1. Particles in an object are in constant random motion, called kinetic energy. This motion is in all directions at different speeds. **Describe** the motion of molecules and in the margin **draw** a picture of the particles in a:

   a. solid _________________________________________________________
      ___________________________________________________________

   b. liquid _________________________________________________________
      ___________________________________________________________

   c. gas ___________________________________________________________
      ___________________________________________________________

2. When a horseshoe is hot, it will bend very easily. When the horseshoe cools, it is rigid. Why is the horseshoe more malleable when it is hot than when it is cool?

   ____________________________________________________________
   ____________________________________________________________

**Materials Per Lab Group**

- ☐ 1 250 mL beaker
- ☐ ice
- ☐ 1 support and ring stand
- ☐ 1 thermometer clamp
- ☐ 1 thermometer
- ☐ 1 hot plate
- ☐ 1 stir rod
- ☐ apron for each student
- ☐ goggles for each student
- ☐ 1 hot mitt
- ☐ 1 beaker tong
Background

Energy is the ability to cause change. All the changes that occur around you involve the conversion of energy from one form to another. We have learned in previous lessons that all matter is made up of atoms, and these atoms are in constant motion. This energy of motion is called kinetic energy. Temperature is a measure of the average kinetic energy of the particles in an object. The faster the particles are moving, the more kinetic energy they have. Therefore, the more kinetic energy particles have, the higher the temperature of that object.

Lesson One: Observing Phase Changes as Temperature Increases

1. Insert a thermometer into the thermometer clamp.

2. Fill a 250 mL beaker half-full with ice.

3. Place the beaker onto a hot plate and insert the mounted thermometer into the ice. Do not allow the thermometer to touch the bottom of the beaker.

4. After 1 minute record the initial temperature for the ice in Table A.

5. Turn the hot plate on to about a setting of “8” and start the stopwatch. As the water heats, stir constantly with the stir rod.

6. Without removing the thermometer, measure the temperature every 30 seconds as the ice melts, the water heats, and then begins to boil. Record all temperatures in Table A.

7. Circle on the Table A the temperature when the ice is completely melted, and then circle the temperature at which the water is steadily boiling.

8. Turn off the hot plate and allow the beaker to cool before removing it with beaker tongs and a hot mitt. Remember to remove the thermometer before trying to remove the beaker from the hot plate.

9. While the water is cooling, graph the temperature data on Graph A.

10. After finishing the graph, clean up the lab station by pouring the cooled water down the drain.
Table A: Change in Temperature Over Time

<table>
<thead>
<tr>
<th>Time (Minutes)</th>
<th>Initial</th>
<th>0.5</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>4.0</th>
<th>4.5</th>
<th>5.0</th>
<th>5.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp (°C)</td>
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<tr>
<td>Time (Minutes)</td>
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<td>6.5</td>
<td>7.0</td>
<td>7.5</td>
<td>8.0</td>
<td>8.5</td>
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<td>9.5</td>
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<td>10.5</td>
<td>11.0</td>
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<tr>
<td>Time (Minutes)</td>
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<td>12.5</td>
<td>13.0</td>
<td>13.5</td>
<td>14.0</td>
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<td>16.0</td>
<td>16.5</td>
<td>17.0</td>
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<tr>
<td>Temp (°C)</td>
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</tr>
<tr>
<td>Time (Minutes)</td>
<td></td>
<td>18.0</td>
<td>18.5</td>
<td>19.0</td>
<td>19.5</td>
<td>20.0</td>
<td>20.5</td>
<td>21.0</td>
<td>21.5</td>
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<td>22.5</td>
<td>23.0</td>
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</tbody>
</table>

**Background**

A **change of state of matter** is the conversion of a substance from one physical form to another. It is important to remember that all changes of state are physical changes since the characteristics of the substance do not change. There are five basic changes of state of matter: melting, freezing, vaporization, condensation, and sublimation. When most substances lose or absorb energy, one of two things happens: its temperature changes or its state changes.

Temperature of an object is a measure of the average kinetic energy of these molecular particles. Therefore, temperature and kinetic energy are related. As energy is added to a substance, the temperature of the substance will increase, because the speed of the particles in random motion increases. Therefore, when energy is taken away from a substance the temperature of the substance will decrease.

If a substance is going through a change of state, its temperature does not change until the change of state is complete. For example, water changing from a solid to a liquid remains at the melting point (temperature) until the entire solid has melted. In the same way, when water is changing from a liquid to a gas, the temperature of the water will remain at the boiling point, until all of the liquid has changed to steam.

A graph showing the state change of water is called a heating curve because it shows the temperature changes of water as thermal energy (heat) is added. The temperature remains the same because all of the energy is used to overcome the attractive forces between the particles. The temperature remains constant during melting. After the attractive forces are broken, particles move more freely and their average kinetic energy, or temperature, increases. At boiling, 100°C, water is vaporized and the temperature remains constant once again. All of the energy goes to overcoming the remaining attractive forces between the water molecules. After the attractive forces are broken, particles move more freely and their average kinetic energy, or temperature, increases.
Graph A: Create a line graph showing the effect of time on the temperature of water. Use data from Table A to create the graph.
   a. Determine which variable is the independent variable and which is the dependent variable. Label each axis appropriately. Title the graph.
   b. **Draw** a line to show the change in temperature of water over time.

Analysis
1. According to your data, at what temperature is water in the form of ice? _________________________
2. According to your data at what temperature does water boil? _____________________________
3. Look at the graph of your data. At approximately what temperature did your ice completely melt? ____________________________________________
List three things that you learned about temperature and change of state.

a. ______________________________________________________________________

b. ______________________________________________________________________

c. ______________________________________________________________________

d. ______________________________________________________________________

1. What evidence shows a “change of state” requires the use of the heat energy that would otherwise have caused the temperature to increase?

   ______________________________________________________________________

   ______________________________________________________________________

2. If the process of melting absorbs heat energy from the surroundings, then hypothesize what would the process of freezing will do?

   ______________________________________________________________________

3. Look at Graph A. What happens to the temperature as the solution:
   a. completes melting? ______________________________________________________________________
   b. is boiling continuously? ______________________________________________________________________
4. In the graph below, a vapor is forming at D. What is happening: at A, at B, and at C? Is this substance water? Explain your answer.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
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