Name _____ Class _____ Date _____

CHAPTER 3 States of Matter

SECTION 3

Changes of State

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What is a change of state?
- What happens during a change of state?
- What can happen when a substance loses or gains energy?

National Science Education Standards
PS 1a, 3a

How Are Changes of State and Energy Related?

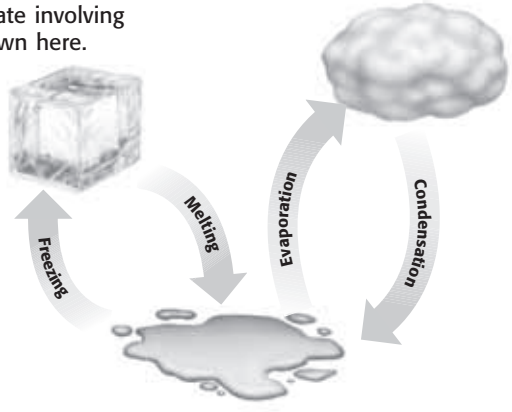
It can be tricky to eat a frozen juice bar outside on a hot day. In just minutes, the juice bar begins to melt. As it melts, the juice bar changes its state from a solid to a liquid. A **change of state** happens when matter changes from one physical form to another. A change of state is always a physical change. Remember that in a physical change, the substance does not change into a new substance.

Energy must be added or removed in order for a substance to change its physical state. It is important to remember that the particles of every substance move differently. This movement of particles depends on the state of the substance (solid, liquid, or gas). ☑

For example, the particles in frozen water or ice (a solid) only vibrate. The particles in liquid water move faster and have more energy than particles in ice. To change ice into liquid water, energy must be added. To change liquid water into ice, energy must be removed.

The figure below shows changes of state that water can undergo.

Changes of state involving water are shown here.



STUDY TIP

Compare As you read the chapter, complete a table with the following headings:
- name of change
- states that are changing
- energy (added or removed).

READING CHECK

1. Identify What must be added or removed when a substance changes state?

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TAKE A LOOK

2. Describe What happens to water in a puddle before it forms droplets of liquid water in a cloud?

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STANDARDS CHECK

PS 3a Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.

Word Help: chemical
of or having to do with the properties or actions of substances

3. Identify What must be added to melt a substance?

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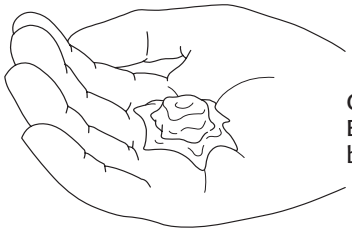
What Is Melting?

When energy is added to a solid, it can melt. **Melting** is the change of state from a solid to a liquid. For example, an ice cube in a glass of lemonade melts as it absorbs heat from the lemonade.



Gallium is a metal that can melt in your hand. Even though gallium is a metal, it would not be very useful as jewelry!

MELTING POINT AND ENERGY

The *melting point* of the substance is the temperature in which it changes from a solid to a liquid. As the temperature of the solid becomes greater, its particles move faster. When a certain temperature is reached, the solid will melt. The melting point of a substance is a physical property of the substance. ☑

READING CHECK

4. Describe What is the melting point of a substance?

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Melting point depends on the composition of, or material that makes up, the substance. It can be used to help identify a substance. For example, copper has a melting point of 420.7°C. Other substances may look like copper, but they will likely have different melting points.

For a solid to melt, particles must absorb energy. The energy makes the particles move faster and have less attraction to each other. This allows the particles to move past each other. The solid melts and becomes a liquid.

What Are Freezing and Freezing Point?

The *freezing point* is the temperature at which a substance changes from a liquid to a solid state. When a liquid freezes, its particles have less energy and become closely locked in position. Energy is removed from the substance during freezing.

Freezing is the exact opposite of melting. The freezing point of a substance is exactly the same as the melting point of the substance. They both happen at the same temperature. For example, liquid water freezes and becomes solid ice at temperatures below 0°C. Solid ice melts and becomes liquid water at temperatures above 0°C. ☑

READING CHECK

5. Identify If the freezing point of a substance is 68°C, what is its melting point?

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What Is the Process of Evaporation?

When you get out of a swimming pool on a windy day, your body sometimes feels cold. Why? The water on your skin is evaporating. **Evaporation** is the change of state from the liquid state to the gas state. The reason you feel cold is because evaporation requires energy. The energy in this case goes from your body into the liquid water. The liquid water changes state to a gas called *water vapor*.

This change of state also happens when you sweat. Sweat is mostly water. When sweat appears on your skin, the water absorbs heat (energy) from your skin. This causes the water to evaporate, and you feel cooler. ☑

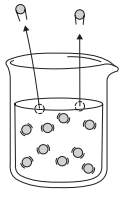
EVAPORATION AND BOILING

Evaporation can occur at low temperatures. Water can evaporate at temperatures near 0°C, but it will evaporate very slowly. For water to evaporate quickly in an open container, it must be heated. If the water is heated to a high enough temperature, it will boil.

