3.2 The Gas Laws

Reading Focus

Key Concepts

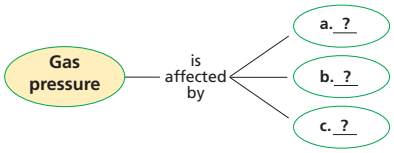
- What causes gas pressure in a closed container?
- What factors affect gas pressure?
- How are the temperature, volume, and pressure of a gas related?

Vocabulary

- pressure
- absolute zero
- Charles's law
- Boyle's law

Reading Strategy

Identifying Cause and Effect Copy the diagram. As you read, identify the variables that affect gas pressure.



The woman in Figure 10 is taking a deep breath. This action helps reduce her breathing rate and increase the volume of air she inhales. When you inhale, the volume of your chest cavity increases and air moves into your lungs. When you exhale, the volume of your chest cavity decreases and air is pushed out of your lungs.

After you read this section, you will understand how changing the volume of your chest cavity causes air to move into and out of your lungs. Changes in the volume, the temperature, the pressure, and the number of particles have predictable effects on the behavior of a gas.

Figure 10 Taking a deep breath increases the volume of your chest cavity, which causes air to move into your lungs.

Pressure

At many hockey rinks, a layer of shatterproof glass keeps the puck away from the spectators. The force with which the puck hits the glass depends on the speed of the puck. The faster the puck is traveling, the greater the force is. The smaller the area of impact is, the greater the pressure produced. **Pressure** is the result of a force distributed over an area. If the edge of the puck hits the glass, it exerts more pressure than if the face of the puck hits the glass at the same speed.

The SI unit of pressure is derived from SI units for force and area. Force is measured in newtons (N) and area in square meters (m^2). When a force in newtons is divided by an area in square meters, the unit of pressure is newtons per square meter (N/m^2). The SI unit for pressure, the pascal (Pa), is shorthand for newtons per square meter. One pascal is a small amount of pressure. Scientists often express larger amounts of pressure in kilopascals. One kilopascal (kPa) is equal to 1000 pascals.

Section Resources

Print

- ***Reading and Study Workbook With Math Support,*** Section 3.2 and **Math Skill:** The Combined Gas Law
- ***Math Skills and Problem Solving Workbook,*** Section 3.2
- ***Transparencies,*** Section 3.2

Technology

- ***Interactive Textbook,*** Section 3.2
- ***Presentation Pro CD-ROM,*** Section 3.2
- ***Go Online,*** *Science News,* Properties of matter

Section 3.2

1 FOCUS

Objectives

3.2.1 **Define** pressure and gas pressure.
3.2.2 **Identify** factors that affect gas pressure.
3.2.3 **Predict** changes in gas pressure due to changes in temperature, volume, and number of particles.
3.2.4 **Explain** Charles's law, Boyle's law, and the combined gas law.
3.2.5 **Apply** gas laws to solve problems involving gases.

Reading Focus

Build Vocabulary L2

Paraphrase Replace less familiar words in a definition with more familiar words or phrases.

Reading Strategy L2

a. Temperature **b.** Volume **c.** Number of particles

2 INSTRUCT

Pressure

Build Science Skills L2

Observing

ACTIVITY

Purpose Show the effect of area on pressure.

Materials clay, CD case, textbook

Advance Prep Prepare two flattened pieces of clay 3 cm thick.

Procedure Put the broad side of the CD case on a piece of clay with the book on top. After about 30 seconds, carefully remove the book and case. Then, put the case on the other piece of clay, narrow side down. Balance the book on the case for 30 seconds. (Place your hands on either side of the book as a precaution.) Remove the book and case. Ask, **How do the depths of the imprints compare?** *(The imprint is deeper when the case is placed on its edge.)* **What caused this difference?** *(Because the weight of the book was applied to a smaller area, the pressure was greater.)*

Expected Outcome When the same force is applied to a smaller area, the depth of the imprint increases.

Visual

Factors that Affect Gas Pressure

Teacher Demo

Changing Volume of a Balloon L2

Purpose Students observe the effect of temperature on the volume of a balloon.

Materials inflated balloons, refrigerator, warm place

Advance Prep One day ahead, inflate a balloon for each class. Place the balloons in a refrigerator overnight.

