical formula of a hydrate ● Evaluate the interaction of molecules in electric fields in PhET Polarity ● Carry out various tasks to investigate the properties of water. Classroom Activity: Water Olympics ● Investigate how water affects	and/or making observational sketches. <u>Alternative Assessment Options</u> ● Engineering Design Challenge: Design, model, and justify a novel material or pharmaceutical molecule by analyzing how molecular geometry, polarity, and intermolecular forces influence its intended function. Evaluate design trade-offs using scientific evidence. ● Claim-Evidence-Reasoning (CER): Construct a scientific argument evaluating the relative impacts of different greenhouse gases by analyzing molecular geometry, polarity, intermolecular forces, and infrared absorption using scientific literature and data. ● Molecular Modeling Investigation: Develop physical and digital molecular models of a series of compounds, predict molecular geometry, polarity, intermolecular forces, and physical properties, then compare predictions with experimental or published
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		soil erosion and the agricultural effects that may have in Investigating Erosivity • Complete Heating it Up Tutorial; Use Molecular Interactions model to investigate the global warming potential of various gases <i>Scientist Spotlights:</i> • Dorothy Crowfoot Hodgkin: x-ray crystallography and molecular structure. • Bettye Washing Greene: An industrial Chemist and Inventor who Lit a Path for Innovation.	data and explain discrepancies. • Research and Scientific Communication Project: Investigate a current application of molecular chemistry (e.g., pharmaceutical design, nanomaterials, biodegradable polymers, or carbon capture technologies) and prepare a scientific poster or formal presentation that evaluates how molecular structure determines function while incorporating peer-reviewed scientific sources.
Interdisciplinary Connections	<u>English Language Arts</u> SL.PE.9-10.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively. SL.II.9-10.2. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source. SL.ES.9-10.3. Evaluate a speaker’s point of view, reasoning, and use of evidence and rhetoric, identifying any false reasoning or distorted evidence. SL.PI.9-10.4. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. SL.UM.9-10.5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest. <u>Mathematics</u> N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.		

	Social Studies 6.2.12.HistoryCA.16.a: Analyze the impact of scientific and technological innovations on society, the environment, and the global economy through investigations of pharmaceuticals, synthetic materials, and sustainable chemical technologies. Visual & Performing Arts 1.5.12prof.Cr1a: Use multiple approaches to create scientific models and visual representations that communicate molecular geometry, polarity, and intermolecular forces. 1.5.12prof.Pr5a: Evaluate and refine scientific diagrams, molecular models, or digital presentations to effectively communicate complex chemical concepts.		
Career Readiness, Life Literacies, and Key Skills	9.1.12.PB.2: Prioritize financial decisions by considering alternatives and possible consequences 9.2.12.CAP.2: Analyze various career paths, including training, education, and skill requirements, and evaluate how these might align with personal interests and talents. 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas		
Computer Science and Design Thinking	8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. 8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience.		
Modifications			
Multi-Lingual Learners	Students with Special Needs/504s	At-Risk	Gifted and Talented
● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner. ● Provide illustrated vocabulary guides for bonding, molecular geometry, polarity, intermolecular forces, and solution chemistry. ● Use color-coded Lewis structures, molecular models,	● Provide guided notes, graphic organizers, and partially completed Lewis structures or VSEPR charts. ● Break molecular drawing, naming compounds, and polarity prediction activities into smaller sequential steps with teacher check-ins. ● Allow students to demonstrate understanding using physical molecular model kits, digital models, oral explanations, or labeled diagrams. ● Provide extended time for laboratory investigations, molecular modeling activities,	● Reinforce bonding concepts using hands-on molecular model kits and color-coded visual representations before transitioning to symbolic representations. ● Provide scaffolded templates for Lewis structures, VSEPR shapes, polarity determination, and compound naming. ● Use guided practice and frequent formative assessments (whiteboards, exit tickets, sorting activities, think-pair-share) to monitor understanding.	● Investigate advanced applications of molecular geometry and intermolecular forces in pharmaceutical development, nanotechnology, or materials science. ● Compare molecular models generated using multiple software platforms and evaluate the strengths and limitations of each representation. ● Design and justify a molecule or material with specific physical properties by manipulating molecular structure, polarity, and intermolecular forces.

and polarity diagrams to reinforce abstract concepts. ● Provide sentence frames and word banks for explaining molecular structure, comparing bond types, and writing CER responses. ● Pair students with peers to analyze molecular models, predict polarity, and interpret laboratory observations. ● Utilize translated directions, visual demonstrations, and interactive simulations (PhET or similar) to support investigations involving molecular geometry and polarity.	and assessments as indicated by student accommodations. ● Use teacher-guided simulations and hands-on manipulatives to reinforce bonding, molecular geometry, and intermolecular forces. Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions ● Molecular Models Lab	● Connect molecular structure to familiar real-world examples such as water, table salt, carbon dioxide, plastics, and medications to increase relevance. ● Provide small-group reteaching for molecular geometry, polarity, and intermolecular force concepts prior to independent practice. ● Incorporate student choice ● Invite parents, neighbors, friends, the school principal, and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Analyze peer-reviewed scientific literature related to biomolecular interactions, drug design, or green chemistry and present findings to the class. ● Extend learning by comparing simple VSEPR models to more advanced bonding theories (e.g., hybridization or molecular orbital concepts) to explain exceptions to predicted molecular behavior. ● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.
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Honors Chemistry	
Unit 3: Moles and Reactions	
Related Phenomena: 1. Combustion for Fuels or Campfires 2. Leavening Agents in Cooking 3. Corrosion of Metals	
Pacing: 4-5 weeks	
New Jersey Student Learning Standards (NJSLS)	
HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.	
HS-PS1-7: Use mathematical representation to support the claim that atoms and therefore mass are conserved during a chemical reaction.	
HS-ESS3-2: Evaluate competing design solutions for developing, conserving, managing, and utilizing energy and mineral resources based on the	

associated economic, social, environmental, and geopolitical costs and risks, as well as benefits

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Constructing Explanations and Designing Solutions - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Using Mathematics and Computational Thinking - Use mathematical representations of phenomena to support claims. Engaging in Argument from Evidence - Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).	PS1.A: Structure and Properties of Matter - The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. PS1.B: Chemical Reactions - The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. ESS3.A: Natural Resources - All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. ETS1.B: Developing Possible Solutions - When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. <i>(secondary)</i>	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. ----- <i>Connections to Nature of Science</i> Scientific Knowledge Assumes an Order and Consistency in Natural Systems - Science assumes the universe is a vast single system in which basic laws are consistent. - Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. - Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. - Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. <i>Connections to Engineering, Technology, and Applications of Science</i> Influence of Science, Engineering, and Technology on Society and the Natural World - Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. - Analysis of costs and benefits is a critical aspect of decisions about technology.

Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How can a model be used to represent chemical reactions? - How can products of chemical reactions be predicted? - How does the law of conservation of mass enable us to predict and balance chemical reactions? - How can we use mole conversions and stoichiometry to predict the amounts of products and reactants involved quantitatively? - How can we use stoichiometry to determine the limiting and excess reactants in a chemical reaction, and how does this impact the amount of product formed? - How should data be collected to measure chemical reactions?	- Construct and/or revise an explanation using evidence that differentiates chemical and physical changes in matter. - Calculate and interpret quantitative relationships among reactants and products using balanced chemical equations and the mole concept. Develop and/or use particulate models, such as balanced chemical equations to demonstrate how mass is conserved during a chemical reaction. - Develop and/or use particulate models, such as balanced chemical equations to demonstrate how mass is conserved during a chemical reaction. - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) to predict whether a chemical reaction between two substances is likely or not, and if so, predict the	- Carry out various tasks to investigate properties of substances and to determine types of evidence that can be used to indicate a chemical change has occurred. - Use/develop various models such as the Balancing Equation simulation to discover/demonstrate how chemical equations represent that mass is conserved during a chemical reaction. Phet: Balancing Equations Simulation & Reactant, Products & Leftovers Mole Lab Chalk lab to illustrate and understand limiting and excess reactant - Develop an activity series for metals from evidence collected from an experiment. - Classroom Lab: Developing an Activity Series - Plan and conduct an experiment to determine the mole ratios of the reactants and the products of a single replacement reaction. - Plan and conduct an experiment to identify	- Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports (formative) - Use/apply various models to demonstrate understanding of chemical change (formative) - Support a claim with evidence to evaluate a chemical reaction at both the particulate and macroscopic levels. (formative) - Employ math representations to demonstrate how the Law of Conservation of Mass applies to chemical reactions. (formative) - Carry out experiments to employ a chemical reaction to solve a problem or answer a question. (formative) - Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test (Formative & Summative) - Assessment of written and verbal mastery of

	products of the reaction. ● Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence to evaluate recycling solutions over extraction of metals from ore. ● Use mathematical representations, based on balanced equations, to make quantitative predictions about chemical reactions. ● Understand the Concept of Limiting and Excess Reactants: Students will be able to define limiting and excess reactants and explain their roles in a chemical reaction. Boundaries limited to: - Five types of major reactions without discussion of oxidation and reduction (electron transfer; simply treat as single displacement) - Focus on predicting products from single and double replacement reactions. - Net ionic equation models excluded.	unknown solutions combined in double replacement reactions based on information on possible precipitates. ● Plan and conduct an investigation individually and collaboratively to produce data that evaluates the potential for solutions of two ionic compounds to react and form a precipitate. ● Plan and carry out an investigation to employ a chemical reaction to isolate a metal resource from a natural ore, such as Extracting Metals with Charcoal, and to determine its potential harm to the environment and a copper cycle experiment. Scientist Spotlight - Dr. Carolyn Bertozzi - She is the inventor of "bioorthogonal chemistry", a class of chemical reactions compatible with living systems that enable molecular imaging and drug targeting	unit-specific vocabulary. (Formative & Summative) ● Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches. (Formative) ● LinkIt! Form B (Benchmark) <u>Alternative Assessment Options</u> ● Claim-Evidence-Reasoning (CER): Develop a scientific argument evaluating the environmental, economic, and societal impacts of recycling metals versus extracting metals from ore. Support conclusions with stoichiometric calculations, laboratory evidence, and scientific literature. ● Performance Task: Analyze a complex chemical reaction by predicting products, balancing equations, identifying the limiting reactant (extension), and calculating theoretical yields. Justify all calculations and conclusions using the Law of Conservation of Mass and quantitative chemical reasoning. ● Engineering Design
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			Challenge: Design and optimize a sustainable industrial chemical process that maximizes product yield while minimizing waste, energy consumption, and environmental impact. Support design decisions with stoichiometric calculations, engineering constraints, and principles of green chemistry. ● Scientific Case Study: Investigate an industrial or environmental chemical process (e.g., Haber-Bosch synthesis, steel production, catalytic converters, corrosion prevention, or metal recycling). Prepare a professional scientific report or presentation that evaluates reaction efficiency, resource utilization, environmental impacts, and recommendations for process improvement using quantitative data and peer-reviewed scientific sources.
Interdisciplinary Connections	<u>English Language Arts</u> SL.PE.9-10.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively.		

	SL.II.9-10.2. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source. SL.PI.9-10.4. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. <u>Mathematics</u> N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. <u>Social Studies</u> 6.2.12.HistoryCA.16.a: Analyze the impact of scientific and technological innovations on society, the environment, and the global economy through investigations of industrial chemistry, metal extraction, recycling, and sustainable resource management. <u>Visual & Performing Arts</u> 1.5.12prof.Cr1a: Use multiple approaches to begin creative endeavors. 1.5.12prof.Pr5a: Evaluate, refine, and prepare works of art for presentation.
Career Readiness, Life Literacies, and Key Skills	9.1.12.PB.2: Prioritize financial decisions by considering alternatives and possible consequences 9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills. 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice. 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
Computer Science and Design Thinking	8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control,

		environmental concerns, manufacturability, maintenance and repair, ergonomics).	
		8.2.12.ED.6: Analyze the effects of changing resources when designing a specific product or system (e.g., materials, energy, tools, capital, labor).	
Modifications			
Multi-Lingual Learners	Students with Special Needs/504s	At-Risk	Gifted and Talented
● Provide illustrated vocabulary guides for chemical reactions, mole conversions, stoichiometry, limiting reactants, and conservation of mass. ● Use color-coded balanced equations and particle diagrams to reinforce relationships between reactants and products. ● Provide sentence frames and calculation templates for explaining chemical reactions, balancing equations, and solving stoichiometry problems. ● Pair students with peers during laboratory investigations and reaction prediction activities to support scientific discussion and mathematical reasoning. ● Use visual models, translated directions, and teacher demonstrations to support laboratory procedures and quantitative problem solving. ● Display labeled images of designs and parts.	● Provide guided notes, graphic organizers, and step-by-step templates for balancing equations and mole conversion calculations. ● Break multi-step stoichiometry problems into smaller sequential tasks with teacher check-ins and immediate feedback. ● Allow students to demonstrate understanding using manipulatives, particle models, graphic representations, or oral explanations in place of lengthy written responses when appropriate. ● Provide extended time for laboratory investigations, calculations, and assessments as outlined in student accommodations. ● Use digital simulations and interactive balancing equation activities to reinforce conservation of mass and reaction concepts. ● Provide alternative choices (i.e. verbal or visual) to	● Reinforce balancing equations and mole concepts using hands-on manipulatives, reaction cards, and color-coded particle models before introducing symbolic calculations. ● Provide scaffolded problem-solving organizers and dimensional analysis templates for stoichiometry calculations. ● Incorporate frequent formative assessments (whiteboards, exit tickets, guided practice, and think-pair-share) to monitor understanding and provide immediate intervention. ● Connect stoichiometry concepts to familiar real-world examples such as cooking recipes, combustion, recycling, corrosion, and manufacturing processes. ● Provide small-group instruction and guided practice for balancing equations, reaction prediction, and quantitative	● Investigate advanced applications of stoichiometry in industrial chemistry, pharmaceutical manufacturing, environmental chemistry, or chemical engineering. ● Design and evaluate a chemical process that maximizes product yield while minimizing waste using principles of green chemistry and quantitative analysis. ● Analyze authentic scientific or industrial data to compare theoretical and actual yields, identifying sources of experimental error and opportunities for process improvement. ● Extend quantitative problem solving through investigations involving limiting reactants, percent yield, and reaction efficiency. ● Research and present how stoichiometric principles are applied in fields such as aerospace, biotechnology, renewable energy, or

● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Use manipulatives to model structures and ratios ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions ● Sit where they learn best (for example, near the teacher) ● Use an alarm or cues to help with time management ● Work with a partner	reasoning prior to independent work. ● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	large-scale chemical manufacturing. ● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.
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Honors Chemistry

Unit 4: Thermochemistry and Thermodynamics

Related Phenomena:

1. [Melting Glaciers and the Changing Arctic Landscape](#)

2. [Creating and Using the Hot/Cold Pack](#)
3. [Melting Ice in a Drink](#)
4. [A Glass “Sweating” on a Humid Summer’s Day](#)

Pacing: 5-6 weeks

New Jersey Student Learning Standards (NJSLS)

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

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

HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

HS-PS3-4: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth’s surface can create feedback that causes changes to other Earth systems.

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

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

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Developing and Using Models - Develop a model based on evidence to illustrate the relationships between systems or between components of a system. - Use a model to provide mechanistic accounts of phenomena. Using Mathematics and Computational Thinking - Create a computational model or simulation of a phenomenon, designed device, process, or system. Constructing Explanations and Designing Solutions - Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	PS1.A: Structure and Properties of Matter - A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart PS1.B: Chemical Reactions - Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. PS3.A: Definitions of Energy - Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to	Energy and Matter - Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. - Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. Systems and System Models - Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. - When investigating or describing a system, the boundaries and initial conditions of the system

Planning and Carrying Out Investigations

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

Analyzing and Interpreting Data

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

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

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

Scientific Investigations Use a Variety of Methods

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

the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

PS3.B: Conservation of Energy and Energy Transfer

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).