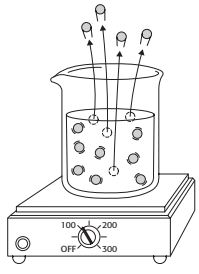
Boiling occurs when a liquid evaporates quickly. The particles leave the liquid state and change to vapor (gas) particles. This change creates a vapor pressure. A liquid boils when the vapor pressure equals the air pressure in the room. The temperature at which boiling occurs is known as the *boiling point* of the substance. ☑

Like melting point, boiling point can help identify a substance. For example, the normal boiling point of water is about 100°C. Many liquids that look like water boil at different temperatures.

The figure below shows water evaporating at room temperature and water boiling.



Evaporation can happen in a liquid below its boiling point. Some particles at the surface of the liquid move fast enough to break away from the particles around them. When they break away, they become a gas (or vapor).



Boiling happens in a liquid at its boiling point. As energy is added to the liquid, particles throughout the liquid move faster. When they move fast enough to break away from other particles, they evaporate. The bubbles you see when water boils contain water vapor.

Say It

Investigate People usually feel warmer on a warm, humid day than on a warm, dry day. Investigate why most people feel warmer on humid days and report to the class.

READING CHECK

6. Describe Why does sweating help cool your body?

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READING CHECK

7. Identify When the vapor pressure of a liquid equals the air pressure in the room, what will the liquid do?

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TAKE A LOOK

8. Identify Are there more water vapor molecules above a beaker of water at room temperature or a beaker of water at its boiling point?

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What Is the Process of Condensation?

On a hot day in the summer, a glass of ice water might look like it is sweating. The water drops on the outside of the glass have formed because of condensation. **Condensation** is the change of state from a gas to a liquid. The water vapor in the air (sometimes called humidity) hits the cold glass. The particles of water vapor lose energy and change into the liquid state.

Condensation happens when a gas is cooled. When the gas cools, the particles lose energy, move slower, and have a greater attraction for each other. The particles begin to clump together. Condensation and evaporation are the opposites of each other. When condensation happens, the particles of gas lose energy and move more slowly. For evaporation to occur, the particles of a liquid must gain energy, and move faster. ☑

The *condensation point* of a substance is the temperature at which a gas becomes a liquid. Under most conditions, the condensation point of a substance is the same temperature as the boiling point of the substance. Condensation can occur when the temperature of a surface is below the condensation point of the gas.

For example, water drops form a haze on a bathroom mirror when you take a shower. The water drops condense from the water vapor in the air. The mirror is at a temperature well below water vapor's condensation point, 100°C.

Take a close look at the spider web in the figure below. Notice the beads of water that have formed on it. This happens because water vapor (a gas) has condensed to form liquid water.

Beads of water form when water vapor in the air contacts a cool surface, such as this spider web.

Critical Thinking

9. Describe How does water from a lake become part of a cloud in the sky?

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READING CHECK

10. Identify Which process requires energy, condensation or evaporation?

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Critical Thinking

11. Explain As the day gets warmer, the water droplets on a spider web are no longer seen. Why?

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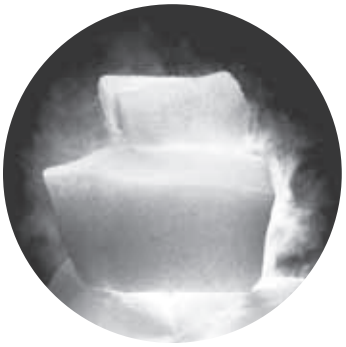
What Is the Process of Sublimation?

The electric company in your community sometimes hands out dry ice when a storm knocks out power. Dry ice keeps groceries cold, but does not melt like ice. Dry ice can change directly from a solid state to a gas state. This process in known as **sublimation**. ☑

Dry ice is frozen carbon dioxide. Its temperature is −78.5°C or lower. When it sublimes, it pulls energy from substances around it. This makes substances around it become cold. The energy it pulls weakens the attraction of the particles in the solid dry ice. When the attraction weakens enough, the solid changes into a gas. It does not melt into a liquid.



Dry ice is a substance that will change directly from a solid to a gas at atmospheric pressure.