Procedure At the beginning of class, bring out a balloon and tell students where it has been. Ask, **Do you predict that the volume of the balloon will increase, decrease, or stay the same after the balloon has been in a warm place?** *(Increase)* Place the balloon in a warm place until shortly before the end of class. Make sure the balloon has room to expand, and that the temperature does not exceed 42°C. Ask, **What happened to the volume of the gas inside the balloon?** *(It increased.)* Explain that as temperature increases, the particles move faster, on average, which increases the pressure of the gas inside the balloon. The increased pressure causes the balloon to expand.

Expected Outcome The balloon's volume will increase as the temperature increases.

Visual, Logical

Use Visuals L1

Figure 11 Bring in a pressure gauge like the one in the photo. (The gauge measures how much the air pressure in the tire exceeds atmospheric pressure.) Have a volunteer note the units of pressure on the gauge. *(Pounds per square inch)* Explain that in the United States, pressure is not always measured in SI units. Ask, **Have you seen any other units used for pressure?** *(Students may have seen barometric pressure reported in inches of mercury.)* **Why is data from experiments measured and reported in SI units?** *(Scientists must use standard units so that their data can be shared with and tested by scientists in all countries.)*

Logical, Visual

An object does not need to be as large as a hockey puck to exert pressure when it collides with another object. Recall that the helium atoms in a balloon are constantly moving. The pressure produced by a single helium atom colliding with a wall is extremely small. However, there are more than 10^{22} helium atoms in a small balloon. When so many particles collide with the walls of a container at the same time, they produce a measurable pressure.

Collisions between particles of a gas and the walls of the container cause the pressure in a closed container of gas. The more frequent the collisions, the greater the pressure of the gas is. The speed of the particles and their mass also affect the pressure.

Reading Checkpoint

How does the frequency of collisions affect the pressure of a gas?

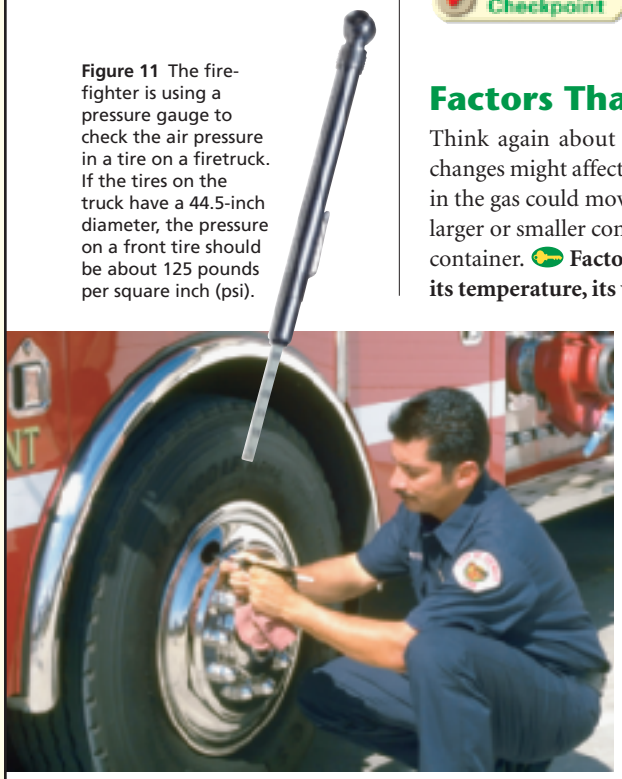


Figure 11 The firefighter is using a pressure gauge to check the air pressure in a tire on a firetruck. If the tires on the truck have a 44.5-inch diameter, the pressure on a front tire should be about 125 pounds per square inch (psi).

Factors That Affect Gas Pressure

Think again about the collisions that produce gas pressure. What changes might affect the pressure of a gas in a container? The particles in the gas could move faster or slower. The gas could be moved into a larger or smaller container. You could add gas or remove gas from the container. **Factors that affect the pressure of an enclosed gas are its temperature, its volume, and the number of its particles.**

Temperature

Suppose you are about to go on a long drive. The driver suspects that the air pressure in the automobile tires might be low. You check the pressure in each tire, using a pressure gauge like the one in Figure 11. You find that the measurements are well within the automobile manufacturer's guidelines. If you checked the tire pressures again after a few hours on the highway, would you be surprised to find that the pressure in the tires had increased?

