

High School Chemistry



Prioritized Standards and Instructional Units 2021-2022

Unit 1: Energy (4 weeks; 6 weeks)

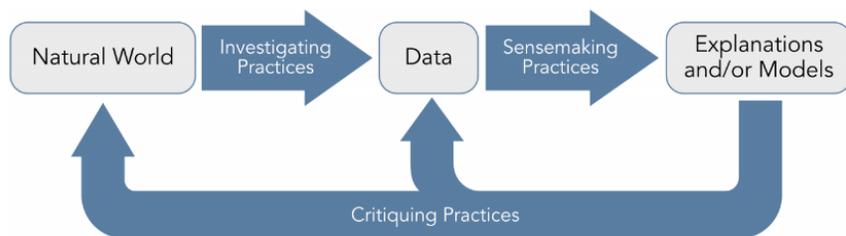
Essential Questions:

Core Idea PS3: Energy

How is energy transferred and conserved?

- What is energy?
- What is meant by conservation of energy? How is energy transferred between objects or systems?
- How are forces related to energy?
- How do food and fuel provide energy? If energy is conserved, why do people say it is produced or used?

Possible Phenomena Coming Soon:



	Investigating Practices	Sensemaking Practices	Critiquing Practices
	1. Asking questions	2. Developing and using models	7. Engaging in argument from evidence
Science Practices	3. Planning and carrying out investigations	4. Analyzing and interpreting data	8. Obtaining, evaluating, and communication information
	5. Using mathematical and computational thinking	6. Constructing explanations	

Possible Benchmarks: After Units 1, 2, 4

HS-PS3-1

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

[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

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HS-PS3-4

Priority Standard

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).

[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.]

[Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]

Science and Engineering Practices:

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HSPS3-4)

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9–12 level builds on K–8 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. Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)

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. (HSPS3-4)

Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HSPS3-1)

Disciplinary Core Ideas:

PS3.A: Definitions of Energy

Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HSPS3- 1),(HS-PS3-2)

PS3.B: Conservation of Energy and Energy Transfer

Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HSPS3-1)

Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4)

Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)

The availability of energy limits what can occur in any system. (HS-PS3-1) 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. (HSPS3-3),(HS-PS3-4)

Unit 2: Atomic Structure (4 weeks; 8 weeks)

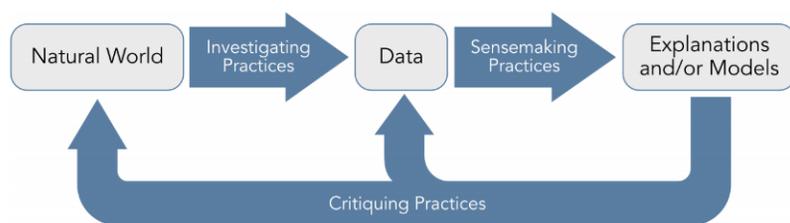
Essential Questions:

Core Idea PSI: Matter and Its Interactions

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

- What forces hold nuclei together and mediate nuclear processes?

Possible Phenomena Coming Soon



	Investigating Practices	Sensemaking Practices	Critiquing Practices
	1. Asking questions	2. Developing and using models	7. Engaging in argument from evidence
Science Practices	3. Planning and carrying out investigations	4. Analyzing and interpreting data	8. Obtaining, evaluating, and communication information
	5. Using mathematical and computational thinking	6. Constructing explanations	

Possible Benchmarks: After Units 1, 2, 4

HS-PS1-1

Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

[Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.]

[Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]

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HS-PS1-8

Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

[Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment

Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]

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<p>HS-PS4-4</p> <p>Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.</p> <p>[Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions.]</p>	<p>Supporting Standard</p>
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<p>Science and Engineering Practices:</p>
<p>Developing and Using Models</p> <p>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. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-8)</p> <p>Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)</p> <p>Obtaining, Evaluating, and Communicating Information</p> <p>Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HSPS4-4)</p>
<p>Crosscutting concepts:</p>
<p>Patterns</p> <p>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),(HSPS1-3)</p> <p>Energy and Matter</p> <p>In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HSPS1-8)</p> <p>Cause and Effect</p> <p>Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4)</p>
<p>Disciplinary Core Ideas:</p>

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)

PS1.C: Nuclear Processes

Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HSPS1-8)

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-PS1-1),(HSPS1-3),(HSPS2-6)

PS4.B: Electromagnetic Radiation

When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4)

Unit 3: Intermolecular and Intramolecular Forces (4 weeks; 9 weeks)

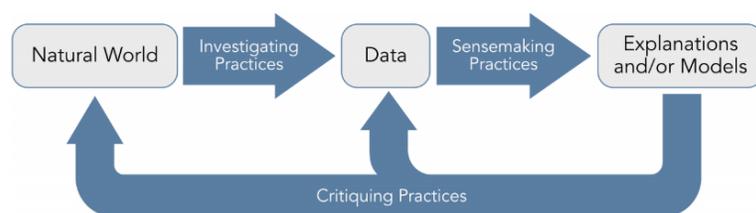
Essential Questions:

Core Idea PSI: Matter and Its Interactions

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

- How do particles combine to form the variety of matter one observes?

