Grade: 9-12

Unit 3: The Chemistry of Climate Change

New Jersey Student Learning Standards

Established Date 2016-2017
Revised Date 2018-2019
Revised Date 2020-2021
Revised Date 2022-2023

Marking Period	Unit Title	Recommended Instructional Days
3	Unit 3: The Chemistry of Climate Change	36

NJSLS - Science: *TItle*	NJSLS - Science: *Performance Expectations*	
• **HS-PS1: Matter and Its Interactions** • **HS-ESS2: Earth's Systems** • **HS-ESS3: Earth and Human Activity** • **HS-ETS1: Engineering Design**	• **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-ESS2-2 -** Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. • **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-ESS2-6 -** Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. • **HS-ESS3-2 -** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. • **HS-ESS3-5 -** Analyze geoscience data and the results from global climate models to	**Recommended Activities, Investigations, Interdisciplinary Connections, and/or Student Experiences to Explore NJSLS-S within Unit**

	make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. ● **HS-ESS3-6 -** Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change). ● **HS-ETS1-2 -** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. ● **HS-ETS1-3 -** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. ● **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.	
FOUNDATION Disciplinary:	**FOUNDATION Disciplinary:**	

Core Idea	*Statement*	
• **HS-PS1.A Structure and Properties of Matter** • **HS-ESS2.A Earth Materials and Systems** • **HS-ESS2.D Weather and Climate** • **HS-ESS3.A Natural Resources** • **HS-ESS.C Human Impacts on Earth Systems** • **HS-ESS3.D Global Climate Change** • **HS-ETS1.B Developing Possible Solutions** • **HS-ETS1.C Optimizing the Design Solution**	**Structure and Properties of Matter** • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3) **Earth Materials and Systems** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2) • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4) **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	**Essential Question/s:** • What is the impact of pressure, temperature, and volume on the behavior of gases? • How does a real gas differ from an ideal gas? • What factors interact and influence weather and climate? • What impact do greenhouse gases and carbon emission have on global climate change? • How have climate changes impacted the environment and ecosystems throughout the world? • How are individuals and countries responding to climate change? **Activity Description**: **The Behavior of Gases** • Inquiry Lab - Compressibility • Analyzing Data - Analyze Gas Volume • CER - Explain Changes in Tire Pressure • Analyzing Data - Gas Volume and Temperature • Inquiry Lab - Relationships Between Gas Variables • Analyzing Data - Relate Gas Pressure and Temperature • Argument Driven Inquiry Lab - Pressure, Temperature, and Volume of Gases: How does changing the volume or temperature of a gas affect the pressure of that gas? • Modeling The Combined Gas Laws • Collaborative Group Activity - The Gas Laws and Scuba Diving • Engineering Design Challenge - What's in a Container? • Inquiry Lab - The Ideal Gas Law • Virtual Lab - Gas Behavior in Popping Candy • CER - Real vs. Ideal Gases • Inquiry Lab - Gas Diffusion • Interactivity - Going for a Hike • CER - Explain Gas Diffusion • Inquiry Lab - Diffusion: Do different gases diffuse at different rates? **Weather and Climate** • Inquiry Lab - Feedback and Climate Change • Analyzing Data - Influence on Dams on Coastal Erosion

	redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2), (HS-ESS2-4) ● Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6) ● Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.(HS-ESS2-6) (HS-ESS2-4) **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. (HS-ESS3-2) **Global Climate Change** ● Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in	● CER - Feedback and Melting Glaciers ● Inquiry Lab - Energy in the Atmosphere ● Analyzing Data - Balance the Energy Budget ● CER - Drought Causes ● Analyzing Data - Energy In and Out of Earth's Atmosphere ● Inquiry Lab - Albedo and Composition of Earth's Surface ● Interactivity - Wetlands and the Carbon Cycle ● CER - Discuss the Wetland Effect ● Engineering Design Challenge - Design a Green Roof ● Inquiry Lab - How Melting Ice Affects Sea Level ● Analyzing Data - Historical Carbon Dioxide Levels ● CER - Heat Expansion ● Inquiry Lab - Observe Air Pollution ● Virtual Lab - Sampling the Past ● Modeling - Milankovitch Cycles ● Analyzing Data - Solar Output **Global Climate Change** [CLIMATE CHANGE, DEI]] ● Inquiry Lab - Carbon Dioxide and Its Role in Climate ● Interactivity - Flow of Energy and Greenhouse Gases ● Modeling - Carbon and the Atmosphere ● Analyzing Data - Earth's Energy Equilibrium ● Inquiry Lab - How Nature Records Changes in Climate ● Analyzing Data - Volcanic Emissions and Climate Over Time ● CER - Ice Core: Records of Climate Change ● Analyzing Data - Tree Rings and Climate Change ● Inquiry Lab - Human Activity and Carbon Emissions ● Analyzing Data - Keeling Curve ● Modeling - Interfering With the Carbon Cycle ● Analyzing Data - Carbon Absorption ● Inquiry Lab - Model Climate Change with Melting Ice ● Virtual Lab - Glaciers on Rainier ● Modeling - Graph Climate Change ● Analyzing Data - Climate Change and Drought ● Inquiry Lab - Climate Change and Keeping Cool ● Interactivity - Climate Change and Fire ● CER - Sea Levels Rising ● Analyzing Data - Climate Change and the Biosphere

	response to human activities. (HS-ESS3-6) **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. (HS-ETS1-3) ● 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. (HS-ETS1-4) **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. (HS-ETS1-2)	● Inquiry Lab - Solar Cell Technology ● Analyzing Data - Ecological Footprint ● Modeling - Model Your Carbon Footprint **<u>Interdisciplinary Connections:</u>** ***Connections to NJSLS – English Language Arts*** ● **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3)(HS-ESS2-2) (HS-ESS3-2)(HS-ESS3-5) ● **RST.11-12.2** Determine the central ideas, themes, or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESS2-2) (HS-ESS3-5) ● **RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ESS3-5) (HS-ETS1-3) ● **RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS3-2) (HS-ETS1-3) ● **RST.11-12.9** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) ● **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self- generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3) ● **WHST.9-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and
FOUNDATION **Science and Engineering Practices:** ***Core Idea***	**FOUNDATION** **Science and Engineering Practices:**	

	Statement	
• **SEP-2 Planning and Carrying Out Investigations** • **SEP-3 Analyzing and Interpreting Data** • **SEP-4 Developing and Using Models** • **SEP-5 Constructing Explanations and Designing Solutions** • **SEP-6 Engaging in Argument from Evidence** • **SEP-7 Using Mathematics and Computational Thinking**	**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. (HS- PS1-3) **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. (HS-ESS2-2) • Analyze data using computational models in order to make valid and reliable scientific claims. (HS-ESS3-5) **Developing and Using Models** • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-6)	overreliance on any one source and following a standard format for citation. (HS-PS1-3) • **WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3) • **SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-4) ***Connections to NJSLS – Mathematics*** • **MP.2** Reason abstractly and quantitatively. (HS-ESS2-2)(HS-ESS2-4) (HS-ESS2-6)(HS-ETS1-3)(HS-ETS1-4)(HS-ESS3-2)(HS-ESS3-5) (HS-ESS3-6) (HS-ETS1-3) (HS-ETS1-4) • **MP.4** Model with mathematics.(HS-ESS2-4)(HS-ESS2-6) (HS-ESS3-6) (HS-ETS1-2)(HS-ETS1-3)(HS-ETS1-4) • **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-3)(HS-ESS2-2)(HS-ESS2-4) (HS-ESS2-6)(HS-ESS3-5)(HS-ESS3-6) • **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-4)(HS-ESS2-6)(HS-ESS3-5) (HS-ESS3-6) • **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-3)(HS-ESS2-2) (HS-ESS2-4) (HS-ESS2-6)(HS-ESS3-5) (HS-ESS3-6)

	● Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4) **Constructing Explanations and Designing Solutions** ● Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) ● Evaluate a solution to a complex real-world problem, based on scientific knowledge, student- generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3) **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). (HS-ESS3-2) **Using Mathematics and Computational Thinking** ● Use a computational representation of phenomena or design solutions to describe	

	and/or support claims and/or explanations. (HS-ESS3-6) ● Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)	
FOUNDATION **Crosscutting Concepts:** ***Core Idea***	**FOUNDATION** **Crosscutting Concepts:** ***Statement***	
● **CCC-1 Patterns** ● **CCC-2 Cause and Effect** ● **CCC-4 Systems and System Models** ● **CCC-5 Energy and Matter** ● **CCC-6 Structure and Function** ● **CCC-7 Stability and Change**	**Patterns** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-3) **Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4) **Systems and System 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. (HS- ETS1-4) **Energy and Matter**	

	● The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6) **Stability and Change** ● Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)	
Social and Emotional Learning: ***Competencies***	**Social and Emotional Learning:** ***Sub-Competencies***	
● **Self-Awareness** ● **Self-Management** ● **Social Awareness** ● **Responsible Decision-Making** ● **Relationship Skills**	● Recognize one's personal traits, strengths, and limitations ● Recognize the importance of self-confidence in handling daily tasks and challenges ● Recognize the skills needed to establish and achieve personal and educational goals ● Identify and apply ways to persevere or overcome barriers through alternative methods to achieve one's goals ● Demonstrate an understanding of the need for mutual respect when viewpoints differ ● Demonstrate an awareness of the expectations for social interactions in a variety of settings ● Develop, implement, and model effective problem-solving and critical thinking skills ● Identify the consequences associated with one's actions in order to make constructive choices	

	• Evaluate personal, ethical, safety, and civic impact of decisions • Utilize positive communication and social skills to interact effectively with others • Identify who, when, where, or how to seek help for oneself or others when needed	

Assessments (Formative) ***To show evidence of meeting the standard/s, students will successfully engage within:***	**Assessments (Summative)** ***To show evidence of meeting the standard/s, students will successfully complete:***
Formative Assessments: • Guided Inquiry Activities • CER Tasks • Virtual Labs • Data Analysis Activities • Group Discussions • Lab Notebook • Experience Notebook • Engineering Design Challenges • Lesson Checks • Lesson Quizzes	**Benchmarks:** • Chemistry Diagnostic Assessment • Chemistry District Assessments **Summative Assessments:** • Unit Assessment - The Behavior of Gases • Unit Assessment - Weather and Climate • Unit Assessment - Global Climate Change • Collaborative Group Project(s)

Differentiated Student Access to Content:
Teaching and Learning *Resources/Materials*

Core Resources	**Alternate Core Resources** ***IEP/504/At-Risk/ESL***	**ELL Core Resources**	**Gifted & Talented Core Resources**
• Experience Chemistry TE • Experience Chemistry SE • POGIL Activities for High School Chemistry • Argument Driven Inquiry in Chemistry: Lab Investigations for Grades 9-12 • Student Chromebooks • Evidence Notebooks	• Auditory Aids • Visual Aids • Science Glossary and Thesaurus • Picture Glossary • Manipulatives • Virtual Nerd	• Multilingual Science Glossary and Thesaurus • Picture Glossary • BrainPOP ELL • Khan Academy En Español	• Chemistry for the Gifted and Talented • Crash Course

Supplemental Resources

Technology:

- Schoology
- Google Apps for Education
- SMARTBoard
- Calculators

Other:

- Teacher created video tutorials
- American Association for the Advancement of Science
- American Chemical Society
- Concord Consortium: Virtual Simulations
- International Technology and Engineering Educators Association
- National Earth Science Teachers Association
- National Science Digital Library
- National Science Teachers Association
- North American Association for Environmental Education
- Phet: Interactive Simulations
- Science NetLinks

Differentiated Student Access to Content:
Recommended *Strategies & Techniques*

Core Resources	**Alternate Core Resources** ***IEP/504/At-Risk/ESL***	**ELL Core Resources**	**Gifted & Talented Core**
• Restructure lessons using UDL principles • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community • Provide students with multiple choices for how they can represent their understandings • Provide opportunities for students to connect with people of similar backgrounds	• Utilize a multi-sensory (VAKT) approach during instruction • Provide alternate presentations of skills by varying the method (repetition, simple explanations, additional examples, modeling, etc.) • Modify test content and/or format	• Provide extended time • Provide preferential seating as needed • Provide positive reinforcement • Check often for understanding of and/or review of course objectives • Provide oral/visual directions/prompts when necessary • Provide students with multiple literacy strategies	• Create an enhanced set of introductory activities • Implement a multi-level and multi-dimensional curriculum • Create tiered assignments • Integrate active teaching/learning opportunities • Incorporate authentic components • Propose interest-based extension activities • Infuse enrichment activities

• Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understanding • Use project-based science learning to connect science with observable phenomena • Structure learning around explaining or solving a social or community-based issue • Collaborate with after-school programs or clubs to extend learning opportunities	• Allow students to retake test or make corrections to test for additional credit • Provide extended time • Provide preferential seating as needed • Review, restate and repeat directions • Provide study guides, and/or break assignments into segments of shorter tasks • Deliver instruction utilizing varied learning styles including audio, visual, and tactile/kinesthetic • Provide individual instruction as needed • Provide modified assessments and/or rubrics when needed	• Provide supplemental materials including use of an online bilingual dictionary • Offer choices of what students can say when they are called on and aren't sure how to respond • Integrate project-based learning to enhance hands-on activities, peer interaction, rich language use, and opportunities to explore personal interests • Provide modified assessments and/or rubrics when needed • Repeat instructions as needed • Provide individual instruction as needed	• Build in time for flexible learning groups • Embrace creative questioning • Explore many points of view about contemporary topics and allow opportunity to analyze and evaluate materia • lEncourage self directed learning • Connect students to related talent development opportunities

NJSLS CAREER READINESS, LIFE LITERACIES & KEY SKILLS	**Disciplinary Concept:**	
	Core Ideas:	**Creativity and Innovation** • With a growth mindset, failure is an important part of success. **Critical Thinking and Problem-solving** • Collaboration with individuals with diverse experiences can aid in the problem-solving process, particularly for global issues where diverse solutions are needed. **Global and Cultural Awareness** • Solutions to the problems faced by a global society require the contribution of individuals with different points of view and experiences. Digital tools such as artificial intelligence, image enhancement and analysis, and sophisticated computer modeling and simulation create new types of information that may have profound effects on society. These new types of

		information must be evaluated carefully. **Information and Media Literacy** ● Digital tools such as artificial intelligence, image enhancement and analysis, and sophisticated computer modeling and simulation create new types of information that may have profound effects on society. These new types of information must be evaluated carefully. ● In order for members of our society to participate productively, information needs to be shared accurately and ethically. ● Accurate information may help in making valuable and ethical choices.
	Performance Expectation/s:	**Creativity and Innovation** ● 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a). **Critical Thinking and Problem-solving** ● 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3). ● 9.4.12.CT.3: Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice). **Global and Cultural Awareness** ● 9.4.12.GCA.1: Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3). **Information and Media Literacy** ● 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8) ● 9.4.12.IML.5: Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2). ● 9.4.12.IML.7: Develop an argument to support a claim regarding a current

		workplace or societal/ethical issue such as climate change (e.g., NJSLSA.W1, 7.1.AL.PRSNT.4).
	Career Readiness, Life Literacies, & Key Skills Practices	
	• Act as a responsible and contributing community member and employee. • Attend to financial well-being. • Consider the environmental, social and economic impacts of decisions. • Demonstrate creativity and innovation. • Utilize critical thinking to make sense of problems and persevere in solving them. • Model integrity, ethical leadership and effective management. • Plan education and career paths aligned to personal goals. • Use technology to enhance productivity, increase collaboration and communicate effectively. • Work productively in teams while using cultural/global competence.	

New Jersey Legislative Statutes and Administrative Code (place an "X" before each law/statute if/when present within the curriculum map)									
	Amistad Law: *N.J.S.A. 18A 52:16A-88*		Holocaust Law: *N.J.S.A. 18A:35-28*		LGBT and Disabilities Law: *N.J.S.A. 18A:35-4.35*	X	Diversity & Inclusion: *N.J.S.A. 18A:35-4.36a*	X	Standards in Action: *Climate Change*