Changes of State Name _____ Mod ____

Directions: Use the reading packet "Chem Talk" to find the answers below.

1. How is the movement of a particle related to its energy?

   _____

2. How is temperature related to kinetic energy?

   _____

3. What happens to the heat energy during a phase change in which heat is added but the temperature does not increase?

   _____

4. Does water always boil at the same temperature? Explain.

   _____

5. Identify the name for each change of state below.

   a) liquid to gas = _____

   b) solid to liquid = _____

   c) solid to gas = _____

   d) liquid to gas = _____

6. What happens to the temperature of a material when it is undergoing a change of state? _____

7. Use the diagram on pg. 19 to answer the following questions.

   a) What is the difference between endothermic and exothermic?

      _____

   b) Identify each change of state as endothermic or exothermic.

      Melting _____ vaporization _____

      Freezing _____ condensation _____

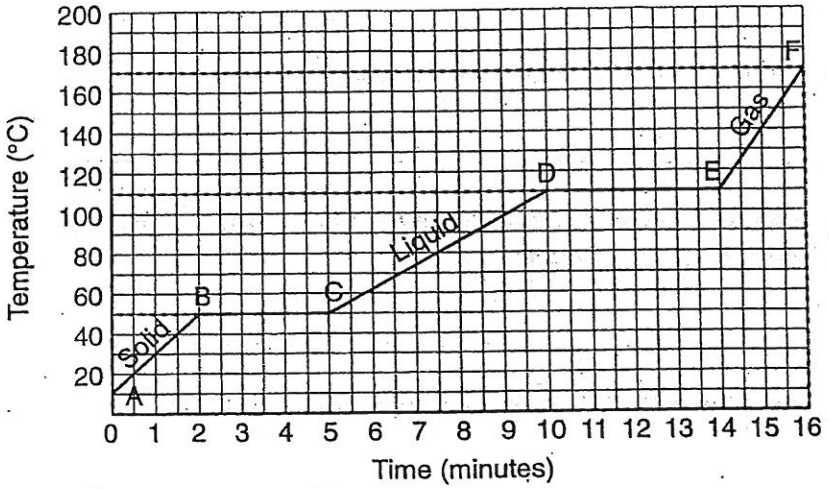
NAME _____ DATE _____ CLASS _____

REINFORCEMENT Chapter 8

Changes in State

Text Pages 200–203

Look carefully at the graph. It was drawn from the data collected when a substance was heated at a constant rate. To heat at a constant rate means to add heat evenly as time passes. Use the graph to complete the paragraphs that follow.



At the start of observations, Point A, the substance exists in the _____ state. The temperature at this point is _____. As energy is _____, the temperature of the substance rises at a constant rate for two minutes. At Point B, the temperature is _____, and the solid begins to _____. The temperature remains constant until the change from solid to _____ is complete. It has taken three minutes to add enough energy to melt the solid completely. From Point C to Point D, the substance is in the _____ state. Its temperature rises at a constant rate to _____. The temperature remains constant while the liquid changes to a _____. At Point E, the substance exists as a _____. Its temperature rises _____ as energy is added.

When the gaseous substance is allowed to cool, it _____ energy. The cooling curve will be the reverse of the warming curve. Energy will be released as the substance changes from a _____ to a _____ and also from a _____ to a _____. The amount of energy released during condensation will be the same as the amount _____ during vaporization.

ChemTalk

CHANGES OF STATE

All matter is made up of tiny particles. Different materials are made of different kinds of particles. These particles are always moving, and there are spaces between them. The more energy the particles have, the faster they move. There are also attractive forces among the particles. The closer the particles are together, the greater are the attractive forces.

Temperature

Chem Words

temperature: an (indirect) measure of the average kinetic energy of particles of a material.

kinetic energy: a form of energy related to the motion of a particle.

Temperature is a measure of how hot or cold something feels to your skin. Your body is at 37°C (98.6°F). When something with a higher temperature comes in contact with your skin, you know that it is "hot." When something with a lower temperature comes in contact with your skin, you know that it is "cold." As you observed in the activity, when the temperature of air increased, the drop of water lifted. This drop of water could be a crude thermometer. As the drop rises, you know that the temperature of the air is higher. Liquids like alcohol and mercury expand when they get hot and are used for the thermometers with which you are most familiar.

The movement of the water drop gives you an insight into another interpretation of temperature. The air molecules inside the tube were moving faster as the temperature of the air increased. The temperature of the air is a measure of the speed of the molecules. In physics, you learned that kinetic energy is related to speed. **Kinetic energy** is equal to one-half the mass times the square of the speed of the particles ($KE = \frac{1}{2}mv^2$). Observing the behavior of many gases, scientists have concluded that temperature is a measure of the average kinetic energy of the molecules.

