

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

## Student Exploration: Phase Changes

**Vocabulary:** altitude, boil, boiling point, freeze, freezing point, gas, liquid, melt, melting point, phase, solid

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

1. A family from Minnesota turns off the heat and flies to Florida for a winter holiday. When they come home, all of their water pipes have burst. What do you think happened?

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2. Spaghetti takes about 9 minutes to cook at sea level, but about 14 minutes in the mountains. Why do you think this is so?

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### Gizmo Warm-up

In the *Phase Changes* Gizmo™, select the **Micro view** and set the **Ice volume** to 50 cc. Click **Play** (▶) and observe molecules in the **solid** (ice), **liquid** (water), and **gas** (air) **phases**.

1. In which phase(s) are the molecules held rigidly together?

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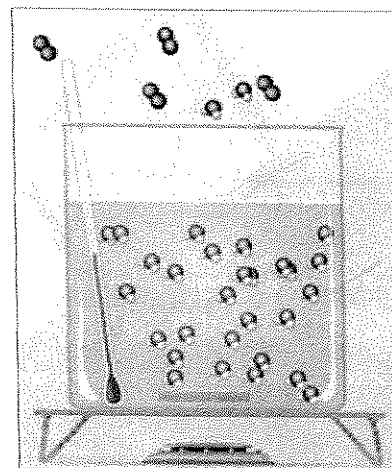
2. In which phase(s) do the molecules move freely?

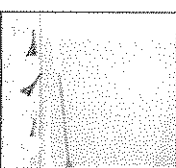
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3. In which phase(s) are the molecules held in a defined shape? \_\_\_\_\_

4. In which phase(s) do the molecules take the shape of their container? \_\_\_\_\_

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<b>Activity A:</b> <b>Phase changes</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Click <b>Reset</b> (↺) and select <b>Macro view</b>.</li> <li>• Set the <b>Water temperature</b> to 10 °C.</li> <li>• Set the <b>Ice volume</b> to 0 cc.</li> </ul>	
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**Question: How is temperature related to phase changes?**

- Predict: Based on your prior knowledge, predict the following:

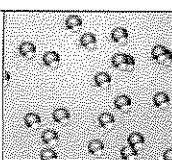
  - At what temperature will water change from a liquid to a solid (**freeze**)? \_\_\_\_\_
  - At what temperature will water change from a solid to a liquid (**melt**)? \_\_\_\_\_
  - At what temperature will water change from a liquid to a gas (**boil**)? \_\_\_\_\_
- Investigate: Use the Gizmo to explore phase changes. Use the **Add/remove heat energy** slider to control the water temperature. Record your observations in your notes, then answer the questions below:

  - At what temperature does water freeze? \_\_\_\_\_ This is the **freezing point**.
  - At what temperature does ice melt? \_\_\_\_\_ This is the **melting point**.
  - At what temperature does water boil? \_\_\_\_\_ This is the **boiling point**.
- Observe: Set up the Gizmo to observe freezing. What do you notice about the temperature while the water is in the process of freezing? \_\_\_\_\_
- Explore: Use the Gizmo to investigate melting and boiling. Does the temperature change while either of these phase changes is occurring? \_\_\_\_\_
- Interpret: Select the GRAPH tab to see a graph of temperature vs. time. Click the “–” button until the whole graph is visible. What does the graph look like during a phase change?

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- Extend your thinking: Why do you think the temperature does not change much during a phase change? If possible, discuss your answer with your classmates and teacher.

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<b>Activity B:</b> <b>Temperature and molecular motion</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Click <b>Reset</b>, and select the <b>Micro view</b>.</li> <li>• Set <b>Ice volume</b> to 0 cc.</li> <li>• Set <b>Add/remove heat energy</b> to 0 J/s.</li> </ul>	
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**Question: Why do phase changes occur?**

1. Compare: Set the **Water temperature** to 0 °C and click **Play**. Observe the water molecules. Click **Reset**, set the **Water temperature** to 100 °C, and click **Play** again.

What do you notice? \_\_\_\_\_  
 \_\_\_\_\_

2. Observe: Click **Reset**. The **mean molecular speed** of the water molecules is displayed below the container. Set the **Water temperature** to 0 °C and **Add/remove heat energy** to 400 J/s. Click **Play**.

A. How does the mean speed of the water molecules change as they are heated?

\_\_\_\_\_

B. Does the mean molecular speed change as much as the temperature as the water heats up? Explain.

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

3. Explain: How is temperature related to the motions of molecules? \_\_\_\_\_

\_\_\_\_\_  
 \_\_\_\_\_

4. Observe: Click **Reset**. Set the **Water temperature** to 20 °C and the **Ice volume** to 50 cc. Set **Add/remove heat energy** to 0 J/s. Click **Play**. How do the molecules in the liquid interact with the molecules in the solid?

\_\_\_\_\_  
 \_\_\_\_\_

(Activity B continued on next page)



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

5. Observe: Click **Reset**. Set the **Water temperature** to 100 °C and the **Ice volume** to 50 cc. Click **Play**. How does this situation compare to the previous one?

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6. Propose a theory: Based on what you have observed, explain why you think phase changes occur. If possible, discuss your theory with your classmates and teacher.

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7. Apply: Use your theory to explain what happens at the molecular level in each of the following situations. Also, list the temperature at which each transition occurs.

A. Ice is warmed to the melting point. \_\_\_\_\_

\_\_\_\_\_ Temperature: \_\_\_\_\_

B. Water is warmed to the boiling point. \_\_\_\_\_

\_\_\_\_\_ Temperature: \_\_\_\_\_

C. Water is cooled to the freezing point. \_\_\_\_\_

\_\_\_\_\_ Temperature: \_\_\_\_\_

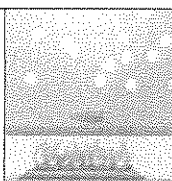
8. Extend your thinking: Click **Reset**. Set the **Water temperature** to 0 °C, the **Ice volume** to 0 cc, and **Add/remove heat energy** to -400 J/s. Click **Play** and wait until *all* the water freezes.

A. What volume of ice is created from 200 cc of water? \_\_\_\_\_

B. Why do water pipes sometimes burst in the winter? \_\_\_\_\_

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<b>Activity C:</b> <b>Altitude and phase changes</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Click <b>Reset</b>.</li> <li>• Set <b>Ice volume</b> to 0 cc.</li> <li>• Set the <b>Altitude</b> to 5,000 meters (16,404 feet).</li> </ul>	
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**Question: The altitude of a location is its vertical distance above sea level. How does altitude affect phase changes?**

1. Form a hypothesis: As altitude increases, the air pressure decreases. How do you think the lower pressure will affect the following? (Circle your answers.)

- |                    |          |               |          |
|--------------------|----------|---------------|----------|
| A. Freezing point: | Increase | Stay the same | Decrease |
| B. Melting point:  | Increase | Stay the same | Decrease |
| C. Boiling point:  | Increase | Stay the same | Decrease |

2. Experiment: Use the Gizmo to find the freezing, melting, and boiling points of water at 5,000 meters (16,404 feet). Write these values below.

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

3. Analyze: How did altitude affect the freezing, melting, and boiling points of water?

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4. Challenge: Try to explain these results based on the fact that air pressure decreases with altitude. If possible, discuss your ideas with your classmates and teacher.

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5. Apply: Why does pasta take longer to cook in the mountains? \_\_\_\_\_

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6. Apply: A pressure cooker allows food to be cooked under high pressure. Why is this useful?

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