Name _____ Class _____ Date _____

CHAPTER 4 States of Matter

SECTION 1

Four States of Matter

BEFORE YOU READ

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

- What is matter made of?
- What are the three most common states of matter?
- How do particles behave in each state of matter?

California Science Standards

8.3.d, 8.3.e

What Are the Four States of Matter?

Have you ever had a steaming bowl of soup and an ice cold drink for lunch? The three most common states of matter are found in this lunch. The soup and the ice cold drink both contain water. However, the water exists in three different forms. The soup and drink are *liquids*. The ice is a *solid*. The soup's smell is carried to your nose along with water vapor, a *gas*.

The **states of matter** are the physical forms that substances take. Solids, liquids, and gases are the most common states, or forms, of matter. There is also a fourth state of matter, known as *plasma*. ☑

Matter is made up of very tiny particles. These particles are called *atoms* and *molecules*. Atoms and molecules behave differently in each state of matter. Atoms and molecules are always in motion, but their motion depends on the state. The particles can only vibrate in the solid state. In the liquid state, the particles can slide past each other. The particles of a gas are free to move anywhere.

The figure below describes three states of matter and how particles behave in each.

Models of a Solid, a Liquid, and a Gas

Particles of a solid have a strong attraction between them. The particles are closely locked in position and only vibrate.

Particles of a liquid are more loosely connected than those of a solid and can move past one another.

Particles of a gas move fast enough that they overcome the attractions between them. The particles move independently and collide frequently.

STUDY TIP

Clarify Concepts Take turns reading this section out loud with a partner. Stop to discuss ideas that seem confusing.

READING CHECK

1. Identify What are the four states of matter?

_____

_____

TAKE A LOOK

2. Identify In which state do the particles move about the most? In which state do they move about the least?

_____

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What Are the Properties of Solids?

Any solid material, such as a penny, a rock, or a marble, has a definite shape and volume. For example, if you place any of these solid objects into a bottle, its shape and volume will stay the same. All of these objects keep their original shape and volume no matter where they are placed. A **solid** is the state of matter that has a definite shape and volume.

The particles of a solid are very close together. They have a strong attraction to one another. So, the particles of a solid are locked in place. However, they do vibrate (or shake). Remember, the particles of any substance are always in motion. ☑

READING CHECK

3. Explain Why can't the particles of a solid move away from one another?

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What Are the Properties of Liquids?

Although an ice cube and liquid water are both made up of the same material, they are physically very different. In solids, particles are closely locked together and vibrate in place. In liquids, particles are able to move more freely.

A **liquid** is a substance that has a definite volume but no definite shape. For example, a liter of milk takes on the shape of its container. The same liter of milk will take on the shape of a bowl it is poured into. Only the shape of the milk changes. The volume of the milk stays the same.

The particles move fast enough in a liquid to overcome their attraction to one another. They can move or slide past one another, but they always stay close together. We know that the particles in liquids can move past one another because liquids can change shape. ☑

READING CHECK

4. Describe What can the particles of a liquid do that the particles of a solid can't do?

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TAKE A LOOK

5. Identify When fruit juice is poured into different containers, what changes? What stays the same?

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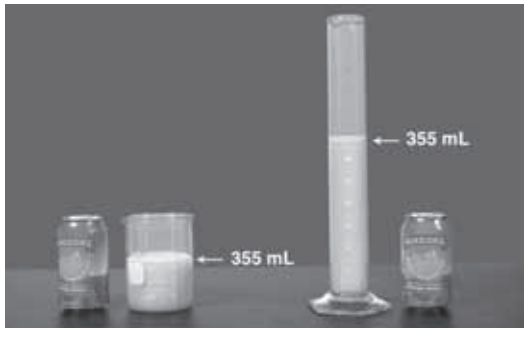

Although their shapes are different, the beaker and the graduated cylinder each contain 355 mL of juice.

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What Are the Properties of Gases?

The properties of a gas are different from the properties of other states of matter. A **gas** is a state of matter that has no definite shape or volume. Any gas will fill, or take on the shape of, any container it is in. This is because gas particles have little attraction to one another.

A gas that may be familiar to you is helium. Helium is the gas that is used to fill birthday balloons. A small tank of helium can fill many balloons. As helium particles are put into a balloon, they move to fill the volume of the balloon. The changes in the shape and volume of a gas happen because gas particles move about freely. The amount of empty space between them can change.

Many balloons can be filled from one tank of helium because the particles of helium gas in a balloon are far apart.

CALIFORNIA STANDARDS CHECK

8.3.d Students know the states of matter (solid, liquid, gas) depend on molecular motion.