The constant motion of tires on the highway causes the tires and the air in the tires to warm up. As the temperature rises, the average kinetic energy of the particles in the air increases. With increased kinetic energy, the particles move faster and collide more often with the inner walls of the tires. The faster-moving particles also hit the walls with greater force. The increase in the number of collisions along with the increase in the force of the collisions causes an increase in the pressure of the air in the tires. **Raising the temperature of a gas will increase its pressure if the volume of the gas and the number of particles are constant.**

Customize for Inclusion Students

Visually Impaired

Have students with visual impairments observe different air pressures in a bicycle tire. Bring a bicycle tire and a pump with a built-in gauge. Let out all of the air in the tire. Attach the pump to the inner tube valve. Read the pressure on the gauge and allow students to feel that the tire is completely flat. Pump up the tire to a third of the maximum recommended pressure (marked on the tire). Read the pressure on the gauge and allow students to feel the tire again. Pump up the tire to the maximum recommended pressure and allow students to repeat the observation. Discuss with students how the quantity of air in the tire affects the firmness of the tire.

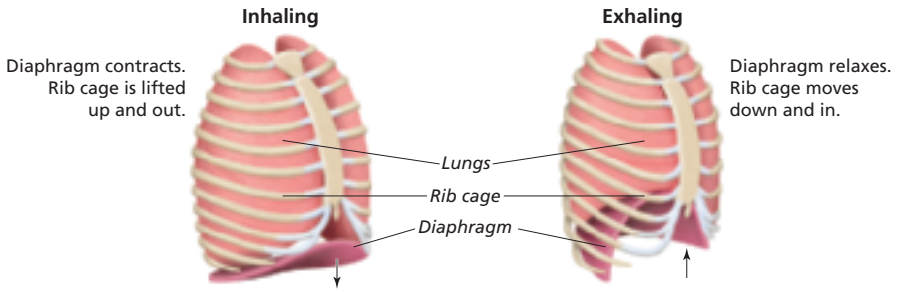


Figure 12 Movement of a muscle called the diaphragm changes the volume of your chest cavity. The volume increases when you inhale and decreases when you exhale.
Interpreting Diagrams ***How does the movement of your rib cage affect the volume of your chest cavity?***

Volume Imagine that you have a plastic bottle that appears empty. If you twist the cap onto the bottle and then squeeze the bottle, what will happen? At first, the plastic will give a little, reducing the volume of the bottle. But soon you will feel pressure from inside the bottle resisting your efforts to further reduce the volume. The pressure you feel is a result of the increased pressure of the air trapped inside the bottle. As the volume is decreased, particles of trapped air collide more often with the walls of the bottle. **Reducing the volume of a gas increases its pressure if the temperature of the gas and the number of particles are constant.**

Figure 12 shows how the relationship between volume and pressure explains what happens when you breathe. As you inhale, a muscle called the diaphragm (DY uh fram) contracts. The contraction causes your chest cavity to expand. This temporary increase in volume allows the particles in air to spread out, which lowers the pressure inside the chest cavity. Because the pressure of the air outside your body is now greater than the pressure inside your chest, air rushes into your lungs.

When you exhale, your diaphragm relaxes and the volume of your chest cavity decreases. The particles in the air are squeezed into a smaller volume and the pressure inside your lungs increases. Because the pressure of the air inside your chest is now greater than the pressure of the air outside your body, air is forced out of your lungs.

Number of Particles You can probably predict what will happen to the pressure when you add more gas to a container. Think about a tire. Once the tire is inflated, its volume is fairly constant. So adding more air will increase the pressure inside the tire. The more particles there are in the same volume, the greater the number of collisions and the greater the pressure. At some point the rubber from which the tire is made will not be strong enough to withstand the increased pressure and the tire will burst. **Increasing the number of particles will increase the pressure of a gas if the temperature and the volume are constant.**

Go Online SCIENCE NEWS
For: Articles on properties of matter
Visit: PHSchool.com
Web Code: cce-1032

Build Reading Literacy L1

Predict Refer to page **66D** in this chapter, which provides the guidelines for predicting.

List on the board examples of volume, temperature, and number of particles increasing or decreasing. Tell students to predict how each change will affect gas pressure in a closed container. Ask students to use the number of particle collisions to explain their predictions. As students provide their predictions and explanations, write the correct effect on pressure and the correct explanation on the board.
Logical, Portfolio

Go Online SCIENCE NEWS
Science News provides students with current information on properties of matter.

