According to the ideal gas law, when the temperature increases, either the pressure or the volume—or both—must also increase. Thus, the air inside the flask exerts a pressure (P_2) on the balloon that serves to inflate the balloon. Because the balloon is expandable, the air expands to a larger volume (V_2) to fill the balloon. When the flask is taken off the burner, the pressure, volume, and temperature of the air inside will slowly return to their initial states.

Another alternative form of the ideal gas law indicates the law's dependence on mass density. Assuming each particle in the gas has a mass m, the total mass of the gas is $N \times m = M$. The ideal gas law can then be written as follows:

$$PV = Nk_BT = \frac{Mk_BT}{m}$$

$$P = \frac{Mk_BT}{mV} = \left(\frac{M}{V}\right)\frac{k_BT}{m} = \frac{\rho k_BT}{m}$$

A real gas

An ideal gas is defined as a gas whose behavior is accurately described by the ideal gas law. Although no real gas obeys the ideal gas law exactly for all temperatures and pressures, the ideal gas law holds for a broad range of physical conditions for all gases. The behavior of real gases departs from the behavior of an ideal gas at high pressures or low temperatures, conditions under which the gas nearly liquefies. However, when a real gas has a relatively high temperature and a relatively low pressure, such as at room temperature and atmospheric pressure, its behavior approximates that of an ideal gas.

For problems involving the motion of fluids, we have assumed that all gases and liquids are ideal fluids. An ideal fluid is a liquid or gas that is assumed to be incompressible. This is usually a good assumption because it is difficult to compress a fluid—even a gas—when it is not confined to a container. A fluid will tend to flow under the action of a force, changing its shape while maintaining a constant volume, rather than compress.

This feature, however, considers confined gases whose pressure, volume, and temperature may change. For example, when a force is applied to a piston, the gas inside the cylinder below the piston is compressed. Even though an ideal gas behaves like an ideal fluid in many situations, it cannot be treated as incompressible when confined to a container.

Did you know?

A third way of writing the ideal gas law may be familiar to you from your study of chemistry:

$$PV = nRT$$

In this equation, n is the number of moles of gas (one mole is equal to 6.02×10^{23} particles). The quantity R is a number called the *molar (universal) gas constant* and has a value of 8.31 J/(mol•K).

extension

Practice Problems

Visit go.hrw.com to find sample and practice problems for the ideal gas law.

Keyword HF6APJX

Quick Lab

Ideal Gas Law

MATERIALS LIST

- **1 plastic 1 L bottle**
- **1 quarter**

Make sure the bottle is empty, and remove the cap. Place the bottle in the freezer for at least 10 min. Wet the quarter with water, and place the quarter over the bottle's opening as you take the bottle out of the freezer. Set the bottle on a nearby tabletop; then observe the bottle and quarter while the air in the bottle warms up. As the air inside the bottle begins to return to room temperature, the quarter begins to jiggle around on top of the bottle. What does this movement tell you about the pressure inside the bottle? What causes this change in pressure? Hypothesize as to why you need to wet the quarter before placing it on top of the bottle.