High School Chemistry Scope and Sequence

Unit of Study 1: Properties and Structure of Matter

Standards that appear this unit: HS-PS1-1, HS-PS1-2, HS-PS1-3, HS-PS2-6*, HS-ETS1-3, HS-ETS1-4

HS. Structure and Properties of Ma	atter	
Students who demonstrate understand HS-PS1-1. Use the periodic table patterns of electrons properties that could be numbers of bonds former		[Clarification Statement: Examples of ty of metals, types of bonds formed, Boundary: Assessment is limited to
	vere developed using the following elements f	rom the NRC document A Framework
Science and Engineering Practices Developing and Using Models Modeling in 9–12 builds on K–8 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 worlds. • Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)	 Disciplinary Core Ideas PS1.A: Structure and Properties of Matter Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) 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. (HS-PS1-1) PS2.B: Types of Interactions Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary to HS-PS1-1) 	Crosscutting Concepts Patterns • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS- PS1-1)
Connections to other DCIs in this grade		:1_1)
Common Core State Standards Connec ELA/Literacy – RST.9-10.7 Translate quantita	tive or technical information expressed in wor I translate information expressed visually or m	ds in a text into visual form (e.g., a

HS. Chemical Reactions Students who demonstrate understanding can: 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. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions. The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education: Science and Engineering Practices **Disciplinary Core Ideas** Crosscutting Concepts **Constructing Explanations and PS1.A: Structure and Properties** Patterns **Designing Solutions** of Matter Different patterns may be observed Constructing explanations and The periodic table orders elements at each of the scales at which a designing solutions in 9–12 builds on horizontally by the number of system is studied and can provide K–8 experiences and progresses to protons in the atom's nucleus and evidence for causality in explanations and designs that are places those with similar chemical explanations of phenomena. (HSsupported by multiple and independent properties in columns. The PS1-2) student-generated sources of evidence repeating patterns of this table consistent with scientific ideas, reflect patterns of outer electron principles, and theories. states. (HS-PS1-2) (Note: This Construct and revise an explanation Disciplinary Core Idea is also

based on valid and reliable evidence addressed by HS-PS1-1.) obtained from a variety of sources **PS1.B:** Chemical Reactions (including students' own The fact that atoms are conserved, investigations, models, theories, together with knowledge of the simulations, peer review) and the chemical properties of the assumption that theories and laws elements involved, can be used to that describe the natural world describe and predict chemical operate today as they did in the past reactions. (HS-PS1-2) and will continue to do so in the future. (HS-PS1-2)

Connections to other DCIs in this grade-band: HS.LS1.C (HS-PS1-2); HS.ESS2.C (HS-PS1-2) Articulation to DCIs across grade-bands: MS.PS1.A (HS-PS1-2); MS.PS1.B (HS-PS1-2) Common Core State Standards Connections: ELA/Literacy -WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2) WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2) Mathematics -Use units as a way to understand problems and to quide the solution of multi-step problems; choose HSN-Q.A.1 and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2) Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-HSN-Q.A.3 PS1-2)

HS. Structure an	d Properties of Matt	ar	
	ionstrate understanding		
		vestigation to gather evidence to comp	are the structure of substances
		er the strength of electrical forces betw	
		n understanding the strengths of forces betw	
		n as dipole-dipole). Examples of particles co	
		such as graphite). Examples of bulk propert	
		point, vapor pressure, and surface tension.]	
		aw calculations of vapor pressure.]	
		e developed using the following elements fro	om the NRC document A Framework
for K-12 Science E			
Science and Eng	gineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Ca		PS1.A: Structure and Properties of	Patterns
Investigations		Matter	 Different patterns may be
Planning and carry	ring out investigations	 The structure and interactions of 	observed at each of the scales at
	(-8 experiences and	matter at the bulk scale are	which a system is studied and
progresses to inclu	ide investigations that	determined by electrical forces within	can provide evidence for
provide evidence f	or and test	and between atoms. (HS-PS1-3)	causality in explanations of
conceptual, mathe	matical, physical, and	PS2.B: Types of Interactions	phenomena. (HS-PS1-3)
empirical models.		 Attraction and repulsion between 	
 Plan and condu 	ct an investigation	electric charges at the atomic scale	
individually and	l collaboratively to	explain the structure, properties, and	
produce data to	o serve as the basis	transformations of matter, as well as	
for evidence, a	nd in the design:	the contact forces between material	
decide on types	s, how much, and	objects. (secondary to HS-PS1-3)	
accuracy of dat	a needed to produce		
	ements and consider		
	he precision of the		
	ber of trials, cost,		
	refine the design		
accordingly. (H			
		and: HS.ESS2.C (HS-PS1-3)	
		MS.PS1.A (HS-PS1-3); MS.PS2.B (HS-PS1	-3)
	te Standards Connectio	ns:	
ELA/Literacy –			
RST.11-12.1		vidence to support analysis of science and te	
		r makes and to any gaps or inconsistencies	
WHST.9-12.7		as more sustained research projects to answ	
		or solve a problem; narrow or broaden the ir	
		ne subject, demonstrating understanding of	the subject under investigation. (HS-
WINCE 44 45 5	PS1-3)		destructions and the second second
WHST.11-12.8		nation from multiple authoritative print and	
		assess the strengths and limitations of each	
		e; integrate information into the text selection	
	51 5	nd overreliance on any one source and follow	wing a standard format for citation.
	(HS-PS1-3)		
WHST.9-12.9	Draw evidence from i	nformational texts to support analysis, reflec	ction, and research. (HS-PS1-3)
Mathematics –			
HSN-Q.A.1		understand problems and to guide the solut	
		nsistently in formulas; choose and interpret	the scale and the origin in graphs and
	data displays. (HS-PS		
HSN-Q.A.3		aracy appropriate to limitations on measuren	nent when reporting quantities. (HS-
	PS1-3)		

HS. Structure and Properties of Matter Students who demonstrate understanding can:

HS-PS2-6. Con imp attr elec cha Bou	portant in the function ractive and repulsive for ctrically conductive mate ined molecules, and pha- undary: Assessment is I	and technical information about why ning of designed materials.* [Clarifican ces that determine the functioning of the prials are often made of metal, flexible but armaceuticals are designed to interact with mited to provided molecular structures of	ation Statement: Emphasis is on the material. Examples could include why durable materials are made up of long h specific receptors.] [Assessment specific designed materials.]
The performance for K-12 Science B		e developed using the following elements	from the NRC document A Framework
	gineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
the claims, metho Communicate s information (e. of developmen performance o or system) in r (including orall textually, and r PS2-6)	Information ting, and formation in 9–12 I progresses to idity and reliability of ds, and designs. scientific and technical .g. about the process it and the design and f a proposed process nultiple formats ly, graphically, mathematically). (HS-	 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. <i>(secondary to HS-PS2-6)</i> 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. (HS-PS2-6) 	 Structure and Function Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)
	her DCIs in this grade-b		
	<u>Is across grade-bands:</u> ate Standards Connectio	MS.PS1.A (HS-PS2-6); MS.PS2.B (HS-P	52-6)
ELA/Literacy –	ile Stanuarus Connectio	115.	
RST.11-12.1 WHST.9-12.2	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. (<i>HS-PS2-6</i>) Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (<i>HS-PS2-6</i>)		
Mathematics –			
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (<i>HS-PS2-6</i>)		
HSN-Q.A.2 HSN-Q.A.3		antities for the purpose of descriptive mo uracy appropriate to limitations on measur	

