Performance Expectation *and Louisiana Connectors*
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 and the composition of the nucleus of atoms. ***LC-HS-PS1-1a Identify the periodic table as a model to use to predict the properties of elements.*** ***LC-HS-PS1-1b Identify that the periodic table was created based on the patterns of electrons in the outermost energy level of atoms.*** ***LC-HS-PS1-1c Identify that the number of electrons in the outermost energy level of atoms impacts the behavior of the element.*** ***LC-HS-PS1-1d Identify the periodic table as a model that predicts the number of electrons and other subatomic particles.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
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. • 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. ***Use a model based on evidence to identify and describe the components of a system.*** ***Use a model based on evidence to identify and describe the relationships between the components of a system.*** ***Use a model based on evidence to predict relationships between systems or within a system.***	**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) ***Atoms are the basic unit of a chemical element.*** ***Atoms are made of subatomic particles: protons, neutrons, and electrons.*** ***Atoms have a nucleus.*** ***The nucleus of an atom is made of positively charged protons and neutrons, which have no net charge.*** ***A positively charged nucleus is surrounded by smaller negatively charged electrons.*** 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) ***Electrons in the outermost energy level are called valence electrons.*** ***The periodic table of elements is an arrangement of the chemical elements ordered by atomic number or the number of protons in atoms.*** ***The periodic table is used to predict the patterns of behavior of elements.*** ***The arrangement of the groups of the periodic table reflects the patterns of electrons in the outermost energy level of atoms, and therefore, the chemical properties of the elements in each group.*** ***The atomic mass listed for each element on the periodic table corresponds to the relative abundance of that element's different isotopes.***	**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. ***Patterns can be used to explain phenomena.*** ***Different patterns can be observed at different scales (micro and macro) in a system.*** ***Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Identify that models can help illustrate relationships between systems or within a system.	**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) ***The patterns and behaviors of elements are based on the attraction and repulsion between electrically charged particles and the patterns of the outermost electrons.*** ***The reactivity and electronegativity of atoms can be determined by an element's location on the periodic table and its valence electrons attraction to the nucleus.*** ***The number and types of bonds formed by an element and between elements, the number and charges of stable ions, and the relative sizes of atoms can be determined by an element's location on the periodic table.***	

Clarification Statement	
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.
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.

Performance Expectation ***and Louisiana Connectors***
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. ***LC-HS-PS1-2a Identify an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms.*** ***LC-HS-PS1-2b Identify an explanation for the outcome of a simple chemical reaction based on trends in the periodic table.*** ***LC-HS-PS1-2c Construct an explanation for the outcome of a simple chemical reaction based on the chemical properties of the elements involved.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) 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. ***Construct an explanation based on valid and reliable evidence from 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.PS1A.b) ***Electrons in the outermost energy level are called valence electrons.*** ***The periodic table of elements is an arrangement of the chemical elements ordered by atomic number as determined by an atoms number of protons.*** ***The periodic table is used to predict the patterns of behavior of elements.*** ***The arrangement of the groups of the periodic table reflects the patterns of electrons in the outermost energy level of atoms, and therefore, the chemical properties of the elements in each group.*** ***The atomic mass listed for each element on the periodic table corresponds to the relative abundance of that element's different isotopes.*** **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.PS1B.c) ***A chemical reaction is the process in which substances undergo chemical changes that results in the formation of new substances.*** ***Atoms are conserved in chemical reactions.*** ***Predicting involves making an inference about a future event based on evidence.***	**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. ***Patterns can be used to explain phenomena.*** ***Different patterns can be observed at different scales (micro and macro) in a system.*** ***Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
variety of sources. *Construct an explanation based on valid and reliable evidence from 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.* *Revise an explanation based on valid and reliable evidence from a variety of sources.* *Revise an explanation based on valid and reliable evidence from 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.*	*An element's chemical and physical properties can be predicted knowing only its position on the periodic table.*	

Clarification Statement	
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.
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).

