**HS-PS1 Matter and Its Interactions**

**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.**

Further explanation: 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. Examples include the properties and bonding of water and the rusting of metals as found in guardrails, ship parts, etc. Consider the metal compounds found in fireworks.

Developing and Using Models, structure and properties of matter, types of interactions, patterns

**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.**

Further explanation: Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or carbon and hydrogen. Examples could include ocean salt formation, combustion (as found in the burning of fuels in Maine homes, cars and the trucking industry) or the detection of carbon monoxide in a home (complete vs incomplete combustion).

Constructing Explanations and Designing Solutions, structure and properties of matter, chemical reaction, patterns

**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.**

Further explanation: 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 networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension. Examples could consider why we salt roads in the winter, differences in melting points of water vs saltwater, the production of maple syrup or the strength of Maine minerals.

Planning and Carrying out Investigations, structure and properties of matter, types of interactions, patterns

**HS-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends on the changes in total bond energy.**

Further explanation: 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.

Developing and Using Models, structure and properties of matter, Energy and Matter

**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.**

Further explanation: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules. Examples could include the varied rates of oxidation of metals in winter vs in summer or the rate of dissolution of calcium shells in the ocean due to an increase in carbon dioxide an increase in temperature from global warming.

Constructing Explanations and Designing Solutions, Chemical Reactions, patterns

**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.**

Further explanation: 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. Other examples to consider include the Kraft paper making process, soap making or rock candy formation.

Constructing Explanations and Designing Solutions, structure and properties of matter, Chemical Reactions, Types of Interactions, Optimizing Design Solution patterns, cause and effect, scale, proportion, and quantity

**HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.**

Further explanation: 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 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. Examples could include the proportion of ingredients combined in baked goods or the combustion of fuels.

Using Mathematics and Computational Thinking, Chemical Reactions, Energy and Matter

**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.**

Further explanation: 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. Examples could include radon gas in basements, thorium in white gas mantles or, historically, Wiscasset’s Maine Yankee nuclear power plant and Fukushima in Japan.

Developing and engineering practices, Nuclear Processes, patterns, cause and effect, scale, proportion, and quantity