HS. Engineering	j Design			
Students who der	nonstrate understanding car	1:		
		mplex real-world problem based o	n prioritized criteria and trade-	
		ge of constraints, including cost, sa		
as	s well as possible social,	cultural, and environmental impact	S.	
The performance	expectations above were de	veloped using the following elements fr	om the NRC document A Framework	
for K-12 Science	•	incloped doing the following clements h		
Science and I	Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts	
Constructing Ex		ETS1.B: Developing Possible	Connections to Engineering,	
Designing Solut		Solutions	Technology,	
	anations and designing	 When evaluating solutions, it is 	and Applications of Science	
	builds on K-8 experiences	important to take into account a		
and progresses to	explanations and designs	range of constraints, including	Influence of Science,	
that are supporte		cost, safety, reliability, and	Engineering, and Technology	
	ent-generated sources of	aesthetics, and to consider social,	on Society and the Natural	
	nt with scientific ideas,	cultural, and environmental	World	
principles and the		impacts. (HS-ETS1-3)	 New technologies can have deep 	
	ution to a complex real-		impacts on society and the	
	, based on scientific		environment, including some	
	udent-generated sources		that were not anticipated.	
	rioritized criteria, and		Analysis of costs and benefits is	
tradeoff considerations. (HS-ETS1-3) a critical aspect of decisions				
			about technology. (HS-ETS1-3)	
Constantion of the U				
		miting Engineering Problems include:		
	ence: HS-PS2-3, HS-PS3-3	ns to Engineering Problems include:		
		IS-ESS3-4, Life Science: HS-LS2-7, HS	2-1 54-6	
	S-ETS1.C: Optimizing the De		5-23-7-0	
	ence: HS-PS1-6, HS-PS2-3	sign solution include.		
		.ETS1.A (HS-ETS1-3); MS.ETS1.B (HS	-ETS1-3)	
	ate Standards Connections:		/	
ELA/Literacy –				
RST.11-12.7	Integrate and evaluate m	ultiple sources of information presented	in diverse formats and media (e.g.	
		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-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-ETS1-3)			
RST.11-12.9		om a range of sources (e.g., texts, expe	eriments, simulations) into a coherent	
		ss, phenomenon, or concept, resolving		
	(HS-ETS1-3)			
Mathematics –	. ,			
MP.2	Reason abstractly and qu	antitatively. (HS-ETS1-3)		
MP.4	Model with mathematics.			

HS. Engineering Design		
	: to model the impact of proposed soluti teria and constraints on interactions w	
The performance expectations above were development for K-12 Science Education:	veloped using the following elements from th	e NRC document A Framework
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting 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. (HS-ETS1-4) 	 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. (HS-ETS1-4) 	 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)
Connections to HS-ETS1.C: Optimizing the Des Physical Science: HS-PS1-6, HS-PS2-3	ns to Engineering Problems include: IS-ESS3-4, Life Science: HS-LS2-7, HS-LS4- sign Solution include:	
Articulation of DCIs across grade-bands: MS.	ETS1.A (HS-ETS1-4); MS.ETS1.B (HS-ETS1	-4); MS.ETS1.C (HS-ETS1-4)
<i>Common Core State Standards Connections:</i> <i>Mathematics</i> –		
MP.2Reason abstractly and quaMP.4Model with mathematics.		

Unit of Study 2: Energy and Its Applications (non-living)

Standards that appear this unit: HS-PS3-4, HS-ESS2-5, HS-ESS3-2*, HS-ETS1-3

HS. Energy			
	onstrate understanding	can:	
HS-PS3-4. Plan a comp energ [Clarif thinkin includ	and conduct an invest openents of different to gy distribution among fication Statement: Emp ng to describe the energ e mixing liquids at differ	tigation to provide evidence that the treemperature are combined within a close the components in the system (second basis is on analyzing data from student investigations both quantitatively and concepture the initial temperatures or adding objects at assessment is limited to investigations based on	ed system results in a more uniform d law of thermodynamics). estigations and using mathematical ally. Examples of investigations could different temperatures to water.]
The performance e 12 Science Educat		e developed using the following elements fro	m the NRC document A Framework for K-
 Planning and Ca Investigations Planning and carry to answer question problems in 9–12 experiences and p investigations that and test conceptua physical, and empi Plan and condu- individually and produce data to evidence, and i on types, how in data needed to measurements limitations on the data (e.g., num 	ring out investigations as or test solutions to builds on K–8 rogresses to include provide evidence for al, mathematical, irical models. Inct an investigation collaboratively to o serve as the basis for an the design: decide much, and accuracy of produce reliable and consider he precision of the aber of trials, cost, refine the design	 Disciplinary Core Ideas PS3.B: Conservation of Energy and Energy Transfer Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS- PS3-4) 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). (HS-PS3-4) 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. (HS-PS3-4) 	Crosscutting Concepts Systems and System Models • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)
Connections to oth	her DCIs in this grade-ba	and: HS.ESS1.A (HS-PS3-4); HS.ESS2.A (H	IS-PS3-4); HS.ESS2.D (HS-PS3-4)
Articulation to DCI	s across grade-bands: N	IS.PS3.B (HS-PS3-4)	
Common Core Sta	te Standards Connectior	15:	
ELA/Literacy –			
RST.11-12.1		vidence to support analysis of science and te	
		makes and to any gaps or inconsistencies i	
WHST.9-12.7 WHST.11-12.8	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-PS3-4) 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		
WHET 0 12 0	and overreliance on a	ny one source and following a standard form	nat for citation. (HS-PS3-4)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (*HS-PS3-4*)

Mathematics –MP.2Reason abstractly and quantitatively. (HS-PS3-4)MP.4Model with mathematics. (HS-PS3-4)

Crosscutting Concepts

natural and designed objects and

systems can be inferred from their

components are shaped and used,

and the molecular substructures of

its various materials. (HS-ESS2-5)

• The functions and properties of

overall structure, the way their

Structure and Function

HS. Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

the planet's dynamics. These

exceptional capacity to absorb,

expand upon freezing, dissolve

lower the viscosities and melting

of energy, transmit sunlight,

and transport materials, and

points of rocks. (HS-ESS2-5)

store, and release large amounts

properties include water's

Disciplinary Core Ideas Science and Engineering **Practices** ESS2.C: The Roles of Water in Planning and Carrying Out Earth's Surface Processes Investigations The abundance of liquid water on Planning and carrying out Earth's surface and its unique investigations in 9-12 builds on K-8 combination of physical and chemical properties are central to

experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

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

 Plan and conduct an investigation accordingly. (HS-ESS2-5)

Connections to other DCIs in this grade-band: HS.PS1.A (HS-ESS2-5); HS.PS1.B (HS-ESS2-5); HS.PS3.B (HS-ESS2-5); 5); HS.ESS3.C (HS-ESS2-5)

Articulation of DCIs across grade-bands: MS.PS1.A (HS-ESS2-5); MS.PS4.B (HS-ESS2-5); MS.ESS2.A (HS-ESS2-5); MS.ESS2.C (HS-ESS2-5); MS.ESS2.D (HS-ESS2-5)

Common Core Sta	te Standards Connections:
ELA/Literacy –	
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-ESS2-5)
Mathematics -	
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-5)

HS. Human Sustainability			
conservation, recycling, ar minimizing impacts where mining (for coal, tar sands	sign solutions for developing, mana d on cost-benefit ratios.* [Clarificat ad reuse of resources (such as minerals it is not. Examples include developing b and oil shales), and pumping (for petr can happen in natural systems—not wh	ion Statement: Emphasis is on the and metals) where possible, and on best practices for agricultural soil use, oleum and natural gas). Science hat should happen.]	
Science and Engineering Practices Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • 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)	 Disciplinary Core Ideas 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. (HS- ESS3-2) ETS1.B. Designing Solutions to Engineering Problems When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary to HS-ESS3-2) 	Crosscutting Concepts Connections to Engineering, Technology, and Applications of Science Influence of Engineering, Technology, and Science on Society and the Natural World • Engineers continuously modify these systems to increase benefits while decreasing costs and risks. (HS-ESS3-2) • Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2) • Connections to Nature of Science Science Addresses Questions About the Natural and Material World • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3- 2) • 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. (HS-ESS3-2) • Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2)	
<i>Connections to other DCIs in this grade-band:</i> HS.PS3.B (HS-ESS3-2); HS.PS3.D (HS-ESS3-2); HS.LS2.A (HS-ESS3-2); HS.LS2.B (HS-ESS3-2); HS.LS4.D (HS-ESS3-2); HS.ESS2.A (HS-ESS3-2) <i>Articulation of DCIs across grade-bands:</i> MS.PS3.D (HS-ESS3-2); MS.LS2.A (HS-ESS3-2); MS.LS2.B (HS-ESS3-2);			
MS.LS4.D (HS-ESS3-2); MS.ESS3.A (HS-ESS3-2); MS.ESS3.C (HS-ESS3-2)			

