

States of Matter — Simulation Lab Worksheet

Name: _____ Class: _____ Date: _____

Open the free **States of Matter** simulation by PhET (eolclassroom-online.com/classroom-simulations/ or phet.colorado.edu). Remember: temperature in kelvin (K) = temperature in °C + 273.

Part A — Solid, liquid, gas (States screen)

For each substance, click **Solid**, **Liquid** and **Gas** in turn. Watch the particles for 10 seconds each time.

State	How are the particles arranged?	How do they move?	Do they fill the container?
Solid			
Liquid			
Gas			

1. What stays the same about the particles when a substance changes state? What changes?

2. Choose **Neon** and click Solid. What temperature does the thermometer show? Convert it to °C.

Part B — Heating and cooling

Choose **Argon** and click **Solid**. Move the slider on the bucket slowly toward **Heat**. Watch the thermometer and the particles.

3. Describe what happens to the particles as you heat the solid.

4. At about what temperature did the argon melt? At about what temperature did it boil?

Melting: _____ K Boiling: _____ K

5. Now cool the gas with the **Cool** setting. What happens to the particles? What is this change called?

6. Repeat the heating test with **Water**. Does water melt and boil at a higher or lower temperature than argon? Suggest a reason.

Part C — Pressure and phase changes (Phase Changes screen)

Choose **Neon** and heat it until it becomes a gas. Watch the **pressure gauge** at the top left.

7. Push the lid down with the finger. What happens to the pressure? Explain using particles.

8. Add more particles with the **pump**. What happens to the pressure? Why?

9. Heat the gas without changing the volume. What happens to the pressure? Why?

10. Watch the red dot on the **Phase Diagram** as you heat and compress. Label what the triple point and the critical point mean.

Triple point: _____

Critical point: _____

Part D — Why particles stick together (Interaction screen)

11. On the **Interaction** screen, drag one atom toward the other. Describe the force when the atoms are far apart, at a medium distance and very close together.

12. Look at the potential energy graph. Where is the potential energy lowest? Why do atoms in a solid sit about this far apart?

13. Increase the **interaction strength (ϵ)**. Predict how this would change a substance's melting and boiling points.

Part E — Apply it

14. Explain, using particles and energy, why a puddle disappears on a warm day even though the water never reaches 100 °C.

Answer Key (Teacher Copy)

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Temperatures shown in the simulation come from a simplified model, so student values may differ from the real ones listed here. Accept answers that are close to the values the simulation shows.

Part A

State	Arrangement	Motion	Fills container?
Solid	Tightly packed in a regular pattern	Vibrate in place	No, keeps its own shape
Liquid	Close together, no fixed pattern	Slide past each other	Takes the shape of the bottom of the container
Gas	Far apart, random	Move fast in straight lines until they collide	Yes, spreads out to fill it

1. The particles themselves (their number and type) stay the same. Their arrangement, spacing, speed and energy change.
2. About 14 K in the simulation. $14\text{ K} = 14 - 273 = -259\text{ }^{\circ}\text{C}$.

Part B

3. The particles vibrate faster and faster, then break out of their fixed positions and slide around (melting), then fly apart (boiling).
4. Real argon melts at about 84 K and boils at about 87 K. The simulation's values will be close to this.
5. The particles slow down and come closer together, forming a liquid: condensation. Further cooling gives freezing.
6. Higher (real water melts at 273 K and boils at 373 K). Water molecules attract each other much more strongly (hydrogen bonding), so more energy is needed to separate them.

Part C

7. The pressure increases. The same particles are squeezed into a smaller space, so they hit the walls more often.
8. The pressure increases, because more particles collide with the walls each second.
9. The pressure increases, because the particles move faster and hit the walls harder and more often. (If it rises too far, the lid blows off.)

10. Triple point: the temperature and pressure where solid, liquid and gas can exist together. Critical point: above this temperature and pressure, liquid and gas can no longer be told apart.

Part D

11. Far apart: almost no force. Medium distance: attraction pulls them together. Very close: strong repulsion pushes them apart, because their electron clouds overlap.
12. At the bottom of the "well" in the graph, the balance point between attraction and repulsion. Particles settle at the distance where their energy is lowest.
13. Stronger attraction means more energy is needed to pull particles apart, so the melting and boiling points rise.

Part E

14. Evaporation: at any temperature, some water molecules at the surface move fast enough to escape into the air. Warmth gives more molecules that much energy, so the puddle evaporates faster. Boiling only happens throughout the liquid at 100 °C (at normal air pressure).