CHEMISTRY		
HS-ESS2-4 Earth's 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.		
Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.		
Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.		
Evidence Statements: HS-ESS2-4		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). Use a model to provide mechanistic accounts of phenomena. **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.	**ESS1.B: Earth and the Solar System** Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary) **ESS2.A: Earth Materials and Systems** 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.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
Connections to other DCIs in this grade-band: HS.PS3.A ; HS.PS3.B ; HS.LS2.C ; HS.ESS1.C ; HS.ESS3.C ; HS.ESS3.D		
Articulation of DCIs across grade-bands: MS.PS3.A ; MS.PS3.B ; MS.PS3.D ; MS.PS4.B ; MS.LS1.C ; MS.LS2.B ; MS.LS2.C ; MS.ESS2.A ; MS.ESS2.B ; MS.ESS2.C ; MS.ESS2.D ; MS.ESS3.C ; MS.ESS3.D		
NJSLS- ELA: SL.11-12.5		
NJSLS- Math: MP.2, MP.4, HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3		

5E Model	
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.	
Engage Anticipatory Set	Climate Change: How Do We Know? http://climate.nasa.gov/evidence/
	Earth's Energy Flows and Climate

Exploration Student Inquiry	http://www.pbslearningmedia.org/resource/pcep15-sci-ess-energyflows/earths-energy-flows-and-climate/ In this lesson, students will learn how Earth's climate results from the ways that energy enters, circulates within, and flows out of the Earth system. Explore the flows of energy in regional locations and then at the global level to understand how the increased greenhouse effect causes global warming. From the given model in the lesson above, students will identify and describe the components of the model relevant for their mechanistic descriptions. Given models include at least one factor that affects the input of energy, at least one factor that affects the output of energy, and at least one factor that affects the storage and redistribution of energy. Factors are derived from the following list: - Changes in Earth's orbit and the orientation of its axis - Changes in the sun's energy output - Configuration of continents resulting from tectonic activity - Ocean circulation - Atmospheric composition (including amount of water vapor and CO2) - Atmospheric circulation - Volcanic activity - Glaciation - Changes in extent or type of vegetation cover - Human activities From the given model, students identify the relevant different time scales on which the factors operate.
Explanation Concepts and Practices	In these lessons Teachers Should: Introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities. Students Should: Verbalize conceptual understandings and demonstrate scientific and engineering practices. Topics to Be Discussed in Teacher Directed Lessons (Disciplinary Core Ideas): ESS1.B: Earth and the Solar System Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary) ESS2.A: Earth Materials and Systems 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.
Elaboration Extension Activity	Global Climate Change https://www3.epa.gov/climatechange/kids/resources/lesson-plans.html
Evaluation Assessment Tasks	Assessment Task A: Students use the given model to provide a mechanistic account of the relationship between energy flow in Earth's systems and changes in climate, including: 1. The specific cause and effect relationships between the factors and the effect on energy flow into and out of Earth's systems; and 2. The net effect of all of the competing factors in changing the climate.

CHEMISTRY		
HS-ETS1-1 Engineering Design		
HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.		
Clarification Statement: N/A		
Assessment Boundary: N/A		
Evidence Statements: HS-ETS1-1		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Asking Questions and Defining Problems	**ETS1.A: Defining and Delimiting Engineering Problems**	**Connections to Engineering, Technology, and Applications of Science**
Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.	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.	**Influence of Science, Engineering, and Technology on Society and the Natural World**
Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	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.
Connections to other DCIs in this grade-band: HS-PS2-3, HS-PS3-3		
Articulation of DCIs across grade-bands: MS.ETS1.A		
NJSLS- ELA: RST.11-12.7, RST.11-12.8, RST.11-12.9		
NJSLS- Math: MP.2, MP.4		

CHEMISTRY		
HS-ETS1-2 Engineering Design		
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.		
Clarification Statement: N/A		
Assessment Boundary: N/A		
Evidence Statements: HS-ETS1-2		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Constructing Explanations and Designing Solutions	**ETS1.C: Optimizing the Design Solution**	
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories.	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.	

Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.		
Connections to other DCIs in this grade-band: HS-PS1-6, HS-PS2-3		
Articulation of DCIs across grade-bands: MS.ETS1.A ; MS.ETS1.B ; MS.ETS1.C		
NJSLS- ELA: N/A		
NJSLS- Math: MP.4		

CHEMISTRY		
HS-ETS1-3 Engineering Design		
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.		
Clarification Statement: N/A		
Assessment Boundary: N/A		
Evidence Statements: HS-ETS1-3		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ETS1.B: Developing Possible Solutions** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.
Connections to other DCIs in this grade-band: Earth and Space Science: HS-ESS3-2, HS-ESS3-4 Life Science: HS-LS2-7, HS-LS4-6		
Articulation of DCIs across grade-bands: MS.ETS1.A ; MS.ETS1.B		
NJSLS- ELA: RST.11-12.7, RST.11-12.8, RST.11-12.9		
NJSLS- Math: MP.2, MP.4		

CHEMISTRY
HS-ETS1-4 Engineering Design
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.
Clarification Statement: N/A
Assessment Boundary: N/A

Evidence Statements: HS-ETS1-4		
Science & Engineering Practices	**Disciplinary Core Ideas**	**Cross-Cutting Concepts**
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.	**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.	**Systems and Systems Models** 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.
Connections to other DCIs in this grade-band: HS-LS2-7, HS-LS4-6		
Articulation of DCIs across grade-bands: MS.ETS1.A ; MS.ETS1.B ; MS.ETS1.C		
NJSLS- ELA: N/A		
NJSLS- Math: MP.2, MP.4		