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?

   _____

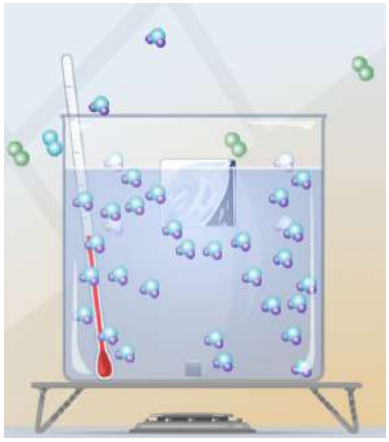
2. Spaghetti takes about 9 minutes to cook at sea level, but about 14 minutes in the mountains. Why do you think this is so?

   _____

   _____

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?

   _____

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

   _____

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? _____

   _____

Activity A: **Phase changes**	Get the Gizmo ready: • Click **Reset** ( ) and select **Macro view**. • Set the **Water temperature** to 10 °C. • Set the **Ice volume** to 0 cc.	

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? _____

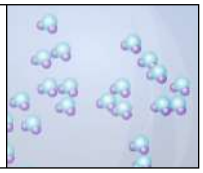
5. Interpret: Select the GRAPH tab to see a graph of temperature vs. time. Click the "–" button until the whole graph is visible. What does the graph look like during a phase change?

   _____

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**	Get the Gizmo ready: • Click **Reset**, and select the **Micro view**. • Set **Ice volume** to 0 cc. • Set **Add/remove heat energy** to 0 J/s.	

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?

_____

_____

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 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? _____

   _____

Activity C: **Altitude and phase changes**	Get the Gizmo ready: • Click **Reset**. • Set **Ice volume** to 0 cc. • Set the **Altitude** to 5,000 meters (16,404 feet).	

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?

   _____

   _____

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 allows food to be cooked under high pressure. Why is this useful?

   _____

   _____