Performance Expectation *and Louisiana Connectors*
HS-PS1-3 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. ***LC-HS-PS1-3a Identify bulk properties of substances (i.e., melting point, boiling point, and surface tension).*** ***LC-HS-PS1-3b Identify that electrical forces within and between atoms can keep particles close together.*** ***LC-HS-PS1-3c Conduct an experiment to gather evidence of the strength of electrical forces between particles.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
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. • 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. ***Plan an investigation individually***	**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) ***Electrical attractions and repulsions between charged particles (i.e., atomic nuclei and electrons) in matter explain the structure of atoms and the forces between atoms that cause them to form compounds.*** ***The varied properties (e.g., hardness, conductivity) of the materials can be understood in terms of the atomic and molecular constituents and the forces within and between them.*** **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) ***An atom's electron structure determines its physical and chemical properties.*** ***The arrangement and motion of atoms vary in characteristic ways, depending on the substance and its current state (e.g., solid, liquid).*** ***The charged substructure of an atom connects to the concepts of attraction and repulsion between electric charges at the atomic scale.*** ***The interactions of the electric charges at the atomic scale explain the structure, properties, and transformations of matter.***	**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. ***Patterns can be used to explain phenomena. Different patterns can be observed at different scales (micro and macro) in a system. Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
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. ***Revise an investigation individually and collaboratively to produce data to serve as the basis for evidence.*** ***Conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence.***		

Clarification Statement	
Physical Science	Examples of evaluation and refinement could include determining the success of a device at protecting an object from damage such as, but not limited to, impact resistant packaging and modifying the design to improve it. Emphasis is on qualitative evaluations.
Chemistry	Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it by applying the impulse-momentum theorem. Examples of a device could include a football helmet or an airbag. Emphasis is on qualitative evaluations and/or algebraic manipulations.

Performance Expectation *and Louisiana Connectors*
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. ***LC-HS-PS1-4a Determine whether energy is released or absorbed in a chemical reaction system using various types of models (e.g., drawings, graphs, etc.).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
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. • 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. ***Develop or use a model to identify and describe the components of a system.*** ***Develop or use a model to identify and describe the relationships between the components of a system.*** ***Develop or use a model to predict relationships between systems or within a system.*** ***Identify that models can help***	**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.PS1A.d) ***Matter can be broken apart and rearranged to form new compounds/substances.*** ***Forces between atoms that cause them to form molecules (via chemical bonds), which range in size from two to thousands of atoms.*** ***The energy required to break apart compound is equal or greater to the energy of its formation.*** **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. (HS.PS1B.a) ***The total energy change of the chemical reaction system is matched by an equal but opposite change of energy in the surroundings.*** ***The properties of the macromolecules depend on the properties of the molecules used in their formation.*** ***Any chemical process involves a change in chemical bonds and the related bond energies and thus in the total chemical binding energy.*** ***This change is matched by a difference between the total kinetic energy of the set of reactant molecules before the collision and that of the set of product molecules after the collision (conservation of energy).***	**ENERGY AND MATTER** 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. ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
illustrate relationships between systems or within a system.		

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.

Performance Expectation ***and Louisiana Connectors***
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. ***LC-HS-PS1-5a Identify the effects of changing the temperature of the reacting particles at the rate at which a simple reaction (i.e., two reactants) occurs using a model (e.g., a table of data) of the number and energy of collisions between particles.*** ***LC-HS-PS1-5b Identify the effects of changing the concentration of the reacting particles at the rate at which a simple reaction (i.e., two reactants) occurs using a model (e.g., a table of data) of the number and energy of collisions between particles.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) 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 ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. ***Apply scientific ideas to provide an explanation of phenomena taking into account possible unanticipated effects.*** ***Apply scientific ideas to solve design problems, taking into***	**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. (HS.PS1B.a) ***The total energy change of the chemical reaction system is matched by an equal but opposite change of energy in the surroundings.*** ***The properties of the macromolecules depend on the properties of the molecules used in their formation.*** ***Any chemical process involves a change in chemical bonds and the related bond energies and thus in the total chemical binding energy.*** ***This change is matched by a difference between the total kinetic energy of the set of reactant molecules before the collision and that of the set of product molecules after the collision (conservation of energy).***	**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. ***Patterns can be used to explain phenomena.*** ***Different patterns can be observed at different scales (micro and macro) in a system.*** ***Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
account possible unanticipated effects. ***Apply scientific principles to provide an explanation of phenomena taking into account possible unanticipated effects.*** ***Apply scientific principles to solve design problems, taking into account possible unanticipated effects.*** ***Apply scientific evidence to provide an explanation of phenomena taking into account possible unanticipated effects.*** ***Apply scientific evidence to solve design problems, taking into account possible unanticipated effects.***		