PS3.D: Energy in Chemical Processes

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

need to be defined and their inputs and outputs analyzed and described using models.

Stability and Change

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

Cause and Effect

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

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

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

Connections to Engineering, Technology, and Applications of Science

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

- Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.
- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

		ESS1.B: Earth and the Solar System - Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. <i>(secondary)</i> ESS2.A: Earth Materials and Systems - Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. - The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. ESS2.D: Weather and Climate - The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. ESS3.D: Global Climate Change - Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. ETS1.A: Defining and Delimiting an Engineering Problem - Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. <i>(secondary)</i>	
Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How do chemical reactions absorb or release energy? - How can we measure and predict these energy changes	Student will be able to: Plan and carry out an investigation to provide evidence for and test	Ask questions about various natural phenomena, such as a morning fog, that rely on observations about energy	Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by

in real-world physical and chemical processes like heating or cooling? • How can models be used to evaluate energy transfer? • What are limitations when quantifying energy of a closed system? • How can Hess's Law be used to determine the enthalpy change of a chemical reaction that cannot be measured directly? • How are humans impacting how energy is transferred in Earth's climate system? • How can evidence be gathered to evaluate or predict human impact on energy transfer on Earth?	conceptual, mathematical, physical, and empirical models of energy transfer via conduction, convection, and radiation. • Develop/use a model to represent how energy is transferred between chemical bonds in the system during chemical reactions. • Make and defend a claim based on evidence about the natural world that reflects scientific knowledge about energy transfer, phase changes, and intermolecular forces. • Use math representations to quantify the energy absorbed by or released from a substance using its specific heat. • Apply Hess's Law to calculate the enthalpy change (ΔH) of a target reaction by manipulating and combining the enthalpy changes of related reactions, demonstrating an understanding of the law's principle that enthalpy is a state function. • Communicate scientific information or ideas in multiple formats (including	exchange. • Develop a model of energy of one type converting into energy of another type via PhET • Plan and carry out an experimental investigation to determine the specific heat of a substance • Plan and carry out an experimental investigation when two substances are brought together of different temperatures Heat Transfer Between Components of a System • Plan and carry out an experimental investigation that employs calorimetry to quantify the energy in a given substance or mixture. (Determine the Calories in Foodstuffs). Use this lab to have students create a model of calorimetry calculations via a spreadsheet. • Use or develop a model that explains how bond energies are exchanged during a chemical reaction. POGIL - Bond Energies. One could also introduce PE diagrams here to discuss the molecular level • Plan and carry out an	submitting Lab Reports (Formative) • Development of scientific questions about energy and phases changes from observations that are testable and lead to a scientific investigation. (Formative) • Employ math representations to make quantitative predictions about energy exchange based on principles of calorimetry and specific heat. (Formative) • Support a claim with evidence to explain the transfer of energy between objects/substances. (Formative) • Construct an explanation from evidence that demonstrates understanding of climate feedback loops. (Formative) • Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test (Formative & Summative) • Assessment of written and verbal mastery of unit-specific vocabulary.
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	orally, graphically, textually, and mathematically) to explain how energy is transferred to account for Earth's energy budget. ● Apply scientific reasoning, theory, and/or climate models to link evidence to determine how reasoning and data support the explanation of climate feedback. Boundaries limited to: - Calculations for entropy changes, Gibbs free energy changes, and reaction spontaneity are excluded - Focus on real-world applications (i.e. food analysis) of energy transfer in terms of calorimetry applications/math representations. - Units of Specific Heat are limited to those including joule and calorie	experimental investigation to quantify the amount of energy either absorbed or released from a chemical reaction. Heat of Reaction Lab ● Plan and carry out an experimental investigation to convert chemical energy into thermal energy (Design a Hand Warmer). This should be an iterative experiment where students refine their design. ● Develop a scientific explanation from evidence gathered from a demonstration of a heating curve as heat is slowly but constantly added to ice to explain energy transfer in a closed system. See Heating Curve Lab Or Heating Curve Simulation ● Hess's law activity ● Use a climate model and/or simulation to evaluate how changes in Earth's energy budget will impact further changes that will result in climate feedback. Feedback Loops and Tipping Points Or Climate Feedback Loops Scientist Spotlights: ● Marie-Anne Lavoisier: helped	(Formative) ● Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches. (Formative) <u>Alternative Assessment Options</u> ● Claim-Evidence-Reasoning (CER): Develop a scientific argument evaluating how changes in Earth's energy budget contribute to climate change by synthesizing evidence from calorimetry investigations, climate models, and peer-reviewed scientific literature. Defend conclusions using principles of thermochemistry and energy conservation. ● Performance Task: Design and conduct a calorimetry investigation to determine the specific heat or enthalpy change of an unknown substance or reaction. Analyze experimental uncertainty, compare experimental and accepted values, and evaluate sources of error using quantitative evidence. ● Engineering Design
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		define the concepts of combustion. ● Dr. Jennie Patrick – one of the first African American women to earn a doctorate in chemical engineering in the United States (from <i>MIT</i>). Her doctoral research and career focus centered extensively on chemical thermodynamics	Challenge: Design, construct, and optimize a thermal energy device (e.g., reusable hand warmer, cold pack, insulated container, or passive heating/cooling system) that maximizes energy efficiency while considering engineering constraints, cost, sustainability, and environmental impact. Support design decisions with thermochemical calculations and experimental data. ● Scientific Research Project: Investigate a real-world application of thermochemistry or thermodynamics (e.g., renewable energy systems, battery technology, climate feedback mechanisms, industrial energy efficiency, or thermal management in engineering). Prepare a professional scientific presentation or research report incorporating quantitative data, energy calculations, graphical analysis, and peer-reviewed scientific sources to support evidence-based conclusions.
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Interdisciplinary Connections	<u>English Language Arts</u> SL.PE.9–10.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively. SL.II.9–10.2. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally), evaluating the credibility and accuracy of each source. SL.ES.9–10.3. Evaluate a speaker’s point of view, reasoning, and use of evidence and rhetoric, identifying any false reasoning or distorted evidence. SL.PI.9–10.4. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. SL.UM.9–10.5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest. <u>Mathematics</u> N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. A.SSE.A.1 Interpret expressions that represent a quantity in terms of its context. A.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. F.BF.A.1 Write a function that describes a relationship between two quantities. <u>Social Studies</u> 6.1.12.GeoHE.13.a: Construct an argument on the effectiveness of environmental movements, their influence on public attitudes, and the efficacy of the government's environmental protection agencies and laws. <u>Visual & Performing Arts</u> 1.5.12prof.Cr1a: Use multiple approaches to begin creative endeavors. 1.5.12prof.Pr5a: Evaluate, refine, and prepare works of art for presentation.		
Career Readiness, Life Literacies, and Key Skills	9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice. 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions		