Common Core Sta	ate Standards Connections:
ELA/Literacy –	
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-ESS3-2))
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)
Mathematics -	
MP.2	Reason abstractly and quantitatively. (HS-ESS3-2)

HS. Engineering	g Design			
Students who der	nonstrate understanding car	1:		
HS-ETS1-3. Ev	valuate a solution to a co	mplex real-world problem based of	n prioritized criteria and trade-	
of	ffs that account for a ran	ge of constraints, including cost, sa	fety, reliability, and aesthetics,	
a	s well as possible social, (cultural, and environmental impact	S.	
The performance	expectations above were de	veloped using the following elements fr	om the NRC document A Framework	
for K-12 Science		······································		
Science and I	Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts	
Constructing Ex		ETS1.B: Developing Possible	Connections to Engineering,	
Designing Solut		Solutions	Technology,	
	anations and designing	 When evaluating solutions, it is 	and Applications of Science	
	builds on K–8 experiences	important to take into account a		
	explanations and designs	range of constraints, including	Influence of Science,	
that are supporte		cost, safety, reliability, and	Engineering, and Technology	
	ent-generated sources of	aesthetics, and to consider social,	on Society and the Natural	
	nt with scientific ideas,	cultural, and environmental	World	
principles and the	ution to a complex real-	impacts. (HS-ETS1-3)	 New technologies can have deep impacts on society and the 	
	, based on scientific		environment, including some	
	udent-generated sources		that were not anticipated.	
	rioritized criteria, and		Analysis of costs and benefits is	
	derations. (HS-ETS1-3)		a critical aspect of decisions	
about technology. (HS-ETS1-3)				
			5, (,	
Connections to H.	S-ETS1.A: Defining and Deli	miting Engineering Problems include:		
	ence: HS-PS2-3, HS-PS3-3			
		ns to Engineering Problems include:		
Earth and Sp	Dace Science: HS-ESS3-2, I	HS-ESS3-4, Life Science: HS-LS2-7, HS	S-LS4-6	
	S-ETS1.C: Optimizing the De	esign Solution include:		
	ence: HS-PS1-6, HS-PS2-3			
		.ETS1.A (HS-ETS1-3); MS.ETS1.B (HS	-ETS1-3)	
	ate Standards Connections:			
ELA/Literacy –				
RST.11-12.7		ultiple sources of information presented		
		multimedia) in order to address a quest		
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the			
		corroborating or challenging conclusions	with other sources of information.	
	(HS-ETS1-3)	, , , , ,		
RST.11-12.9		om a range of sources (e.g., texts, expe		
		ss, phenomenon, or concept, resolving	contricting information when possible.	
Mathanastiss	(HS-ETS1-3)			
Mathematics –				
MP.2	Reason abstractly and qu			
MP.4	Model with mathematics.	(ПЭ-ЕТЭТ-Э)		

Unit of Study 3: Bonding and Chemical Reactions

Standards that appear this unit: HS-PS1-7, HS-PS1-4, HS-PS1-5, HS-PS1-6*, HS-ETS1-2

HS. Chemical Re	actions				
	onstrate understand	ing can:			
		esentations to support the claim tha	t atoms, and therefore mass, are		
		mical reaction. [Clarification Statemen			
		proportional relationships between mass			
		on of these relationships to the macrosco			
		c to the macroscopic scale. Emphasis is c			
		not on memorization and rote applicatio			
LASSes	sment Boundary: A	ssessment does not include complex che			
The newformence		ware developed using the following close	ante from the NDC desument A		
		vere developed using the following eleme	ents from the NRC document A		
Framework for K-1	12 Science Education				
	Engineering	Disciplinary Core Ideas	Crosscutting Concepts		
	tices	PS1.B: Chemical Reactions	Energy and Matter		
Using Mathemat		 The fact that atoms are 	 The total amount of energy and 		
Computational T		conserved, together with	matter in closed systems is		
Mathematical and		knowledge of the chemical	conserved. (HS-PS1-7)		
thinking at the 9–1		properties of the elements	 Changes of energy and matter in 		
K-8 and progresse	es to using	involved, can be used to describe	a system can be described in		
algebraic thinking	and analysis, a	and predict chemical reactions.	terms of energy and matter flows		
range of linear and	d nonlinear	(HS-PS1-7)	into, out of, and within that		
functions including	y trigonometric		system. (HS-PS1-4)		
functions, exponer	ntials and		, , , ,		
logarithms, and co					
	ical analysis to analyze, Connections to Nature of Science				
represent, and mo					
	putational simulations are Scientific Knowledge Assumes				
	ted and used based on an Order and Consistency in				
mathematical mod			Natural Systems		
assumptions.			 Science assumes the universe is a 		
	cal representations		vast single system in which basic		
	to support claims.		laws are consistent. (HS-PS1-7)		
(HS-PS1-7)					
	her DCIs in this arad	e-band: HS.PS3.B (HS-PS1-7); HS.LS1.	C (HS-DS1-7): HS IS2 B (HS-DS1-7)		
		s: MS.PS1.A (HS-PS1-7); MS.PS1.B (H			
	1-7); MS.ESS2.A (F		13-F31-7), FIS.L31.C (113-F31-7),		
	te Standards Connec				
Mathematics -					
MP.2	Reason abstractly	and quantitatively. (HS-PS1-7)			
HSN-Q.A.1		to understand problems and to guide th	e solution of multi-step problems:		
11314-Y.A.1		et units consistently in formulas; choose			
			and mile precime scale and the origin		
		displays. (HS-PS1-7)	modeling (UC PC1 7)		
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-7)				
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.				
	(HS-PS1-7)				

HS. Chemical Reactions				
Students who demonstrate understan	ding can:			
HS-PS1-4. Develop a model t	o illustrate that the release or absorption o	of energy from a chemical		
reaction system de	epends upon the changes in total bond ene	ergy. [Clarification Statement:		
Emphasis is on the id	lea that a chemical reaction is a system that aff	ects the energy change.		
Examples of models	could include molecular-level drawings and diag	rams of reactions, graphs		
showing the relative	energies of reactants and products, and represe	entations showing energy is		
conserved.] [Assessr	nent Boundary: Assessment does not include ca	alculating the total bond energy		
changes during a che	emical reaction from the bond energies of reacta	ants and products.]		
The performance expectations above	were developed using the following elements fr	om the NRC document A		
Framework for K-12 Science Educatio	n:			
Science and Engineering	Disciplinary Core Ideas	Crosscutting Concepts		
Practices	PS1.A: Structure and Properties of	Energy and Matter		
Developing and Using Models	Matter	 Changes of energy and 		
Modeling in 9–12 builds on K–8 and	 A stable molecule has less energy than 	matter in a system can be		
progresses to using, synthesizing,	the same set of atoms separated; one	described in terms of energy		
		and matter flows into, out		
ind developing models to predict and most provide at least this energy in order				
and show relationships among variables between systems and PS1.B: Chemical Reactions of, and within that system. (HS-PS1-4)				
their components in the natural and	 Chemical processes, their rates, and whather or not operative stored or 			
designed worlds.	whether or not energy is stored or			
 Develop a model based on 	released can be understood in terms of			
evidence to illustrate the	the collisions of molecules and the			
relationships between systems	rearrangements of atoms into new			
or between components of a	molecules, with consequent changes in			
system. (HS-PS1-4)	the sum of all bond energies in the set of			
	molecules that are matched by changes			
	in kinetic energy. (HS-PS1-4)			
	de-band: HS.PS3.A (HS-PS1-4); HS.PS3.B (HS	5-PS1-4); HS.PS3.D (HS-PS1-4);		
HS.LS1.C (HS-PS1-4)				
	ds: MS.PS1.A (HS-PS1-4); MS.PS1.B (HS-PS1	L-4); MS.PS2.B (HS-PS1-4);		
MS.PS3.D (HS-PS1-4); MS.LS1.C (H	IS-PS1-4)			

