PHENOMENON-BASED INSTRUCTIONAL TASK | **GRADE LEVEL:** Physical Science - Chemistry

It's the Little Things That Matter

TARGETED DCI AND/OR ASSOCIATED PE

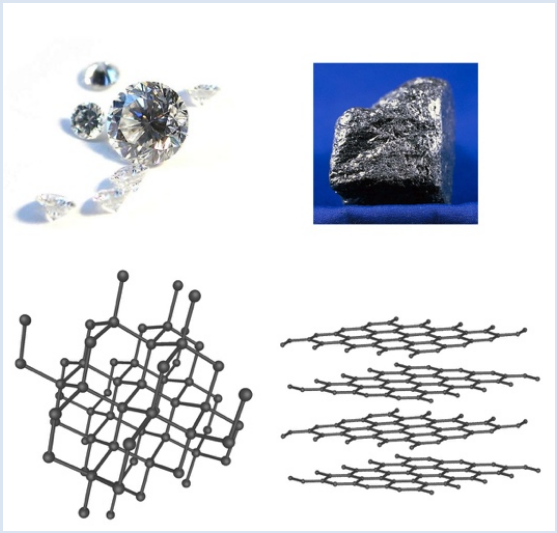
PE | HS-PS2-6

Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

DCI | Types of Interactions:

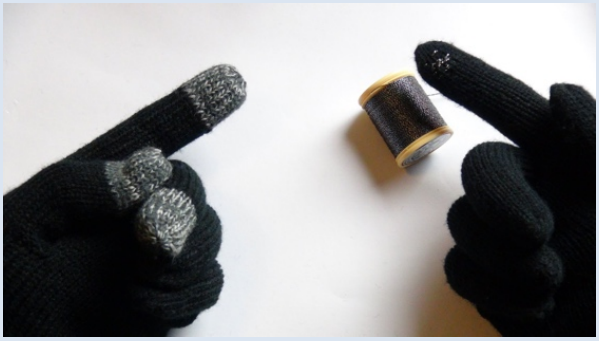
Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

POSSIBLE DRIVING PHENOMENA



Student observation or initial interaction:

Students observe images of graphite and diamonds and discuss how they are used. Students are informed that both graphite and diamonds are composed entirely of carbon. Students make observations of the physical properties of both diamond and graphite, as well as how they function. Students use these observations to begin to make comparisons and generate questions about how the structural composition of each substance relates to it's functionality.



Student observation or initial interaction:

Students make observations of individuals using touchscreen devices with gloves on their hands. In small groups, students are given one touchscreen-capable glove and one normal (non-touchscreen-capable) glove. Students observe that one glove allows touchscreen functioning while the other glove does not. Students use the observations of the physical properties of the gloves to generate questions about the cause of the gloves' differing functionality.

Funded by a USDE Math Science Partnership (MSP) grant through the Oklahoma State Department of Education.

Phenomenon Explanation for Teachers:

Although both diamond and graphite are composed entirely of carbon atoms, the way these carbon atoms are bonded to each other at the molecular level is quite different, leading to vastly different properties at the large scale. In diamond each carbon atom is bonded to four other carbon atoms in a tetrahedral shape. This three-dimensional shape creates a crystalline latticework in which the bond between each carbon atom is 109°. This creates an infinite network of atoms and explains the diamond's extraordinary hardness (a 10 on Moh's scale of hardness), strength, durability, and high density. Diamonds do not conduct electricity but are a very good conductor of heat. They also allow light to pass through easily and even disperse it. In comparison, the carbon atoms in graphite are also arranged in an infinite array structure, however they are arranged in layers. In graphite each carbon atom is bonded to only three other atoms spaced 120° apart. This creates a flat layer much like a chicken wire fence. Each layer is stacked on top of another layer. The layers are held together through weak forces. Because of this structure, graphite cleaves or breaks into flat layers easily. Graphite is soft (less than 1 on Moh's scale) and slippery making it useful as a lubricant. Graphite also conducts electricity and heat easily and it absorbs all wavelengths of light, causing its appearance to be black.

Phenomenon Explanation for Teachers:

Most touchscreen devices such as smartphones or tablets use capacitive or projected capacitive touch technology. These methods utilize the fact that our bodies carry a small charge and our skin can conduct electricity. When a person touches a touchscreen a tiny grid of wires embedded in the glass screen sense the electrical current conducted through skin on the fingertip and provide a touchpoint on the screen to indicate a touch. Gloves that allow individuals to use touchscreens have special properties that allow part or all of the glove's material to conduct electric currents. Normal thread and cloth materials are made of materials such as cotton, nylon, and polyester. These materials are composed of elements that are insulators of electricity and do not allow the free movement of electrons. In order for gloves to work with touchscreens, engineers have developed new textiles and threads that are able to conduct electricity. Conductive thread is typically made using two methods. The first is to have a non-conductive core (such as nylon, cotton, or polyester) that is then coated with a conductive element such as carbon, nickel, copper, gold, silver, or titanium. The second method is to use braided fibers composed of conductive materials such as graphite fibers, carbon nanotubes, or stainless steel. The two most common conductive threads are silver coated and stainless-steel thread. At the molecular scale, these conductive elements form a closely packed lattice of positive ions with delocalized electrons that can freely move from one atom to another within the lattice structure. Using these types of materials in the gloves allow electrons to travel from the person's fingertips to the touchscreen.

