

Gas Mixtures and Collection of a Gas Over Water

Dalton's Law of Partial Pressures

$$P_{\text{Total}} = P_A + P_B + P_C + \dots + P_n$$

1. What is the total pressure, in atm, in a vessel that holds 1.45 atm of N_2 gas and 3.98 atm of Ar gas?

$$\text{The total pressure is } 1.45 \text{ atm} + 3.98 \text{ atm} = \mathbf{5.43 \text{ atm}}$$

2. A 4.15 L vessel holds 0.345 moles of oxygen gas and 1.25 moles of nitrogen gas at a temperature of 101 °C. What is the pressure in atm?

$$P = \frac{nRT}{V} = \frac{0.345 \text{ mol } O_2 \times 0.0821 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \times 374 \text{ K}}{4.15 \text{ L}} = 2.55 \text{ atm } (O_2)$$

$$P_{N_2} = \frac{1.25 \text{ mol} \times 0.0821 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \times 374 \text{ K}}{4.15 \text{ L}} = 9.25 \text{ atm}$$

$$P_t = 2.55 \text{ atm} + 9.25 \text{ atm} = \mathbf{11.8 \text{ atm}}$$

3. What is the partial pressure of each gas in a vessel containing 2.1 g Ne, 0.38 g of Xe, and 1.5 g of Ar if the total pressure is 3.1 atm?

$$2.1 \text{ g Ne} \times \frac{1 \text{ mol Ne}}{20.1797 \text{ g}} = 0.10 \text{ mol Ne} \quad 0.38 \text{ g Xe} \times \frac{1 \text{ mol Xe}}{131.29 \text{ g}} = 0.0029 \text{ mol Xe}$$

$$1.5 \text{ g Ar} \times \frac{1 \text{ mol Ar}}{39.948 \text{ g}} = 0.038 \text{ mol Ar}$$

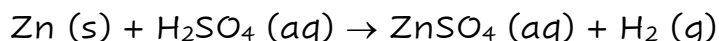
$$\chi_{Ne} = \frac{0.10 \text{ mol}}{0.10 \text{ mol} + 0.0029 \text{ mol} + 0.038 \text{ mol}} = 0.71 \quad \chi_{Xe} = \frac{0.0029 \text{ mol}}{0.10 \text{ mol} + 0.0029 \text{ mol} + 0.038 \text{ mol}} = 0.021$$

$$\chi_{Ar} = \frac{0.038 \text{ mol}}{0.10 \text{ mol} + 0.0029 \text{ mol} + 0.038 \text{ mol}} = 0.27$$

$$P_{Ne} = 0.71 \times 3.1 \text{ atm} = \mathbf{2.2 \text{ atm}}, \quad P_{Xe} = 0.021 \times 3.1 \text{ atm} = \mathbf{0.065 \text{ atm}}$$

$$P_{Ar} = 0.27 \times 3.1 \text{ atm} = 0.27 \times 3.1 = \mathbf{0.84 \text{ atm}}$$

4. Hydrogen gas can be prepared in the laboratory with the reaction of zinc metal and sulfuric acid, H_2SO_4 .



The hydrogen gas is collected over water. What volume of H_2 gas is produced by the reaction of 0.245 g of zinc metal in excess H_2SO_4 if the temperature is 22.0 °C and the barometric pressure is 750 torr?

Vapor Pressure of Water

$$\text{Vapor Pressure of } H_2O \text{ at } 22.0 \text{ }^\circ\text{C} = 19.8 \text{ mmHg} = 19.8 \text{ torr}$$

$$750 \text{ torr} - 19.8 \text{ torr} = 730 \text{ torr} \quad \text{and} \quad 730 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} = 0.961 \text{ atm}$$

$$0.245 \text{ g Zn} \times \frac{1 \text{ mol Zn}}{65.38 \text{ g}} \times \frac{1 \text{ mol } H_2}{1 \text{ mol Zn}} = 0.00374 \text{ mol } H_2$$

$$V = \frac{nRT}{P} = \frac{0.00374 \text{ mol} \times 0.0821 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \times 295 \text{ K}}{0.961 \text{ atm}} = \mathbf{0.0943 \text{ L } H_2 \text{ gas}}$$