HS. Chemical Reactions Students who demonstrate understanding can: 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. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.] The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education: Science and Engineering Crosscutting Concepts **Disciplinary Core Ideas** Practices **PS1.B:** Chemical Reactions Patterns **Constructing Explanations and** Chemical processes, their rates, and Different patterns may be **Designing Solutions** whether or not energy is stored or observed at each of the scales Constructing explanations and released can be understood in terms at which a system is studied designing solutions in 9–12 builds of the collisions of molecules and the and can provide evidence for on K–8 experiences and progresses rearrangements of atoms into new causality in explanations of to explanations and designs that molecules, with consequent changes phenomena. (HS-PS1-5) are supported by multiple and in the sum of all bond energies in the set of molecules that are matched by independent student-generated sources of evidence consistent with changes in kinetic energy. (HS-PS1-5) scientific ideas, principles, and theories. Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) Connections to other DCIs in this grade-band: HS.PS3.A (HS-PS1-5) Articulation to DCIs across grade-bands: MS.PS1.A (HS-PS1-5); MS.PS1.B (HS-PS1-5); MS.PS2.B (HS-PS1-5); MS.PS3.A (HS-PS1-5); MS.PS3.B (HS-PS1-5) Common Core State Standards Connections: ELA/Literacy -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-PS1-5) WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-5) Mathematics -MP.2 Reason abstractly and quantitatively. (HS-PS1-5) 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-PS1-5) Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. HSN-Q.A.3 (HS-PS1-5)

HS. Chemical Reactions

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.* [Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

	Calonse and Engineering Dreatices					
	gineering Practices	Disciplinary Core Ideas	Crosscutting Concepts			
Constructing Ex						
Designing Soluti		 In many situations, a dynamic and 	 Much of science deals with 			
Constructing expla		condition-dependent balance	constructing explanations of how			
	s in 9–12 builds on	between a reaction and the reverse	things change and how they			
K–8 experiences a		reaction determines the numbers of	remain stable. (HS-PS1-6)			
explanations and c		all types of molecules present. (HS-				
	iple and independent	PS1-6)				
	sources of evidence	ETS1.C: Optimizing the Design				
consistent with sci	-	Solution				
principles, and the		 Criteria may need to be broken 				
	on to a complex real-	down into simpler ones that can be				
-	based on scientific	approached systematically, and				
	dent-generated	decisions about the priority of				
	ence, prioritized	certain criteria over others (trade-				
	deoff considerations.	offs) may be needed. (secondary to				
(HS-PS1-6)		HS-PS1-6)				
		oand: HS.PS3.B (HS-PS1-6)				
Articulation to DCIs across grade-bands: MS.PS1.B (HS-PS1-6)						
Common Core State Standards Connections:						
ELA/Literacy –						
WHST.9-12.7	,					
		or solve a problem; narrow or broaden the				
		he subject, demonstrating understanding c				
	PS1-6)					
	-					

HS. Engineering Design

Students who demonstrate understanding can:

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.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

 Science and Engineering Practices 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. 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) 	 Disciplinary Core Ideas 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. (HS-ETS1-2) 	Crosscutting Concepts N/A
Physical Science: HS-PS2-3, HS-PS Connections to HS-ETS1.B: Designing Sc Earth and Space Science: HS-ESS Connections to HS-ETS1.C: Optimizing th Physical Science: HS-PS1-6, HS-PS	lutions to Engineering Problems include: 3-2, HS-ESS3-4, Life Science: HS-LS2-7, the Design Solution include: 2-3 MS.ETS1.A (HS-ETS1-2); MS.ETS1.B (H	
MP.4 Model with mathema	atics. (HS-ETS1-2)	

Unit of Study 4: Transfer of Energy and Its Applications (living)

Standards that appear this unit: HS-LS1-5, HS-LS1-7, HS-LS1-6, HS-LS1-6, HS-LS1-7

HS. Matter and Energy in Organism	ns and Ecosystems	
Students who demonstrate understandi		
energy. [Clarification transfer and transform Examples of models co	trate how photosynthesis transforms I Statement: Emphasis is on illustrating inpu- lation of energy in photosynthesis by plants buld include diagrams, chemical equations, a it does not include specific biochemical step	uts and outputs of matter and the and other photosynthesizing organisms. and conceptual models.] [Assessment
The performance expectations above w for K-12 Science Education:	ere developed using the following elements	from the NRC document A Framework
Science and Engineering	Disciplinary Core Ideas	Crosscutting Concepts
Practices	LS1.C: Organization for Matter and	Energy and Matter
 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 worlds. Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1- 5) 	 Energy Flow in Organisms The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5) 	 Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5)
	e-band: HS.PS1.B (HS-LS1-5); HS.PS3.B (
Articulation across grade-bands: MS.PS LS1-5)	51.B (HS-LS1-5); MS.PS3.D (HS-LS1-5); M	S.LS1.C (HS-LS1-5); MS.LS2.B (HS-
Common Core State Standards Connect	tions:	
ELA/Literacy –		
	of digital media (e.g., textual, graphical, au hance understanding of findings, reasoning	

HS. Matter and Energy in Organisms and Ecosystems				
Students who dem HS-LS1-6. Cons from carb simul speci The performance of for K-12 Science Ed Science and Eng Constructing Exp Designing Solutia Constructing expla designing solutions K-8 experiences an explanations and d supported by multi student-generated consistent with scie principles, and there • Construct and r based on valid a obtained from a (including stude investigations, re assumption that that describe th operate today a	onstrate understanding struct and revise an on-based molecules ations to support expla- fic chemical reactions expectations above were ducation: ineering Practices blanations and ons nations and a in 9–12 builds on and progresses to esigns that are ple and independent sources of evidence entific ideas, ories. evise an explanation and reliable evidence a variety of sources ents' own models, theories, er review) and the t theories and laws		orm amino acids and/or other large in using evidence from models and ment does not include the details of the	
the future. (HS-				
	grade-bands: MS.PS1	band: HS.PS1.B (HS-LS1-6) I.A (HS-LS1-6); MS.PS1.B (HS-LS1-6); M	S.PS3.D (HS-LS1-6); MS.LS1.C (HS-	
	te Standards Connectio	ons:		
ELA/Literacy – RST.11-12.1	Cita aposifia toutural	avidance to support analysis of esigned and	d technical toute attending to important	
WHST.9-12.2	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-LS1-6) Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1-6)			
WHST.9-12.5	Develop and strengt	hen writing as needed by planning, revisin on addressing what is most significant for a		
WHST.9-12.9		informational texts to support analysis, rel	flection, and research. (HS-LS1-6)	

