



Name: _____

Date: _____

Student Exploration: Phase Changes

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

Prior Knowledge Question (Do this BEFORE using the Gizmo.)

Marla wants a hard-boiled egg for breakfast. The recipe says boil water, then lower the heat so the water is simmering. But Marla is in a rush, so she keeps the heat on high as the egg cooks.

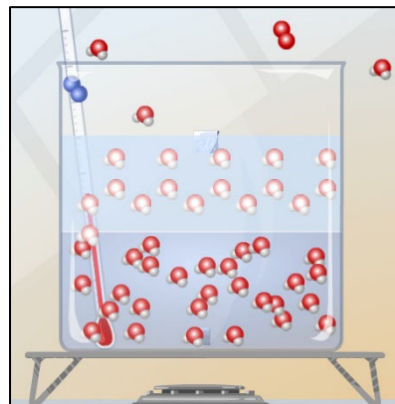
Do you think the egg will be done faster if the heat is kept on high as the water boils? _____

Explain your answer. _____

Gizmo Warm-up

In the *Phase Changes* Gizmo, select **Micro view**. Notice the nitrogen (blue), oxygen (red), and water (red and white) molecules.

To start, create ice. Set **Add/remove heat energy** to -200 J/s, click **Play** (▶), and then click **Pause** (⏸) when the container is about half ice, half water. Set **Add/remove heat energy** back to 0 J/s, and then click **Play**.



1. Observe water molecules in the **solid** (ice), **liquid** (water), and **gas** (air) phases.


- A. In which phase(s) do molecules move freely? _____
- B. In which phase(s) are molecules held together? _____
- C. What do you notice about the positions of the ice molecules? _____

When frozen, water molecules form a hexagon (six-sided shape) pattern.

2. Click **Reset** (↺), and select **Macro view**. Set the **Ice volume** to 25 cm³.

- A. In which phase(s) is water held in a defined shape? _____
- B. In which phase(s) does the water take the shape of the container? _____



Activity A: Phase changes	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> • Click Reset. Check that Macro view is selected. • Set the Water temperature to 20 °C. • Set the Ice volume to 0 cm³. 	
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Question: How is temperature related to phase changes?

1. Predict: Based on your prior knowledge, predict the following:
 - A. At what temperature will water change from a liquid to a solid (**freeze**)? _____
 - B. At what temperature will water change from a solid to a liquid (**melt**)? _____
 - C. At what temperature will water change from a liquid to a gas (**boil**)? _____

2. 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:
 - A. At what temperature does water freeze? _____ This is the **freezing point**.
 - B. At what temperature does ice melt? _____ This is the **melting point**.
 - C. At what temperature does water boil? _____ This is the **boiling point**.

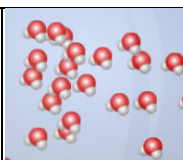
3. Observe: Set up the Gizmo to observe freezing. What do you notice about the temperature while the water is in the process of freezing? _____

4. Explore: Use the Gizmo to investigate melting and boiling. Does the temperature change while either of these phase changes is occurring? _____

5. 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?

6. 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.



Activity B: Temperature and molecular motion	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> • Click Reset, and select the Micro view. • Set Ice volume to 0 cm³. • Set Add/remove heat energy to 0 J/s. 	
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Question: Why do phase changes occur?

1. Compare: Set the **Water temperature** to 10 °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 **average molecular speed** of the water molecules is displayed below the container. Set the **Water temperature** to 0 °C and **Add/remove heat energy** to 500 J/s. Click **Play**.

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

B. Does the average 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 -10 °C and **Add/remove heat energy** to 100 J/s. Click **Play**. As the ice melts, 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 **Add/remove heat energy** to 500 J/s. Click **Play**. How does this situation compare to the previous one?

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.

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. _____

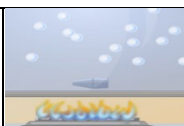
_____ Temperature: _____

8. Extend your thinking: Click **Reset**. Set the **Water temperature** to 20 °C and **Add/remove heat energy** to -500 J/s. Click **Play** and wait until *all* of the water freezes.

A. What volume of ice is created from 100 cm³ of water? _____

B. Why might it be a bad idea to put a glass container full of liquid in the freezer?



Activity C: Altitude and phase changes	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> • Click Reset. Check the Ice volume is 0 cm³. • Set the Altitude to 5,000 meters (16,404 feet). 	
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Introduction: Boxes of pasta have special instructions for people who live in the mountains. They are told to cook the pasta in boiling water a few minutes longer than normal.

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 increasing altitude affect the freezing, melting, and boiling points of water?

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.

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

6. Apply: A pressure cooker heats liquids at high pressure. Why do you think this is useful?

