## SAMPLE PROBLEM B

### Solving Pressure-Volume Problems

A given sample of gas occupies 523 mL at 1.00 atm. The pressure is increased to 1.97 atm, while the temperature remains the same. What is the new volume of the gas?

**1 Gather information.**

The initial volume and pressure and the final pressure are given. Determine the final volume.

$P_1 = 1.00 \text{ atm}$ $\quad V_1 = 523 \text{ mL}$

$P_2 = 1.97 \text{ atm}$ $\quad V_2 = ?$

**2 Plan your work.**

Place the known quantities into the correct places in the equation relating pressure and volume.

$$P_1V_1 = P_2V_2$$

$$(1.00 \text{ atm})(523 \text{ mL}) = (1.97 \text{ atm})V_2$$

**3 Calculate.**

$$V_2 = \frac{(1.00 \text{ atm})(523 \text{ mL})}{1.97 \text{ atm}} = 265 \text{ mL}$$

**4 Verify your results.**

The pressure was almost doubled, so the new volume should be about one-half the initial volume. The answer is therefore reasonable.

**PRACTICE HINT**

It does not matter what units you use for pressure and volume when using Boyle's law as long as they are the same on both sides of the equation.

### PRACTICE

1. A sample of oxygen gas has a volume of 150.0 mL at a pressure of 0.947 atm. What will the volume of the gas be at a pressure of 1.000 atm if the temperature remains constant?
2. A sample of gas in a syringe has a volume of 9.66 mL at a pressure of 64.4 kPa. The plunger is depressed until the pressure is 94.6 kPa. What is the new volume, assuming constant temperature?
3. An air mass of volume $6.5 \times 10^5$ L starts at sea level, where the pressure is 775 mm Hg. It rises up a mountain where the pressure is 622 mm Hg. Assuming no change in temperature, what is the volume of the air mass?
4. A balloon has a volume of 456 mL at a pressure of 1.0 atm. It is taken under water in a submarine to a depth where the air pressure in the submarine is 3.3 atm. What is the volume of the balloon? Assume constant temperature.

PROBLEM SOLVING SKILL

## SAMPLE PROBLEM C

### Solving Volume-Temperature Problems

A balloon is inflated to 665 mL volume at 27°C. It is immersed in a dry-ice bath at –78.5°C. What is its volume, assuming the pressure remains constant?

**1 Gather information.**

The initial volume and temperature and the final temperature are given. Determine the final volume.

$V_1 = 665$ mL $\qquad T_1 = 27°C$

$V_2 = ?$ $\qquad T_2 = -78.5°C$

**2 Plan your work.**

Convert the temperatures from degrees Celsius to kelvins:

$T_1 = 27°C + 273 = 300$ K $\qquad T_2 = -78.5°C + 273 = 194.5$ K

Place the known quantities into the correct places in the equation relating volume and temperature.

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

$$\frac{665 \text{ mL}}{300 \text{ K}} = \frac{V_2}{194.5 \text{ K}}$$

**3 Calculate.**

$$V_2 = \frac{(665 \text{ mL})(194.5 \text{ K})}{300 \text{ K}} = 431 \text{ mL}$$

**4 Verify your results.**

Charles's law tells you that volume decreases as temperature decreases. The temperature decreased by about one-third, and according to the calculation, so did the volume. The answer is therefore reasonable.

**PRACTICE HINT**

In gas law problems, always convert temperatures to kelvins. The gas law equations do not work for temperatures expressed in the Celsius or Fahrenheit scales.

**PROBLEM SOLVING SKILL**

### PRACTICE

1. Helium gas in a balloon occupies 2.5 L at 300.0 K. The balloon is dipped into liquid nitrogen that is at a temperature of 80.0 K. What will the volume of the helium in the balloon at the lower temperature be?
2. A sample of neon gas has a volume of 752 mL at 25.0°C. What will the volume at 50.0°C be if pressure is constant?
3. A helium-filled balloon has a volume of 2.75 L at 20.0°C. The volume of the balloon changes to 2.46 L when placed outside on a cold day. What is the temperature outside in degrees Celsius?
4. When $1.50 \times 10^3$ L of air at 5.00°C is injected into a household furnace, it comes out at 30.0°C. Assuming the pressure is constant, what is the volume of the heated air?

## Avogadro's Law

**Avogadro's law**

the law that states that equal volumes of gases at the same temperature and pressure contain equal numbers of molecules

Avogadro's idea turned out to be correct and is now known as **Avo law.** With this knowledge, chemists gained insight into the fo of chemical compounds for the first time. In 1858, Cannizzar Avogadro's law to deduce that the correct formula for water is $H_2$ important discovery will be discussed in more detail in the next se

Avogadro's law also means that gas volume is directly proporti the number of moles of gas at the same temperature and pressu relationship is expressed by the equation below, in which $k$ is a p tionality constant.

$$V = kn$$

But volumes of gases change with changes in temperature and pr A set of conditions has been defined for measuring volumes of ga example, we know that argon exists as single atoms, and that its mass is 39.95 g/mol. It has been determined that 22.41 L of argon and 1 atm have a mass of 39.95 g. *Therefore, 22.41 L is the volume of any gas at STP.* The mass of 22.41 L of a gas at 0°C and a pres 1 atm will be equal to the gas's molecular mass.

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## 2 Section Review

### UNDERSTANDING KEY IDEAS

1. What is the name of the gas law relating pressure and volume, and what does it state?
2. What is the name of the gas law relating volume and absolute temperature, and what does it state?
3. What is the name of the gas law relating pressure and absolute temperature, and what does it state?
4. What relationship does Avogadro's law express?

### PRACTICE PROBLEMS

5. A sample of gas occupies 1.55 L at 27.0°C and 1.00 atm pressure. What will the volume be if the pressure is increased to 50.0 atm, but the temperature is kept constant?
6. A sample of nitrogen gas occupies 1.55 L at 27°C and 1.00 atm pressure. What will the volume be at –100°C and the same pressure?
7. A 1.0 L volume of gas at 27.0°C exer pressure of 85.5 kPa. What will the pr be at 127°C? Assume constant volur
8. A sample of nitrogen has a volume o 275 mL at 273 K. The sample is heate the volume becomes 325 mL. What is new temperature in kelvins?
9. A small cylinder of oxygen contains 300.0 mL of gas at 15 atm. What will volume of this gas be when released the atmosphere at 0.900 atm?

### CRITICAL THINKING

10. A student has the following data: $V_1$ 822 mL, $T_1 = 75°C$, $T_2 = -25°C$. He c lates $V_2$ and gets –274 mL. Is this cor Explain why or why not.
11. Aerosol cans have a warning not to of them in fires. Why?
12. What volume of carbon dioxide cont same number of molecules as 20.0 m oxygen at the same conditions?