experiences and progresses to using different organizational levels of one place and another place,	HS. Matter and Energy in Organisms		
food molecules and oxygen molecules are broken and the bonds in new compounds are form resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.] The performance expectations above were developed using the following elements from the NRC document A Framew for K-12 Science Education: Science and Engineering Practices 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 worlds. • Use a model based on evidence to illustrate the relationships between systems or between components of a system. (H5-LS1-7) • As a result of these chemical molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (H5-LS1-7); HS.PS3.B (H5-LS1-7);			
resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.] The performance expectations above were developed using the following elements from the NRC document <i>A Framew</i> for <i>K-12 Science Education</i> : Science and Engineering Practices 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 worlds. Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7) As a result of these chemical respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7); HS.PS3.B (HS-LS1-7); HS.PS3.B (HS-LS1-7);			
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Image: respiration.] The performance expectations above were developed using the following elements from the NRC document A Framew for K-12 Science Education: Science and Engineering Practices 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 worlds. Science and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-7) Energy cannot be created or destroyed—it only moves between objects and/or fields, or between objects and/or fields, or another cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are formed that can transport energy to muscless. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7); HS.PS3.B (HS-LS1-7) Connections to other DCIs in this grade-bard: HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
The performance expectations above were developed using the following elements from the NRC document <i>A Framew</i> for K-12 Science Education: Science and Engineering Practices 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 worlds. Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7) Science and Engineering protections to other DCIs in this grade-band: HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)		lude identification of the steps or specific p	processes involved in cellular
Science and Engineering Practices Disciplinary Core Ideas 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 worlds.			
Science and Engineering Practices Disciplinary Core Ideas Developing and Using Models LS1.C: Organization for Matter and Energy Flow in Organisms Energy and Matter 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 worlds. As a matter and energy flow through different organizational levels of form different products. (HS-LS1-7) Finergy and Matter • Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7) As a result of these chemical respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7); HS-PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)		ere developed using the following elements	from the NRC document A Framework
PracticesDeveloping and Using ModelsModeling in 9–12 builds on K–8experiences 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 worlds As a result of these chemical reactions, energy is transferred from one system of interacting molecules to and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7); HS.PS3.B (HS-LS1-7)Connections to other DCIs in this grade-band:HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)	for K-12 Science Education:		
PracticesDeveloping and Using ModelsModeling in 9–12 builds on K–8experiences 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 worlds As a result of these chemical reactions, energy is transferred from one system of interacting molecules to and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7); HS.PS3.B (HS-LS1-7)Connections to other DCIs in this grade-band:HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
 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 worlds. Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7) As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7); HS.PS3.B (HS-LS1-7); HS.PS3.B (HS-LS1-7) 		Disciplinary Core Ideas	
 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 worlds. Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7) As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7); HS.PS3.B (HS-LS1-7) 	Practices	IS1 C: Organization for Matter	
 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 worlds. Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7) As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7); HS.PS3.B (HS-LS1-7); Connections to other DCIs in this grade-band: HS.PS1.B (HS-LS1-7); HS.PS3.B (HS-LS1-7); 	Developing and Using Models		 Energy cannot be created or
 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 worlds. Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7) As a result of these chemical reacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7); HS.PS3.B (HS-LS1-7); 			destroyed—it only moves between
 and the program of the program of the program of the product of the product of the product of the products of the product of the products of the product of the pr			one place and another place,
 to predict and show relationships among variables between systems and their components in the natural and designed worlds. Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7) As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7); HS.PS3.B (HS-LS1-7) 			between objects and/or fields, or
 among variables between systems and their components in the natural and designed worlds. Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7) As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7); HS.PS3.B (HS-LS1-7) 			between systems.(HS-LS1-7)
 As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7) <i>Connections to other DCIs in this grade-band:</i> HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7) 			, , , ,
designed worlds. Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7) reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7) <i>Connections to other DCIs in this grade-band:</i> HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
 Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-7) from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7) <i>Connections to other DCIs in this grade-band:</i> HS-PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7) 			
illustrate the relationships between systems or between components of a system. (HS-LS1-7) molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7); HS.PS3.B (HS-LS1-7) <i>Connections to other DCIs in this grade-band:</i> HS.PS1.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
systems or between components of a system. (HS-LS1-7) respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1- 7) Connections to other DCIs in this grade-band: HS-PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
a system. (HS-LS1-7) which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1- 7) Connections to other DCIs in this grade-band: HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1- 7) Connections to other DCIs in this grade-band: HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1- 7) Connections to other DCIs in this grade-band: HS-PS1.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)	a system. (HS-LS1-7)		
that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1- 7) Connections to other DCIs in this grade-band: HS.PS1.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1- 7) Connections to other DCIs in this grade-band: HS-PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
<i>connections to other DCIs in this grade-band:</i> HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
Connections to other DCIs in this grade-band: HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
Connections to other DCIs in this grade-band: HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
<i>surrounding environment.</i> (HS-LS1- 7) <i>Connections to other DCIs in this grade-band:</i> HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
7) Connections to other DCIs in this grade-band: HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
Connections to other DCIs in this grade-band: HS.PS1.B (HS-LS1-7); HS.PS2.B (HS-LS1-7); HS.PS3.B (HS-LS1-7)			
Articulation across grade-bands: MS.PS1.B (HS-LS1-7); MS.PS3.D (HS-LS1-7); MS.LS1.C (HS-LS1-7): MS.LS2.B (H			
5 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	5	1.B (HS-LS1-7); MS.PS3.D (HS-LS1-7); M	IS.LS1.C (HS-LS1-7); MS.LS2.B (HS-
LS1-7)			
Common Core State Standards Connections:	Common Core State Standards Connecti	ions:	
ELA/Literacy –	ELA/Literacy –		
SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements	SL.11-12.5 Make strategic use (of digital media (e.g., textual, graphical, a	udio, visual, and interactive elements) in
presentations to enhance understanding of findings, reasoning, and evidence and to add interest.			
LS1-7)			

Unit of Study 5: Nuclear Energy

Standards that appear this unit: HS-PS1-8, HS-ESS1-3, HS-ESS1-1, HS-ESS1-2, HS-ESS1-6

HS. Structure ar	nd Properties of Mat	ter			
	nonstrate understandin				
HS-PS1-8. Dev	velop models to illus	trate the changes in the composition	of the nucleus of the atom and the		
ene	ergy released during	the processes of fission, fusion, and	radioactive decay. [Clarification		
Stat	tement: Emphasis is o	n simple qualitative models, such as pictur	es or diagrams, and on the scale of		
ene	rgy released in nuclear	processes relative to other kinds of transf	formations.] [Assessment Boundary:		
		de quantitative calculation of energy relea	sed. Assessment is limited to alpha,		
beta	a, and gamma radioact	ive decays.]			
The performance	expectations above we	re developed using the following elements	from the NRC document A Framework		
for K-12 Science E	Education:				
Science and Eng	gineering Practices	Disciplinary Core Ideas	Crosscutting Concepts		
Developing and	Using Models	PS1.C: Nuclear Processes	Energy and Matter		
Modeling in 9–12		 Nuclear processes, including fusion, 	 In nuclear processes, atoms are not 		
•	g, synthesizing, and	fission, and radioactive decays of	conserved, but the total number of		
	developing models to predict and show unstable nuclei, involve release or protons plus neutrons is conserved.				
	ng variables between	absorption of energy. The total	(HS-PS1-8)		
	components in the	number of neutrons plus protons			
natural and design		does not change in any nuclear			
	el based on evidence	process. (HS-PS1-8)			
to illustrate the					
between syster					
	a system. (HS-PS1-				
8)	, ,				
		band: HS.PS3.A (HS-PS1-8); HS.PS3.B ((HS-PS1-8); HS.PS3.C (HS-PS1-8);		
		PS1-8); HS.ESS1.C (HS-PS1-8)			
		MS.PS1.A (HS-PS1-8); MS.PS1.B (HS-P	PS1-8); MS.PS1.C (HS-PS1-8);		
MS.ESS2.A (HS-F					
Common Core Sta	te Standards Connectio	ons:			
Mathematics –					
MP.4	Model with mathematics. (HS-PS1-8)				
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				
	data displays. (HS-PS				
HSN-Q.A.2		uantities for the purpose of descriptive mo			
HSN-Q.A.3		curacy appropriate to limitations on measu	rement when reporting quantities. (HS-		
	PS1-8)				

HS. Space System	S		
Students who demoi HS-ESS1-3.	nstrate understanding can: Communicate scientin [Clarification Statement: varies as a function of th many different nucleosy	fic ideas about the way stars, over their lif Emphasis is on the way nucleosynthesis, and the mass of a star and the stage of its lifetime.] [Inthesis pathways for stars of differing masses a reloped using the following elements from the N	therefore the different elements created, [Assessment Boundary: Details of the re not assessed.]
 Obtaining, Evalu Communicating Obtaining, evaluat communicating inf builds on K–8 expe progresses to evaluate reliability of the classical Communicate se about phenome process of deve design and per proposed procession 	Information ing, and formation in 9–12 eriences and uating the validity and aims, methods, and scientific ideas (e.g., ena and/or the elopment and the formance of a ess or system) in ts (including orally, ctually, and	 Disciplinary Core Ideas 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. (HS-ESS1-3) 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. (HS-ESS1-3) 	Crosscutting Concepts Energy and Matter • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3)
		and: HS.PS1.A (HS-ESS1-3); HS.PS1.C (MS.PS1.A (HS-ESS1-3); MS.ESS1.A (HS-	
	te Standards Connection Write informative/exp experiments, or techr Present claims and fir evidence, sound valid	lanatory texts, including the narration of h lical processes. <i>(HS-ESS1-3)</i> ndings, emphasizing salient points in a focu reasoning, and well-chosen details; use a	istorical events, scientific procedures/ used, coherent manner with relevant
<i>Mathematics –</i> MP.2		nunciation. <i>(HS-ESS1-3)</i> I quantitatively. (HS-ESS1-3)	

