Name _____ Class _____ Date _____

CHAPTER 3 States of Matter

SECTION 2

Behavior of Gases

BEFORE YOU READ

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

- What affects how a gas behaves?
- What are the gas laws?

National Science Education Standards

PS 1a

What Affects the Behavior of a Gas?

Gases behave differently than solids or liquids. Gas particles have a large amount of space between them. The space that the gas particles take up is the gas's volume. Its volume depends on its temperature and pressure.

STUDY TIP

Brainstorm With a partner, describe situations where Boyle's Law and Charles's Law apply.

TEMPERATURE

Helium is a gas that is used to fill balloons. The amount of helium needed to fill a balloon depends on the temperature. **Temperature** is a measure of how fast the particles of an object are moving. ☑

READING CHECK

1. Describe What is temperature?

_____

_____

_____

When it is hot, the helium particles have more energy. They move faster and bump into the walls of the balloon more often than they do when it is cool. This causes the gas particles to move apart and take up a larger volume. Therefore, less helium is needed to fill the balloons on a hot day. If the balloon is heated too much, it might burst.

When the temperature is cooler, the helium has less energy. The particles do not hit the walls of the balloon as hard or as often. The helium doesn't take up as much volume. Therefore, more helium is needed to fill the balloons when the temperature is lower. ☑

READING CHECK

2. Identify Does a helium balloon have a larger volume when it is heated or cooled?

_____

_____

The following table describes what happens to gas particles at different temperatures.

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 _____ energy than 20°C, but not as much as 80°C	volume is _____ than 20°C but smaller than 80°C
3. 80°C	particles have the _____ amount of energy	volume is _____

TAKE A LOOK

3. Complete Fill in the missing words in the table.

VOLUME

The **volume** of an object is how much space it takes up. Gas particles do not stick together. They spread out. Therefore, the volume of a gas always depends on the container the gas is in.

For example, what happens when you gently squeeze a balloon? The balloon does not usually break unless a lot of pressure is put on the balloon. When you squeeze the balloon, you change the volume of the gas inside of it. The particles of the gas are being forced into a smaller volume.

PRESSURE

The amount of force that is put on an area is called **pressure**. You can think about pressure as the number of times the particles of a gas hit the inside of their container. ☑

The figure below shows two different kinds of balls: a basketball and a beach ball. They are both the same size and hold the same volume of air, which is a gas. There are more particles of gas in the basketball than in the beach ball. This means there are more particles that are hitting the inside of the basketball. There is greater pressure in the basketball. This makes the basketball feel harder than the beach ball.

READING CHECK

4. Describe What is pressure?

_____

_____

STANDARDS CHECK

PS 1a A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.

5. Identify What two factors influence the volume of a gas?

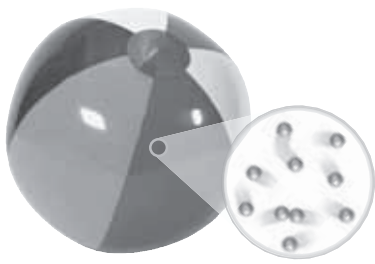
_____

Gas and Pressure

High pressure

The basketball has a higher pressure because there are more particles of gas in it, and they are closer together. The particles collide with the inside of the ball at a faster rate.

Low pressure



The beach ball has a lower pressure because there are fewer particles of gas, and they are farther apart. The particles in the beach ball collide with the inside of the ball at a slower rate.

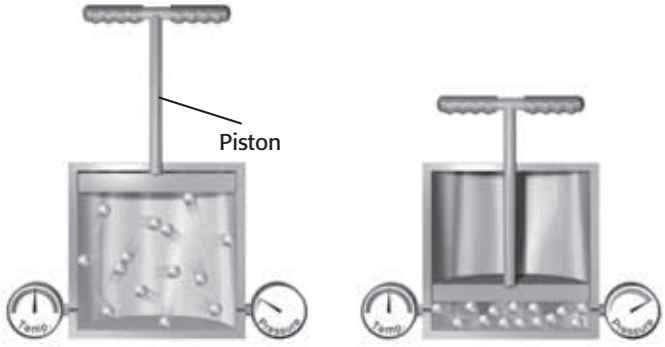
What Are the Gas Laws?

The temperature, pressure, and volume of a gas are linked to each other. When one of these changes, the other two change. The gas laws describe how the temperature, pressure, and volume of a gas are related to each other.

1. BOYLE'S LAW

Boyle's law says that the volume of a gas is inversely related to its pressure when temperature stays the same. This means that when the pressure of a gas increases, its volume will decrease. For example, if the pressure of a gas doubles, the volume will be cut in half. This is seen in the figure below.

Boyle's Law



Lifting the piston lets the particles of gas spread far apart. The volume of the gas increases as the pressure decreases.

Pushing the piston forces the gas particles close together. The volume of the gas decreases as the pressure increases.

Math Focus

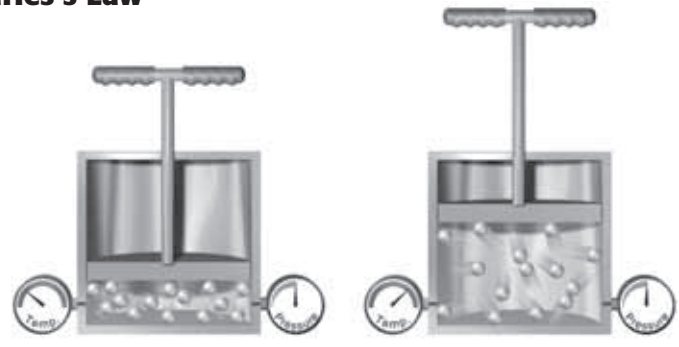
6. Determine If the pressure of a gas is tripled and its temperature remains constant, what happens to its volume?

_____

2. CHARLES'S LAW

Charles's law says that the volume of a gas is directly related to its Kelvin temperature when pressure stays the same. Therefore, if the Kelvin temperature of a gas increases, the volume of a gas will increase. For example, if the Kelvin temperature of a gas doubles, the volume doubles.

Charles's Law



Decreasing the temperature of a gas makes the particles move more slowly. The gas particles hit the piston less often and with less force. Therefore, the volume of the gas decreases.

Increasing the temperature of a gas makes the particles move more quickly. The gas particles hit the piston more often and with more force. Therefore, the volume of the gas increases.

Math Focus

7. Determine If the Kelvin temperature of a gas is cut in half and its pressure remains constant, what happens to its volume?

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Section 2 Review

NSES **PS 1a**

SECTION VOCABULARY

Boyle's Law the law that states that the volume of a gas is inversely proportional to the pressure of a gas when temperature is constant

Charles's Law the law that states that the volume of a gas is directly proportional to the temperature of a gas when pressure is constant

pressure the amount of force exerted per unit area of a surface

temperature a measure of how hot (or cold) something is; specifically, a measure of the average kinetic energy of the particles in an object

volume a measure of the size of a body or region in three-dimensional space

1. **Identify** Name the three factors that affect how a gas behaves.

2. **Describe** What happens to the temperature and volume of a balloon if it is taken outside on a cold winter day?

3. **Calculate** You have three liters of gas at a certain Kelvin temperature and a certain pressure. The Kelvin temperature triples and the pressure stays the same. What is the gas volume? Explain your answer.

4. **Analyze** The pressure of the gas is cut in half and the temperature stays the same? What happens to the gas volume? Explain your answer.

5. **Explain** When scientists record a gas's volume, they also record its temperature and pressure. Why?

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.