**STATES OF MATTER WEBQUEST**

**Learning Goals:** At the end of this web-quest, you should be able to successfully...

1. Describe the various states of matter in terms of the motion and arrangement of the molecules (atoms) making up the substance (C2.2B).
2. Explain changes in pressure, volume, and temperature for gases using the kinetic molecular model (C2.2c).
3. Determine processes you could use to make solids, liquids and gases change phases.
4. Compare and contrast the behavior of the 4 substances in the simulation and use their understanding about molecules to explain their observations.
5. Recognize that solids have a more ordered, regular arrangement of their particles than liquids and that liquids are more ordered than gases (C4.3B).
6. Describe melting on a molecular level (C3.3B).

**ACTIVITY #1: PARTICLE CHARACTERISTICS**

**Steps:**

2. Click on the <Gas> button. The compound should melt and then begin to boil. On the right, inside the gray circle, you will notice a microscopic representation of the gas particles. Discuss what you see in terms of particle size, particle motion, particle energy, and particle density of the gas.
   - Particle Size: SMALL
   - Particle Motion: Rapid
   - Particle Energy: HIGH
   - Particle Density: LOW

3. Now, click on <Liquid>. The substance should stop boiling. Record what you notice about the particles in the liquid. How are the particles behaving differently/the same as the gas was?
   - Still small particles, still moving
   - Not as rapid, not as much energy, very dense.
Finally, click on <Solid>. The substance should turn into a solid.
Record the microscopic properties of the particles in the solid.

Wait! You mean to tell me the particles making up my desk, text book, and pen are actually moving?!?!?!? The answer is Yes. They are vibrating ever so slightly!

**ACTIVITY #2: SOLID, LIQUID, GAS SIMULATION**

Steps:

2. Click the green box that says <Run Now>.
3. At the top, click on the <Teacher> tab and change the temperature from Kelvin to Celsius.
4. I know right now you are tempted to play around with the simulation (that is if you haven’t already). So, go ahead. Take a brief minute to experiment with it. Change the substances, change the state of matter, add heat or cool down the container.
5. Well that was fun now wasn’t it. Now, down to business. Click the box on the lower left of the simulation that says <Reset All>. If at any time, you make a mistake, remember you can click this button and everything will reset to the default setting.
6. Write in the temperatures at which Neon, Argon, Oxygen, and Water exist as a solid, liquid, and gas (use the presets on the right hand side and record the temperatures).

<table>
<thead>
<tr>
<th>Atom or Molecule</th>
<th>Solid</th>
<th>Liquid</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neon</td>
<td>-264 °C</td>
<td>-247 °C</td>
<td>-219 °C</td>
</tr>
<tr>
<td>Argon</td>
<td>-239 °C</td>
<td>-187 °C</td>
<td>-84 °C</td>
</tr>
</tbody>
</table>
Oxygen | -242°C | -204°C | -79°C |
Water  | -110°C | 55°C  | 5 36°C |

7. Why do you think, based on what we've learned this year, that neon, argon, and oxygen exist as gases at such lower temperatures than water? (2-3 sentences)
   **Intermolecular attractive forces**

8. Click <Reset All>. The solid state of Neon should be depicted. You might expect the molecules of a solid to be stagnant, but what do you actually see?
   **Vibration**

9. Click and drag the slide bar under the container down to <Cool> and hold it there. What do you notice about the movement of the atoms in the container as you decrease the temperature?
   **Less vibration**

10. Can you decrease the temperature to a point where the atoms stop moving? ✗

    If so, record that temperature: **-273°C**

    What is the name for this temperature? **Absolute 0°C**

    Has this temperature ever been achieved in a lab? (Don't guess! Go out and search the web. Provide your answer and where you found it.)
    **No!**
11. Now, increase the temperature by sliding the bar up to <Heat> and holding it there. As you start to see the temperature increase, what do you notice about the movement of the atoms? 

More movement

12. **Fill in the blank:**

**Temperature** is a measure of the average kinetic energy of the particles in a sample of matter.

13. As you increase the temperature inside the container, the number of **elastic collisions** between gas particles increases. What is meant by an 'elastic collision'?

No net loss of energy

14. Now, click <Reset All> and press the <Pause> button. Take a mental picture of what solid neon looks like. Next, click <Play> and change the molecule to <Water>. Press <Pause> again. Note at least two differences you observe between solid neon and solid water:

- Water is not as compacted, has space between molecules.
- Neon is 9 times more dense than 3 atoms.

15. **Define Density:**

Mass/Unit Volume (g/L)

16. Click <Reset All>. Compare solid neon to liquid neon by clicking back and forth between <solid> and <liquid>.

Which is more dense: liquid neon or solid neon? **Solid**

17. Click <Water>. Now, compare solid water to liquid water by clicking back and forth between <solid> and <liquid>.

Does the number of particles in the container change? **No**

Which takes up more space in the container: solid or liquid water? **Solid**

So... which is more dense: liquid water or solid water? **Liquid**
What does this tell us about the properties of water?

