

MATTER AND ITS INTERACTIONS

Performance Expectation	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 and the composition of the nucleus of atoms.
Clarification Statement	<p>Physical Science: Examples of properties that could be predicted from patterns could include metals, nonmetals, metalloids, number of valence electrons, types of bonds formed, or atomic mass. Emphasis is on main group elements.</p> <p>Chemistry: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, atomic radius, atomic mass, or reactions with oxygen. Emphasis is on main group elements and qualitative understanding of the relative trends of ionization energy and electronegativity.</p>

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. 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. <ul style="list-style-type: none"> • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematical and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>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.PS1A.a)</p> <p>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.PS1A.b)</p> <p>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.PS2B.c)</p>	<p>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.</p>

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Performance Expectation	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	<p>Physical Science: Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or hydrogen and oxygen. Reaction classification includes synthesis, decomposition, single displacement, double displacement, and acid-base.</p> <p>Chemistry: Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or carbon and hydrogen. Reaction classification aids in the prediction of products (e.g. synthesis, decomposition, single displacement, double displacement, and acid-base).</p>

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<p>Performance Expectation</p>	<p>Plan and conduct an investigation to gather evidence to compare the structure of substances at the macroscale to infer the strength of electrical forces between particles.</p>
<p>Clarification Statement</p>	<p>Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and network solids (such as graphite). Examples of macro-properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.</p>



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<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) 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. <ul style="list-style-type: none"> • Plan and conduct an investigation individually and/or 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. 4. Analyzing and interpreting data 5. Using mathematical and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>STRUCTURE AND PROPERTIES OF MATTER The structure and interactions of matter at the macro scale are determined by electrical forces within and between atoms. (HS.PS1A.c)</p> <p>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) (HS.PS2B.c)</p>	<p>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.</p>

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Performance Expectation	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.

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Performance Expectation	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	Student reasoning should focus on the number and energy of collisions between molecules. Emphasis is on simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.

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Performance Expectation	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 Chatelier'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.

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Performance Expectation	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
Clarification Statement	<p>Physical Science: Emphasis is on using mathematical ideas to communicate the relationship between masses of reactants and products as well as balancing chemical equations.</p> <p>Chemistry: Emphasis is on using mathematical ideas as they relate to stoichiometry to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these 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.</p>

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. 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, 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 <ul style="list-style-type: none"> • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>CHEMICAL REACTIONS</p> <p>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.PS1B.c)</p>	<p>ENERGY AND MATTER</p> <p>The total amount of energy and matter in closed systems is conserved.</p>

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Performance Expectation	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	<p>Physical Science: Emphasis is only 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. Radioactive decay focus is on its relationship to half-life.</p> <p>Chemistry: 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. Emphasis is on alpha, beta, and gamma radioactive decays.</p>

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MOTION AND STABILITY: FORCES AND INTERACTIONS

<p>Performance Expectation</p>	<p>Communicate scientific and technical information about why the atomic-level, subatomic-level, and/or molecular level structure is important in the functioning of designed materials.</p>
<p>Clarification Statement</p>	<p>Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, fireworks and neon signs are made of certain elements, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.</p>

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ENERGY

Performance Expectation	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	<p>Chemistry: Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations, systems of two or three components, and thermal energy.</p> <p>Physics: Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations; systems of two or three components; and thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.</p>



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<ol style="list-style-type: none"> 1. Asking questions and defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. 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, 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. <ul style="list-style-type: none"> • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information 	<p>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. (HS.PS3A.a)</p> <p>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. (HS.PS3B.a) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS.PS3B.b) Mathematical expressions allow the concept of conservation of energy to be used to predict and describe system behavior. These expressions 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 velocity. (HS.PS3B.c) The availability of energy limits what can occur in any system. (HS.PS3B.d)</p>	<p>SYSTEMS AND SYSTEM MODELS 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.</p>

ENERGY

Performance Expectation	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
Clarification Statement	<p>Physical Science: Emphasis is on qualitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Emphasis is on devices constructed with teacher approved materials. Examples of devices can be drawn from chemistry or physics clarification statements below.</p> <p>Chemistry: Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Emphasis is on devices constructed with teacher approved materials. Examples of devices in chemistry could include hot/cold packs and batteries.</p> <p>Physics: Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Emphasis is on devices constructed with teacher approved materials. Examples of devices in physics could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and electric motors.</p>

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<p>Performance Expectation</p>	<p>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).</p>
<p>Clarification Statement</p>	<p>Physical Science, Physics and Chemistry: Emphasis is on analyzing data from student investigations and using mathematical thinking appropriate to the subject to describe the energy changes quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.</p>

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ENERGY

Performance Expectation	Evaluate the validity and reliability of claims in published materials about the viability of nuclear power as a source of alternative energy relative to other forms of energy (e.g., fossil fuels, wind, solar, geothermal).
Clarification Statement	Emphasis is on the trade-offs existing between the amount of energy produced, the types and amounts of pollution produced, safety, and cost . Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.

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