HOW DOES THE PHENOMENON CONNECT TO THE DCI OR PE?

All matter is composed of atoms of different elements which are combined/bonded in specific ways. The observed properties of matter at the macroscopic level can be explained by the structure of matter at the molecular level. Students can make observations of different materials in order to describe and communicate the properties at the macroscopic level. Students can obtain and evaluate information about the properties of the different materials at the molecular level such as the type of bonding occurring between atoms and the structure of these bonds. Students will be able to begin to notice patterns in the way that the properties at the molecular level effect the observable properties at the macroscopic level. The properties of a material at the molecular level will directly affect the functionality of that material at the macroscopic level. These properties and the functionality of the material determine how these materials can be used in designed systems. Students can make and communicate claims supported by evidence for how the observable properties and functionality of matter at the macroscopic level are related to the properties at the molecular level. Once students are able to understand and communicate this cause and effect relationship, they can begin to relate these properties to how these materials function within designed systems.

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GATHERING AND REASONING IN ORDER TO CONSTRUCT AND REFINE EXPLANATIONS

How could students gather evidence using SEPs and CCCs that will help them construct/refine a supported explanation of the phenomenon?

1. INITIAL ENGAGEMENT WITH THE PHENOMENON:

Students make observations of the phenomena and begin to ask questions that can lead to further investigation.

a. **For phenomenon 1**:
Students can make observations of images and physical descriptions of both a diamond and graphite in addition to descriptions of their physical properties. Students can begin to ask questions as they make comparisons of the two substances.

b. **For phenomenon 2:**
In small groups students can make observations of both a touchscreen capable and a normal, non-touchscreen glove. Students can compare their funcionality and their physical properties in order to begin asking questions about why they function differently.

c. Students can construct a beginning explanation of each phenomenon which can further be revised as the continue to investigate.

Overarching question: How does the molecular structure of matter affect the properties at the macroscopic scale?

GUIDING QUESTIONS:

- Describe how the organization of the molecular structure of a material might impact its function.
- What types of molecular forces or interactions could explain why identical atoms can form different materials that have different properties and behave in unique ways?
- What is the relationship between the structure of the atoms that make up the material and how the material functions?
- What patterns in molecular structures might help you explain why materials function the way they do?
- What patterns in molecular structures allow us to decide which materials might be best suited for a specific purpose?
- If you needed a material to (describe a function or set of properties), what type(s) of molecular structures might best support a material to function in this way?
- How do humans use the specific properties of various substances to engineer materials and objects that help us perform needed functions in our lives?

2. CONTINUING EXPLORATION:

- Students can be given appropriate resources that describe molecular level structure of the matter being investigated. Students can synthesize information across these resources to begin to look for patterns in the relationship between the molecular level structure of given materials and their physical properties and functionality at the macroscopic level.
- Students can investigate the use of a given set of materials. Students can use oral, written or forms such as models, drawings, writing, or numbers to begin to communicate how the molecular level properties of the materials directly relate the physical properties exhibited at the macroscopic level. Students can construct explanations using their observations and relevant research for why certain materials are chosen for certain purposes in human designed systems.
- Students can be given a specific human-designed system, a set of possible materials that could function for a specific purpose in that system, and information about the molecular structure and properties of the materials. Students can them make claims about which material might be best suited to perform the needed functions using the molecular properties as evidence for their claims.

  Examples:
  - Flexible polymers created from long-chained molecules are used in glues and bendable silicone bakeware.
  - Some materials such as metals are conductive of heat and electricity, others do not conduct heat or electricity, and others are semiconductors having very unique properties.
  - Materials such as carbon fiber or Kevlar are used for their rigidity and durability.

COMMUNICATE FINAL EXPLANATION OF THE PHENOMENON

How might students communicate their understanding of the targeted DCI or PE in an explanation supported by evidence?

Students can construct and communicate an explanation about how the molecular structure of a given material affects how it functions at the macroscopic level and how these properties can determine the material's possible use in designed systems.

Possible formats for constructing explanations of this phenomenon.

- When given information about a set of materials students can make claims about which materials might be best suited for specific purposes. Students can provide information about the molecular structure of each material as evidence for their claims.
- Students can use molecular models to communicate how the molecular structure affects the physical properties and ultimately how that material could be utilized in a human designed system.
- Students can present information synthesized from scientific texts and media to support claims about which materials might be best suited for specific purposes.
- Students can use materials (such as conductive thread) to create a functional wearable product requiring electrical interaction. Students can communicate how the structure of the chosen materials relate to the functioning of the product.