*Warning: Do not exit the simulation*

**ACTIVITY #3: PHASE DIAGRAMS**

Steps:

1. At the top of the page, change the tab from <solid, liquid, gas> to <Phase Changes>. You'll notice a different layout. We now have the ability to adjust the temperature, volume, and pressure in the container. Take a minute to experiment with the new options. By moving the lever up and down on the pump to the right we can add more molecules to the container. Moving the finger up and down changes the size (volume) of the container while the heating/cooling method remains the same at the bottom.

2. After a minute, click <Reset All> to return to the default setting.

3. **Volume**: As you move the finger down into the container decreasing its volume, slowly make contact with the solid Neon atoms (Don't go too far down!). Record what happens to the solid Neon atoms:

   [spread out]

   [spread out]

   [spread out]

What happens to the pressure in the container? **goes up**

Continue to move the lid down. **Whoa! What happened?**

**Why did this occur?**

[too much pressure]
4. **Temperature**: Click <Reset All>. Use the slide bar at the bottom to increase the temperature in the container. What do you notice happens to the pressure gauge as you increase the temperature?

   [Space for input]

   Why does this happen?

   [Space for input]

5. **Pressure**: Click <Reset All>. What do you hypothesize will happen to the pressure of the container if you add more atoms?

   [Space for input]

   Use the finger to move the lid down almost half way. Begin pumping atoms into the container and watch the pressure gauge on the left side. Was your assumption about the pressure correct? Yes

6. Click <Reset All>. On the far right click <phase diagram> and a graph should appear.

   Phase diagrams are a graph of **Temperature** vs. **Pressure**

7. Now, slowly add heat to the system by sliding the bar up located underneath the container. Watch the red dot on the phase diagram begin to rise up the graph. When it reaches the dot that says 'triple point' STOP!

   While the red dot is covering the triple point dot on the graph, record what is happening with the Neon atoms in the container.
Use your textbook to look up the definition of triple point.

**Triple point:**

*3 phases can coexist*.

Hopefully the definition helps clarify what is happening to the atoms in the container.

8. Add more heat to the container and watch the red dot continue to rise. When it reaches the dot labeled 'critical point' STOP!

Record what is happening inside the container.

*At pressure, atoms moving faster like gas*.

Use your textbook to look up the definition of critical point.

**Critical point:**

*Below stable liquid+vapor coexistence*.

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**ACTIVITY #4: MELTING AND BOILING**

Steps:

2. Click on the first of the three substances (the white one).
3. The substance will be placed on the hotplate and a graph will appear.
   - What variable is on the Y-axis of the graph?
4. This substance melted at \( 20^\circ\text{C} \) and boiled at \( 100^\circ\text{C} \).
5. Based on the melting and boiling points, can you guess what substance this is? ______
6. Next, click on the middle substance (the purple one).
7. This time, pay close attention to the graph AS the substance is changing from solid to liquid and from liquid to gas. As the substance is physically melting, is the temperature increasing, decreasing, or staying the same? (Refresh the page and redo the experiment if you missed it.)
8. As the substance is boiling, does the temperature increase, decrease, or stay the same?
9. This substance melted at \( 47^\circ\text{C} \) and boiled at \( 75^\circ\text{C} \).
10. Click on the final substance (the green one).
11. This substance melted at \( 70^\circ\text{C} \) and boiled at \( 70^\circ\text{C} \).

Big Concept: When a solid melts, the temperature of the solid and the liquid being produced remains constant. Once the entire solid has melted, additional energy (heat) added to the system increases the kinetic energy of the liquid molecules. The temperature then begins to rise again. (Did you answer #7 & #8 correctly?)

**ACTIVITY #5: PHASE CHANGES**

Steps:

1. Matter changes phase when \( \text{Heat} \) is added or removed.
2. Click on the links below one at a time. After viewing the picture, determine which phase change is occurring in the picture. Fill in Diagram 1 below after each picture as well.
3. Pictures:
   a. [Link](http://mmp.bz/FXhWU)
      What phase change(s) is occurring in the picture? ______
b. http://mrg.bz/pcePh
What phase change(s) is occurring in the picture?

condensation

What phase change(s) is occurring in the picture?

deposition

gas $\rightarrow$ solid

solid $\rightarrow$ gas

sublimation
Diagram 1: Phase Changes
ACTIVITY #6: OTHER STATES OF MATTER???
(Chem B Required; Chem B Optional)

1. Over the last hundred years, there have been other states of matter
discovered beyond the typical solid, liquid, gas, and plasma states of matter
that we are most familiar with. Search the web for a 5th or 6th state of matter
that you haven't heard of before. Write a brief paragraph describing this
state of matter, how it was discovered, and why you think it
deserves/doesn't deserve to be classified as a specific state of matter. Don't
forget to cite your sources at the bottom.

Sources:

*Still need more help with States of Matter and Phase Changes?