Central Oklahoma Rural Partnership For Science

PHENOMENON-BASED INSTRUCTIONAL TASK | **GRADE LEVEL:** 6th Grade

LOOK WHAT YOU'VE DONE— I'M MELTING!

TARGETED DCI AND/OR ASSOCIATED PE

PE | MS-PS1-4

Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

DCI |

STRUCTURE AND PROPERTIES OF MATTER:

Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.

The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

DEFINITIONS OF ENERGY: (secondary to MS-PS1-4)

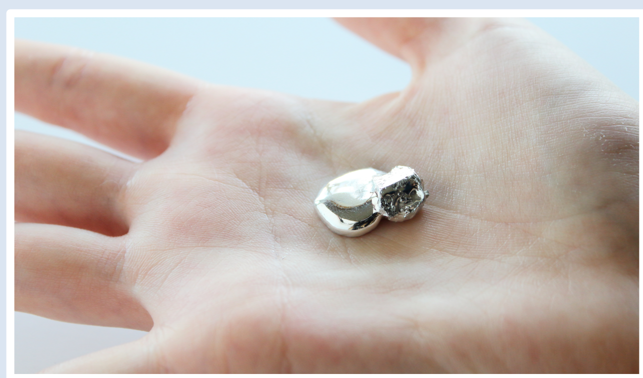
The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects.

POSSIBLE DRIVING PHENOMENA

Student observation or initial interaction:

Students observe a demonstration of solid dry ice turning to a visible gas.

(WARNING: Dry ice can cause severe cold burns and is not safe for student use. Use appropriate equipment to protect your skin while demonstrating. Because dry ice is carbon dioxide (CO_2), demonstrations should be performed in a ventilated room.)



Student observation or initial interaction:

Students observe solid metal gallium melting in the palm of their hand (or in the teacher's hand). Alternatively, students could observe the melting of an ice cube.

(Gallium is relatively inexpensive and easily purchased online. It is considered non-toxic and safe to handle, though gloves are recommended for lab safety and mess concerns.)

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Phenomenon explanation for teachers:

At room temperature, thermal energy moves from the room into the ice, which heats it up. This temperature increase causes the particles in dry ice to speed up and move around so quickly that they get far enough apart that the solid ice turns into (carbon dioxide) gas.

Phenomenon explanation for teachers:

Gallium has a low melting point. Because my hand has a higher temperature than the metal, thermal energy moves from me into the piece of gallium and heats it up. The gallium particles start to move around and get far enough apart that it turns into a liquid, but not far enough apart that it turns into a gas.

HOW DOES PHENOMENON CONNECT TO THE DCI OR PE?

Dry ice is frozen carbon dioxide (CO_2). Due to its chemical bonds, it is not possible for CO_2 to be in a liquid state under normal air pressure. As a result, a temperature increase causes dry ice to immediately undergo sublimation, in which it changes directly from a solid to a gas. **Students do not need to know the details about pressure and the molecular bonds in CO_2 that lead to sublimation.*

The change in the temperature of dry ice is caused by heating due to the transfer of thermal energy from the environment into the ice. Room temperature is warm enough to cause the CO_2 molecules to increase their speed. The more the molecules move around, the greater the space between them, which produces a gas phase when they reach a sufficient distance from one another.

Gallium metal has a very low melting point (approximately 85° F). Just like the dry ice at room temperature, normal body temperature is warm enough to cause the gallium atoms to increase their motion until they produce a phase change. Your hand will heat the metal as thermal energy is transferred from you into the gallium, causing the increase in temperature necessary to produce a liquid phase. Body temperature is not sufficiently high to increase the speed of the gallium atoms until the space between them is enough to become a gas.

Because molecular motion cannot be observed directly, models provide a way to examine the effects of temperature on particle motion. Students can observe the phase change visually (dry ice) or in their gloved hands (gallium) and draw models or diagrams that show how the transfer of thermal energy (heat) from the environment into the ice or metal increases temperature and therefore increases the amount of atomic movement necessary to produce a phase change.

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 observe dry ice sublimating as demonstrated by the teacher or melt a piece of gallium in their hand while wearing gloves. Using these experiences, they should draw an initial model or diagram that explains what the particles (CO_2 or gallium) are doing as the phase changes. Students could also generate questions to explore that would help them figure out the mechanisms that drive phase changes.

2. CONTINUING EXPLORATION:
With either phenomenon, students could measure the temperature of the substances before, during, and after the phase change. Additionally, liquid gallium can be turned back into a crystal solid when it is cooled in a plastic container at room temperature or with ice. Using the temperature information, students could revise

GUIDING QUESTIONS:

- How would particles in the dry ice or metal need to interact with each other to make the ice or metal solid?
- What is different about the way particles interact in a liquid compared to a solid? In a gas?
- (If returning gallium to solid phase): What do you predict will happen to the gallium if it cools? How would [student prediction] happen? What evidence do you have to support your prediction?
- How do you know that a change in temperature caused the dry ice to change to a gas phase or the gallium to melt? ***or*** How can you test whether temperature caused a phase change to happen?

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their models or create an initial written explanation for the phase change.

The class (whole or 2-3 large groups) could engage in a physical model demonstrating how the particles are interacting with each other in each of the three phases. With each student serving as a molecule or atom, class members can spatially arrange themselves to represent phases.

- What caused the temperature (of the dry ice/gallium/air/etc.) to change? Where did the energy move from and where did the energy move to?
- What other factors that we haven't described yet might explain the phase changes you observed?

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 generate a model or diagram that explains how changes in temperature due to the transfer of thermal energy (heat) cause a substance to change phase.

Possible formats for constructing explanations of this phenomenon.

- Students revise their previous models to accurately account for temperature change due to thermal energy transfer, the effect of temperature on the movement of particles, and the spatial relationships of particles that produce different phases. Students can draw and label the model components, interactions among components, and mechanisms in the model.
- When pointed out to students that water expands when it freezes, students can explain why their model does or does not describe how water changes phases from liquid to solid due to changes in temperature.
- Students can be presented with a new example of phase change and can draw and label a model that predicts how the phase change would occur due to thermal energy transfer.
- Students can construct an explanation for dry ice and/or gallium phase changes due to temperature differences using the model and any data they might have collected as supporting evidence.

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