6. Compare How does the motion of the particles change when water changes from a solid to a liquid to a gas?

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_____

TAKE A LOOK

7. Identify Where are the particles of helium farthest apart, in the tank or in the balloon?

_____

What Is Plasma?

Most people can name only the three most common states of matter. The fourth state of matter is plasma. It is the most common state of matter in the universe. The sun and other stars are made of plasma. Plasma is similar to gas because it has no definite shape or volume. However, **plasmas** consist of ions and free-moving electrons. Other states of matter consist of neutral atoms and molecules.

An example of plasma is in a glowing neon sign. Neon is a gas that is often found in the light tube of a sign. When the switch is turned on, electrons are ripped from the neon atoms. This makes ions and free electrons. So, turning on the sign changes neon gas into a plasma.

On Earth, natural plasmas can be found in lightning and in fires. Artificial plasmas are found in glowing fluorescent lights and neon signs.

Critical Thinking

8. Infer A fluorescent light works like a neon sign. What happens to the gas inside a fluorescent light when it is switched on?

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Name _____ Class _____ Date _____

Section 1 Review

8.3.d, 8.3.e

SECTION VOCABULARY

gas a form of matter that does not have a definite volume or shape

liquid the state of matter that has a definite volume but not a definite shape

plasma in physical science, a state of matter that starts as a gas and then becomes ionized; it consists of free-moving ions and electrons, it takes on an electric charge, and its properties differ from the properties of a solid, liquid, or gas

solid the state of matter in which the volume and shape of a substance are fixed

states of matter the physical forms of matter, which include solid, liquid, and gas

1. Identify What are you and all the matter around you made of?

_____

_____

2. Identify Name the four states of matter, and give an example of each.

_____

_____

_____

_____

3. Compare What can the particles of a liquid do that the particles of a solid can't do?

_____

_____

4. Compare What can the particles of a gas do that the particles of a liquid can't do?

_____

_____

5. Describe Complete the following table to show how states of matter differ from one another.

State of matter	Definite shape	Definite volume	Type of particles present
Solid			atoms, molecules
Liquid	no		
Gas		no	
Plasma			

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Name _____ Class _____ Date _____

CHAPTER 4 States of Matter

SECTION 2

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 are the changes that matter can undergo?
- How are changes of state related to energy and temperature?

California Science Standards

8.3.d, 8.3.e, 8.5.d, 8.7.c

How Are Changes of State and Energy Related?

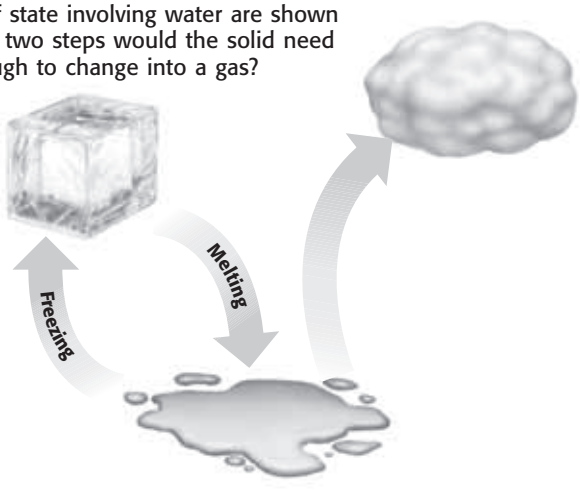
It can be tricky to eat a frozen juice bar outside on a hot day. In just minutes, the juice bar begins to melt. As it melts, the juice bar changes state from a solid to a liquid. A **change of state** happens when matter changes from one physical form to another. A change of state is always a physical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

Energy must be added or removed in order for a substance to change its physical state. Particles of different substances 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 the possible changes of state for water.

Changes of state involving water are shown here. What two steps would the solid need to go through to change into a gas?



STUDY TIP

Organize As you read the chapter, complete a table with the following headings:
- name of change
- change that occurs
- energy (added or removed)

READING CHECK

1. Identify What must be added or removed for a substance to undergo a change of state?

_____

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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What Is Melting?

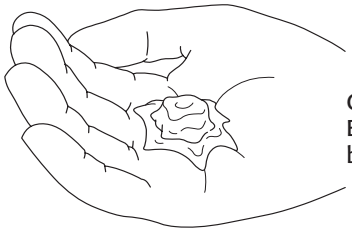
When energy is added to a solid, it can melt. **Melting** is the change of state from a solid to a liquid. For example, an ice cube in a glass of lemonade melts as it absorbs heat from the lemonade.

CALIFORNIA STANDARDS CHECK

8.5.d Students know physical processes include freezing and boiling, in which a material changes form with no chemical reaction.