Facts and Figures

Fainting Couches During the Victorian era, well-to-do households often had fainting couches. The tightly laced, whalebone corsets women wore restricted their ability to breathe deeply. As a result, they had low levels of oxygen in their blood, causing them to faint, or swoon. Today, Victorian fainting couches can be seen in historic houses or museums. Antique fainting couches and reproductions are available in some furniture and antique stores.

Answer to . . .

Figure 12 *The volume increases as the rib cage is lifted up and out. The volume decreases as the rib cage moves down and in.*

Reading Checkpoint *The more frequent the collisions, the greater the pressure of the gas is.*

Charles's Law

Build Science Skills

L2

Using Tables and Graphs Have students analyze Figure 13. Have students look first at the graph for Charles's law. Point out the straight line with the positive slope. Ask, **What relationship does this line describe?** *(It describes a direct relationship between volume and temperature: As temperature increases, volume also increases.)* Ask, **Why is part of the line solid and part dashed?** *(The solid line represents actual data, while the dotted line is the extension of the collected data toward the zero point for volume.)* Have students refer to the Boyle's Law graph. Ask, **What happens to pressure as volume increases?** *(As volume increases, pressure decreases.)* **Visual, Logical**

Build Math Skills

L1

Line Graphs Students are likely to need help understanding why Charles's law does not apply when temperatures are expressed in degrees Celsius. Have students find the point on the graph where the temperature is 0°C and ask them to estimate the volume at that temperature. Then, tell them that the straight line must pass through (0, 0) for the responding variable to be directly proportional to the manipulated variable. **Logical, Portfolio**

Direct students to the **Math Skills** in the **Skills and Reference Handbook** at the end of the student text for additional help.

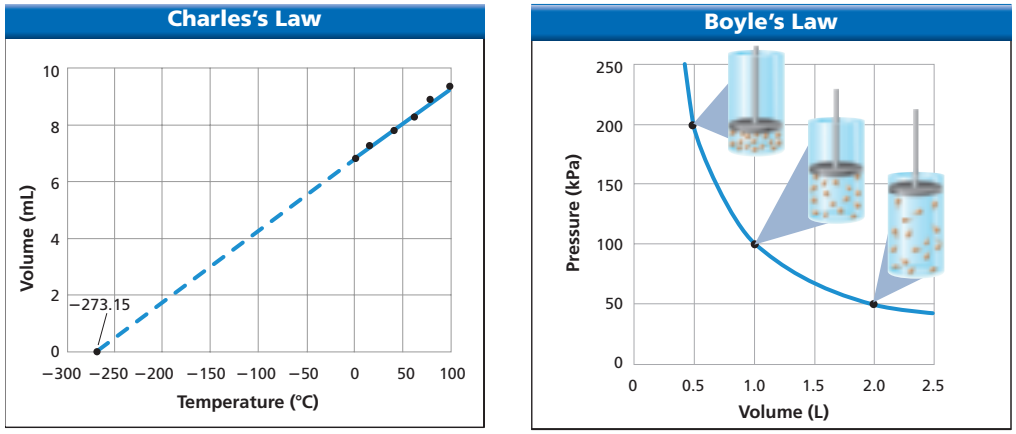


Figure 13 These graphs compare the effects of temperature and volume on the pressure of a gas. Charles's law describes the direct relationship between the temperature and the volume. Boyle's law describes the inverse relationship between the volume and the pressure.
Controlling Variables ***For each graph, name the manipulated variable and the responding variable.***

Charles's Law

During his lifetime, the French physicist Jacques Charles (1746–1823) was known for his inventions, including the hydrogen balloon. Today, Charles is best known for his investigations of the behavior of gases. Charles collected data on the relationship between the temperature and volume of gases. When he graphed the data, the graph was a straight line, as shown in Figure 13. The graph shows that the volume of a gas increases at the same rate as the temperature of the gas.

Charles extended the line on his graph beyond the measured data to see what the temperature would have to be to produce a volume of 0 L. The temperature at the point where the line crossed the *x*-axis was −273.15°C. This temperature is equal to 0 K on the Kelvin temperature scale. A temperature of 0 K is called **absolute zero.** No scientist has produced a temperature of absolute zero in a laboratory, but some have come extremely close. As a gas cools to temperatures near 0 K, the gas changes to a liquid, a solid, or sometimes a Bose-Einstein condensate.

Charles's law states that the volume of a gas is directly proportional to its temperature in kelvins if the pressure and the number of particles of the gas are constant. Charles's law can be written as a mathematical expression in which T_1 and V_1 represent the temperature and volume of a gas before a change occurs. T_2 and V_2 represent the temperature and volume after a change occurs.