	9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. 9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills. 9.1.12.PB.2: Prioritize financial decisions by considering alternatives and possible consequences.		
Computer Science and Design Thinking	8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. 8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics).		
Modifications			
Multi-Lingual Learners	Students with Special Needs/504s	At-Risk	Gifted and Talented
● Provide illustrated vocabulary guides for thermochemistry, calorimetry, specific heat, phase changes, endothermic/exothermic processes, and climate feedback. ● Use color-coded energy diagrams, heating curves, particle models, and graphic organizers to visualize energy transfer. ● Provide sentence frames and guided calculation templates for explaining energy flow, calorimetry investigations, and interpreting heating curves. ● Pair students with peers during laboratory investigations and engineering design activities to reinforce scientific	● Provide guided notes, graphic organizers, and step-by-step templates for calorimetry calculations, heating curve analysis, and energy transfer investigations. ● Break multi-step laboratory investigations and mathematical calculations into smaller sequential tasks with frequent teacher check-ins. ● Allow students to demonstrate understanding using physical models, digital simulations, oral explanations, or labeled diagrams in place of lengthy written responses when appropriate. ● Provide extended time for laboratory investigations, engineering design	● Reinforce energy transfer concepts using hands-on demonstrations, particle models, and real-world examples before introducing quantitative calculations. ● Provide scaffolded problem-solving organizers and guided formulas for specific heat and calorimetry calculations. ● Incorporate frequent formative assessments (whiteboards, exit tickets, think-pair-share, and guided practice) to monitor understanding and provide timely intervention. ● Connect thermochemistry concepts to familiar experiences such as hot and cold packs, cooking, weather, melting ice, and home	● Investigate advanced applications of thermodynamics in renewable energy systems, chemical engineering, climate science, or materials science. ● Design, build, and optimize a thermal energy device that maximizes efficiency while evaluating engineering constraints, sustainability, and environmental impacts. ● Analyze authentic climate or calorimetry data sets to evaluate energy transfer, identify trends, and justify conclusions using quantitative evidence. ● Extend quantitative problem solving through investigations involving Hess's Law, reaction enthalpy, entropy, or Gibbs

vocabulary and collaborative problem solving. ● Utilize translated directions, visual demonstrations, and interactive simulations to support investigations involving calorimetry, phase changes, and climate systems. ● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	challenges, graph interpretation, and assessments as outlined in student accommodations. ● Use interactive simulations and teacher-guided demonstrations to reinforce concepts related to energy transfer, phase changes, and climate feedback loops. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions ● Sit where they learn best (for example, near the teacher) ● Use an alarm or cues to help with time management ● Work with a partner	insulation to increase relevance. ● Provide small-group instruction and guided practice for interpreting heating curves, energy diagrams, and calorimetry calculations before independent work. ● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	free energy as enrichment beyond the core curriculum. ● Research and present how thermochemical principles are applied in fields such as aerospace engineering, environmental science, battery technology, or industrial process engineering. ● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.
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Honors Chemistry

Unit 5: Environmental Chemistry, Gases, Climate Change

Related Phenomena:

1. [Arctic Sea Ice over Time](#)
2. [Automobile Airbags](#)

3. [Carbonated Beverages, the Fizz, and the Hiss](#)4. [Wildfires](#)

Pacing: 4-6 weeks

New Jersey Student Learning Standards (NJSLS)**HS-ESS2-4:** Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.**HS-ESS3-1:** Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.**HS-ESS3-2:** Evaluate competing design solutions for developing, conserving, managing, and utilizing energy and mineral resources based on the associated economic, social, environmental, and geopolitical costs and risks, as well as benefits
HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.**HS-ESS3-5:** Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Developing and Using Models - Create or use models (e.g., diagrams, simulations) to explain how energy flow variations (solar radiation, greenhouse gases) affect Earth's climate systems. Analyzing and Interpreting Data - Use data from models to identify patterns in energy flow and climate change. - Use geoscience data (e.g., temperature records, ice core data) and climate model outputs to predict climate trends. Constructing Explanations and Designing Solutions - Develop evidence-based explanations for how resources, hazards, and climate shape human societies. - Evaluate trade-offs in resource management solutions. Obtaining, Evaluating, and Communicating Information - Gather and assess data on resource availability, hazards, and climate impacts. Engaging in Argument from Evidence - Compare and critique design solutions (e.g., renewable vs. nonrenewable energy) based on data and cost-benefit analyses.	ESS2.A: Earth Materials and Systems - Earth's systems interact through energy flows, driving climate patterns. ESS2.D: Weather and Climate - Changes in energy inputs/outputs (e.g., solar radiation, albedo, greenhouse effect) lead to climate shifts. ESS3.A: Natural Resources - Resource availability influences human population growth and societal development. ESS3.B: Natural Hazards - Natural hazards (e.g., earthquakes, floods) impact human infrastructure and migration. ESS3.C: Human Impacts on Earth Systems - Climate changes drive human adaptation (e.g., agriculture, settlement patterns). ESS3.A: Natural Resources - Resource extraction and use impact the environment and society. ETS1.B: Developing Possible Solutions - Solutions must balance economic, environmental, and social costs and benefits. ESS3.C: Human Impacts on Earth Systems	Cause and Effect - Variations in energy flow cause changes in climate systems. - Resource scarcity, hazards, and climate shifts cause changes in human behavior and societal organization. Systems and System Models - Models help predict how energy changes impact Earth's interconnected systems. - Human activities adapt to changing environmental conditions. - Resource management involves interconnected economic and environmental systems. - Solutions address interactions between human and natural systems. Influence of Science, Engineering, and Technology on Society and the Natural World - Technological solutions affect resource sustainability. - Technologies can reduce environmental degradation. Stability and Change - Climate systems change over time due to natural and anthropogenic factors.

Constructing Explanations and Designing Solutions: - Design or refine technologies (e.g., carbon capture, renewable energy systems) to mitigate human impacts. Engaging in Argument from Evidence - Justify refinements to solutions based on data. Using Mathematics and Computational Thinking - Quantify rates of climate change using data analysis.	- Human activities (e.g., deforestation, pollution) disrupt natural systems. ETS1.B: Developing Possible Solutions - Technological solutions can minimize environmental harm. ESS3.D: Global Climate Change - Human activities (e.g., burning fossil fuels) drive climate change, affecting Earth systems. ESS2.D: Weather and Climate - Climate models predict future changes based on current trends.	Patterns Data analysis reveals trends in climate change and impacts.
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Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How can predictions about gas behavior be made? - How can gaseous products of chemical reactions be predicted with respect to the law of conservation of matter? - How do variations in Earth's energy flow and human activities interact to drive climate change, and what evidence-based solutions can mitigate their impacts on natural systems? - How can we evaluate and balance the costs and benefits of managing natural resources and addressing environmental challenges to create sustainable solutions for human and Earth systems?	- Student will be able to: - Explain the relationships among pressure, volume, temperature, and amount of gas using the ideal gas law ($PV = nRT$) and predict changes in one variable when others are altered. - Students will be able to apply Dalton's Law of Partial Pressures to calculate the total pressure of a gas mixture and determine the partial pressures of individual gases using mole fractions. - Apply the kinetic molecular theory to describe the behavior of gases under varying conditions, such as	- Use a computer simulation to model and predict gas behavior. - Phet Simulations: Introduction to Gases, Gas Properties, Greenhouse Effect - Explore Learning: Boyles' Law & Charles' Law & Ideal Gas Law - Plan and conduct an investigation that involves quantitative predictions of gaseous substances as a product of a chemical reaction. - Flinn: Micromole Rocket - Pasco: Air Bag Module - Students will explore how natural resources, natural hazards, and climate changes have historically shaped human settlement, migration, and economic activities.	- Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports (formative) - Plan and conduct an experiment to compare any two gas variables (pressure, temperature, volume, amount) to verify the appropriate gas law. (formative) - Math representations used to make quantitative predictions about closed gaseous systems. (formative) - Math representations used to support quantitative predictions about gaseous chemicals involved in a