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.

Performance Expectation ***and Louisiana Connectors***
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. ***LC-HS-PS1-6a Identify a change in one variable (i.e., temperature, concentration, pressure) of a chemical equation that would produce increased amounts of products at equilibrium.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) 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, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.*** ***Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-***	**CHEMICAL REACTIONS** 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.PS1B.b) ***A system at equilibrium appears stable at the macroscopic level.*** ***The speeds at which a reaction and its reverse reaction occur determines the numbers of all types of reactants and products present in a system. (Sometimes they are not balanced.)*** ***Reversible reactions will reach an equilibrium point where the concentrations of the reactants and products will no longer change.*** ***The balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.*** **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). (HS.ETS1C.a) ***It is important to prioritize the benefits and costs of the design of a solution to a problem.*** ***The decision as to which criteria are critical and which ones can be traded off is a judgment based on the situation and the needs of the system.***	**STABILITY AND CHANGE** Much of science deals with constructing explanations of how things change and how they remain stable. ***Science deals with constructing explanations of how things change.*** ***Science deals with constructing explanations of how things remain stable.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
generated sources of evidence, prioritized criteria, and tradeoff considerations. ***Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.***		

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.

Performance Expectation *and Louisiana Connectors*
HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. ***LC-HS-PS1-7a Identify a chemical equation, and identify the reactants and products which support the claim that matter (i.e., atoms) is neither created or destroyed in a chemical reaction.*** ***LC-HS-PS1-7b Identify a mathematical representation (e.g., table, graph) or pictorial depictions that illustrates the claim that mass is conserved during a chemical reaction.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
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. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of***	**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.PS1B.c) ***A chemical reaction is the process in which substances undergo chemical changes that results in the formation of new substances.*** ***Atoms are conserved in chemical reactions.*** ***Predicting involves making an inference about a future event based on evidence.*** ***An element's chemical and physical properties can be predicted knowing only its position on the periodic table.*** ***The periodic table can be used to predict the outcome of chemical reactions.***	**ENERGY AND MATTER** The total amount of energy and matter in closed systems is conserved. ***When materials interact within a closed system, the total mass of the system remains the same.*** ***When materials interact within a closed system, energy may change forms, but the total amount of energy within the system remains the same.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
design solutions to describe claims. *Use mathematical or algorithmic forms for scientific modeling of phenomena to support claims.* *Use mathematical or algorithmic forms for scientific modeling of design solutions to support claims.* *Use mathematical or algorithmic forms for scientific modeling of phenomena to describe explanations.* *Use mathematical or algorithmic forms for scientific modeling of design solutions to describe explanations.* *Use mathematical or algorithmic forms for scientific modeling of phenomena to support explanations.* *Use mathematical or algorithmic forms for scientific modeling of design solutions to support explanations.*		

Clarification Statement	
Physical Science	Emphasis is on using mathematical ideas to communicate the relationship between masses of reactants and products as well as balancing chemical equations.
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

Clarification Statement	
	macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.

