Answer Key: Atoms in Motion

Background
In this activity you will develop your understanding about how and why matter exists in three forms on Earth (solid, liquid, gas) and what causes matter to change from one form to another. You will explore how particles behave in the different states of matter. Then you will discover how thermal energy effects the interactions and behavior of these particles in the three states of matter. You will also observe that particles are in constant motion and that this motion changes with the addition of or removal of thermal energy.

Prelab Questions
1. What are the states of matter?
   Solid, liquid, gas

2. Have you ever seen a solid turn into a liquid? Provide an example:
   Yes, example: ice melting; anything melting.

3. Have you ever seen a liquid turn into a gas? Provide an example:
   Yes, example: steam produced when cooking.

4. Have you ever seen a liquid turn into a solid? Provide an example:
   Yes, example: substance freezing, water freezing to ice.

5. Have you ever seen a gas turn into a liquid? Provide an example:
   Yes, example: water vapor condensing on the side of a glass.

Driving Question
What is the effect of thermal energy on the atoms/molecules in a sample of matter?

Make your Claim:
Answers will vary. Example: Increasing thermal energy will increase the motion of particles in a sample. Decreasing thermal energy will decrease the motion of particles in a sample.

Exploration
1. Click on the link for the PhET Interactive Simulation: States of Matter Basics
2. The below screen will open and you will need to click on “States”.

3. Now you should see different types of atoms and molecules to explore on the upper right-hand side. There is neon, argon, oxygen, and water.
4. Under the *Atoms and Molecules* header, there are boxes, each marked “Solid, Liquid, Gas”, click on one and watch as the atoms and molecules change to represent that state of matter.

5. First click the “neon” button, then the solid button and increase the heat and observe what happens to the particles. Then decrease the heat and observe what happens to the particles. Observe the temperature as well.

6. Record your observations for Neon in the data table below.

7. Repeat step 4 for the argon, oxygen, and then water.

8. Change the state of matter and repeat step 4 for each state.

**Observations: Complete the table for Neon**

<table>
<thead>
<tr>
<th>State of Matter</th>
<th>Sketch 10 atoms the way they appear</th>
<th>Does the group of atoms have a fixed shape? YES/NO</th>
<th>Are the atoms vibrating? YES/NO</th>
<th>Are the atoms changing location? YES/NO</th>
<th>Rank the speed of the particles 1=slowest 2=mid 3=fastest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solid</strong></td>
<td>Close together</td>
<td>Yes</td>
<td>Yes</td>
<td>No, not within the sample</td>
<td>1</td>
</tr>
<tr>
<td><strong>Liquid</strong></td>
<td>More space between</td>
<td>No</td>
<td>Yes, but faster than solid</td>
<td>Yes</td>
<td>2</td>
</tr>
<tr>
<td><strong>Gas</strong></td>
<td>Most space</td>
<td>No</td>
<td>No, moving faster</td>
<td>Yes</td>
<td>3</td>
</tr>
</tbody>
</table>

**Analysis**

1. Choose oxygen from the *Atoms & Molecules* list and then choose solid as the state of matter. Record the temperature shown: -242°C

2. Describe the motion of the oxygen molecules in complete sentences. What are they doing? How fast are they moving? How are the molecules arranged?  
   The oxygen molecules are moving/vibrating very slowly. *Note that oxygen exists as a diatomic molecule (pairs of atoms), and the sample of molecules is retaining its shape.
3. Heat the oxygen molecules until the temperature is around 74 K or -200°C. How did this affect the motion of the oxygen molecules? Explain in complete sentences. The oxygen molecules increased their speed as the temperature increased. The melting point of oxygen is -218°C, so it is now evident that the sample is behaving like a liquid rather than a solid.

4. Did the oxygen change state as you heated the molecules? Explain how you know in complete sentences.
Yes it did. The molecules in the sample are moving faster, the space between the molecules has increased, and the sample is no longer retaining its shape.

5. Heat the oxygen molecules until the temperature is around 194 K or -80°C. How did this affect the motion of molecules? Explain in complete sentences. The particles are now moving much faster, and have increased the distance between molecules. The sample is now a gas.

6. Now choose water as the molecule type and add heat to the system by adjusting the heat at the bottom of the simulator. Once the temperature is at its highest point, make a drawing and write your observations about the behavior of the molecules.

<table>
<thead>
<tr>
<th>Drawing</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water Molecules are moving very quickly, colliding with one another and the container.</td>
</tr>
</tbody>
</table>

7. Now remove heat from the system by controlling the heat at the bottom of the simulator. Once the temperature is at its lowest point, make a drawing and write your observations about the behavior of the molecules.

<table>
<thead>
<tr>
<th>Drawing</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The speed of the Water Molecules decreased significantly, they are vibrating as a solid.</td>
</tr>
</tbody>
</table>

**Conclusion**
Based on your data, what can you conclude about the different states of matter and how each atom or molecule changed as the temperature changed? Write your conclusion in CER (Claim, Evidence, Reasoning) format.

**Answers will vary**

Re-read your conclusion:
- Did you restate your claim?
- Did you include all your evidence?
- Did you end with your reasoning?