7.6: The volume-amount relationship

Figure $7.6.1$ illustrates the effect of the amount of gas on the volume. Adding more gas molecules increases the collision frequency of the molecules with the walls increasing the gas pressure. The gas expands to reduce pressure until the pressure of gas in the chamber is equal to the outside pressure.

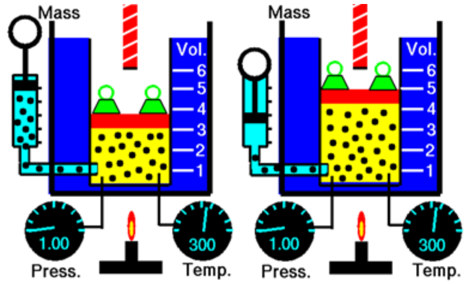

Figure $7.6.1$: When more gas is added the volume of a gas increases, i.e., $V_1/n_1 = V_2/n_2$. Source: NASA's Glenn Research Center / Public domain.

Avogadro's law

Avogadro's law states that the volume of a gas is directly proportional to the amount of gas in moles provided the temperature and pressure of the gas are not changed.

The mathematical forms of Avogadro's law are the following.

$$V \propto n$$

or

$$V = \mathrm{k} n$$

or

$$\frac{V}{n} = \mathrm{k}$$

where V is the volume, n is the number of moles, and k is the constant for the gas under the conditions of constant temperature and pressure. Since V/n is a constant, it implies that:

$$\frac{V_1}{n_1} = \frac{V_2}{n_2} = \mathrm{k}$$

where V_1 and n_1 is initial volume and the initial amount of gas, respectively, and V_2 and n_2 is final volume and the final amount of gas in mole, provided the temperature and pressure are not changed.

Example 7.6.1

A weather balloon containing 3.0 moles of helium has a volume of $66\ \mathrm{L}$. What is the final volume if 2.0 moles of helium is added to it. The pressure and temperature of the gas do not change?

Solution

Given $\quad V_1 = 66L, \quad n_1 = 3.0\ \mathrm{mol}, \quad V_2 = ?, \quad n_2 = 3.0 + 2.0 = 5.0\ \mathrm{mol}$

Formula:

$$\frac{V_1}{n_1} = \frac{V_2}{n_2},$$

rearrange the formula to isolate the desired variable:

$$V_2 = \frac{V_1 n_2}{n_1}.$$

Plug in the values and calculate:

$$V_2 = \frac{66 \text{ L} \times \times 5.0 \text{ mol}}{3.0 \text{ mol}} = 110 \text{ L}.$$