	temperature and pressure changes. ● Use mathematical models (e.g., Boyle's Law, Charles's Law, Avogadro's Law, Dalton's law, Grahams law) to calculate and predict gas behavior in real-world scenarios, such as in weather balloons or scuba diving. ● Calculate the volume of gaseous products formed in a chemical reaction using stoichiometric relationships and the ideal gas law under standard conditions. ● Evaluate real-world applications (e.g., airbag inflation, carbon dioxide production in fermentation) to predict gaseous products and assess their environmental or practical impacts. ● Describe the components of Earth's energy flow (e.g., solar radiation, greenhouse effect, albedo) and explain how they contribute to global climate patterns. ● Analyze the role of human activities (e.g., fossil fuel combustion, deforestation, agriculture) in altering	Students will develop evidence-based explanations connecting Earth's systems—resources, hazards, and climate—to their influence on human populations and behaviors. ● Resources, Hazards, and Climate: Shaping Human History ● Explain the chemical properties and bonding of greenhouse gases (CO₂, CH₄, H₂O). Analyze data on greenhouse gas emissions and their environmental impact. Evaluate strategies for reducing greenhouse gas emissions. Create a public awareness campaign synthesizing chemistry and climate change concepts. ● Investigating Greenhouse Gases: Chemistry and Climate Change ● Greenhouse Gases: A Closer Look (IR Windows Learning Tool) ● Concord Consortium: Greenhouse gases ● Carbon Footprint Calculator ● Identify and explain at least two AI applications that can mitigate climate	chemical reaction. (formative) ● Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. (formative & Summative) ● Use multiple lines of evidence to support how variations in the flow of energy into and out of Earth's systems result in climate changes. (formative) ● Analyze and discuss design decisions based on learned concepts related to systems that rely on gaseous products. (formative) ● Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test (Formative & Summative) ● Assessment of written and verbal mastery of unit-specific vocabulary. (formative) ● Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure,
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	Earth's energy balance and driving climate change. - Evaluate and refine a technological solution to issues regarding climate change Boundaries limited to: - Applications and discussions about Ideal gases only. Real gas applications limited to discussions in context of error in laboratory data when appropriate. - Focus on mathematical developing understanding of relationships predicted through graph models to equations. - calculations of the molar mass of gases are excluded.	change. Evaluate the ethical implications of using AI in climate policy. Evaluate the pros and cons of using AI in climate change and suggest ways to refine solutions. Communicate research findings through a presentation or written report. AI and Climate Change: A Futuristic Inquiry <i>Scientist Spotlights:</i> Winifred Burks-Houck: An environmental organic chemist and the first woman president of the National Organization for the Professional Advancement of Black Chemists and chemical Engineers. Warren Washington – atmospheric climate scientist	and/or making observational sketches. (formative) <u>Alternative Assessment Options</u> Claim-Evidence-Reasoning (CER): Develop a scientific argument evaluating the effectiveness of current strategies for mitigating climate change by synthesizing evidence from atmospheric data, climate models, gas law principles, and peer-reviewed scientific literature. Defend conclusions using scientific, environmental, and economic evidence. Performance Task: Analyze atmospheric or experimental gas law data to develop mathematical models describing the relationships among pressure, volume, temperature, and moles. Apply these models to explain and predict real-world phenomena such as airbag deployment, atmospheric changes, scuba diving, or carbonated beverage systems. Engineering Design Challenge: Design, model, and evaluate an innovative
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			technology that reduces greenhouse gas emissions, improves energy efficiency, or captures atmospheric carbon dioxide. Justify design decisions using gas law principles, engineering constraints, cost-benefit analysis, sustainability considerations, and scientific evidence. ● Scientific Research Project: Investigate a contemporary environmental chemistry issue (e.g., carbon capture technologies, hydrogen fuel systems, atmospheric pollution, wildfire emissions, or climate feedback mechanisms). Prepare a professional scientific presentation or research report that incorporates quantitative data analysis, climate model interpretation, gas law applications, and peer-reviewed scientific sources to develop evidence-based recommendations.
Interdisciplinary Connections	<u>English/Language Arts</u> RI.MF.9–10.6. Analyze, integrate, and evaluate multiple interpretations (e.g., charts, graphs, diagrams, videos) of a single text or text/s presented in different formats (visually, quantitatively) as well as in words in order to address a question or solve a problem. RI.AA.9–10.7. Describe and evaluate the argument and specific claims in an informational text, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and reasoning.		

	W.AW.9–10.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient textual and non-textual evidence. W.WR.9–10.5. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. SL.PE.9–10.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. SL.II.9–10.2. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source. SL.PI.9–10.4. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. SL.UM.9–10.5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest. <u>Social Studies</u> 6.1.12.GeoHE.5.a: Generate/make an evidence-based argument regarding the impact of rapid urbanization on the environment and on the quality of life in cities. 6.1.12.GeoHE.16.a: Explain why natural resources (i.e., fossil fuels, food, and water) continue to be a source of conflict and analyze how the United States and other nations have addressed issues concerning the distribution and sustainability of natural resources and climate change. <u>Mathematics</u> N.Q.A.1 - Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.A.2 - Define appropriate quantities for the purpose of descriptive modeling. A.CED.A.2 - Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. A.CED.A.4 - Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. F.IF.C.7 - Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. F.BF.A.1 - Write a function that describes a relationship between two quantities. F.IF.B.5 - Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. S.ID.B.6 - Represent data on two quantitative variables on a scatter plot, and describe how those variables are related.
Career Readiness, Life Literacies, and Key Skills	9.1.12.PB.2: Prioritize financial decisions by considering alternatives and possible consequences 9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills. 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice. 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
Computer Science and Design Thinking	8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.

8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). 8.2.12.ETW.4: Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints			
Modifications			
Multi-Lingual Learners	Students with Special Needs/504s	At-Risk	Gifted and Talented
● Provide illustrated vocabulary guides for gas laws, atmospheric chemistry, greenhouse gases, climate change, pressure, volume, temperature, and environmental systems. ● Use color-coded diagrams, climate models, particle models, and gas law simulations to reinforce scientific concepts. ● Provide sentence frames and graphic organizers for interpreting climate data, explaining gas behavior, and constructing scientific explanations. ● Pair students with peers during laboratory investigations and climate data analysis to reinforce scientific vocabulary and collaborative discussion. ● Utilize translated directions, visual demonstrations, and interactive simulations to	● Provide guided notes, graphic organizers, and step-by-step templates for gas law calculations, graph interpretation, and climate data analysis. ● Break multi-step laboratory investigations and gas law problems into smaller sequential tasks with frequent teacher check-ins. ● Allow students to demonstrate understanding through physical models, digital simulations, oral explanations, or labeled diagrams when appropriate. ● Provide extended time for laboratory investigations, graph interpretation, engineering design activities, and assessments as outlined in student accommodations.	● Reinforce gas law concepts using hands-on demonstrations, balloon investigations, syringe activities, and particle models before introducing mathematical relationships. ● Provide scaffolded problem-solving organizers and guided formulas for gas law calculations and graph interpretation. ● Incorporate frequent formative assessments (whiteboards, exit tickets, think-pair-share, and guided practice) to monitor understanding and provide immediate intervention. ● Connect environmental chemistry concepts to familiar real-world examples such as weather, airbags, carbonated beverages, air pollution, and wildfires to increase relevance. ● Provide small-group instruction and guided practice for interpreting climate graphs,	● Investigate advanced applications of gas behavior and environmental chemistry in atmospheric science, renewable energy, aerospace engineering, or climate modeling. ● Analyze authentic climate and atmospheric data sets to identify trends, evaluate climate models, and justify conclusions using scientific evidence. ● Design and evaluate an engineering solution that reduces greenhouse gas emissions or improves energy efficiency while considering scientific, economic, and environmental constraints. ● Extend quantitative problem solving through investigations involving the Combined Gas Law, Ideal Gas Law, and real-world applications of atmospheric chemistry.

support investigations involving gas laws, atmospheric chemistry, and climate systems. ● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	● Use teacher-guided simulations and hands-on demonstrations to reinforce gas behavior, atmospheric processes, and climate feedback mechanisms. ● Provide adequate scaffolds for concept development and note-taking. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Use manipulatives to model structures and ratios. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a different setting, such as a quiet room with few distractions ● Sit where they learn best (for example, near the teacher) ● Use an alarm or cues to help with time management ● Work with a partner	gas law relationships, and environmental data before independent work. ● Incorporate student choice ● Invite parents, neighbors, friends, the school principal and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Research and present how environmental chemistry and gas laws are applied in fields such as meteorology, environmental engineering, climate science, renewable energy, or industrial process engineering. ● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.
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Honors Chemistry		
Unit 6: Equilibrium and Kinetics		
Related Phenomena: 1. The Fading Glow Stick 2. The Color-Changing Equilibrium Dance (Use a portion and no audio)		
Pacing: 3-4 weeks		
New Jersey Student Learning Standards (NJSLS)		
HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.		
HS-PS1-6 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium		
HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.		
Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Constructing Explanations and Designing Solutions - Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Constructing Explanations and Designing Solutions - Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Using Mathematics and Computational Thinking - Create a computational model or simulation of a phenomenon, designed device, process, or system.	PS1.B: Chemical Reactions - Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. PS1.B: Chemical Reactions - In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. PS3.A: Definitions of Energy - Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	Patterns - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Stability and Change - Much of science deals with constructing explanations of how things change and how they remain stable. Systems and System Models - Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. ----- <i>Connections to Nature of Science</i> Scientific Knowledge Assumes an Order and Consistency in Natural Systems