HS. Space Syste	ems				
	nonstrate understanding can:				
HS-ESS1-1. Dev	velop a model based on evid	ence to illustrate the life span of the sun to release energy that eventually reache			
		ient: Emphasis is on the energy transfer mech			
		un's core to reach Earth. Examples of evidence			
		times of other stars, as well as the ways that t			
		space weather"), the 11-year sunspot cycle, ar			
		dary: Assessment does not include details of t	he atomic and sub-		
	mic processes involved with the				
	expectations above were develo 12 Science Education:	ped using the following elements from the NRG	L document A		
Science and	Engineering Practices	Disciplinary Core Ideas	Crosscutting		
Developing and	Using Models	ESS1.A: The Universe and Its Stars	Concepts		
	builds on K–8 experiences	 The star called the sun is changing and 	Scale, Proportion,		
	using, synthesizing, and	will burn out over a lifespan of	and Quantity		
	eloping models to predict and show approximately 10 billion years. (HS- • The significance of				
	ng variables between systems	ESS1-1)	a phenomenon is		
and their components in the natural and designed world(s). PS3.D: Energy in Chemical Processes dependent on the scale, proportion,					
	lel based on evidence to	 Nuclear Fusion processes in the center 	and quantity at		
	elationships between systems	of the sun release the energy that	which it occurs.		
	mponents of a system. (HS-	ultimately reaches Earth as radiation.	(HS-ESS1-1)		
ESS1-1)		(secondary to HS-ESS1-1)			
		.PS1.C (HS-ESS1-1); HS.PS3.A (HS-ESS1-1)			
	<i>Is across grade-bands:</i> MS.PS1 ESS1-1); MS.ESS2.D (HS-ESS1-	A (HS-ESS1-1); MS.PS4.B (HS-ESS1-1); MS. 1)	ESS1.A (HS-ESS1-1);		
	ate Standards Connections:				
ELA/Literacy –					
RST.11-12.1		to support analysis of science and technical tex			
	important distinctions the aut <i>ESS1-1)</i>	hor makes and to any gaps or inconsistencies i	n the account. <i>(HS-</i>		
Mathematics –	S 1 1 1 1 1				
MP.2	Reason abstractly and quantitatively. (HS-ESS1-1) Model with mathematics. (HS-ESS1-1)				
MP.4 HSN-Q.A.1	Model with mathematics. (HS-ESS1-1) Use units as a way to understand problems and to guide the solution of multi-step problems;				
1.91Å'Y-11511	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-ESS1-1)				
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1)				
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.				
HSA-SSE.A.1		(HS-ESS1-1) Interpret expressions that represent a quantity in terms of its context. <i>(HS-ESS1-1)</i>			
HSA-CED.A.2		pre variables to represent relationships between			
		with labels and scales. (HS-ESS1-1)	, , , , , , , , , , , , , , , , , , ,		
HSA-CED.A.4	Rearrange formulas to highlig	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving			
	equations. (HS-ESS1-1)				

HS. Space Systems

Students who demonstrate understanding can:

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. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices 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.

 Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

 A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-2)

Disciplinary Core Ideas

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 (HS ESC1 2)
- distances from Earth. (HS-ESS1-2)
 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 rediction (counting improvement)
- radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2)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. (HS-ESS1-2)
- PS4.B Electromagnetic Radiation

 Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary to HS-ESS1-2)

Crosscutting Concepts Energy and Matter

 Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)

Connection to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology

 Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2)

Connection to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2)
- Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)

Connections to other DCIs in this grade-band: HS.PS1.A (HS-ESS1-2); HS.PS1.C (HS-ESS1-2); HS.PS3.A (HS-ESS1-2); HS.PS3.A (HS-ESS1-2); HS.PS3.A (HS-ESS1-2);

Articulation of DCIs across grade-bands: MS.PS1.A (HS-ESS1-2); MS.PS4.B (HS-ESS1-2); MS.ESS1.A (HS-ESS1-2)

Common Core Stat ELA/Literacy –	te Standards Connections:
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. (<i>HS-ESS1-2</i>)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-2)
Mathematics –	
MP.2	Reason abstractly and quantitatively. (HS-ESS1-2)
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-ESS1-2)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-2)
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-2)
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-2)
HSA-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-ESS1-2)
HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving
equations. (HS-ES	S1-2)
·	•

Constructing Explanations and Designing SolutionsESS1.C: The History of PlanetConceConstructing 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.• Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of• Conce	ent: th, which absolute st minerals), ces.] work for K- osscutting oncepts lity and ge uch of science als with nstructing planations of w things ange and
 surfaces to construct an account of Earth's formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, with formed along with the rest of the solar system developed using the following elements from the NRC document <i>A Framework 12 Science Education</i>: Science and Engineering Practices Science and Engineering Practices Constructing Explanations and Designing Solutions Constructing explanations and designing Solutions in 9–12 builds on theories. Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support theories. Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6) 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 (HS-ESS1-6) Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6) Models, mechanisms, and explanation scollectively serve as tools in the development of a scientific theory. (HS-ESS1-6) Models, mechanisms, and explanations of some aspect for the development of a scientific theory. (HS-ESS1-6) Models, mechanisms, and explanation of some aspect for the development of a scientific theory. (HS-ESS1-6) Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6) Models, mechanisms, and explanations (HS-ESS1-6) Models, mechanis	ent: th, which absolute st minerals), ces.] work for K- oscutting oncepts lity and ge uch of science als with nstructing planations of w things ange and w they main stable.
Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, wh formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absol ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest min 12 Science and Engineering Practices Constructing explanations and Designing Solutions 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. • Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6) • 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. (HS-ESS1-6) • Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6) • Connections to other DCIs in this grade-banić. HS.PS2.A (HS-ESS1-6); HS.PS2.A (HS-ESS1-6);	th, which absolute absolute absolute absolute absolute absolutions and absolutions ange and absolutions ange and absolutions a
formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absol ages of ancient materials (obtained by radiometric dating of meterites, moon rocks, and Earth's oldest min the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces. The performance expectations above were developed using the following elements from the NRC document A Framework 12 Science Education: Science and Engineering Practices Disciplinary Core Ideas Constructing Explanations and Designing Solutions Disciplinary Core Ideas Constructing explanations and Designing Solutions Disciplinary Core Ideas Constructing explanations and Designing Solutions Disciplinary Core Ideas Science and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, adsess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6) Alter of the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth formation and eary how the reparately 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 mo	absolute st minerals), ces.] work for K- osscutting oncepts lity and ge uch of science als with nstructing planations of w things ange and w they main stable.
ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest min the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.] The performance expectations above were developed using the following elements from the NRC document A Framework 12 Science Education: Science and Engineering Practices 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. Disciplinary Core Ideas 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 tools in the development of a scientific theory. (HS-ESS1-6) Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6) Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6); Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6); Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6);	t minerals), ces.] work for K- osscutting oncepts lity and ge uch of science als with nstructing planations of w things ange and w they main stable.
The sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.] The performance expectations above were developed using the following elements from the NRC document A Framework 12 Science Education: Science and Engineering Practices 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. Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6) Actionus of the natural work, 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. (HS-ESS1-6) Sontancetriat (HS-ESS1-6) Sontancetriatic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary to HS-ESS1-6) Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory is generally modified in light of this new evidence. (HS-ESS1-6) Sontancetriatic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary to HS-ESS1-6) Concections to other DCIs in this grade-band: HS.PS2.A (HS-ESS1-6); HS.PS2.B (HS-ESS1-6)	bes.] work for K- psscutting oncepts lity and ge uch of science als with nstructing planations of w things ange and w they main stable.
The performance expectations above were developed using the following elements from the NRC document A Framework 12 Science Education: Science and Engineering Practices 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. Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6) A scientific theory is a substantiated explanation of some aspect of the natural work], 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. (HS-ESS1-6) Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6) Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6) Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6) Connections to other DCIs in this grade-band: HS.PS2.A (HS-ESS1-6); HS.PS2.B (HS-ESS1-6) 	bes.] work for K- psscutting oncepts lity and ge uch of science als with nstructing planations of w things ange and w they main stable.
The performance expectations above were developed using the following elements from the NRC document A Framework 12 Science Education: Science and Engineering Practices Disciplinary Core Ideas Constructing Explanations and Designing Solutions Constructing explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. Disciplinary Core Ideas Crosscut • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6) Outer of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena Connections to Nature of Science PSI.C: Nuclear Processes PSI.C: Nuclear Processes PSI.C: Nuclear Processes Sopontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary to HS-ESS1-6) Models, mechanisms, and explanation collectively serve as tools in the development of a scientific theory. (HS-ESS1-6) HS-PS2.A (HS-ESS1-6); HS-PS2.B (HS-ESS1-6);	work for K- osscutting oncepts lity and ge uch of science als with nstructing planations of w things ange and w they main stable.
12 Science And Engineering Practices Disciplinary Core Ideas Constructing Explanations and Designing Solutions ESS1.C: The History of Planet 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. Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the explanation or conclusion. (HS-ESS1-6) • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the explanation or conclusion. (HS-ESS1-6) • Much of deals will contend the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) • Much of deals will contend 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. (HS-ESS1-6) • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary to HS-ESS1-6) Connections to other DCIs in this grade-band: • HS-PS2.A (HS-ESS1-6); HS-PS2.B (HS-ESS1-6)	osscutting oncepts lity and ge uch of science als with nstructing planations of w things ange and w they main stable.
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Articulation of DCIs across grade-bands: MS.PS2.B (HS-ESS1-6): MS.ESS1-B (HS-ESS1-6): MS.ESS1-C (HS-ESS1-6):	
	6);
MS.ESS2.A (HS-ESS1-6); MS.ESS2.B (HS-ESS1-6)	
Common Core State Standards Connections:	
ELA/Literacy –	
RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to importa	portant
distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS1-6)	
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the	the data
when possible and corroborating or challenging conclusions with other sources of information. (HS-E	
WHST.9-12.1 Write arguments focused on <i>discipline-specific content</i> . (HS-ESS1-6)	
Mathematics –	
MP.2 Reason abstractly and quantitatively. (HS-ESS1-6),	
HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose	
interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and d	hoose and
displays. (HS-ESS1-6)	
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling (<i>HS-ESS1-6</i>)	
HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities (HS	
6)	and data
HSF-IF.B.5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it	and data
describes. (HS-ESS1-6)	and data s (HS-ESS1-
	and data s (HS-ESS1-
HSS-ID.B.6 Represent data on two quantitative variables on a scatter plot, and describe how those variables are	and data s (HS-ESS1- hip it