Performance Expectation *and Louisiana Connectors*
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. ***LC-HS-PS1-8a Identify models that illustrate nuclear processes (i.e., fusion, fission, and radioactive decays), involve the release or absorption of energy.*** ***LC-HS-PS1-8b Contrast changes during the processes of alpha, beta, or gamma radioactive decay using graphs or pictorial depictions of the composition of the nucleus of the atom and the energy released.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • 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. ***Develop or use a model to identify and describe the components of a system.*** ***Develop or use a model to identify and describe the relationships between the components of a system.*** ***Develop or use a model to predict relationships between systems or within a system.*** ***Identify that models can help***	**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. (HS.PS1C.a) ***Fission, fusion, and radioactive decay (alpha, beta, and gamma) are nuclear processes.*** ***Nuclear fission and fusion reactions release energy.*** ***In fission reactions, an atom is split into two or more smaller atoms.*** ***In fusion reactions, two smaller atoms fuse together to create a heavier atom.*** ***When a nuclear process takes place, radioactive particles and/or rays may be produced.*** ***Radioactive decay is the breakdown of an atomic nucleus resulting in the release of energy and matter from the nucleus.*** ***The total number of neutrons plus protons is the same both before and after the nuclear process of radioactive decay.*** ***Typically nuclear processes release much more energy per atom involved than do chemical processes.*** ***The energy that is released or absorbed during nuclear processes are harmful to human tissues.***	**ENERGY AND MATTER** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. ***The total number of protons plus neutrons is the same before and after nuclear processes occur.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
illustrate relationships between systems or within a system.		

Clarification Statement	
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.
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.

Performance Expectation *and Louisiana Connectors*
HS-PS2-6 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. ***LC-HS-PS2-6a Communicate that different materials have different molecular structures and properties which determine different functioning of the material (e.g., flexible, but durable).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically). ***Communicate scientific information in multiple formats (i.e., orally, graphically, textually, mathematically).*** ***Communicate technical information in multiple formats (i.e., orally, graphically, textually, mathematically).***	**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) ***Electrical attractions and repulsions between charged particles (i.e., atomic nuclei and electrons) in matter explain the structure of atoms and the forces between atoms that cause them to form compounds.*** ***The varied properties (e.g., hardness, conductivity) of the materials can be understood in terms of the atomic and molecular constituents and the forces within and between them.*** **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) ***An atom's electron structure determines its physical and chemical properties.*** ***The arrangement and motion of atoms vary in characteristic ways, depending on the substance and its current state (e.g., solid, liquid).*** ***The charged substructure of an atom connects to the concepts of attraction and repulsion between electric charges at the atomic scale.*** ***The interactions of the electric charges at the atomic scale explain the structure, properties, and transformations of matter.*** **ELECTROMAGNETIC RADIATION** Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS.PS4B.c)	**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. ***Designing new structures/systems requires knowledge of the properties (e.g., rigidity and hardness) of the materials needed for specific parts of the structure.*** ***Designing new structures/systems requires knowledge of***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Communicate scientific ideas in multiple formats (i.e., orally, graphically, textually, mathematically).	***The photoelectric effect is the movement of electrons in a substance when light is shined on it. This movement causes an electric current to flow.*** ***Some materials (e.g., solar panels) absorb photons of light and release electrons that can be transformed into an electric current.*** 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. (HS.PS4B.d) ***When the atoms of an element absorb energy, the electrons make transitions from lower energy levels to higher energy levels.*** ***When electrons subsequently return from higher energy levels to lower energy levels, energy is released predominantly in the form of electromagnetic radiation.*** ***If emitted photons are in the visible region of the spectrum, they may be perceived different colors.*** ***The result is called a line emission spectrum and can serve as a 'fingerprint' of the element to which the atoms belong.***	***the structures of different components.*** ***Designing a new structure requires a detailed examination of the connections of components to reveal its function.*** ***Designing a new structure requires a detailed examination of the connections of components to reveal any problems.***

Clarification Statement
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.