	PS3.B: Conservation of Energy and Energy Transfer - Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. - Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. - Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. - The availability of energy limits what can occur in any system. ETS1.C: Optimizing the Design Solution - Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. <i>(secondary)</i>	Science assumes the universe is a vast single system in which basic laws are consistent.
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Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How do molecular collisions and energy changes influence the rates of chemical reactions? - How can we use this understanding to control reaction outcomes in real-world processes? - How does dynamic equilibrium establish a balance between forward and reverse reactions? - What factors can shift this balance to favor desired	- Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature, particle size or concentration of the reacting particles on the rate at which a reaction occurs. - Create a computational model of the effect of either temperature or concentration on rate of reaction - Refine the design of a chemical system by specifying	- Plan and carry out an experimental investigation to determine how changing conditions (i.e., temperature, concentration, surface area) influence the rate of a reaction similar to AACT Activity, an Iodine Clock Challenge or an Alka Seltzer Kinetics Lab. Create a computational model based on the data in these activities. - Explain the difference	- Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports - Support a claim with evidence to explain how changing conditions (i.e., temperature, concentration, surface area) influence the rate of a reaction. - Present a written/oral scientific argument to evaluate the claims,

products? - How can we use mathematical models or simulations to predict and optimize the behavior of chemical systems at equilibrium or during reactions? - How can we use experimental data to determine the differential rate law for a chemical reaction? - How do we relate the equilibrium constant in terms of concentration (K_c) to the equilibrium constant in terms of partial pressure (K_p) for a given chemical reaction? - How can we use the solubility product constant (K_{sp}) to predict the solubility of ionic compounds and determine whether a precipitate will form in a chemical reaction? - How can we determine whether a chemical system is at equilibrium by comparing the reaction quotient (Q) to the equilibrium constant (K_c)?	a change in conditions that would produce increased amounts of products at equilibrium. - Translate among reaction energy profile representations, particulate representations, and symbolic representations (chemical equations) of a chemical reaction occurring in the presence and absence of a catalyst. - Given a set of experimental observations regarding physical, chemical, biological, or environmental processes that are reversible, construct an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes. - Develop or use a model to explain on the molecular level what happens to a system in chemical equilibrium when a stress is applied. - Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and	between collisions that convert reactants to products and those that do not in terms of energy distributions and molecular orientation PhET: Reactions and Rates - Create a computational model of the kinetics of a reaction - Understand that chemical reactions need not be unidirectional via PhET: Reversible Reactions - Plan and carry out an experiment to investigate how given stresses will shift a given reaction which is at equilibrium in the spirit of Le Chat Soda Lab After completing the POGIL: Le Chatelier's Principle - Refine the design of a chemical reaction in PhET: Reversible Reactions in order to specify changes to reaction conditions which optimize the yield. Evaluate the trade-offs of optimizing the reaction yield in this way. - Critically read "What's So Equal about Equilibrium" from ACS to determine the central ideas or conclusions and/or to obtain scientific and/or technical information	evidence, and/or reasoning behind Le Chatelier's principle to determine its merits. - Debate/discussions about observations of physical, chemical, biological, or environmental processes that are explained by reversible reactions. - Summarize an article adapted for classroom use that illustrates (an) example(s) of equilibrium in a natural system. - Use math representations or a model to predict/explain the solubility of a salt. - Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test - Assessment of written and verbal mastery of unit-specific vocabulary. - Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches.
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	student-generated evidence from investigating a reversible reaction. ● Apply kinetic principles, and/or evidence to provide an explanation of phenomena that demonstrates Le Chatelier's principle. ● Students will be able to analyze concentration-time data from a chemical reaction to determine the reaction order and rate constant as well as to express the differential rate law. ● Students will be able to calculate the equilibrium constant (K_p) from the equilibrium constant (K_c), and vice versa, using the ideal gas law relationship, and apply this understanding to solve problems involving gaseous reactions. ● Students will be able to calculate the solubility of ionic compounds using K_{sp} values and apply the concept of K_{sp} to predict the formation of a precipitate in solution. ● Students will be able to calculate both the equilibrium constant (K_c) and	to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. ● Understand the difference between K_c and K_p video tutorial ● K_{sp}: NaCl lab or <i>Precipitation Prediction Lab: Will It Stay or Will It Fall?</i> ● Use Positive Physics to determine the difference between K_c and Q. <i>Scientist Spotlight:</i> ● John Cornforth – an Australian-British chemist whose life and career were shaped by a hearing disorder that left him profoundly deaf by the age of 20.	Alternative Assessment Options ● Claim-Evidence-Reasoning (CER): Develop a scientific argument evaluating how changes in temperature, concentration, pressure, or catalysts influence both reaction rate and chemical equilibrium. Support conclusions using laboratory data, mathematical models, Le Châtelier's Principle, collision theory, and peer-reviewed scientific literature. ● Performance Task: Design and conduct an investigation to determine how a selected variable affects reaction rate or equilibrium. Analyze experimental data, construct graphical models, evaluate sources of uncertainty, and use quantitative evidence to predict system behavior under new conditions. ● Engineering Design Challenge: Design and optimize an industrial chemical process that maximizes product yield while minimizing energy consumption, waste, and production costs. Justify engineering decisions using
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	the reaction quotient (Q) for a given chemical reaction and interpret the comparison between them to predict the direction in which the reaction will shift to reach equilibrium. Boundaries limited to: - Equilibrium focus is on context when explaining macroscopic outcomes from reversible reactions		equilibrium principles, reaction kinetics, engineering constraints, and sustainability considerations. ● Scientific Research Project: Investigate a real-world application of chemical kinetics or equilibrium (e.g., Haber-Bosch ammonia synthesis, catalytic converters, enzyme catalysis, pharmaceutical manufacturing, or industrial chemical production). Prepare a professional scientific presentation or research report that incorporates quantitative analysis, reaction modeling, engineering trade-offs, and peer-reviewed scientific sources to develop evidence-based recommendations.
Interdisciplinary Connections	<u>English Language Arts</u> SL.PE.9-10.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively. SL.PI.9-10.4. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. <u>Mathematics</u> N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.		

