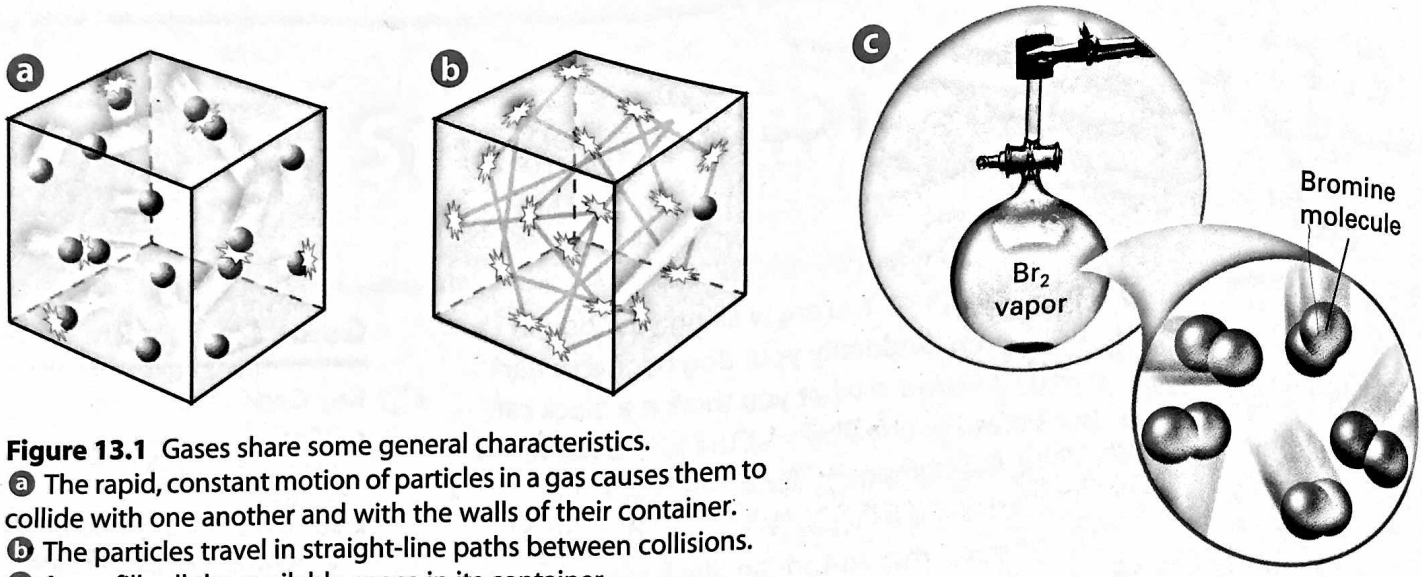

Figure 13.1 Gases share some general characteristics.
ⓐ The rapid, constant motion of particles in a gas causes them to collide with one another and with the walls of their container.
ⓑ The particles travel in straight-line paths between collisions.
ⓒ A gas fills all the available space in its container.

Gas Pressure

A helium-filled balloon maintains its shape because of the pressure of the gas within it. **Gas pressure** results from the force exerted by a gas per unit surface area of an object. What causes this force? Moving bodies exert a force when they collide with other bodies. Although a single particle in a gas is a moving body, the force it exerts is extremely small. Yet it is not hard to imagine that simultaneous collisions involving many particles would produce a measurable force on an object. **Gas pressure is the result of simultaneous collisions of billions of rapidly moving particles in a gas with an object.** If there are no particles, there cannot be collisions. Consequently, there is no pressure. An empty space with no particles and no pressure is called a **vacuum.**

A gas pressure that you are familiar with is that caused by a mixture of gases—air. Air exerts pressure on Earth because gravity holds the particles in air in Earth's atmosphere. **Atmospheric pressure** results from the collisions of atoms and molecules in air with objects. Atmospheric pressure decreases as you climb a mountain because the density of Earth's atmosphere decreases as the elevation increases.

A **barometer** is a device that is used to measure atmospheric pressure. Figure 13.2 shows an early type of mercury barometer. The height of the mercury column in the tube depends on the pressure exerted by particles in air colliding with the surface of the mercury in the dish. Atmospheric pressure depends on weather and on altitude. In fair weather at sea level, the atmospheric pressure is sufficient to support a mercury column about 760 mm high.

