HIGH SCHOOL CHEMISTRY: MOLECULAR STRUCTURE

Standards Bundle

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon potential for related phenomena that can be used throughout a unit.

HS-PS1-3 Plan and carry out an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (SEP: 3; DCI: PS1.A, PS2.B; CCC: Patterns) [Clarification Statement: 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.] *[Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]*

HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. (SEP: 8; DCI: PS1.A, PS2.B; CCC: Structure/Function) [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, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] *[Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]*

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

Forces between particles, such as atoms, ions, molecules, and network materials, determine properties such as melting point, boiling point, vapor pressure, surface tension, volatility, malleability, conductivity, and solubility. These forces include covalent bonds, ionic bonds, metallic bonds and intermolecular forces. The values of these properties can be collected and compared through scientific experiment using assorted solids and liquids. These values may be compared to infer the strength of the forces within the compound or molecule and between the molecules or compounds.

Molecular-level structure is important in the design and use of materials at the macroscopic-level. Attractive and repulsive forces play a crucial role in the overall properties of matter seen on the bulk scale. Molecular shape is also determined by attractive and repulsive forces and is important in the interaction with specific biological receptors. The properties of materials related to their molecular structure are important to consider in the design of materials. For example, materials may exhibit properties such as conductivity, flexibility and hardness, based on their molecular structure and atom choice. Students will explore the relationship between the molecular level structure and the functioning of designed materials and communicate its significance.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- Graphite and diamond are both made of just carbon, but we can write with soft graphite and cannot with diamond.
- Oil and gasoline will not dissolve in water; however, oil and gasoline will dissolve in one another.
- Some students' phone glass breaks easily while others do not.
- Some automotive manufacturers are investing in the use of plant material for the interior of cars.
- Hockey sticks have radically changed in design over the last 30 years.
- When you have blood drawn to check your cholesterol, the lab technician uses a capillary tube to collect your blood sample.
- Copper is still used for electrical wiring inside homes today, but copper plumbing has been replaced with PEX- cross-linked polyethylene.

Storyline

This section aims to decode not only the DCI connections, but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations ● 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. **Obtaining, Evaluating, and Communicating Information** ● Communicate scientific and technical information (e.g., about the process of development and the design and performance of a proposed process or system) in multiple formats (including oral, graphical, textual and mathematical).	**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. **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.	**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. **Structure/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.

Planning and carrying out scientific investigations can be used to determine the patterns in the relationships between measurable properties such as melting point, boiling point, vapor pressure, or surface tension, and the strength of electrical forces between the particles. Examples of particles include atoms, ions, molecules, and networked materials. Through investigations, students can mathematically predict electrostatic forces between macroscopic and molecular objects and can use evidence to support those predictions. Patterns of electrostatic forces and types of molecules may be observed during experimentation. Communicating scientific and technical information about molecular-level structure, including an understanding of electrostatic forces between macroscopic and molecular objects, is important in connecting the components of structure and function. Electrostatic forces between both macroscopic and molecular objects can be mathematically predicted as structure and function are examined. These findings may affect material strength, conductivity, states of matter, and durability. Specific molecular level structure, intermolecular forces, polarity, and the ability of electrons to flow, can be used to describe how molecular properties explain patterns and relationships of a material's macroscopic properties and function.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard or lesson-level performance expectation.

SEP Obtaining, Evaluating, and Communicating Information

- Use at least two different formats (including oral, graphical, textual and mathematical) to communicate scientific and technical information fully describing the structure, properties, and design of the chosen material, citing the origin of the material as appropriate.
- Use two different formats to communicate why graphene, diamond, and graphite are composed of carbon yet exhibit different properties.

SEP Planning and Carrying Out Investigations

- Describe the phenomenon under investigation, which includes properties such as melting point, boiling point, vapor pressure, and surface tension, of a substance as related to the strength of the electrical forces between the particles of the substance.
- Develop an investigation to collect data for the bulk properties of a substance (e.g., melting point, boiling point, volatility, surface tension) that would allow inferences to be made about the strength of electrical forces between the particles.
- Collect and record data, quantitative and/or qualitative, on the bulk properties of substances.
- Obtain information and carry out an investigation to identify given elements based on their physical properties.
- Evaluate investigations, including the assessment of the accuracy and precision of the data collected, as well as the limitations of the investigations and the ability of the data to provide the evidence required, and if necessary, refine the plan to produce more accurate, precise, and useful data.

CCC Patterns

- What patterns are seen in the bulk properties of ionic compounds, polar covalent compounds, nonpolar covalent compounds, covalent networks, metals, and polymers?
- How are patterns of interactions between the particles at the molecular scale reflected in the patterns of behavior at the macroscopic scale?
- How can patterns observed at multiple scales provide evidence of the causal relationships between the strength of the electrical forces between particles and the structure of substances at the bulk scale?

CCC Structure/Function

- What is the evidence for why molecular level structure is important in the functioning of designed materials?
- How does the structure and properties of matter and the types of interaction of the matter at the atomic scale determine the function of the chosen designed material?
- How does the material's properties such as melting point, make it suitable for use in its designed function?
- How can molecular structure be identified of the chosen designed material using an appropriate representation such as a ball and stick model, geometric shapes, etc.?
- How can the intended function of the designed material be described?
- How can the relationship between the material's function and its macroscopic properties (e.g., material strength, conductivity, reactivity, state of matter, durability) be described in relationship to its molecular structure, intermolecular forces and polarity, and its ability of electrons to move freely?
- How can the effects of the attractive and repulsive electrical forces between molecules on the arrangement of the chosen designated materials of molecules (e.g. solids, liquids, gases, network solids, polymers) be described?
- How are electrostatic forces on the atomic and molecular scale related to contact forces (e.g., friction, normal forces, stickiness) on the macroscopic scale?
- How does the data about bulk properties provide information about strength of the electrical forces between the particles of the chosen substances?
- What effect does adding thermal energy have on the electrical attraction between particles?

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain-size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- **Use at least two different formats (including oral, graphical, textual, and mathematical) to communicate** the properties and design of the chosen material(s), *structure and function.*
- **Plan and carry out an investigation** to gather evidence to compare the structure of substances at the bulk *scale* to infer the strength of electrical forces between particles.
- **Identify and communicate the evidence** why *molecular level* structure is important in the functioning of designed materials.
- **Identify and communicate how the** *structure and* properties of matter and the types of interactions of matter at the atomic scale *determine the function* of the chosen designed material(s).
- **Analyze and communicate how a** *material's properties, such as melting point, make it suitable for use in its designed function?*
- **Analyze and communicate the** *relationship between the material's function and its macroscopic properties* (e.g., material strength, conductivity, reactivity, state of matter, durability) and molecular level structure of the material.
- **Identify and communicate the** *relationship between the material's function and its macroscopic properties* (e.g., material strength, conductivity, reactivity, state of matter, durability) and intermolecular forces and polarity of molecules.
- **Identify and communicate the** relationship between the material's function and its macroscopic properties (e.g., material strength, conductivity, reactivity, state of matter, durability) and the ability of electrons to move relatively freely in metals.
- **Identify and communicate the** effects that attractive and repulsive electrical forces between molecules have on the arrangement (structure) of the chosen designed material(s) or molecules (e.g., solids, liquids, gases, network solid, polymers).
- **Analyze and communicate *how the patterns*** for all materials, electrostatic forces on the atomic and molecular scale result in contact forces (e.g., friction, normal forces, stickiness) on the macroscopic scale.