	N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. A.SSE.A.1 Interpret expressions that represent a quantity in terms of its context. A.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. Social Studies 6.2.12.HistoryCA.16.a: Analyze the impact of scientific and technological innovations on society, the environment, and the global economy through investigations of industrial chemical processes, catalytic technologies, and sustainable manufacturing practices. Visual & Performing Arts 1.5.12prof.Cr1a: Use multiple approaches to begin creative endeavors. 1.5.12prof.Pr5a: Evaluate, refine, and prepare works of art for presentation.
Career Readiness, Life Literacies, and Key Skills	9.4.12.Cl.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice. 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. 9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills. 9.1.12.PB.2: Prioritize financial decisions by considering alternatives and possible consequences.
Computer Science and Design Thinking	8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. 8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics).
Modifications	

Multi-Lingual Learners	Students with Special Needs/504s	At-Risk	Gifted and Talented
● Provide illustrated vocabulary guides for reaction rates, equilibrium, catalysts, activation energy, collision theory, reversible reactions, and Le Châtelier's Principle. ● Use color-coded particle models, reaction coordinate diagrams, equilibrium simulations, and graphic organizers to reinforce abstract concepts. ● Provide sentence frames and guided templates for explaining reaction rate changes, equilibrium shifts, and interpreting laboratory data. ● Pair students with peers during laboratory investigations and equilibrium modeling activities to reinforce scientific vocabulary and collaborative discussion. ● Utilize translated directions, visual demonstrations, and interactive simulations to support investigations involving reaction rates, catalysts, and equilibrium systems. ● Display labeled images of designs and parts.	● Provide guided notes, graphic organizers, and step-by-step templates for graph interpretation, equilibrium predictions, and reaction rate investigations. ● Break multi-step laboratory investigations and equilibrium analyses into smaller sequential tasks with frequent teacher check-ins. ● Allow students to demonstrate understanding through physical models, digital simulations, oral explanations, or labeled diagrams in place of lengthy written responses when appropriate. ● Provide extended time for laboratory investigations, graph interpretation, engineering design activities, and assessments as outlined in student accommodations. ● Use teacher-guided demonstrations and interactive simulations to reinforce collision theory, reaction rates, and equilibrium concepts. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency.	● Reinforce reaction rate and equilibrium concepts using hands-on demonstrations, particle models, and real-world examples before introducing symbolic representations and quantitative analysis. ● Provide scaffolded graphic organizers and guided prediction charts for determining how changes in temperature, concentration, pressure, or catalysts affect reaction systems. ● Incorporate frequent formative assessments (whiteboards, exit tickets, think-pair-share, and guided practice) to monitor understanding and provide timely intervention. ● Connect equilibrium concepts to familiar real-world examples such as glow sticks, carbonated beverages, cooking, refrigeration, and industrial manufacturing. ● Provide small-group instruction and guided practice for interpreting reaction coordinate diagrams, equilibrium models, and experimental	● Investigate advanced applications of chemical equilibrium and kinetics in pharmaceutical manufacturing, industrial chemistry, environmental engineering, or biochemical systems. ● Design and optimize an industrial chemical process by manipulating reaction conditions to maximize product yield while evaluating engineering constraints and sustainability. ● Analyze authentic experimental or industrial data to model reaction rates, evaluate equilibrium systems, and justify conclusions using quantitative evidence. ● Extend quantitative problem solving through enrichment involving equilibrium constants, reaction mechanisms, or introductory rate law concepts beyond the core curriculum. ● Research and present how kinetics and equilibrium principles are applied in fields such as chemical engineering, biotechnology, renewable energy, environmental

• Use body movement and gestures to further explain concepts to students. • Restate design steps aloud before project activity. • Assign a native language partner.	• Use color to identify and differentiate important aspects of concepts and problem-solving. • Provide an outline of lessons • Get a written list of instructions • Work or take a test in a different setting, such as a quiet room with few distractions • Sit where they learn best (for example, near the teacher) • Use an alarm or cues to help with time management • Work with a partner	data before independent work. • Incorporate student choice • Invite parents, neighbors, friends, the school principal, and other community members to support classroom activities. • Provide peer mentoring to improve techniques. • Provide alternative assessments to demonstrate proficiency	remediation, or catalyst development. • Lead the class in the deciphering of new learning. • Share understanding through peer tutoring • Evaluate concepts through scientific literature. • Provide AP Chem options for problem-solving.
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Honors Chemistry

Unit 7: Acids and Bases

Related Phenomena:

1. [Stomach Acid and the use of Antacids](#)
2. [Ocean Acidification of Coral Reefs](#)
3. [Tight pH Control of Blood](#)
4. [Acid Rain Damage in Washington, D.C.](#)

Pacing: 2-3 weeks**New Jersey Student Learning Standards (NJSLS)**

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

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

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

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

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

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

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
Constructing Explanations and Designing Solutions - Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. - Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Using Mathematics and Computational Thinking - Create a computational model or simulation of a phenomenon, designed device, process, or system. - Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. Analyzing and Interpreting Data - Analyze data using computational models in order to make valid and reliable scientific claims. ----- <i>Connections to Nature of Science</i>	PS1.B: Chemical Reactions - In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. - Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. PS3.A: Definitions of Energy - Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. PS3.B: Conservation of Energy and Energy Transfer - Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. - Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	Stability and Change - Much of science deals with constructing explanations of how things change and how they remain stable. - Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. Patterns - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Systems and System Models - Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. - Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. -----

Scientific Investigations Use a Variety of Methods - Science investigations use diverse methods and do not always use the same set of procedures to obtain data. - New technologies advance scientific knowledge. Scientific Knowledge is Based on Empirical Evidence - Science knowledge is based on empirical evidence. - Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. - The availability of energy limits what can occur in any system. ESS3.D: Global Climate Change - Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. ETS1.B: Developing Possible Solutions - Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. ETS1.C: Optimizing the Design Solution - Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (<i>secondary</i>)	<i>Connections to Nature of Science</i> Scientific Knowledge Assumes an Order and Consistency in Natural Systems Science assumes the universe is a vast single system in which basic laws are consistent.
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Essential Questions	Student Learning Objectives	Suggested Tasks/Activities	Evidence of Learning (Assessment)
- How are acids and bases recognized as unique compounds? - How can chemical principles be used to explain why acids differ from each other? - How is pH used to make predictions? - How are acids and bases affected by an equilibrium shift?	- Develop and/or use particulate models, such as balanced chemical equations to demonstrate how acids/bases are defined. - Use math representations to explain changes in acidity/alkalinity in terms of pH. - Construct and revise an	POGIL activity to develop definitions of acids and bases based on various models. Link to proton transfer. - Investigate the properties of acids and bases by analyzing several household products. AACT Qualitative Analysis of Unknown Household Products - Use a model/simulation to collect data to investigate the	- Assessment of lab skills (Experimental Design, Data Analysis, and/or Arguing a Scientific Claim) by submitting Lab Reports (formative) - Support a claim with evidence to explain how titration method is used to make predictions about a neutralization reaction.

- How are tools/techniques used to measure the strength of acids? - How do natural systems respond to changes in pH?	explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) to differentiate between acid (or base) strength and pH. - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) that demonstrates how acid/base strength is a result of a reversible reaction and therefore can be predicted using equilibrium constant calculations. - Use a computer model/simulation to investigate the impact of changes in pH on natural systems. - Use math representations, based on balanced chemical equations, to make quantitative predictions about	pH scale. PhET's: pH Scale Basics, pH Scale, and Acid-Base Solutions - Plan and conduct an experiment to collect data from a neutralization reaction using titration method to determine the concentration of a strong acid. Microscale Or Traditional Use data collected to create a computational titration model. - Plan and conduct an experiment to investigate the pH ranges for a set of indicators. - Plan and conduct a research project to understand changes in pH in a natural system. (ie. natural rain $\text{pH} < 7$ as a result of reaction of CO_2 with atmospheric water) - Use NOAA Data in the Classroom Ocean Acidification Model to investigate how anthropogenic CO_2 atmospheric changes affect ocean water pH and coral reef systems. <i>Scientist Spotlight:</i> - Eunice Foot – amateur scientists from the mid-1800s whose experiments foreshadowed the discovery of	(formative) - Employ math representations on collected data to quantify acid strength. (formative) - Use models to describe a system and define its boundaries, initial conditions, inputs, and outputs to explain a change in pH. (formative) - Summarize an article adapted for classroom use that illustrates an example(s) of impact of pH changes in a natural system. (formative) - Assessment of skills such as Problem Solving, Creating and Interpreting Graphs, and/or Creating Scientific Explanations by taking quizzes as well as the Unit Test (formative & summative) - Assessment of written and verbal mastery of unit-specific vocabulary. (formative) - Assessment of modeling skills by drawing and labeling diagrams, making analogies, building a 3D structure, and/or making observational sketches. (formative) - Linkit! Form C (benchmark) Alternative Assessment Options
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	neutralization reactions. Boundaries limited to: - Prediction of pH of strong acids and bases - Prediction of pH of weak acids only (ICE with weak acids, not bases) - Other than at the half-equivalence point and the equivalence point, titration work with weak acids and bases limited to qualitative understanding only	Earth's Greenhouse effect.	● Claim-Evidence-Reasoning (CER): Develop a scientific argument evaluating the impacts of ocean acidification or acid rain on biological and environmental systems by synthesizing laboratory data, pH measurements, equilibrium principles, climate data, and peer-reviewed scientific literature. ● Performance Task: Design and conduct an investigation to analyze the effectiveness of buffers, antacids, or neutralization reactions. Interpret quantitative pH data, evaluate experimental uncertainty, and explain results using acid-base theory and equilibrium principles. ● Engineering Design Challenge: Design, model, and evaluate an engineering solution to reduce the effects of acid rain, ocean acidification, or industrial acid waste while considering scientific evidence, engineering constraints, environmental impacts, sustainability, and cost-benefit analysis. ● Scientific Research Project:
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			Investigate a contemporary application of acid-base chemistry (e.g., carbon capture and ocean acidification, blood pH regulation, wastewater treatment, industrial neutralization processes, agricultural soil management, or pharmaceutical antacid development). Prepare a professional scientific presentation or research report incorporating quantitative data analysis, acid-base modeling, environmental or biological implications, and peer-reviewed scientific sources to develop evidence-based recommendations.
Interdisciplinary Connections	<u>English Language Arts</u> SL.PE.9-10.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with peers on grades 9–10 topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively. SL.II.9-10.2. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) evaluating the credibility and accuracy of each source. SL.ES.9-10.3. Evaluate a speaker’s point of view, reasoning, and use of evidence and rhetoric, identifying any false reasoning or distorted evidence. SL.PI.9-10.4. Present information, findings, and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience. SL.UM.9-10.5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance findings, reasoning, and evidence and to add interest. <u>Mathematics</u>		