READING CHECK

12. Describe What occurs when a substance sublimes?

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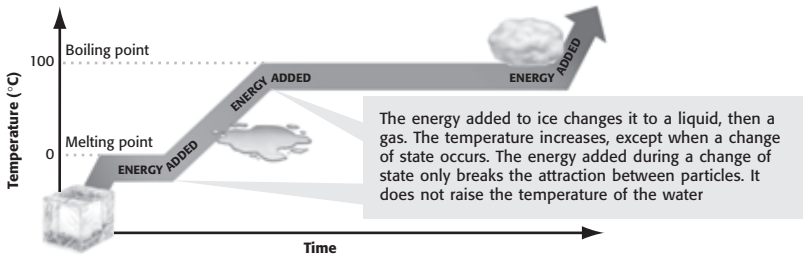
How Are Changes of State and Temperature Related?

Two things can happen to a substance when it gains or loses energy. Either the temperature of the substance changes, or the state of the substance changes. During a change of state, the temperature of a substance will not change until the change of state is complete.

Take a close look at the figure below. The figure shows the effects and state changes that happen when energy is added to ice.

Changing the State of Water



Say It

Demonstrate Put an ice cube in the freezer compartment of a refrigerator. Allow it to sit, undisturbed, for about two weeks. Report to the class on how its size changed.

TAKE A LOOK

13. Describe What is the shape of the graph at the melting and freezing points of water? What does this shape tell you about the temperature?

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Section 3 Review

NSES **PS 1a, 3a**

SECTION VOCABULARY

boiling the conversion of a liquid to a vapor when the vapor pressure of the liquid equals the atmospheric pressure

change of state the change of a substance from one physical state to another

condensation the change of state from a gas to a liquid

evaporation the change of state from a liquid to a gas

melting the change of state by which a solid becomes a liquid by adding heat

sublimation the process in which a solid changes directly into a gas

1. Describe How do the motions of the particles differ between the states of matter?

2. Describe What happens to energy during a change of state? Why is it a physical change?

3. Describe What are the differences between freezing and melting? How are they similar?

4. Explain How are evaporation and boiling the same? How do they differ?

5. Describe and Compare What is needed for a solid to sublime and what change of state occurs? How does sublimation differ from condensation?

6. Complete Fill in the missing boxes in the table below.

Property	Solid	Liquid	Gas
attraction between particles		weaker than in a solid	
distance between particles	close	close	
movement of particles		they can move past each other	

3. The particles of a liquid can move past one another, but the particles of a solid stay in fixed positions.
4. The particles of a gas can move far away from one another, but the particles of a liquid stay close to one another.
5. surface tension
6.

State of matter	Definite shape	Definite volume
Solid	yes	yes
Liquid	no	yes
Gas	no	no

SECTION 2 BEHAVIOR OF GASES

1. a measure of how fast the particles of an object are moving
2. when it is heated
3.

Temperature of gas particles	Energy of gas particles	Volume of gas particles
1) 20°C	Particles have the smallest amount of energy.	Volume is smallest.
2) 50°C	Particles have more energy than at 20°C, but not as much as at 80°C.	Volume is larger than at 20°C but smaller than at 80°C.
3) 80°C	Particles have the largest amount of energy.	Volume is largest.

4. the amount of force that is put on an area
5. temperature and pressure
6. It is one-third as much.
7. It is one-half as much.

Review

1. temperature, volume, and pressure
2. The balloon goes from a warm temperature in the house to a cold temperature outside. The volume of the balloon will decrease outside because the gas particles move more slowly and exert less pressure. The air particles in the balloon take up less space.
3. 9 L; according to Charles's law, at constant pressure, volume is directly related to temperature.
4. The volume will double. According to Boyle's law, at constant temperature, volume is inversely related to pressure.
5. The volume, temperature, and pressure of a gas are all related. If there is a change in one, it will affect the others as well.

SECTION 3 CHANGES OF STATE

1. energy
2. It changes into a gas, or evaporates, or vaporizes.
3. energy
4. the temperature at which it changes from a solid to a liquid
5. 68°C
6. The sweat removes energy from your body as it evaporates.
7. boil
8. beaker of boiling water
9. Water from a lake evaporates, then it condenses to become part of a cloud.
10. evaporation
11. The warmer temperatures cause the water droplets to evaporate.
12. It changes directly from a solid to a gas.
13. The graph is flat, or horizontal. This means that the temperature is constant.

Review

1. The particles of a solid only vibrate. The particles of a liquid can move past one another. The particles of a gas are free to move anywhere.
2. Energy is added or removed during a change of state. A change of state does not make a new substance, so changes of state are physical changes.
3. Melting requires energy. Freezing is the removal of energy. Both happen at the same temperature.
4. Both processes change a liquid to a gas. Evaporation is a slower process than boiling. In an open container, you need to heat a liquid in order to boil it.
5. Sublimation requires energy and changes a solid directly to a gas. Condensation gives off energy and changes a gas to a liquid.
6.

Property	Solid	Liquid	Gas
Attraction between particles	strong	weaker than in a solid	little or no attraction
Distance between particles	close	close	far apart
Movement of particles	They vibrate only.	They can move past each other.	There is freedom of movement.