Unit of Study 6: Chemistry and Human Impact

Standards that appear this unit: HS-ESS2-4, HS-ESS2-6, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4

HS. Weather and Climate					
Students who demonstrate understa	nding can:				
HS-ESS2-4. Use a model to dea	scribe how variations in the flow of energy into and out of Earth's	systems result in			
	. [Clarification Statement: Examples of the causes of climate change diff				
over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean					
	put; 10-100s of thousands of years: changes to Earth's orbit and the orien				
	ons of years: long-term changes in atmospheric composition.] [Assessment				
	sults of changes in climate is limited to changes in surface temperatures,	precipitation			
	volumes, sea levels, and biosphere distribution.]				
	e were developed using the following elements from the NRC document A	Framework for K-			
12 Science Education:					
Colongo and Engineering	Dissiplinary Care Ideas	Cuccounting			
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts			
	ESS1.B: Earth and the Solar System	Concepts			
Developing and Using Models	 Cyclical changes in the shape of Earth's orbit around the sun, 	Cause and			
Modeling in 9–12 builds on K–8	together with changes in the tilt of the planet's axis of rotation,	Effect			
experiences and progresses to	both occurring over hundreds of thousands of years, have altered	 Empirical 			
using, synthesizing, and	the intensity and distribution of sunlight falling on the earth. These	evidence is			
developing models to predict and	phenomena cause a cycle of ice ages and other gradual climate	required to			
show relationships among	changes. (secondary to HS-ESS2-4)	differentiate			
variables between systems and	ESS2.A: Earth Materials and Systems	between caus			
their components in the natural	 The geological record shows that changes to global and regional 	and correlatio			
and designed world(s).	climate can be caused by interactions among changes in the sun's	and make			
 Use a model to provide 	energy output or Earth's orbit, tectonic events, ocean circulation,	claims about			
mechanistic accounts of	volcanic activity, glaciers, vegetation, and human activities. These	specific causes and effects.			
phenomena. (HS-ESS2-4)	changes can occur on a variety of time scales from sudden (e.g.,				
	volcanic ash clouds) to intermediate (ice ages) to very long-term	(HS-ESS2-4)			
Connections to Nature of	tectonic cycles. (HS-ESS2-4) ESS2.D: Weather and Climate				
Science	 The foundation for Earth's global climate systems is the 				
Science	electromagnetic radiation from the sun, as well as its reflection,				
Scientific Knowledge is Based	absorption, storage, and redistribution among the atmosphere,				
on Empirical Evidence	ocean, and land systems, and this energy's re-radiation into space.				
 Science arguments are 	(HS-ESS2-4), (secondary to HS-ESS2-2)				
strengthened by multiple lines	 Changes in the atmosphere due to human activity have increased 				
of evidence supporting a single	carbon dioxide concentrations and thus affect climate. (HS-ESS2-				
explanation. (HS-ESS2-4)	4)				
Connections to other DCIs in this gr	ade-band: HS.PS3.A (HS-ESS2-4); HS.PS3.B (HS-ESS2-4); HS.LS2.C (H	IS-ESS2-4);			
	.C (HS-ESS2-4); HS.ESS3.D (HS-ESS2-4)	-			
	nds: MS.PS3.A (HS-ESS2-4); MS.PS3.B (HS-ESS2-4); MS.PS3.D (HS-ES				
	H); MS.LS2.B (HS-ESS2-4); MS.LS2.C (HS-ESS2-4); MS.ESS2.A (HS-ESS				
(HS-ESS2-4); MS.ESS2.C (HS-ESS2	-4); MS.ESS2.D (HS-ESS2-4); MS.ESS3.C (HS-ESS2-4); MS.ESS3.D (HS	S-ESS2-4)			

Common Core Sta	ate Standards Connections:	
ELA/Literacy -		
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. <i>(HS-ESS2-4)</i>	
Mathematics -		
MP.2	P.2 Reason abstractly and guantitatively. (HS-ESS2-4)	
MP.4	Model with mathematics. (HS-ESS2-4)	
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-ESS2-4)	
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-4)	
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2- 4)	

