High School Chemistry: Year at a Glance

UNIT 1, STRUCTURE AND PROPERTIES OF MATTER

Instructional days: 40

Essential question: How can one explain the structure, properties, and interactions of matter?

Unit abstract: Students are expected to develop understanding of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students are able to use the periodic table as a tool to explain and predict the properties of elements. Students are expected to communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

The crosscutting concepts of structure and function, patterns, energy and matter, and stability and change are called out as organizing concepts for these disciplinary core ideas. In the PS1 performance expectations, students are expected to demonstrate proficiency in developing and using models, planning and conducting investigations, using mathematical thinking, and constructing explanations and designing solutions. In PS2-6, students are expected to communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

PE DCI	Performance Expectations	Grade Band DCI Connections			Science and Engineering Practices	Crosscutting Concepts
		Physical Science	Life Science	Earth and Space Science		
HS-PS1-1 PS1.A PS2.B	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.		LS1.C		Developing and Using Models	Patterns
HS-PS1-2 PS1.A PS2.B	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.		LS1.C	ESS2.C	Constructing Explanations and Designing Solutions	Patterns
HS-PS1-3 PS1.A PS2.B	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.			ESS2.C	Planning and Carrying Out Investigations	Patterns
HS-PS2-6* PS1.A PS2.B	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials				Obtaining, Evaluating and Communicating Information	Structure and Function
HS-ETS1-3 ETS1.B	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.				Constructing Explanations and Designing Solutions	
HS-ETS1-4	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.				Using Mathematics and Computational Thinking	Systems and System Models

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Notes:

UNIT 2, ENERGY AND ITS APPLICATIONS (NONLIVING) — Instructional days: 40

Essential questions:
How is energy transferred and conserved?
How do the major Earth systems interact?
How do the properties and movements of water shape Earth's surface and affect its systems?
How do humans depend on Earth's resources?
How do people model and predict the effects of human activities on Earth's climate?

Unit abstract: In this unit of study, students will understand energy as a quantitative property of a system—a property that depends on the motion and interactions of matter and radiation within that system. They will also understand that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students develop an understanding that energy, at both the macroscopic and the atomic scales, can be accounted for as motions of particles or as energy associated with the configurations (relative positions) of particles.

Students understand the role that water plays in affecting weather. Students can examine the ways that human activities cause feedback that create changes to other systems. In the HS Earth's Systems performance expectations, students are expected to demonstrate proficiency in developing and using models, planning and carrying out investigations, analyzing and interpreting data, engaging in argument from evidence, and using these practices to demonstrate understanding of core ideas.

Students understand the complex and significant interdependencies between humans and the rest of Earth's systems through the impacts of natural hazards, our dependencies on natural resources, and environmental impacts of human activities.

Developing possible solutions for major global problems begins by breaking these problems into smaller problems that can be tackled with engineering methods. To evaluate potential solutions, students are expected not only to consider a wide range of criteria, but also to recognize that criteria need to be prioritized.

Improving designs at the high school level may involve sophisticated methods, such as using computer simulations to model proposed solutions. Students are expected to use such methods to take into account a range of criteria and constraints, to try to anticipate possible societal and environmental impacts, and to test the validity of their simulations by comparison to the real world.

PE DCI	Performance Expectations	Grade Band DCI Connections			Science and Engineering Practices	Crosscutting Concepts
		Physical Science	Life Science	Earth and Space Science		
HS-PS3-4 PS3.B PS3.D	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).			ESS1.A ESS2.A ESS2.D	Planning and Carrying Out Investigations	Systems and System Models
HSESS2-5 ESS2.C	Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.	PS1.A PS1.B PS3.B		ESS3.C	Planning and Carrying Out Investigations	Structure and Function
HS-ESS3-2* ESS3.A ETS1.B	Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.	PS3.B PS3.D	LS2.A LS2.B LS4.D	ESS2.A	Engaging in Argument from Evidence	

HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.				Constructing Explanations and Designing Solutions	
Notes:						

UNIT 3, BONDING AND CHEMICAL REACTIONS

Instructional days: 30

Essential questions:
- How can one explain the structure, properties, and interactions of matter?
- How is energy transferred and conserved?
- How do substances combine or change (react) to make new substances?
- How does one explain reactions and make predictions about them?

Unit abstract: In this unit of study, students are expected to develop understanding of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students are also able to apply an understanding of the process of optimization and engineering design to chemical reaction systems.

The crosscutting concepts of patterns, energy and matter, and stability and change are the organizing concepts for these disciplinary core ideas. In the PS1 performance expectations, students are expected to demonstrate proficiency in developing and using models, planning and conducting investigations, using mathematical thinking, and constructing explanations and designing solutions.

PE DCI	Performance Expectations	Grade Band DCI Connections: Physical Science	Grade Band DCI Connections: Life Science	Grade Band DCI Connections: Earth and Space Science	Science and Engineering Practices	Crosscutting Concepts
HS-PS1-7 PS1.B	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.	PS3.B	LS1.C LS2.B		Using Mathematics and Computational Thinking	Energy and Matter
HS-PS1-4 PS1.A PS1.B	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.	PS3.A PS3.B PS3.D	LS1.C		Developing and Using Models	Energy and Matter
HS-PS1-5 PS1.B	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.	PS3.A			Constructing Explanations and Designing Solutions	Patterns
HS-PS1-6* PS1.B ETS1.C	Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.	PS3.B			Constructing Explanations and Designing Solutions	Stability and Change
HS-ETS1-2 ETS1.C	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.				Constructing Explanations and Designing Solutions	

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UNIT 4, ENERGY AND ITS APPLICATIONS (LIVING)

Instructional days: 12

Essential questions: How is energy transferred and conserved?
How do organisms obtain and use the energy they need to live and grow?