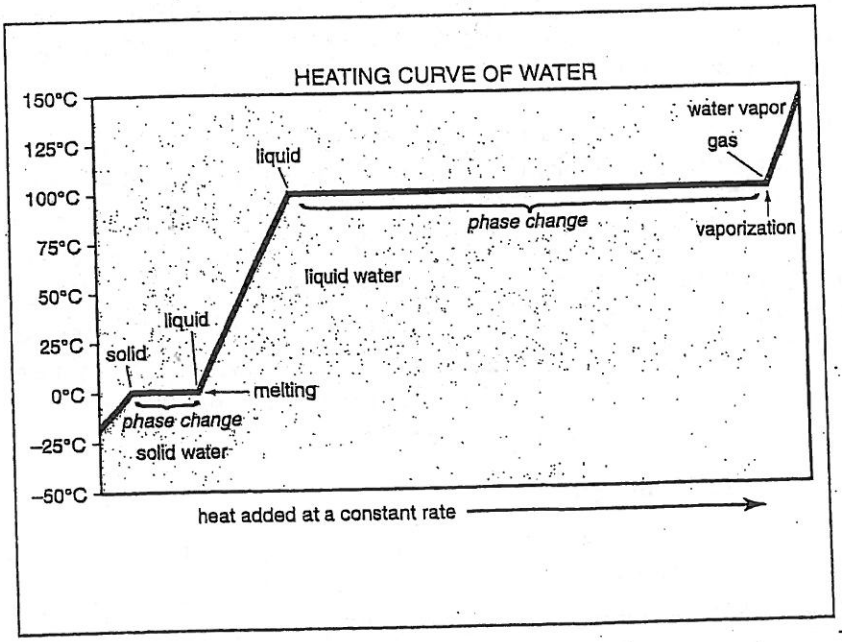
Melting and Boiling Points

In this activity you started with a beaker of crushed ice that was at a temperature less than 0°C. As you heated the ice it did not initially melt, but the temperature of the ice began to rise. As the temperature of any solid increases, the average kinetic energy (energy of motion) of the particles of the material increases.

This motion is mainly a vibration-type motion where the molecules vibrate around a fixed location. As you continued to add heat, the temperature of the ice increased until it reached 0°C. This is called the **normal melting point** of water. It is the temperature at which water changes from a solid to a liquid state at 1 atm (atmospheric pressure at sea level). It is also the **normal freezing point** of water, when water changes from a liquid to a solid at 1 atm. Each material has its own characteristic normal melting/freezing point.

The temperature then remained at about 0°C as the solid water changed to a liquid. Since the temperature remained constant, the average kinetic energy did not change. All the heat energy that was added caused a phase change during which the molecules of water were rearranging or separating. There was a change in the **potential energy**. If there is a change in kinetic energy you will see a change in temperature and if there is a change in potential energy, the temperature will remain constant while heat energy is added to a material.

When all of the water had melted at 0°C, the temperature of the liquid water increased until it reached 100°C. This is called the **normal boiling point** of water at 1 atm.



Chem Words

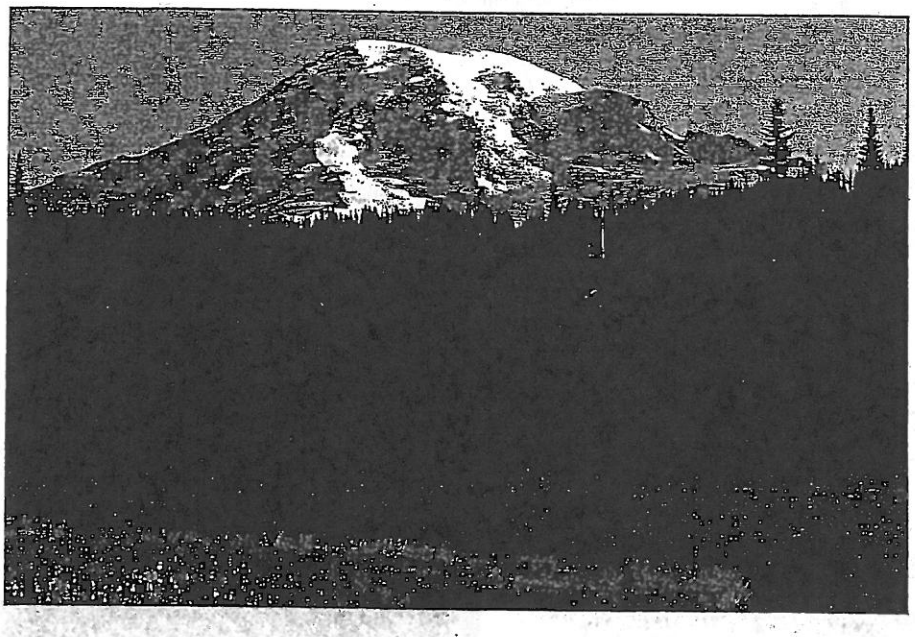
normal melting point: the characteristic temperature, at 1 atm, at which a material changes from a solid state to its liquid state.