	N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. A.SSE.A.1 Interpret expressions that represent a quantity in terms of its context. A.SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. A.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. F.BF.B.5 Use the inverse relationship between exponents and logarithms to solve problems involving logarithms and exponents.		
Career Readiness, Life Literacies, and Key Skills	9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice. 9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving. 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data. 9.1.12.PB.2: Prioritize financial decisions by considering alternatives and possible consequences. 9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills.		
Computer Science and Design Thinking	8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena. 8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs, and aesthetic and ethical considerations and share this information with an appropriate audience. 8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics).		
Modifications			
Multi-Lingual Learners	Students with Special Needs/504s	At-Risk	Gifted and Talented
● Provide illustrated vocabulary guides for acids, bases, pH, neutralization, buffers, indicators, equilibrium, and acid rain. ● Use color-coded pH scales, molecular models, neutralization	● Provide guided notes, graphic organizers, and step-by-step templates for interpreting pH data, buffer systems, and neutralization reactions. ● Break multi-step laboratory investigations and acid-base	● Reinforce acid-base concepts using hands-on pH testing, indicator demonstrations, neutralization activities, and real-world examples before introducing symbolic representations.	● Investigate advanced applications of acid-base chemistry in medicine, environmental science, pharmaceutical development, wastewater treatment, or industrial chemical processes.

diagrams, and buffer simulations to reinforce scientific concepts. ● Provide sentence frames and graphic organizers for explaining pH changes, neutralization reactions, and environmental impacts of acid-base chemistry. ● Pair students with peers during laboratory investigations and pH analysis activities to strengthen scientific vocabulary and collaborative discussion. ● Utilize translated directions, visual demonstrations, and interactive simulations to support investigations involving acids, bases, buffers, and pH. ● Display labeled images of designs and parts. ● Use body movement and gestures to further explain concepts to students. ● Restate design steps aloud before project activity. ● Assign a native language partner.	analyses into smaller sequential tasks with frequent teacher check-ins and immediate feedback. ● Allow students to demonstrate understanding using physical models, digital simulations, oral explanations, or labeled diagrams in place of lengthy written responses when appropriate. ● Provide extended time for laboratory investigations, graph interpretation, engineering design activities, and assessments as outlined in student accommodations. ● Use teacher-guided demonstrations and interactive simulations to reinforce pH, neutralization, buffering, and equilibrium concepts. ● Provide alternative choices (i.e. verbal or visual) to demonstrate proficiency. ● Use color to identify and differentiate important aspects of concepts and problem-solving. ● Use manipulatives to model structures and ratios. ● Provide an outline of lessons ● Get a written list of instructions ● Work or take a test in a	● Provide scaffolded graphic organizers and guided prediction charts for classifying substances as acids, bases, or neutral and explaining pH changes. ● Incorporate frequent formative assessments (whiteboards, exit tickets, guided practice, and think-pair-share) to monitor understanding and provide timely intervention. ● Connect acid-base chemistry to familiar real-world examples such as antacids, sports drinks, swimming pools, acid rain, household cleaners, and ocean acidification. ● Provide small-group instruction and guided practice for interpreting pH scales, neutralization reactions, and laboratory data before independent work. ● Incorporate student choice ● Invite parents, neighbors, friends, the school principal, and other community members to support classroom activities. ● Provide peer mentoring to improve techniques. ● Provide alternative assessments to demonstrate proficiency	● Design and evaluate an engineering solution to reduce the effects of acid rain, ocean acidification, or industrial acid waste while considering scientific evidence, sustainability, and engineering constraints. ● Analyze authentic environmental or biological data sets to evaluate pH changes, buffer systems, and acid-base equilibria using quantitative evidence. ● Extend quantitative problem solving through enrichment involving buffer systems, acid-base equilibria, titration analysis, or equilibrium constants beyond the core curriculum. ● Research and present how acid-base chemistry is applied in fields such as environmental engineering, medicine, agriculture, biotechnology, pharmaceutical science, or water quality management. ● Lead the class in the deciphering of new learning. ● Share understanding through peer tutoring ● Evaluate concepts through scientific literature. ● Provide AP Chem options for problem-solving.
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	different setting, such as a quiet room with few distractions • Sit where they learn best (for example, near the teacher) • Use an alarm or cues to help with time management • Work with a partner.		
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Professional Resources

- 2026 New Jersey Student Learning Standards for Science – <https://www.nj.gov/education/standards/science/>
- American Association of Chemistry Teachers (AACT) – <https://teachchemistry.org/>
- Beyond Benign (Green Chemistry Resources) – <https://www.beyondbenign.org/>
- ChemCollective – <https://chemcollective.org/>
- CK-12 Foundation – <https://www.ck12.org/>
- Concord Consortium – <https://learn.concord.org/>
- Data Nuggets – <https://datanuggets.org/>
- Edpuzzle – <https://edpuzzle.com/>

- ExploreLearning Gizmos – <https://www.explorelearning.com/>
- Flinn Scientific – <https://www.flinnsci.com/>
- Gapminder – <https://www.gapminder.org/>
- LabXchange – <https://www.labxchange.org/>
- LinkIt! Assessment Platform
- National Aeronautics and Space Administration (NASA) – <https://www.nasa.gov/>
- National Oceanic and Atmospheric Administration (NOAA) – <https://www.noaa.gov/>
- NJ Department of Environmental Protection (NJDEP) – <https://www.nj.gov/dep/>
- OpenSciEd – <https://www.openscienced.org/>
- PASCO Scientific – <https://www.pasco.com/>
- PhET Interactive Simulations – <https://phet.colorado.edu/>
- Positive Physics – <https://positivephysics.org/>
- POGIL (Process Oriented Guided Inquiry Learning) – <https://pogil.org/>
- Royal Society of Chemistry – <https://edu.rsc.org/>
- The Concord Consortium – <https://learn.concord.org/>
- The Wonder of Science – <https://thewonderofscience.com/>
- U.S. Department of Energy (DOE) Office of Science – <https://science.osti.gov/>
- U.S. Environmental Protection Agency (EPA) – <https://www.epa.gov/>
- U.S. Geological Survey (USGS) – <https://www.usgs.gov/>
- Vernier Science Education – <https://www.vernier.com/>