Unit abstract: In this unit of study, students can construct explanations for the role of energy in the cycling of matter in organisms. They can apply mathematical concepts to develop evidence to support explanations of the interactions of photosynthesis and cellular respiration and develop models to communicate these explanations. The crosscutting concept of matter and energy provides students with insights into the structures and processes of organisms.

PE DCI	Performance Expectations	Grade Band DCI Connections: Physical Science	Grade Band DCI Connections: Life Science	Grade Band DCI Connections: Earth and Space Science	Science and Engineering Practices	Crosscutting Concepts
HS-LS1-5 LS1.C	Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.	PS1.B PS1.C			Developing and Using Models	Energy and Matter
HS-LS1-7 LS1.C	Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.	PS1.B PS2.B PS3.B			Developing and Using Models	Energy and Matter
HS-LS1-6 LS1.C	Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.	PS1.B			Constructing Explanations and Designing Solutions	Energy and Matter

Notes:

UNIT 5, NUCLEAR ENERGY

Instructional days: 16

Essential questions:
How do substances combine or change (react) to make new substances?
What is the universe and what goes on in stars?
What is the universe, and what is Earth's place in it?

Unit abstract: n this unit of study, energy and matter are studied further by investigating the processes of nuclear fusion and fission that govern the formation, evolution, and workings of the solar system in the universe. Some concepts studied are fundamental to science and demonstrate scale, proportion, and quantity, such as understanding how the matter of the world formed during the Big Bang and within the cores of stars over the cycle of their lives. In addition, an important aspect of Earth and space sciences involves understanding the concept of stability and change while making inferences about events in Earth's history based on a data record that is increasingly incomplete the farther one goes back in time. A mathematical analysis of radiometric dating is used to comprehend how absolute ages are obtained for the geologic record.

High school students are expected to demonstrate proficiency in developing and using models; constructing explanations and designing solutions; using mathematical and computational thinking; and obtaining, evaluating, and communicating information; and they are expected to use these practices to demonstrate understanding of the core ideas. The crosscutting concepts of energy and matter; scale, proportion, and quantity; and stability and change are called out as organizing concepts for this unit.

PE DCI	Performance Expectations	Grade Band DCI Connections: Physical Science	Grade Band DCI Connections: Life Science	Grade Band DCI Connections: Earth and Space Science	Science and Engineering Practices	Crosscutting Concepts
HS-PS1-8 PS1.C	Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.	PS3.A PS3.B PS3.C PS3.D		ESS1.A ESS1.C	Developing and Using Models	Energy and Matter
HS-ESS1-3 ESS1.A	Communicate scientific ideas about the way stars, over their life cycle, produce elements.	PS1.A PS1.C			Obtaining, Evaluating and Communicating Information	Energy and Matter
HS-ESS1-1 ESS1.A PS3.D	Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.	PS1.C PS3.A			Developing and Using Models	Scale, Proportion, and Quantity
HS-ESS1-2 ESS1.A PS1.B	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.	PS1.A PS1.C PS3.A PS3.B PS4.A			Constructing Explanations and Designing Solutions	Energy and Matter
HS-ESS1-6 ESS1.C PS1.C	Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.	PS2.A PS2.B			Constructing Explanations and Designing Solutions	Stability and Change

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UNIT 6, HUMAN IMPACT

Instructional days: 20

Essential question: How do Earth's surface processes and human activities affect each other?

Unit abstract: In this unit of study, students use cause and effect to develop models and explanations for the ways that feedbacks among different Earth systems control the appearance of Earth's surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth's surface (e.g., volcanism and mountain building), and the sun-driven surface systems that tear down the land through weathering and erosion. Students begin to examine the ways that human activities cause feedbacks that create changes to other systems. Students understand the system interactions that control weather and climate, with a major emphasis on the mechanisms and implications of climate change. Students model the flow of energy and matter between different components of the weather system and how this affects chemical cycles such as the carbon cycle. Engineering and technology figure prominently here, as students use mathematical thinking and the analysis of geoscience data to examine and construct solutions to the many challenges facing long-term human sustainability on Earth. Here students will use these geoscience data to explain climate change over a wide range of timescales, including over one to ten years: large volcanic eruption, ocean circulation; ten to hundreds of years: changes in human activity, ocean circulation, solar output; tens of thousands to hundreds of thousands of years: changes to Earth's orbit and the orientation of its axis; and tens of millions to hundreds of millions of years: long-term changes in atmospheric composition).

PE DCI	Performance Expectation	Grade Band DCI Connections			Science and Engineering Practices	Crosscutting Concepts
		Physical Science	Life Science	Earth and Space Science		
HS-ESS2-4 ESS1.B ESS2.A ESS2.D	Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.	PS3.A PS3.B	LS2.C	ESS1.C ESS3.C ESS3.D	Developing and Using Models	Cause and Effect
HS-ESS2-6 ESS2.D	Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.	PS1.A PS1.B PS3.D	LS1.C LS2.B	ESS3.C ESS3.D	Developing and Using Models	Energy and Matter
HS-ETS1-1 ETS1.A	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.				Asking Questions and Defining Problems	
HS-ETS1-2 ETS1.C	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.				Constructing Explanations and Designing Solutions	
HS-ETS1-3 ETS1.B	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.				Constructing Explanations and Designing Solutions	
HS-ETS1-4 ETS1.B	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.				Using Mathematics and Computational Thinking	Systems and System Models

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