normal freezing point: the characteristic temperature, at 1 atm, at which a material changes from a liquid state to its solid state.

potential energy: a stored form of energy of a material that depends on the relative position of the particles.

normal boiling point: the characteristic temperature, at 1 atm, at which a material changes from a liquid state to its gaseous state.

If the atmospheric pressure is less than 1 atm, then the water will boil at less than 100°C and is just called the boiling point of the liquid. For example, on Mt. Rainier in Washington State, at an altitude of about 4393 m (14,411 ft), the atmospheric pressure is much less than 1 atm, and you would find that water boils at a lower temperature.



When the water arrived at the boiling point, you again noted that the temperature remained the same, even though you were still adding heat. The temperature would remain the same until all of the liquid is **vaporized.** Then, with additional heat, the temperature would again increase and the gas molecules of water would have greater average kinetic energy.

Chem Words

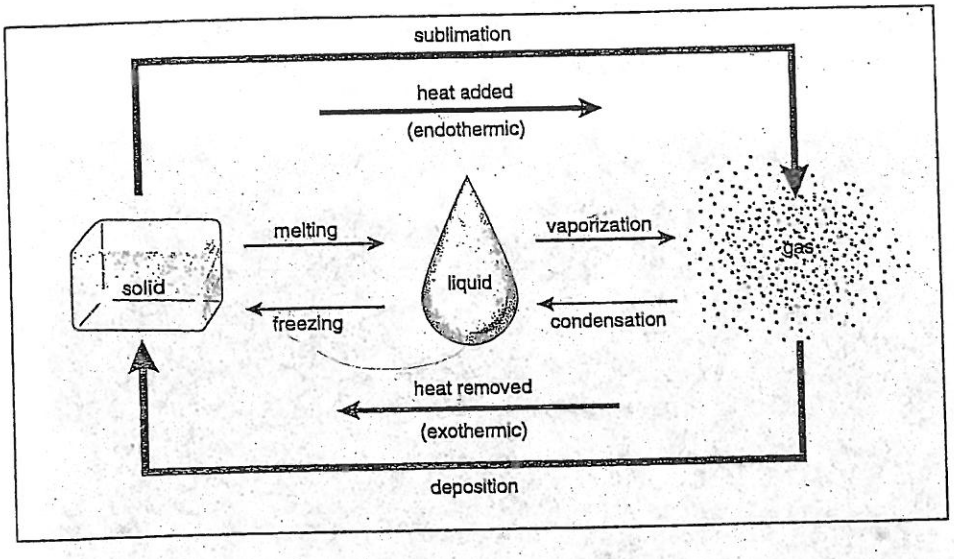
vaporization: the change of state from a liquid to a gas (also called evaporation and boiling).

sublimation: the change of state directly from a solid to a gas, without going through the liquid state.

Heating Curve of Water

These changes in the temperature of a material, as heat energy is added, can be summarized in a graph, similar to the one you constructed. The heating curve of water is shown in the diagram on the previous page. The length of the first horizontal section corresponds to the amount of heat energy required to make the material change from solid to liquid.

Dry ice (solid carbon dioxide) that your teacher used in the demonstration, does not have a normal melting point; instead, it has a normal sublimation point (-78.5°C at 1 atm). **Sublimation** is the process where the solid goes directly to the gaseous state. The changes of state are summarized in the diagram below.



Checking Up

1. What does temperature measure?
2. Describe what is happening to particles of a material when heat energy is added and the temperature increases.
3. What happens to the temperature of a material when it is undergoing a change of state?
4. What is the difference between the normal boiling point of water, and the temperature at which water might boil?

Reflecting on the Activity and the Challenge

In this exercise you focused on very simple chemistry, the motions of particles in solids, liquids, and gases. You can use the techniques learned in this activity to animate more complicated chemical systems. Consider how you could illustrate a phase change, like boiling or freezing. With research you might be able to use animation to explain the chemistry you use in staging your special effect.