Charles's Law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

The temperatures must be expressed in kelvins. If temperatures in degrees Celsius are used in the expression, the volume will not be directly proportional to the temperature.

Facts and Figures

Absolute Zero Based on the decrease in the volume of a gas as it cooled, scientists hypothesized that if an ideal gas were cooled to absolute zero (0 K on the Kelvin temperature scale or −273.15 on the Celsius scale), its volume would be zero. However, as actual gases are cooled, they reach temperatures at which they change to liquids or solids.

Theoretically, all motion of particles in matter should cease at absolute zero. But according to quantum mechanics, a substance will contain some energy of motion, regardless of its temperature. For that reason, substances cannot be cooled to absolute zero. However, Bose-Einstein condensates produced in laboratories exist at temperatures very close to absolute zero.

Boyle's Law

Robert Boyle, who was born in Ireland in 1627, was the first to describe the relationship between the pressure and volume of a gas. The graph in Figure 13 shows what happens when the volume of a cylinder containing a set amount of gas is decreased. What happens when the volume of the cylinder is reduced from 2.0 liters to 1.0 liter? The pressure of the gas in the cylinder doubles from 50 kilopascals to 100 kilopascals.

Boyle's Law

$$P_1V_1 = P_2V_2$$

Boyle's law states that the volume of a gas is inversely proportional to its pressure if the temperature and the number of particles are constant. Boyle's law can be expressed mathematically. P_1 and V_1 represent the pressure and volume of a gas before a change occurs. P_2 and V_2 represent the pressure and volume of a gas after a change occurs.

Reading Checkpoint

How is Boyle's law expressed mathematically?

Quick Lab

Observing the Effect of Temperature on Gas Pressure

Materials

pan, metric ruler, empty beverage can, masking tape, hot plate, clock, tongs

Procedure

1. Fill a pan with cold water to a depth of 3 cm.
2. Use masking tape to cover half the opening of the can. **CAUTION** *Do not cover the entire opening with tape.*
3. Place the can on the hot plate and turn the hot plate to a high setting. Heat the can for 5 minutes and then turn off the hot plate.
4. Use tongs to remove the can from the hot plate and place it upside down in the pan of water as shown. The opening should be below the surface of the water. Observe the can as it cools.

Analyze and Conclude

1. **Inferring** How did the temperature of the air inside the can change when you heated the can? How did it change when you put the can in the water?
2. **Drawing Conclusions** What happened to the pressure of the air inside the can when you put the can in the cold water?
3. **Inferring** Did the air pressure outside the can change during the experiment?
4. **Formulating Hypotheses** What caused the change you observed in Step 4?

Facts and Figures

Experimental Evidence Robert Boyle was a founding member of The Royal Society, the oldest continuous scientific society in the world. The society's motto is *Nullius in Verba*, Latin for "Nothing in Words." The motto means that science should be based on experimental evidence, not debates.

Boyle's adherence to a scientific method was one of his most important contributions to science. He was among the first scientists to publish detailed experimental results, even results of unsuccessful experiments. In 1661, Boyle's *The Sceptical Chymist* was published. It disputed Aristotle's theories about elements. His 1662 publication of *The Spring and Weight of the Air* included experiments that led to Boyle's law. For these and earlier experiments, Boyle developed an improved vacuum pump, which required only one person to operate.

Boyle's Law

Quick Lab

Observing the Effect of Temperature on Gas Pressure

L2

Objective

After completing this activity, students will be able to

- predict the effect of temperature on the pressure of a gas.

Address Misconceptions

This lab helps dispel the misconception that a gas does not have mass. Explain that air pressure is the result of particles in air colliding with the can. The force of the collisions (and pressure) depends on the mass and speed of the particles.

Skills Focus Inferring

Prep Time 10 minutes

Materials pan, metric ruler, empty beverage can, masking tape, hot plate, clock, tongs

Advance Prep Ask students to contribute clean, empty beverage cans. Use dissecting pans, cake pans, or plastic dishpans.

Class Time 20 minutes

Safety Caution students not to touch the hot plate or the can once the hot plate has been turned on.

Expected Outcome The can will crack or collapse within one minute after being placed in cold water.

Analyze and Conclude

1. The temperature increased when the can was heated and decreased when it was placed in cold water.
2. The pressure decreased.
3. The air pressure outside the can did not change.
4. As the gas inside the can cooled, its pressure decreased until it could no longer offset the outside air pressure.

