Gas Mixtures and Collection of a Gas Over Water

Dalton's Law of Partial Pressures

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

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?

   The total pressure is 1.45 atm + 3.98 atm = **5.43 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?

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

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

   Pt = 2.55 atm + 9.25 atm = **11.8 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?

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

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

   $$\chi_{Ne} = \frac{0..10\ mol}{0.10\ mol + 0.0029\ mol + 0.038\ mol} = 0.71 \quad \chi_{Xe} = \frac{0.0029\ mol}{0.10\ mol + 0.0029\ mol + 0.038\ mol} = 0.021$$

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

   P_{Ne} = 0.71 x 3.1 atm = **2.2 atm**, P_{Xe} = 0.021 x 3.1 atm = **0.065 atm**

   P_{Ar} = 0.27 x 3.1 atm = 0.27 x 3.1 = **0.84 atm**

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

   $Zn\ (s) + H_2SO_4\ (aq) \rightarrow ZnSO_4\ (aq) + H_2\ (g)$

   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

   Vapor Pressure of H_2O at 22.0 °C = 19.8 mmHg = 19.8 torr

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

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

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