8th Grade Science

Independent Learning Packet

Packet 7

Name: _________________________________

Teacher: _______________________________

Period: _________________________
Suppose you take an ice cube out of the freezer and place it on a hot pan. It will eventually melt and become a liquid. What exactly is happening to change the state of the matter of the ice cube?

When substances gain thermal energy, their particles speed up. When the particles speed up, the substance's temperature rises, and the substance can melt, evaporate, or sublime. How can you use your knowledge of these cause-and-effect relationships to predict when a substance will change state?

**Melting** When a solid object, such as an ice cube, sits in a hot pan, it gains thermal energy as heat transfers from the metal of the pan to the ice. As the hot pan’s particles vibrate against the water molecules that make up the ice cube, the water molecules move faster and faster. They vibrate more and more excitedly within their fixed positions. As they vibrate, the particles of water bump into each other, vibrating faster and faster. As a result, the temperature of the ice cube increases.

When a particle gains enough energy, it can break away from its fixed position in the solid. Figure 2A shows how molecules that are struck by the fast-moving particles of the hot pan at this temperature break from their positions. Then they are able to move about as a liquid. As the solid gains more energy, more fast-moving molecules join the liquid puddle forming under the ice cube of slow-moving particles. The ice is melting, or changing from the solid to liquid state.

As the water gains even more thermal energy from the hot pan, its temperature will rise. Eventually, the liquid arrives at its boiling point, which for water is 100°C. At the boiling point, bubbles form throughout the liquid. The substance boils as its particles move into the gas state.

**Subliming** For some substances, solids under conditions similar to that of the ice cube in the pan do not melt when they gain thermal
energy. Instead, their particles pass directly into the gas state. They do not enter the liquid state at all because they are able to overcome the attractions that hold them close together. As these solid substances gain thermal energy, they sublime, or change from a solid to a gas. This is what happens to solid carbon dioxide (dry ice) when it gains thermal energy. When solid carbon dioxide gains thermal energy, it sublimes, forming carbon dioxide gas. Recall that a substance’s state depends on its particle motion. When the particles break away from their fixed locations with enough energy to behave like a gas, then they have sublimed.

**Answer the following questions using the text above:**

1. Explain the melting process. __________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

2. Explain the evaporating process. ______________________________________________________
   ____________________________________________________________
   ____________________________________________________________

3. Explain the subliming process. _________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

**Objects Lose Thermal Energy**

Imagine that you place a clear glass lid on a pot of boiling water. You might notice that tiny drops of water collect on the underside. At first they just cloud the glass. However eventually, more and more will collect together there until they form large drops that are so heavy they drip back into the
How does thermal energy cause the liquid water to form?

**Condensing** The liquid water collecting on the underside of the lid comes from water vapor that has lost thermal energy. Here’s how it happens. The molecules of water vapor above the boiling water collide with the particles that make up the lid. The lid is cooler than the water vapor, so thermal energy transfers from the water vapor to the lid when particles collide. The particles slow down and lose thermal energy. The water vapor gets cooler.

When a gas loses enough thermal energy, its particles collide and stick together instead of bouncing away and continuing on in a different direction. You could model this behavior with two tennis balls that are covered in slightly sticky tape. If the balls collide at high speeds, the slight stickiness of the tape might not affect their motion. If they collide at lower speeds, they might stick together and stay connected.

When the water vapor loses enough energy, the water will **condense**, or change from a gas to a liquid. This is shown in Figure 3A. This change of state occurs as energy is lost at the substance’s boiling point. For the water vapor in the pot, condensation happens at 100°C. At this temperature, the particles no longer have enough energy to overcome their attractions, and so they stick together when they collide.

When a substance has cooled to its melting point and further energy is lost, a change of state takes place. The substance will **freeze**, or change from a liquid to a solid. For water, freezing happens at a temperature of 0°C. As the water loses energy, its molecules no longer can overcome any of the attractions that can hold them into fixed positions. They get locked into place. They can move only by vibrating within the fixed arrangement of the solid phase. Freezing happens when you place a pan of water in the freezer overnight. It also happens when molten metal that has been poured into a mold cools to room temperature and forms a solid shape.

**Depositing** Recall that some substances can sublime instead of melt when they gain thermal energy. Similarly, they can undergo the opposite process when they lose thermal energy. The loss of energy under certain conditions can cause
substances to **deposit**, to change from a gas to a solid. At cold temperatures in the atmosphere, water vapor deposits rather than condenses to form crystals of solid ice. Additionally, scientists often use deposition to place a thin film of gold on insects to study them. Though the insect in the photo looks like it is covered with gold paint, it is actually covered with a thin layer of pure solid gold. This allows scientists to study the insect’s body structures under certain powerful microscopes.

**Answer the following questions using the text above:**

1. Explain the condensing process.  
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

2. Explain the freezing process.  
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

3. Explain the depositing process.  
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

**Attractions Between Particles**

Different substances change state under different temperatures and pressures. Water is a gas above its boiling point, 100°C. Helium is a gas at much lower temperatures; its boiling point is –269°C. Why do different substances have different melting points and boiling points?

Different substances differ in the strength of the attraction between particles. Water molecules have very strong attractions, while helium atoms have much weaker ones. If their particles were tennis balls, water would be covered in sticky duct tape while helium would be covered in less sticky cellophane tape. It is much easier for water molecules to stick together. The strength of the attractions between particles helps
It takes more energy to overcome strong attractions than it does to overcome weak attractions. Helium atoms have very weak attractions, so it takes very little energy to change from a liquid to a gas. Water molecules have stronger attractions, so it takes more energy for the molecules to overcome them and change liquid water to a gas.

Boiling and melting points can tell you how strongly particles are attracted to one another. Helium has a much lower boiling point than water because its particles are so weakly attracted to each other. In fact, the attractions between atoms in helium are so weak that it is not even possible to freeze it at atmospheric pressure. Helium's boiling and melting point show how weak the attractions between its atoms are.

Answer the following questions using the text above:

1. The strength of attraction between particles ____________________ between different substances. Strong attractions require ____________________ energy to be overcome than weak attractions. These attractions are related to the amount of ____________________ required for a substance to change state.

2. Use the data table to answer the following question.

<table>
<thead>
<tr>
<th></th>
<th>Melting Point (°C)</th>
<th>Boiling Point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Helium</strong></td>
<td>-272.2</td>
<td>-268</td>
</tr>
<tr>
<td><strong>Carbon Dioxide</strong></td>
<td>-78.5 (sublimes)</td>
<td></td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td><strong>Gallium</strong></td>
<td>29.8</td>
<td>2403</td>
</tr>
</tbody>
</table>
Come up with a claim for which substance has the strongest attractions between its particles. Then, list the evidence and your reasoning.

Claim:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Evidence:

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________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Reasoning:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________