HS. Earth's Systems				
Students who den	nonstrate understand	ing can:		
		re model to describe the cycling of c	carbon among the hydrosphere,	
atr	nosphere, geosphe	ere, and biosphere. [Clarification State	ement: Emphasis is on modeling	
bio	geochemical cycles th	nat include the cycling of carbon through	the ocean, atmosphere, soil, and biosphere	
(ind	cluding humans), pro	viding the foundation for living organism	IS.]	
The performance	expectations above v	vere developed using the following elem	ents from the NRC document A Framework	
for K-12 Science E		· · · · · · · · · · · · · · · · · · ·		
Science and	l Engineering	Disciplinary Core Ideas	Crosscutting Concepts	
	ctices	ESS2.D: Weather and Climate		
		 Gradual atmospheric changes 	Energy and Matter	
Developing and		were due to plants and other	 The total amount of energy and matter in closed systems is concerned. (US) 	
Modeling in 9–12		organisms that captured carbon	in closed systems is conserved. (HS-	
experiences and p		dioxide and released oxygen.	ESS2-6)	
using, synthesizing models to predict		(HS-ESS2-6)		
relationships amo		 Changes in the atmosphere due 		
between systems		to human activity have increased		
components in the		carbon dioxide concentrations		
designed world(s)		and thus affect climate. (HS-		
 Develop a mod 		ESS2-6)		
evidence to illu				
	etween systems or			
between comp				
system. (HS-E				
Connections to ot	her DCIs in this grade	e-band: HS.PS1.A (HS-ESS2-6); HS.PS	1.B (HS-ESS2-6); HS.PS3.D (HS-ESS2-6);	
HS.LS1.C (HS-ES	S2-6); HS.LS2.B (HS	S-ESS2-6); HS.ESS3.C (HS-ESS2-6); HS	S.ESS3.D (HS-ESS2-6)	
Articulation of DC.	Is across grade-band	s: MS.PS1.A (HS-ESS2-6); MS.PS3.D	(HS-ESS2-6); MS.PS4.B (HS-ESS2-6);	
		HS-ESS2-6); MS.ESS2.B (HS-ESS2-6);	MS.ESS2.C (HS-ESS2-6); MS.ESS3.C (HS-	
ESS2-6); MS.ESS3.D (HS-ESS2-6)				
Common Core State Standards Connections:				
Mathematics –				
MP.2	Reason abstractly and quantitatively. (HS-ESS2-6)			
MP.4	Model with mathematics. (HS-ESS2-6)			
HSN-Q.A.1			ne solution of multi-step problems; choose	
	and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs			
	and data displays.			
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-6)			
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-			
	ESS2-6)			

HS. Engineering I				
Students who demo	onstrate understandi	ng can:		
		I challenge to specify qualitative and (ns that account for societal needs and		
		ere developed using the following elements		
for K-12 Science Ed				
Science and		Disciplinary Core Ideas	Crosscutting Concepts	
Pract		ETS1.A: Defining and Delimiting	Connections to Engineering,	
Asking Questions	and Defining	Engineering Problems	Technology, and Applications of Science	
Problems		 Criteria and constraints also include 	Science	
Asking questions ar	-	satisfying any requirements set by	Influence of Science, Engineering,	
problems in 9–12 b		society, such as taking issues of risk mitigation into account, and they	and Technology on Society and	
experiences and pro	-	should be quantified to the extent	the Natural World	
formulating, refining	•	possible and stated in such a way	 New technologies can have deep 	
empirically testable	•	that one can tell if a given design	impacts on society and the	
design problems us	ing models and	meets them. (HS-ETS1-1)	environment, including some that were not anticipated. Analysis of	
simulations.		 Humanity faces major global 	costs and benefits is a critical	
 Analyze complex 	(rool world	challenges today, such as the need	aspect of decisions about	
problems by spe		for supplies of clean water and food or for energy sources that minimize	technology. (HS-ETS1-1)	
and constraints		pollution, which can be addressed		
solutions. (HS-E		through engineering. These global		
		challenges also may have		
		manifestations in local communities.		
		(HS-ETS1-1)		
<u> </u>				
		d Delimiting Engineering Problems include:		
	ETS1 B: Designing S	Solutions to Engineering Problems include:		
		53-2, HS-ESS3-4, Life Science: HS-LS2-7,	HS-I S4-6	
		the Design Solution include:		
Physical Science: HS-PS1-6, HS-PS2-3				
Articulation of DCIs across grade-bands: MS.ETS1.A (HS-ETS1-1)				
Common Core State Standards Connections:				
ELA/Literacy –	.			
RST.11-12.7				
RST.11-12.8	quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ETS1-1)			
NJ111-12.0	B 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-ETS1-1)			
RST.11-12.9		Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent		
		process, phenomenon, or concept, resolvir		
	(HS-ETS1-1)			
Mathematics –				
MP.2		ind quantitatively. (HS-ETS1-1)		
MP.4	Model with mathen	natics. (HS-ETS1-1)		

HS. Engineering Design

Students who demonstrate understanding can:

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.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting 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	 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. (HS-ETS1-2) 	N/A	
 consistent with scientific ideas, principles and theories. 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) 			
Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems include:			
Physical Science: HS-PS2-3, HS-PS			
Connections to HS-ETS1.B: Designing So	1utions to Engineering Problems Include: 3-2, HS-ESS3-4, Life Science: HS-LS2-7, I	HS_I \$4_6	
Connections to HS-ETS1.C: Optimizing th			
Physical Science: HS-PS1-6, HS-PS			
Articulation of DCIs across grade-bands:	MS.ETS1.A (HS-ETS1-2); MS.ETS1.B (H	IS-ETS1-2); MS.ETS1.C (HS-ETS1-2)	
Common Core State Standards Connection	ons:		
Mathematics –			
MP.4 Model with mathema	atics. (HS-ETS1-2)		

HS. Engineering	g Design		
	monstrate understanding car		
		mplex real-world problem based o	
		ge of constraints, including cost, sa	
		cultural, and environmental impact	
		veloped using the following elements fr	om the NRC document A Framework
for K-12 Science	Education:		
Science and	Engineering Departices	Disciplinary Core Ideas	Crosseutting Concents
	Engineering Practices	ETS1.B: Developing Possible	Crosscutting Concepts Connections to Engineering,
Designing Solu		Solutions	Technology,
	lanations and designing	 When evaluating solutions, it is 	and Applications of Science
	builds on K–8 experiences	important to take into account a	
	o explanations and designs	range of constraints, including	Influence of Science,
	ed by multiple and	cost, safety, reliability, and	Engineering, and Technology
	lent-generated sources of	aesthetics, and to consider social,	on Society and the Natural
	ent with scientific ideas,	cultural, and environmental	World
principles and the		impacts. (HS-ETS1-3)	 New technologies can have deep
	ution to a complex real-		impacts on society and the
	n, based on scientific udent-generated sources		environment, including some that were not anticipated.
	rioritized criteria, and		Analysis of costs and benefits is
	derations. (HS-ETS1-3)		a critical aspect of decisions
			about technology. (HS-ETS1-3)
			, , , , , , , , , , , , , , , , , , ,
Connections to H	S-ETS1.A: Defining and Delii	miting Engineering Problems include:	
	ence: HS-PS2-3, HS-PS3-3		
		ns to Engineering Problems include:	
		HS-ESS3-4, Life Science: HS-LS2-7, HS	S-LS4-6
	S-ETS1.C: Optimizing the De	sign Solution include:	
	ence: HS-PS1-6, HS-PS2-3		
		.ETS1.A (HS-ETS1-3); MS.ETS1.B (HS	-ETS1-3)
	ate Standards Connections:		
ELA/Literacy –			
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g.,		
DOT 11 12 0	quantitative data, video, multimedia) in order to address a question or solve a problem. (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-ETS1-3)		with other sources of information.
RST.11-12.9	(ID-E151-3) Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a cohere		priments simulations) into a coherent
NG1111 1217		ss, phenomenon, or concept, resolving	
	(HS-ETS1-3)		
Mathematics –	(
MP.2	Reason abstractly and qu	antitatively. (HS-ETS1-3)	
MP.4	Model with mathematics.(HS-ETS1-3)		

HS. Engineering Design		
Students who demonstrate understanding can HS-ETS1-4 . Use a computer simulation	: to model the impact of proposed soluti teria and constraints on interactions w	
The performance expectations above were dev for K-12 Science Education:	veloped using the following elements from th	e NRC document A Framework
Science and Engineering Practices 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. (HS-ETS1-4)	Disciplinary Core Ideas 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. (HS-ETS1-4)	Crosscutting Concepts 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)
Connections to HS-ETS1.A: Defining and Delin Physical Science: HS-PS2-3, HS-PS3-3 Connections to HS-ETS1.B: Designing Solution Earth and Space Science: HS-ESS3-2, H Connections to HS-ETS1.C: Optimizing the Des Physical Science: HS-PS1-6, HS-PS2-3 Articulation of DCIs across grade-bands: MS. Common Core State Standards Connections: Mathematics – MP.2 Reason abstractly and qua	ns to Engineering Problems include: IS-ESS3-4, Life Science: HS-LS2-7, HS-LS4- sign Solution include: ETS1.A (HS-ETS1-4); MS.ETS1.B (HS-ETS1	
MP.4 Model with mathematics.		