$8.00\ g\ N_2O_4 \times \frac{1\ mol\ N_2O_4}{92.02\ g\ N_2O_4}$

$= 0.0869\ mol\ N_2O_4$

$4.00\ g\ N_2H_4 \times \frac{1\ mol\ N_2H_4}{32.06\ g\ N_2H_4}$

$= 0.125\ mol\ N_2H_4$

actual mole ratio $= \frac{0.125\ mol\ N_2H_4}{0.0869\ mol\ N_2O_4} = 1.44$

Because the actual mole ratio is less than the balanced equation mole ratio, the limiting reactant is hydrazine.

2. mass of product (N_2)

$0.125\ mol\ N_2H_4 \times \frac{3\ mol\ N_2}{2\ mol\ N_2H_4} = 0.188\ mol\ N_2$

$0.188\ mol\ N_2 \times \frac{28.02\ g\ N_2}{1\ mol\ N_2} = 5.27\ g\ N_2$

3. mass of excess reactant

$0.125\ mol\ N_2H_4 \times \frac{1\ mol\ N_2O_4}{2\ mol\ N_2H_4}$

$= 0.0625\ mol\ N_2O_4$

$0.0625\ mol\ N_2O_4 \times \frac{92.02\ g\ N_2O_4}{1\ mol\ N_2O_4}$

$= 5.75\ g\ N_2O_4$

$8.00\ g\ N_2O_4 - 5.75\ g\ N_2O_4 = 2.25\ g\ N_2O_4$

7. One step in the industrial refining of nickel is the decomposition of nickel carbonyl ($Ni(CO)_4$) into nickel and carbon monoxide. In a laboratory reaction, 25.0 g nickel carbonyl yielded 5.34 g nickel.

a. Balance the following equation for the reaction.

__1__ $Ni(CO)_4(g) \rightarrow$

__1__ $Ni(s)$ + __4__ $CO(g)$

b. Determine the theoretical yield of nickel.

$25.0\ g\ Ni(CO)_4 \times \frac{1\ mol\ Ni(CO)_4}{170.73\ g\ Ni(CO)_4}$

$= 0.146\ mol\ Ni(CO)_4$

$0.146\ mol\ Ni(CO)_4 \times \frac{1\ mol\ Ni}{1\ mol\ Ni(CO)_4}$

$= 0.146\ mol\ Ni$

$0.146\ mol\ Ni \times \frac{58.69\ g\ Ni}{mol\ Ni} = 8.57\ g\ Ni$

c. Determine the percent yield.

$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$

$\frac{5.34\ g\ Ni}{8.57\ g\ Ni} \times 100 = 62.3\%$

Chapter 13

1. Calculate the ratio of effusion rates of oxygen (O_2) to hydrogen (H_2).

$\frac{Rate_{O_2}}{Rate_{H_2}} = \frac{\sqrt{molar\ mass_{H_2}}}{\sqrt{molar\ mass_{O_2}}} = \frac{\sqrt{2.02\ g/mol}}{\sqrt{32.00\ g/mol}}$

$= \frac{1.42}{5.657} = 0.251$

2. Methane (CH_4) effuses at a rate of 2.45 mol/s. What will be the effusion rate of argon (Ar) under the same conditions?

$\frac{Rate_{Ar}}{Rate_{CH_4}} = \frac{\sqrt{molar\ mass_{CH_4}}}{\sqrt{molar\ mass_{Ar}}}$

$Rate_{Ar} = Rate_{CH_4} \times \frac{\sqrt{molar\ mass_{CH_4}}}{\sqrt{molar\ mass_{Ar}}}$

$= 2.45\ mol/s \times \frac{\sqrt{16.05\ g/mol}}{\sqrt{39.95\ g/mol}}$

$= 2.45\ mol/s \times \frac{4.006}{6.321}$

$= 1.55\ mol/s$

3. The effusion rate of hydrogen sulfide (H_2S) is 1.50 mol/s. Another gas under similar conditions effuses at a rate of 1.25 mol/s. What is the molar mass of the second gas?

$$\frac{\text{Rate}_{H_2S}}{\text{Rate}_{\text{unknown}}} = \frac{\sqrt{\text{molar mass}_{\text{unknown}}}}{\sqrt{\text{molar mass}_{H_2S}}}$$

$$\frac{(\text{Rate}_{H_2S})^2}{(\text{Rate}_{\text{unknown}})^2} = \frac{\text{molar mass}_{\text{unknown}}}{\text{molar mass}_{H_2S}}$$

$$\text{molar mass}_{\text{unknown}} = \text{molar mass}_{H_2S} \times \frac{(\text{Rate}_{H_2S})^2}{(\text{Rate}_{\text{unknown}})^2}$$

$$= 34.09 \text{ g/mol} \times \frac{(1.50 \text{ mol/s})^2}{(1.25 \text{ mol/s})^2}$$

$$= 34.09 \text{ g/mol} \times \frac{2.25}{1.56}$$

$$= 49.2 \text{ g/mol}$$

4. The pressure of a gas in a manometer is 12.9 mm Hg. Express this value in each of the following units.

a. torr

$$12.9 \text{ mm Hg} \times \frac{1 \text{ torr}}{1 \text{ mm Hg}} = 12.9 \text{ torr}$$

b. atmosphere

$$12.9 \text{ mm Hg} \times \frac{1 \text{ atm}}{760 \text{ mm Hg}} = 1.70 \times 10^{-2} \text{ atm}$$

c. kilopascal

$$12.9 \text{ mm Hg} \times \frac{1 \text{ kPa}}{7.501 \text{ mm Hg}} = 1.72 \text{ kPa}$$

5. The vapor pressure of water is 2.3 kPa at 23°C. What is the vapor pressure of water at this temperature expressed in atmospheres?

$$2.3 \text{ kPa} \times \frac{1 \text{ atm}}{101.3 \text{ kPa}} = 2.3 \times 10^{-2} \text{ atm}$$

6. What is the pressure of a mixture of nitrogen (N_2) and oxygen (O_2) if the partial pressure of N_2 is 594 mm Hg and the partial pressure of O_2 is 165 mm Hg?

$$P_{\text{total}} = P_{N_2} + P_{O_2}$$

$$= 594 \text{ mm Hg} + 165 \text{ mm Hg}$$

$$= 759 \text{ mm Hg}$$

7. A sample of air is collected at 101.1 kPa. If the partial pressure of water vapor in the sample is 2.8 kPa, what is the partial pressure of the dry air?

$$P_{\text{total}} = P_{\text{dry air}} + P_{\text{water vapor}}$$

$$P_{\text{dry air}} = P_{\text{total}} - P_{\text{water vapor}}$$

$$= 101.1 \text{ kPa} - 2.8 \text{ kPa}$$

$$= 98.3 \text{ kPa}$$

8. Suppose that 5-mL containers of helium (He), neon (Ne), and argon (Ar) are at pressures of 1 atm, 2 atm, and 3 atm, respectively. The He and Ne are then added to the container of Ar.

a. What is the partial pressure of He in the container after the three gases are mixed?

1 atm

b. What is the total pressure in the container after the three gases are mixed?

$$P_{\text{total}} = P_{\text{He}} + P_{\text{Ne}} + P_{\text{Ar}}$$

$$= 1 \text{ atm} + 2 \text{ atm} + 3 \text{ atm}$$

$$= 6 \text{ atm}$$