Answer to . . .

Figure 13 *For Charles's law, the manipulated variable is temperature and the responding variable is volume. For Boyle's law, the manipulated variable is volume and the responding variable is pressure.*

Reading Checkpoint $P_1V_1 = P_2V_2$

Build Math Skills

L1

Formulas and Equations A gas has a pressure of 200 kPa in a 0.5-L container. Use Boyle's law to determine the pressure of the gas in a 2.0 container. *(50 kPa)* **Logical**

Direct students to the **Math Skills** in the **Skills and Reference Handbook** at the end of the student text for additional help.

The Combined Gas Law

Integrate Math

L2

Have students show how the combined gas law can be used to derive Boyle's and Charles's laws. If temperature is constant, the temperature cancels out to reveal Boyle's law $P_1V_1 = P_2V_2$. Similarly, if volume remains constant, Charles's law of $P_1/T_1 = P_2/V_2$ is derived. **Logical**

Math Practice

L2

Solutions

1. $V_2 = (P_1V_1/P_2) =$
(50 kPa)(5.0 L)/125 kPa = 2.0 L

2. $T_2 = (P_2T_1/P_1) =$
(825 kPa)(273 K)/388 kPa = 580 K

3. $T_2 = (V_2T_1/V_1) =$
(0.285 L)(283 K)/0.250 L =
323 K or 50°C **Logical**

For Extra Help

L1

Remind students that before they solve a specific problem, they should determine which variable is not changing and remove that variable from the combined gas law. Then, they need to identify which of the variables is the unknown—V_2, T_2, or P_2—and rearrange the equation to solve for that variable. If students are having trouble rearranging the equation, provide students with the six possible forms of the equation. **Logical**

Additional Problems

1. A gas is stored at constant volume at a pressure of 137 kPa at 274 K. If the temperature rises to 296 K, what is the pressure? *(148 kPa)*

2. At constant temperature, the volume of a gas at 1000 kPa is changed from 100 L to 10 L. What is the new pressure? *(10,000 kPa)* **Logical**

The Combined Gas Law

The relationships described by Boyle's law and Charles's law can be described by a single law. The combined gas law describes the relationship among the temperature, volume, and pressure of a gas when the number of particles is constant.

Combined Gas Law

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

The combined gas law is used to solve many problems involving gases.

Math Skills

The Combined Gas Law

A cylinder that contains air at a pressure of 100 kPa has a volume of 0.75 L. The pressure is increased to 300 kPa. The temperature does not change. Find the new volume of air.

1 Read and Understand

What information are you given?

$P_1 = 100\ \text{kPa}$ $P_2 = 300\ \text{kPa}$ $V_1 = 0.75\ \text{L}$

2 Plan and Solve

What unknown are you trying to calculate?

V_2

What expression can you use?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Cancel out the variable that does not change and rearrange the expression to solve for V_2.

$$P_1V_1 = P_2V_2 \qquad V_2 = \frac{P_1V_1}{P_2}$$

Replace each variable with its known value.

$$V_2 = 100\ \cancel{\text{kPa}} \times \frac{0.75\ \text{L}}{300\ \cancel{\text{kPa}}} = 0.25\ \text{L}$$

3 Look Back and Check

Is your answer reasonable?

Volume should decrease as pressure increases. The pressure tripled from 100 kPa to 300 kPa. The answer, 0.25 L, is one third the original volume, 0.75 L.

Math Practice

1. A gas has a volume of 5.0 L at a pressure of 50 kPa. What happens to the volume when the pressure is increased to 125 kPa? The temperature does not change.
2. Gas stored in a tank at 273 K has a pressure of 388 kPa. The safe limit for the pressure is 825 kPa. At what temperature will the gas reach this pressure?
3. At 10°C, the gas in a cylinder has a volume of 0.250 L. The gas is allowed to expand to 0.285 L. What must the final temperature be for the pressure to remain constant? (*Hint:* Convert from degrees Celsius to kelvins using the expression °C + 273 = K.)

Facts and Figures

Weather Balloons Large weather balloons are made of natural or synthetic rubber. They are filled with either helium or hydrogen. As the balloon expands, the thickness of the rubber decreases from about 0.051 mm to 0.0025 mm at the altitude when the balloon bursts. A balloon that is about 2 m in diameter at launch will be about 6 m in diameter after it expands. Balloons are launched twice a day at sites around the world.

