Charles's Law: Volume-Temperature Relationship

Balloonists, such as those in the photo at the beginning of this chapter, are making use of a physical property of gases: if pressure is constant, gases expand when heated. When the temperature increases, the volume of a fixed number of gas molecules must increase if the pressure is to stay constant. At the higher temperature, the gas molecules move faster. They collide with the walls of the container more frequently and with more force. The volume of a flexible container must then increase in order for the pressure to remain the same.

The quantitative relationship between volume and temperature was discovered by the French scientist Jacques Charles in 1787. Charles's experiments showed that all gases expand to the same extent when heated through the same temperature interval. Charles found that the volume changes by 1/273 of the original volume for each Celsius degree, at constant pressure and an initial temperature of 0°C. For example, raising the temperature to 1°C causes the gas volume to increase by 1/273 of the volume it had at 0°C. If the temperature is increased by 273°C, the volume increases by 273/273 of the original, that is, the volume doubles. The same regularity of volume change occurs if a gas is cooled at constant pressure, as the balloons in **Figure 8** show.

The Kelvin temperature scale is a scale that starts at a temperature corresponding to –273.15°C. That temperature is the lowest one possible. *The temperature –273.15°C is referred to as* **absolute zero** *and is given a value of zero in the Kelvin scale.* This fact gives the following relationship between the two temperature scales.

$$K = 273.15 + °C$$

For calculations in this book, 273.15 is rounded off to 273.

CHEMISTRY INTERACTIVE TUTOR
Module 6: Gas Laws

FIGURE 8 As air-filled balloons are exposed to liquid nitrogen, they shrink greatly in volume because the air molecules in the balloon get closer together. When the balloons are removed from the liquid nitrogen and the air inside them is warmed to room temperature, they expand to their original volume.