Gay-Lussac's Law: Pressure-Temperature Relationship

You have just learned about the quantitative relationship between volume and temperature at constant pressure. What would you predict about the relationship between pressure and temperature at constant volume? You have seen that pressure is the result of collisions of molecules with container walls. The energy and frequency of collisions depend on the average kinetic energy of molecules. For a fixed quantity of gas at constant volume, the pressure should be directly proportional to the Kelvin temperature, which depends directly on average kinetic energy.

That prediction turns out to be correct. For every kelvin of temperature change, the pressure of a confined gas changes by 1/273 of the pressure at 0°C. Joseph Gay-Lussac is given credit for recognizing this in 1802. The data plotted in **Figure 10** illustrate **Gay-Lussac's law:** *The pressure of a fixed mass of gas at constant volume varies directly with the Kelvin temperature.* Mathematically, Gay-Lussac's law is expressed as follows.

$$P = kT \quad \text{or} \quad \frac{P}{T} = k$$

The value of T is the temperature in kelvins, and k is a constant that depends on the quantity of gas and the volume. For a given mass of gas at constant volume, the ratio P/T is the same for any set of pressure-temperature values. Unknown values can be found using the following form of Gay-Lussac's law.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

P_1 and T_1 represent initial conditions. P_2 and T_2 represent a different set of conditions. When values are known for three of the four quantities, the fourth value can be calculated for a system at constant volume.

Pressure Vs. Temperature for a Gas at Constant Volume

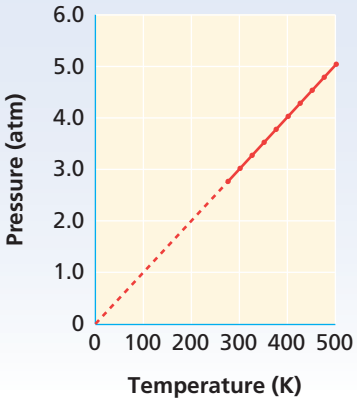

FIGURE 10 A graph of pressure versus temperature of a sample of gas at constant volume is a straight line, indicating a direct relationship between pressure and temperature.

SAMPLE PROBLEM E

For more help, go to the Math Tutor at the end of this chapter.

The gas in a container is at a pressure of 3.00 atm at 25°C. Directions on the container warn the user not to keep it in a place where the temperature exceeds 52°C. What would the gas pressure in the container be at 52°C?

SOLUTION

1 ANALYZE

Given: P_1 of gas = 3.00 atm

T_1 of gas = 25°C + 273 = 298 K; T_2 of gas = 52°C + 273 = 325 K

Unknown: P_2 of gas in atm

2 PLAN

Because the gaseous contents remain at the constant volume of the container, an increase in temperature will cause an increase in pressure. Rearrange Gay-Lussac's law to obtain P_2.

$$P_2 = \frac{P_1 T_2}{T_1}$$