3. Identify What kind of change occurs when a substance melts?

_____



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 at 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.

Melting point depends on the composition, or makeup, of the substance. It can be used to help identify a substance. For example, copper has a melting point of 420.7°C. You can tell that a substance that looks like copper is not really copper if it does not melt at 420.7°C.

For a solid to melt, particles must absorb energy. The particles move faster and have less attraction to one another. This allows the particles to flow, or move past one another. The solid melts and becomes a liquid. ☑

READING CHECK

4. Describe What do the particles of a liquid do that particles of a solid don't do?

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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. ☑

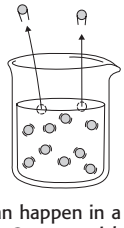
EVAPORATION AND BOILING

Evaporation can occur at low temperatures. In fact, water can evaporate at temperatures near its freezing point. However, at low temperatures, the water does not evaporate quickly. 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.

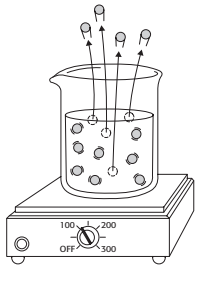
Boiling occurs when a liquid evaporates quickly. The particles leave the liquid state and change to particles of vapor, or gas. This change creates a vapor pressure. When a liquid is boiling, the vapor pressure equals the air pressure in the room. The temperature at which boiling occurs is known as the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

Like the melting point, the 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. Try to find out why, and report to the class.

READING CHECK

6. Describe Why does sweating help cool your body?

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_____

Math Focus

7. Calculate What is the difference between the freezing point and boiling point of water? What is the difference between the freezing point and melting point of water?

_____

_____

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 looks as if it is sweating. The water drops that are seen on the outside of the glass form 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. As the gas cools, the particles loose energy, move more slowly, and have a greater attraction for one another. The particles begin to clump together. They change to the liquid state. Condensation and evaporation are the opposite of each other. For evaporation to occur, the particles of a liquid must gain energy, move faster, and change to the gas state. ☑

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 droplets form a haze on a bathroom mirror when you take a shower. The water droplets 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 happened because water vapor condensed on the web from gas to liquid water.

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?

_____

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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_____

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

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What Is the Process of Sublimation?

The electric company in your community may sometimes hand out dry ice when a storm knocks out power. Dry ice keeps groceries cold, but it does not melt, as ice does. 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.

READING CHECK

12. Describe What occurs when a substance sublimes?

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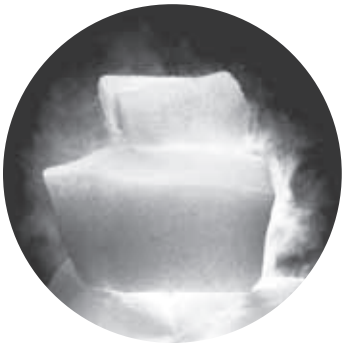
_____



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

Say It

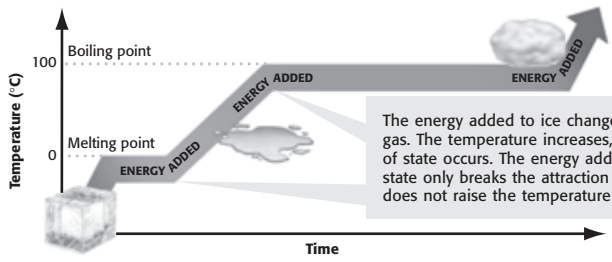
Investigate Put an ice cube in the freezer compartment of a refrigerator. Allow it to sit, undisturbed, for about two weeks. Report to the class on how its size changes.

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. When temperature changes, the speed of the particles that make up the substance also changes. During a change of state, the temperature of a substance does not change. It will change only after 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



The energy added to ice changes it to a liquid, then a gas. The temperature increases, except when a change of state occurs. The energy added during a change of state only breaks the attraction between particles. It does not raise the temperature of the water

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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Name _____ Class _____ Date _____

Section 2 Review

8.3.d, 8.3.e, 8.5.d, 8.7.c

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

Wordwise The prefix *e-* means "out" or "from." The root *vapor* means "gaseous form of any substance that is usually a liquid or solid."

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. Compare How do the states of matter differ in terms of motions of their particles?

_____

_____

2. Describe In terms of energy, what happens during a change of state? Why is it a physical change?

_____

_____

3. Compare What is the difference between freezing and melting? How are they similar?

_____

_____

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

_____

_____

5. Describe What is needed for a solid to sublime, and what change of state occurs?

_____

_____

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

Property	Solid	Liquid	Gas
Attraction between particles		weaker than in a solid	
How close the particles are	close	close	
Movement of particles		movement past one another	

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