



Name: \_\_\_\_\_

Date: \_\_\_\_\_

## Student Exploration: Melting Points

**Vocabulary:** boiling point, covalent bond, intermolecular forces, ionic bond, melting point, metallic bond, molecular solid, network solid, salt, smoke, sublimation, sublimation point, transition point

**Prior Knowledge Questions** (Do these BEFORE using the Gizmo.)

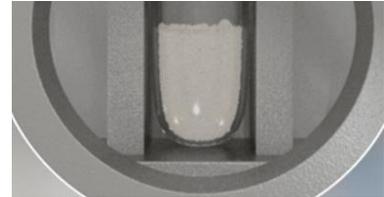
1. Suppose you had two socks sticking together in the clothes dryer from static electricity.

What happens if they are spun gently? \_\_\_\_\_  
\_\_\_\_\_

2. What could happen if they are tumbled rapidly? \_\_\_\_\_  
\_\_\_\_\_

### Gizmo Warm-up

Like socks in the dryer, solids are held together by molecular-scale forces. When solids are heated, molecules move faster and spread apart as the solid becomes liquid and gas. In the *Melting Points* Gizmo, you will measure the **transition points** at which melting and boiling occur for a variety of substances.



The Gizmo shows a lab device used to determine **melting points** and **boiling points**. A small amount of substance is placed in a glass tube and heated inside the device.

1. To begin, check that **Sodium chloride** is selected. Drag the dial to the right to apply heat.

A. When the temperature is around 600 °C, drag the dial back to 0. Notice that the sodium chloride is red-hot, but it is still a solid.

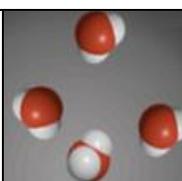
B. Drag the dial to the right. When the sodium chloride melts, move the dial back to 0.

About what temperature does sodium chloride melt? \_\_\_\_\_

2. Click **Reset**. This time, decrease the setting on the dial as you get close to the melting point. Notice that melting occurs over a range of temperatures. Can you determine the exact range of temperatures over which melting occurs? (This may take several tries, be patient.)

What is the temperature range over which melting occurs? \_\_\_\_\_



<b>Activity A:</b> <b>Covalent compounds</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Select the COLD ROOM tab.</li> <li>• Turn on <b>Show molecular view</b>.</li> <li>• Check that <b>Water</b> is selected.</li> </ul>	
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**Introduction:** A cold room is used to find the melting points of substances that are liquids or gases at room temperature. This simulated cold room has a temperature of  $-120\text{ }^{\circ}\text{C}$ .

**Question: What happens when a substance melts?**

1. Observe: Look at the molecular view of water.

A. What do you see? \_\_\_\_\_

The atoms in each water molecule are held together by **covalent bonds**. The molecules are held together by **intermolecular forces**. This kind of substance is called a **molecular solid**.

B. In the solid state, do the molecules move around freely or are they stuck in position?  
 \_\_\_\_\_

C. Using the Gizmo, determine the melting point and boiling point of water. To find the approximate melting and boiling points you can heat the sample quickly. Then, run another trial at a slower speed to find the exact temperatures.

Melting point: \_\_\_\_\_ Boiling point: \_\_\_\_\_

D. Do the molecules move around more or less when water is a liquid? \_\_\_\_\_

2. Experiment: Record the melting point and boiling point of water in the table below. Then, use the Gizmo to find the melting and boiling points of hydrogen sulfide and ethanol. In each case, record the range of temperature for each transition.

Chemical	Melting point ( $^{\circ}\text{C}$ )	Boiling point ( $^{\circ}\text{C}$ )	Other transition point ( $^{\circ}\text{C}$ )
Water			
Hydrogen sulfide			
Ethanol			
Carbon dioxide			

Now try carbon dioxide. Do you notice anything unusual? \_\_\_\_\_

\_\_\_\_\_

**(Activity A continued on next page)**



### Activity A (continued from previous page)

3. **Observe:** At normal atmospheric pressure, carbon dioxide undergoes **sublimation**, where the solid transforms directly to a gas. Using the Gizmo, determine the **sublimation point** of carbon dioxide and record it in the table under "Other transition point."
4. **Interpret:** The melting point and boiling point can be used to measure the strength of intermolecular forces holding the molecules together. Based on the melting and boiling points, which substance do you think has the strongest intermolecular forces? The weakest?

\_\_\_\_\_

Explain your conclusions: \_\_\_\_\_

\_\_\_\_\_

5. **Extend your thinking:** Ethanol is an alcohol. The boiling points and molecular weights of other alcohols are in the table (you can fill in ethanol's boiling point from the last page).

Chemical	Molecular weight (u)	Boiling point (°C)
Methanol	32	65
Ethanol	46	
1-Propanol	60	97
1-Butanol	74	117

A. Is there a pattern in the data? Explain. \_\_\_\_\_

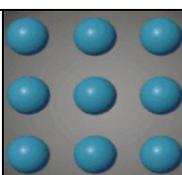
\_\_\_\_\_

B. Make a prediction about the boiling point of 1-pentanol, an alcohol with a molecular weight of 88 u. Explain. \_\_\_\_\_

\_\_\_\_\_

6. **Analyze:** Based on the boiling point data in your data on the previous page, does the pattern in the alcohol boiling points always apply? Is molecular weight an important contributor to intermolecular forces? Why or why not?
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_



<b>Activity B:</b> <b>Melting points of high-melting point chemicals</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Select the LABORATORY tab.</li> <li>• Check that <b>Show molecular view</b> is selected.</li> </ul>	
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**Introduction:** The LABORATORY tab represents a normal lab with a temperature of 20 °C. This room is used for substances that are solid at room temperature. Substances available include **salts** with **ionic bonds** like sodium chloride, metals like silver and tungsten with **metallic bonds**, molecular solids like paraffin wax, and a **network solid**, graphite.

**Question: How can we predict melting points?**

1. Observe: Select **Lead**. Add heat until the lead melts. Does lead melt into individual atoms or molecules? \_\_\_\_\_
2. Collect data: Using the table below, record the melting point temperatures for the remaining compounds. Each compound has been identified as an ionic salt, a metal, a network solid, or a molecular solid. If the substance boils, record that temperature as well.

Chemical	Substance type	Melting point (°C)	Boiling point (°C)	Other transition temperature (°C)
Sodium chloride	Ionic salt			
Copper (II) chloride	Ionic salt			
Lead	Metal			
Silver	Metal			
Tungsten	Metal			
Graphite	Network solid			
Paraffin wax	Molecular solid			
Caffeine	Molecular solid			

3. Interpret: Do all of the chemicals melt? How can you tell? \_\_\_\_\_

Note: Graphite is an example of a network solid. Graphite crystals are held together by covalent bonds that together form one large net. Around 700 degrees, pieces of solid graphite begin breaking off and traveling through the air. However, these pieces are still solid. When a solid is suspended in a gas, it is called **smoke**.

**(Activity B continued on next page)**



**Activity B (continued from previous page)**

4. Sort: Look for patterns by listing the chemicals from lowest to highest melting point. (For carbon dioxide, list the sublimation point.)

Chemical	Substance type	Melting point (°C)

5. Analyze: Think about the types of forces holding the atoms together in different chemicals. Are there any patterns that can be drawn from the data? Explain.

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6. Extend your thinking: What is the relative strength of intermolecular forces compared to the forces between ions in a salt or the forces between metal atoms in a metallic bond?

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