

Chapter 17 Problem 25 †

Given

H_2 at 75 K

SO_2 at 350 K

Solution

Find the gas that has the faster moving molecules.

Use the relationship between kinetic energy and temperature.

$$\frac{1}{2}mv^2 = \frac{3}{2}kT$$

Solving for velocity gives

$$v = \sqrt{\frac{3kT}{m}}$$

The mass of the hydrogen gas is

$$m_{H_2} = 2 \text{ u} \left(\frac{1.67 \times 10^{-27} \text{ kg}}{1 \text{ u}} \right) = 3.34 \times 10^{-27} \text{ kg}$$

The velocity of the hydrogen gas is then

$$v = \sqrt{\frac{3(1.38 \times 10^{-23} \text{ J/K})(75 \text{ K})}{(3.34 \times 10^{-27} \text{ kg})}} = 964 \text{ m/s}$$

The mass of the sulfur dioxide is

$$m_{SO_2} = 64 \text{ u} \left(\frac{1.67 \times 10^{-27} \text{ kg}}{1 \text{ u}} \right) = 1.07 \times 10^{-25} \text{ kg}$$

The velocity of the sulfur dioxide is

$$v = \sqrt{\frac{3(1.38 \times 10^{-23} \text{ J/K})(350 \text{ K})}{(1.07 \times 10^{-25} \text{ kg})}} = 368 \text{ m/s}$$

Comparing the velocities we have

$$\frac{v_{H_2}}{v_{SO_2}} = \frac{964 \text{ m/s}}{368 \text{ m/s}} = 2.62$$

The hydrogen gas is travelling at 2.62 times the speed of the sulfur dioxide gas.

†Problem from Essential University Physics, Wolfson