Possible Phenomena Coming Soon



	Investigating Practices	Sensemaking Practices	Critiquing Practices
Science Practices	1. Asking questions	2. Developing and using models	7. Engaging in argument from evidence
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HS-PS1-3

Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

[Clarification Statement: Emphasis is on understanding the strengths of forces between particles, and not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]

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Science and Engineering Practices:

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. Plan and conduct an investigation individually and collaboratively to

produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

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),(HSPS1-3)

Disciplinary Core Ideas:

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. (HS-PS1-3),(secondary to HS-PS2-6)

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-PS1-1),(HSPS1-3),(HSPS2-6)

Unit 4: Chemical Reactions (4 weeks; 9 weeks)

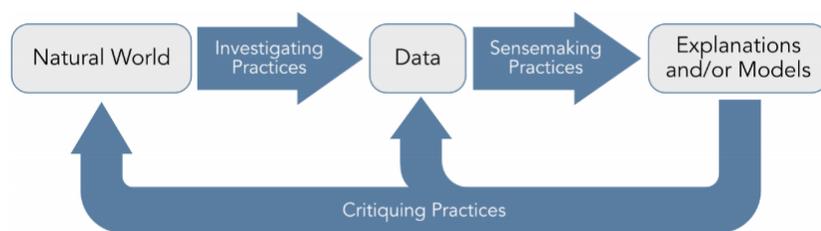
Essential Questions:

Core Idea PSI: Matter and Its Interactions

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

- How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and predictions about them?

Possible Phenomena Coming Soon



	Investigating Practices	Sensemaking Practices	Critiquing Practices
	1. Asking questions	2. Developing and using models	7. Engaging in argument from evidence
Science Practices	3. Planning and carrying out investigations	4. Analyzing and interpreting data	8. Obtaining, evaluating, and communication information
	5. Using mathematical and computational thinking	6. Constructing explanations	

Possible Benchmarks: After Units 1, 2, 4

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.]

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HS-PS1-7

Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

[Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these

Priority Standard

relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]

Science and Engineering Practices:

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9–12 level builds on K–8 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 representations of phenomena to support claims. (HSPSI-7)

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

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. (HSPSI-2),(HS-PSI-5)

Energy and Matter

The total amount of energy and matter in closed systems is conserved. (HS-PSI-7)

Disciplinary Core Ideas:

PS1.A: Structure and Properties of Matter

The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PSI-2) (Note: This Disciplinary Core Idea is also addressed by HS-PSI-1.)

PS1.B: Chemical Reactions

The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and

predict chemical reactions. (HS-PS1- 2),(HS-PS1-7)

Unit 5: Rates and Stability of Chemical Reactions (2 weeks; 4 weeks)

Essential Questions:

Core Idea PSI: Matter and Its Interactions

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

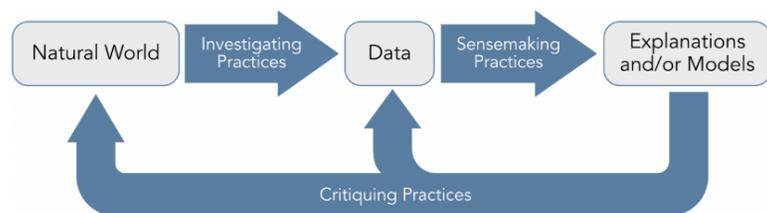
- How do particles combine to form the variety of matter one observes?
- How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and predictions about them?

Core Idea ETSI: Engineering Design

How do engineers solve problems?

- How can the various proposed design solutions be compared and improved?

Possible Phenomena Coming Soon



	Investigating Practices	Sensemaking Practices	Critiquing Practices
	1. Asking questions	2. Developing and using models	7. Engaging in argument from evidence
Science Practices	3. Planning and carrying out investigations	4. Analyzing and interpreting data	8. Obtaining, evaluating, and communication information
	5. Using mathematical and computational thinking	6. Constructing explanations	

HS-PS1-4

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

[Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]

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HS-PS1-5

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<p>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.</p> <p>[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.]</p>	
<p style="text-align: center;">HS-PS1-6</p> <p>Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.</p> <p>[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.]</p> <p>[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.]</p>	Priority Standard

Science and Engineering Practices:
<p>Developing and Using Models</p> <p>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. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4)</p> <p>Constructing Explanations and Designing Solutions</p> <p>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 principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)</p> <p>Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)</p>
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. (HSPS1-2),(HS-PS1-5)

Stability and Change

Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)

Disciplinary Core Ideas:**PS1.A: Structure and Properties of Matter**

A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)

PS1.B: Chemical Reactions

Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HSPS1-4),(HS-PS1-5)

In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)

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 (tradeoffs) may be needed. (secondary to HS-PS1-6)