HS.PS-SPM Structure and Properties of Matter

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Students who demonstrate understanding can:

a. Construct models showing that stable forms of matter are those with minimum magnetic and electrical field energy. [Clarification Statement: Examples of stable forms of matter can include noble gas atoms, simple molecules, and simple ionic substances.] [Assessment Boundary: Only for common substances- for example, water, carbon dioxide, common hydrocarbons, sodium chloride.]

b. Construct various types of models showing that energy is needed to take molecules apart and that energy is released when the atoms come together to form new molecules. [Assessment Boundary: Only for common substances (e.g., water, carbon dioxide, common hydrocarbons, sodium chloride]

c. Develop explanations about how the patterns of electrons in the outer level of atoms, as represented in the periodic table, reflect and can predict properties of elements. [Clarification Statement: An example of a pattern that predicts element properties is the first column of the periodic table: These elements all have one electron in the outer most energy level and as such are all highly reactive metals.] [Assessment Boundary: Only for main group elements (not transition metals or elements beyond the third row).]

d. Construct arguments for which type of atomic and molecular representation best explains a given property of matter. [Clarification Statement: Types of atomic and molecular representations can include computer-based, simulations, physical, ball and stick, and symbolic. Properties of matter can include reactivity, and polar vs. non-polar.] [Assessment Boundary: Not theoretical models]

e. Analyze and interpret data obtained from measuring the bulk properties of various substances to explain the relative strength of the interactions among particles in the substance. [Clarification Statement: Bulk properties of substances can include melting point and boiling point.] [Assessment Boundary: Comparisons between ionic and molecular species or network and molecular species are included, but those that require understanding of different intermolecular forces are not included. Only the following types of particles are included in data and explanations: atoms, ions, and molecules.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and constructing models to predict and explain relationships between systems and their components in the natural and designed world.

- Use multiple types of models to represent and explain phenomena and move flexibly between model types based on merits and limitations. (b)
- Construct, revise, and use models to predict and explain relationships between systems and their components. (a)

Analyzing and Interpreting Data

Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims or determine an optimal design solution. (e)

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 knowledge, principles, and theories.

- Construct and revise explanations and arguments based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories) and peer review. (c)

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds from K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world. Arguments may also come from current scientific or historical episodes in science.

- Evaluate the merits of competing arguments, design solutions and/or models. (d)
- Evaluate the claims, evidence, and reasoning of currently accepted explanations or solutions as a basis for the merits of the arguments. (d)

Disciplinary Core Ideas

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. (c),(d)
- 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. (c)
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (e)
- Stable forms of matter are those in which the electric and magnetic field energy is minimized. A stable molecule has less energy, by an amount known as the binding energy, than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (a),(b)

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. (d),(e)

Crosscutting Concepts

Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. 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. Systems can be designed to cause a desired effect. Changes in systems may have various causes that may not have equal effects. (a),(b),(c),

- [Clarification Statement for a: Stability is caused by minimization of energy.]
- [Clarification Statement for c: The likelihood of interactions between elements is caused by the number of electrons in their valence shell, and thus the arrangement of the periodic table.]

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. (d)

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. The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (e)

- [Clarification Statement for e: The relative strength of interactions among particles causes different bulk properties.]

Connections to other DCIs in this grade-level: **HS.LS-MEOE, HS.ESS-SS, HS.ESS-ES**

Articulation to DCIs across grade-levels: **MS.PS-SPM**

Common Core State Standards Connections: [Note: these connections will be made more explicit and complete in future draft releases]

ELA –

RST.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

SL.9-10.2 Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, orally) evaluating the credibility and accuracy of each source.

RST.9-10.9 Compare and contrast findings presented in a text to those from other sources (including their own experiments), nothing when the findings support or contradict previous explanations or accounts.

SL.11-12.2 Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Mathematics –

MP.4 Model with mathematics.

8.F Use functions to model relationships between quantities

S.ID Summarize, represent, and interpret data on two categorical and quantitative variables

S.IC Make inferences and justify conclusions from sample surveys, experiments, and observational studies