SAMPLE PROBLEM J

Compare the rates of effusion of hydrogen and oxygen at the same temperature and pressure.

SOLUTION

1 ANALYZE

Given: identities of two gases, H_2 and O_2
Unknown: relative rates of effusion

2 PLAN

molar mass ratio $\longrightarrow$ ratio of rates of effusion

The ratio of the rates of effusion of two gases at the same temperature and pressure can be found from Graham's law.

$$\frac{\text{rate of effusion of A}}{\text{rate of effusion of B}} = \frac{\sqrt{M_B}}{\sqrt{M_A}}$$

3 COMPUTE

$$\frac{\text{rate of effusion of } H_2}{\text{rate of effusion of } O_2} = \frac{\sqrt{M_{O_2}}}{\sqrt{M_{H_2}}} = \frac{\sqrt{32.00\ \text{g/mol}}}{\sqrt{2.02\ \text{g/mol}}} = \sqrt{\frac{32.00\ \text{g/mol}}{2.02\ \text{g/mol}}} = 3.98$$

Hydrogen effuses 3.98 times faster than oxygen.

4 EVALUATE

The result is correctly reported to three significant figures. It is also approximately equivalent to an estimated value of 4, calculated as $\sqrt{32}\,/\,\sqrt{2}$.

PRACTICE

Answers in Appendix E

1. Compare the rate of effusion of carbon dioxide with that of hydrogen chloride at the same temperature and pressure.
2. A sample of hydrogen effuses through a porous container about 9 times faster than an unknown gas. Estimate the molar mass of the unknown gas.
3. If a molecule of neon gas travels at an average of 400. m/s at a given temperature, estimate the average speed of a molecule of butane gas, C_4H_{10}, at the same temperature.

extension
Go to **go.hrw.com** for additional problems that ask you to compare rates of effusion.
Keyword: HC6GASX

SECTION REVIEW

1. Compare diffusion with effusion.
2. State Graham's law of effusion.
3. Estimate the molar mass of a gas that effuses at 1.6 times the effusion rate of carbon dioxide.
4. Determine the molecular mass ratio of two gases whose rates of effusion have a ratio of 16:1.
5. List the following gases in order of increasing average molecular velocity at 25°C: H_2O, He, HCl, BrF, and NO_2.

Critical Thinking

6. **ANALYZING INFORMATION** An unknown gas effuses at one-half the speed of oxygen. What is the molar mass of the unknown? The gas is known to be either HBr or HI. Which gas is it?