12 States of Matter

4 Phase Changes

**MAIN IDEA**
Write the Main Idea for this lesson.

Matter changes phase when energy is added or removed.

**REVIEW VOCABULARY**
phase change

**NEW VOCABULARY**
melting point
vaporization
evaporation
vapor pressure
boiling point
freezing point
condensation
deposition
phase diagram
triple point

Recall the definition of the Review Vocabulary term.

phase change a change from one state of matter to another

Define each New Vocabulary term.

melting point The temperature at which the forces holding the crystal lattice together are broken so that the solid becomes a liquid is called the melting point.

vaporization Vaporization is the process by which a liquid changes to a gas or vapor.

evaporation When vaporization occurs only at the surface of a liquid, this is called evaporation.

vapor pressure the pressure exerted by a vapor over a liquid

boiling point the temperature at which the vapor pressure of a liquid equals the external or atmospheric pressure

freezing point The freezing point is the temperature at which a liquid is converted to a crystalline solid.

condensation process by which a gas or a vapor becomes a liquid

deposition process by which a substance changes from a gas or vapor to a solid without first becoming a liquid

phase diagram a graph of pressure versus temperature that shows in which phase a substance exists under different conditions of temperature and pressure

triple point The point on a phase diagram that represents the temperature and pressure at which three phases of a substance can coexist is the triple point.
Classify the types of phase changes by completing the table below. Use Figure 23 in your text for reference.

<table>
<thead>
<tr>
<th>Phase Transition</th>
<th>Type of Transition</th>
</tr>
</thead>
<tbody>
<tr>
<td>gas to solid</td>
<td>deposition</td>
</tr>
<tr>
<td>solid to liquid</td>
<td>melting</td>
</tr>
<tr>
<td>liquid to gas</td>
<td>vaporization</td>
</tr>
<tr>
<td>liquid to solid</td>
<td>freezing</td>
</tr>
<tr>
<td>gas to liquid</td>
<td>condensation</td>
</tr>
<tr>
<td>solid to gas</td>
<td>sublimation</td>
</tr>
</tbody>
</table>

Describe the phase changes that require energy by completing the following outline.

I. Melting
   A. Heat energy disrupts **hydrogen bonds**
   B. The amount of energy required depends on **the strength of the bonds**
   C. The melting point is the temperature at which a crystalline solid becomes a liquid
   D. The melting point of **amorphous substances** may be unspecified.

II. Vaporization
   A. In liquid water, some particles have more **energy**
   B. Particles that escape from liquid enter the **gas phase**
   C. When vaporization occurs only at a surface it is called **evaporation**
   D. The pressure exerted by a vapor over liquid is called **vapor pressure**
   E. The temperature at which vapor pressure equals atmospheric pressure is called the **boiling point**

III. Sublimation
   A. Many solids can become gases without **entering the liquid phase first**
   B. Some solids sublime at **room temperature**
   C. The process of **freeze drying** is an example of sublimation.
4 Phase Changes (continued)

Use with pages 428–429.

GET IT? Describe what happens to the particles in the shaded portion on the graph.

The particles enter the vapor phase.

Organize the phase changes that release energy. Identify the phase, describe the process, and identify the reverse process by completing the table below.

<table>
<thead>
<tr>
<th>Phase Change</th>
<th>Process Description</th>
<th>Reverse Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>condensation</td>
<td>process by which a gas or vapor becomes a liquid</td>
<td>vaporization</td>
</tr>
<tr>
<td>freezing</td>
<td>process in which a liquid becomes a solid</td>
<td>melting</td>
</tr>
<tr>
<td>deposition</td>
<td>process by which a gas becomes a solid without ever becoming a liquid</td>
<td>sublimation</td>
</tr>
</tbody>
</table>

GET IT? Describe the condensation of water vapor in the atmosphere.

Water in the air condenses on condensation nuclei when it rises or passes over cooler land or water.

Explain how the critical point affects water.

The critical point is the critical pressure and critical temperature above which water cannot exist as a liquid. Water vapor at critical temperature cannot be changed into a liquid if pressure is increased.
Identify normal freezing point, normal boiling point, critical point, and triple point in the phase diagram for H₂O below. Use Figure 30 in your text for reference.

**Phase Diagram for H₂O**

- **Normal freezing point**
- **Normal boiling point**
- **Critical point**
- **Triple point**

**GET IT?** Determine the phase of water at 2.00 atm and 100.00°C.

**GET IT?** Contrast the slope of the red line in water’s phase diagram with that of the red line in carbon dioxide’s phase diagram. How do water and carbon dioxide differ in their reaction to increased pressure at the solid/liquid boundary?

At high pressures, water will form a solid at lower temperatures. This is not true for carbon dioxide.
4 Phase Changes (continued)

REVIEW IT!

27. **MAIN IDEA** Explain how the addition or removal of energy can cause a phase change.

The addition of energy increases the kinetic energy of the particles, which reduces the intermolecular forces between the particles. As energy is removed, the kinetic energy of the particles decreases and intermolecular forces increase.

28. Explain the difference between the processes of melting and freezing.

Freezing occurs when a liquid becomes a solid and energy is released. Melting requires an input of energy to convert a solid to a liquid.

29. Compare deposition and sublimation.

A substance undergoes deposition when it goes from the vapor phase to the solid phase without going through the liquid phase. A substance undergoes sublimation when it goes from the solid phase directly to the vapor phase without going through the liquid phase.

30. Compare and contrast sublimation and evaporation.

In both processes, the substances become a vapor. During sublimation, the substance goes from the solid phase directly to the vapor phase. During evaporation, particles in a liquid gain enough energy to enter the vapor phase.

31. Describe the information that a phase diagram supplies.

the combinations of temperature and pressure under which a given substance exists as a solid, liquid, and/or gas

32. Explain what the triple point and the critical point on a phase diagram represent.

**Triple point:** the temperature at which the three phases of a substance can coexist; **critical point:** the pressure and temperature above which a substance cannot exist as a liquid.

33. Determine the phase of water at 75.00°C and 3.00 atm using Figure 29.

liquid