Attached to the weather balloon is a radiosonde, an instrument that measures pressure, temperature, and relative humidity. Because the radiosonde can be reconditioned and used again, a parachute and mailing bag are also attached to the weather balloon. (The photograph in Figure 14 was taken at the National Weather Station in Maryland.)

It is harder for scientists to do a controlled experiment when they are studying events that occur in natural settings. Scientists need laws like the combined gas law to deal with situations in which multiple variables are changing. Balloons like the one in Figure 14 are used by scientists to gather data about Earth's atmosphere. The balloon is filled with hydrogen or helium. It carries a package of weather instruments up into the atmosphere. The instruments measure temperature, pressure, and water content at different levels in the atmosphere.

What will happen to the volume of the weather balloon as it rises through the atmosphere? Both pressure and temperature decrease as the altitude increases in Earth's atmosphere. A decrease in external pressure should cause the balloon to expand to a larger volume. A decrease in temperature should cause the balloon to contract to a smaller volume. Whether the balloon actually expands or contracts depends on the size of the changes in pressure and temperature.

Figure 14 These scientists are releasing a weather balloon into the atmosphere. The balloon is designed to burst when it reaches an altitude of about 27,400 meters.
Drawing Conclusions ***What happens to the pressure inside a weather balloon as it rises?***

Section 3.2 Assessment

Reviewing Concepts

1. How is the gas pressure produced in a closed container of gas?
2. What three factors affect gas pressure?
3. How does increasing the temperature affect the pressure of a contained gas?
4. What happens to the pressure of a gas if its volume is reduced?
5. How does increasing the number of particles of a contained gas affect its pressure?

Critical Thinking

6. **Predicting** What happens to the pressure in a tire if air is slowly leaking out of the tire? Explain your answer.
7. **Comparing and Contrasting** What do Boyle's law and Charles's law have in common? How are they different?
8. **Applying Concepts** Some liquid products are sold in aerosol cans. Gas is stored in a can under pressure and is used to propel the liquid out of the can. Explain why an aerosol can should never be thrown into a fireplace or incinerator.

Math Practice

9. Two liters of hydrogen gas are stored at a pressure of 100 kPa. If the temperature does not change, what will the volume of the gas be when the pressure is decreased to 25 kPa?
10. You know that a gas in a sealed container has a pressure of 111 kPa at 23°C. What will the pressure be if the temperature rises to 475°C?

Use Visuals

L1

Figure 14 The balloon will burst when it reaches an altitude of about 27,400 m. Ask, **What variables change as the balloon rises? How do they change?** *(Temperature and pressure both decrease.)* **How does each change affect the volume of the balloon?** *(Decreasing atmospheric pressure causes the balloon to expand. Decreasing temperature causes the balloon to shrink.)*
Visual, Logical

3 ASSESS

Evaluate Understanding

L2

Have students look at the mathematical presentations of Charles's law on p. 78 and Boyle's law on p. 79 and describe the relationships in their own words.

Reteach

L1

Write Charles's law and Boyle's law on the board. Have students quiz each other about the behavior of the responding variable when another variable increases or decreases.

Math Practice

Solutions
9. $V_2 = (P_1V_1/P_2) =$
(100 kPa)(2.0 L)/25 kPa = 8.0 L
10. $P_2 = (P_1T_2/T_1) =$
(111 kPa)(748 K)/296 K = 280 kPa

Interactive Textbook If your class subscribes to the Interactive Textbook, use it to review key concepts in Section 3.2.

Answer to . . .

Figure 14 *The pressure increases.*

Section 3.2 Assessment

1. Collisions between particles of a gas and the walls of the container cause the pressure in a closed container of gas.
2. Temperature, volume, and number of particles
3. Raising the temperature will increase the pressure if volume and number of particles are constant.
4. If the volume is reduced, the pressure of a gas increases if temperature and number of particles are constant.
5. Increasing the number of particles will increase the pressure if temperature and volume are constant.
6. Because the number of particles of air is reduced from the leak, the pressure will slowly decrease.
7. Both laws describe a relationship between two variables that affect a gas when other variables are constant. Charles's law shows how the volume of a gas is directly proportional to its temperature in kelvins. Boyle's law shows how the volume of a gas is inversely proportional to its pressure.
8. At a high temperature, the pressure in the gas might increase to the point where the can would explode.