Effusion of Gases

$$\mu_{rms} = \sqrt{\frac{3\,RT}{M_m}} \qquad \frac{Rate_{Gas\,A}}{Rate_{Gas\,B}} = \sqrt{\frac{M_{m_B}}{M_{m_A}}}$$

1. Calculate the rms speed of nitrogen molecules, N_2, at 22.0 °C. Report the speed in meters.

T = 22.0 °C + 273.15 = 295.15 K, M_m = 28.0 g/mol = 0.0280 kg/mol

1 J = $\frac{kg \cdot m^2}{s^2}$

$$\mu_{rms} = \sqrt{\frac{3\,RT}{M_m}} = \sqrt{\frac{3 \times 8.314\,\frac{J}{mol \cdot K} \times 295.15\,K}{0.0280\,kg/mol}} = \mathbf{513\ m/s}$$

2. What is the molar mass of a gas that diffuses 1.92 times slower than Ne gas?

$$\frac{Rate\ Unknown}{Rate\ Ne} = \sqrt{\frac{M_m Ne}{M_m Unknown}}$$

$$\frac{1}{1.92} = \sqrt{\frac{20.1797\frac{g}{mol}}{M_m Unknown}}$$ Square both sides of equation; solve for M_m Unknown.

$$M_m Unknown = 20.1797\frac{g}{mol} \times (1.92)^2 = \mathbf{74.4\ g/mol}$$

3. A given volume of O_2 gas takes 68.2 seconds to diffuse. Another gas took 86.3 seconds to diffuse under the same conditions. Calculate the molar mass of the gas?

In this case we are given time.

$$\frac{86.3\ s}{68.2\ s} = \sqrt{\frac{M_m\ Unknown\ gas}{31.999\ g/mol}}$$ Square both sides of equation

$$\left(\frac{86.3\ s}{68.2\ s}\right)^2 = \frac{M_m\ Unknown\ gas}{31.999\ g/mol}$$ and Mm = **51.24 g/mol**

4. A sample of Ne gas diffuses 15.5 cm in 3.4 minutes. How long would it take for Cl_2 gas to diffuse the same distance?

$$\frac{rate\ He}{rate\ Cl_2} = \sqrt{\frac{70.9\frac{g}{mol}}{20.1797\frac{g}{mol}}} = 1.9$$

Ne effuses 1.9 times faster than Cl_2. 1.9 x 3.4 min = 6.0 min.