Performance Expectation ***and Louisiana Connectors***
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. ***LC-HS-PS3-1a Identify a model showing the change in the energy of one component in a system compared to the change in energy of another component in the system.*** ***LC-HS-PS3-1b Identify a model showing the change in 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.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
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. • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. ***Create a computational model of a phenomenon.*** ***Revise a computational model of a phenomenon.*** ***Create a simulation of 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. (HS.PS3A.a) ***Energy is the ability to do work or cause change.*** ***Energy transforms from one form to another, but these transformations are not always reversible.*** ***A system's total energy is conserved regardless of the transfers within the system.*** ***The total energy of a system changes only by the amount of energy transferred into and out of the system.*** **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) ***The law of conservation of energy states that when one form of energy is converted to another, no energy is destroyed in the process.*** ***According to the law of conservation of energy, energy cannot be created or destroyed.*** ***The total change of energy in any system is always equal to the total energy transferred into or out of the system.***	**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. ***Models can be valuable in predicting a system's behaviors.*** ***Any model of a system incorporates assumptions and approximations.*** ***As a result, model-based predictions have limited precision and reliability.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
phenomenon. ***Revise a simulation of a phenomenon.*** ***Create a computational model of a designed device.*** ***Revise a computational model of a designed device.*** ***Create a simulation of a designed device.*** ***Revise a simulation of a designed device.*** ***Create a computational model of a process.*** ***Revise a computational model of a process.*** ***Create a simulation of a process.*** ***Revise a simulation of a process.*** ***Create a computational model of a system.*** ***Revise a computational model of a system.*** ***Create a simulation of a system.*** ***Revise a simulation of a system.***	Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS.PS3B.b) ***Energy cannot be created or destroyed.*** ***Energy can be transferred from one object to another and can be transformed from one form to another.*** ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.*** 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 amount of energy available in a system is mathematically calculable.*** ***Mathematical expressions quantify forms of energy in a system.*** ***These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and energy fields (potential energy).*** The availability of energy limits what can occur in any system. (HS.PC3B.d) ***The amount of energy available in a system determines what the system is capable of doing.***	

Clarification Statement	
Physical Science	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.
Chemistry	Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations; systems of

Clarification Statement	
	two or three components; and thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.

Performance Expectation *and Louisiana Connectors*
HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. ***LC-HS-PS3-3a Identify the forms of energy that will be converted by a device that converts one form of energy into another form of energy.*** ***LC-HS-PS3-3b Identify steps in a model of a device showing the transformations of energy that occur (e.g., solar cells, solar ovens, generators, turbines).*** ***LC-HS-PS3-3c Describe constraints to the design of the device which converts one form of energy into another form of energy (e.g., cost or efficiency of energy conversion).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) 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, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off***	**DEFINITIONS OF ENERGY** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS.PS3A.b) ***Energy takes many forms; forms may include motion, sound, light, and thermal energy.*** **ENERGY IN CHEMICAL PROCESSES** Although energy cannot be destroyed, it can be converted to other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a) ***A system does not destroy energy when carrying out any process.*** ***When carrying out a process, most often some or all of the energy has been transferred to heat the surrounding environment.*** ***Energy can be transformed into other energy forms.*** ***To produce energy typically means to convert some stored energy into a desired form.*** **DEFINING AND DELIMITING ENGINEERING PROBLEMS** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS.ETS1A.a) ***A first step in designing a device to solve a problem is prioritizing criteria and constraints for the design of the device.***	**ENERGY AND MATTER** 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. ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
considerations. *Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.* *Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.*	*The social, economic, and political forces of a society have a significant influence on what science and technology solutions are implemented.*	

Clarification Statement	
Physical Science	Examples of phenomena at the macroscopic scale could include the conversion of potential energy to kinetic and thermal energy. Examples of models could include diagrams, drawings, descriptions, and computer simulations.
Chemistry	Examples of phenomena at the macroscopic scale could include the conversion of potential energy to kinetic and thermal energy, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.