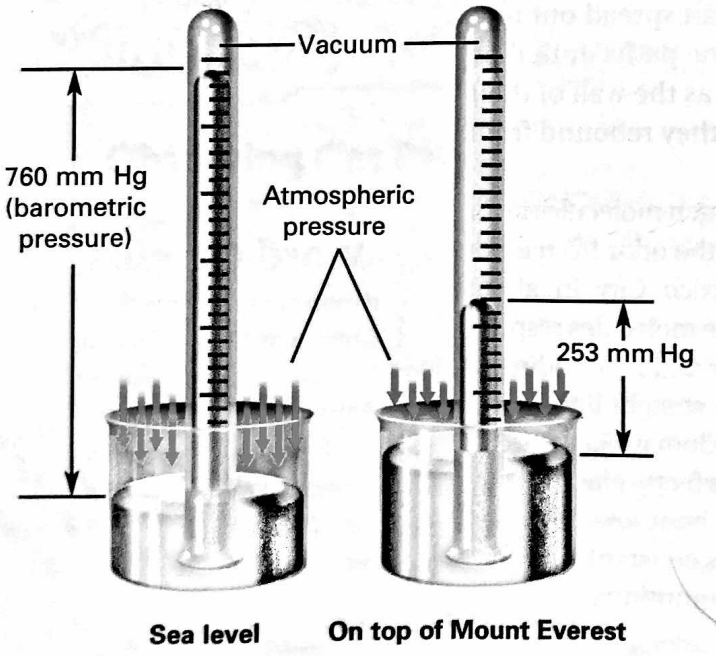

Figure 13.2 At sea level, air exerts enough pressure to support a 760-mm column of mercury. On top of Mount Everest, at 9000 m, the air exerts only enough pressure to support a 253-mm column of mercury.
Calculating ***What is the decrease in pressure from sea level to the top of Mount Everest?***

The SI unit of pressure is the **pascal (Pa).** It represents a very small amount of pressure. For example, normal atmospheric pressure is about 100,000 Pa, that is, 100 kilopascals (kPa). Two older units of pressure are still commonly used. These units are millimeters of mercury (mm Hg) and atmospheres. One **standard atmosphere (atm)** is the pressure required to support 760 mm of mercury in a mercury barometer at 25°C. The numerical relationship among the three units is given below.

$$1 \text{ atm} = 760 \text{ mm Hg} = 101.3 \text{ kPa}$$

In the case of gases, it is important to be able to relate measured values to standards. Recall that the standard temperature and pressure (STP) are defined as a temperature of 0°C and a pressure of 101.3 kPa, or 1 atm.

SAMPLE PROBLEM 13.1

Converting Between Units of Pressure

A pressure gauge records a pressure of 450 kPa. What is this measurement expressed in atmospheres and millimeters of mercury?

1 Analyze ***List the knowns and the unknowns.***

Knowns
- pressure = 450 kPa
- 1 atm = 101.3 kPa
- 1 atm = 760 mm Hg

Unknowns
- pressure = ? atm
- pressure = ? mm Hg

For converting kPa ⟶ atm, the appropriate conversion factor is

$$\frac{1 \text{ atm}}{101.3 \text{ kPa}}$$

For converting kPa ⟶ mm Hg, the appropriate conversion factor is

$$\frac{760 \text{ mm Hg}}{101.3 \text{ kPa}}$$

2 Calculate ***Solve for the unknowns.***

$$450 \text{ kPa} \times \frac{1 \text{ atm}}{101.3 \text{ kPa}} = 4.4 \text{ atm}$$

$$450 \text{ kPa} \times \frac{760 \text{ mm Hg}}{101.3 \text{ kPa}} = 3400 \text{ mm Hg} = 3.4 \times 10^3 \text{ mm Hg}$$

3 Evaluate ***Do the results make sense?***

Because the first conversion factor is much less than 1 and the second much greater than 1, it makes sense that the values expressed in atm and mm Hg are respectively smaller and larger than the value expressed in kPa.

Practice Problems

1. What pressure, in kilopascals and in atmospheres, does a gas exert at 385 mm Hg?
2. The pressure at the top of Mount Everest is 33.7 kPa. Is that pressure greater or less than 0.25 atm?

CHEMath

Using a Calculator

After you analyze a sample problem, you can use a calculator to solve for the unknown. A calculator provides the four basic arithmetic functions of addition (+), subtraction (−), multiplication (×), and division (÷). You can also raise to a power (x^2), take the square root ($\sqrt{x}$), and take the logarithm (*log*). You will need to be able to enter measurements written in scientific notation. On many calculators, you will use the *EE* key or *EXP* key to enter such measurements.

Math Handbook

For help using a calculator, go to page R62.

Interactive Textbook

Problem-Solving 13.1 Solve Problem 1 with the help of an interactive guided tutorial.

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