Performance Expectation *and Louisiana Connectors*
HS-PS3-4 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). ***LC-HS-PS3-4a Identify the temperatures of two liquids of different temperature before mixing and after combining to show uniform energy distribution.*** ***LC-HS-PS3-4b Investigate the transfer of thermal energy when two substances are combined within a closed system.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions to problems (engineering) 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. ***Plan an investigation individually and collaboratively to produce data***	**CONSERVATION OF ENERGY AND ENERGY TRANSFER** Energy cannot be created or destroyed, but it can be transported from one place to another, transformed into other forms, and transferred between systems. (HS.PS3B.b) ***Energy cannot be created or destroyed.*** ***Energy can be transferred from one object to another and can be transformed from one form to another.*** ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.*** 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.PS3B.e) ***Energy can change from one kind to another.*** ***When two substances (e.g., water or air) of different temperatures are combined (within a closed system), the result will be a more uniform temperature (energy) distribution in the system.*** **ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE** Although energy cannot be destroyed, it can be converted to less useful other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a) ***Energy can be transformed into other energy forms.***	**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. ***Making models help people understand things they cannot observe directly.*** ***Scientists use models to represent things that are either very large or very small.*** ***Any model of a system incorporates assumptions and approximations (e.g., the boundaries and initial conditions of the***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
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. *Revise an investigation individually and collaboratively to produce data to serve as the basis for evidence.* *Conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence.*	*When "producing" or "using" energy, most often some or all of the energy has been transferred to heat the surrounding environment.*	*system, inputs and outputs).* *It is critical to be aware of a system's physical, chemical, biological, and social interactions and how they affect the model's reliability and precision.*

Clarification Statement	
Physical Science, Chemistry, and Physics	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.

Performance Expectation ***and Louisiana Connectors***
HS-PS3-6 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). ***LC-HS-PS3-6a Identify the relationship between increasing energy demand and the technologies developed to meet these needs.*** ***LC-HS-PS3-6b Identify an alternative energy system with minimal social and environmental consequences.*** ***LC-HS-PS3-6c Evaluate a claim about nuclear energy as an alternative source of energy as opposed to other forms of energy.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. ***Evaluate the validity and reliability of claims that appear in scientific and technical texts, verifying the data when possible.*** ***Evaluate the validity and reliability of claims that appear in media reports, verifying the data when possible.*** ***Evaluate the validity and reliability***	**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. (HS.PS1C.a) ***Fission, fusion, and radioactive decay (alpha, beta, and gamma) are nuclear processes.*** ***Nuclear fission and fusion reactions release energy.*** ***In fission reactions, an atom is split into two or more smaller atoms.*** ***In fusion reactions, two smaller atoms fuse together to create a heavier atom.*** ***When a nuclear process takes place, radioactive particles and/or gamma radiation may be produced.*** ***Radioactive particles or decay occur when an unstable atomic nucleus loses energy by emitting radiation.*** ***The total number of neutrons plus protons is the same both before and after the nuclear process of radioactive decay.*** ***Typically nuclear processes release much more energy per atom involved than do chemical processes.*** ***The energy that is released or absorbed during nuclear processes are harmful to human tissues.*** **DEVELOPING POSSIBLE SOLUTIONS** When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (HS.ETS1B.a)	**ENERGY AND MATTER** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. ***The total number of nuclear particles are the same both before and after the nuclear process, although the total number of protons and the total number of neutrons may be different before and after.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
of methods that appear in scientific and technical texts, verifying the data when possible. ***Evaluate the validity and reliability of methods that appear in media reports, verifying the data when possible.*** ***Evaluate the validity and reliability of designs that appear in scientific and technical texts, verifying the data when possible.*** ***Evaluate the validity and reliability of designs that appear in media reports, verifying the data when possible.***	***It is important to determine the full impact of the advantages and disadvantages when evaluating a solution.*** ***The development of solutions is driven by the following factors: economical, political, cultural, social, safety, and environmental.*** **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.ESS3A.b) ***Energy production has associated economic, social, environmental, and geopolitical costs and risks.*** ***Energy production also has associated economic, social, environmental, and geopolitical benefits.*** ***Advances in technology can and advancement in science influence and drive each other forward to help balance these factors.***	

Clarification Statement
Emphasis is on the tradeoffs 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.