Gas Mixtures & Partial Pressures

Advanced Chemistry

Introduction

- So far we have considered mainly pure gases – one substance in the gaseous state.
- How do we deal with mixtures of two or more different gases?
- John Dalton's Observation: The total pressure of a mixture of gases equals the sum of the pressures that each would exert if it were present alone.
  - Partial pressure: pressure exerted by a particular component of a mixture of gases

Dalton's Law of Partial Pressures

P_t = total pressure

- Dalton's Law of Partial Pressures
  - $P_t = P1 + P2 + P3 + \ldots$
- The equation implies each gas behaves independently of the others. Therefore, we can use the ideal gas law to determine the pressure of each gas involved.
  - $P1 = \frac{n_1 RT}{V}$, $P2 = \frac{n_2 RT}{V}$, and so forth.

$PV = nRT$

$\frac{PV}{V} = \frac{nRT}{V}$

Applying Dalton's Law of Partial Pressures

$6g\,O_2 \times \frac{1\,mol}{31.998g} =$

$9g \times \frac{1\,mol}{16.0426g} =$

- A mixture of 6.00 g $O_2(g)$ and 9.00g $CH_4(g)$ is placed in a 15.0 L vessel at $0^{o}C$. What is the partial pressure of each gas, and what is the total pressure in the vessel?

$(X) = \frac{(.187511719 5)(.08206)(273.15)}{15}$

$X = .2802011251$

$.280\,atm\,O_2$

$(x) = \frac{(.5610063207)(.08206)(273.15)}{15}$

$x = .8383188137$

$.838\,atm\,CH_4$

$P_t = 1.12\,atm$

More Practice

- What is the total pressure exerted by a mixture of 2.00 g of $H_2(g)$ and 8.00 g $N_2(g)$ at 273 K in a 10.0 L vessel?

Partial Pressures & Mole Fractions

- Because each gas in a mixture behaves independently, we can relate the amount of a given gas in a mixture to its partial pressure.
  - $\frac{P_1}{P_t} = \frac{n_1 RT/V}{n_t RT/V} = \frac{n_1}{n_t}$
- The ratio n_1/n_t is called the mole fraction of gas 1 (X_1)
- Combining equations gives us:
  - $P_1 = \left(\frac{n_1}{n_t}\right) Pt = X_1 P_t$
- The mole fraction can be represented as a percent
  - Mole fraction of N_2 in air is 0.78 = 78% of molecules in air are N_2

Relating Mole Fractions and Partial Pressures

$P_1 = \left(\frac{n_1}{n_t}\right)(P_t)$

$745\ torr \times \frac{1\ atm}{760\ atm} =$

- A study of the effects of certain gases on plant growth requires a synthetic atmosphere composed on 1.50 mol percent CO_2, 18.00 mol percent O_2, and 80.5 mol percent Ar. Calculate the partial pressure of each gas in the mixture if the total pressure of the atmosphere is 745.0 torr.

CO_2

$X = \left(\frac{1.50}{100}\right)(.9802631579) = .0147\ atm\ CO_2$

O_2

$X = \left(\frac{18}{100}\right)(.9802631579) = .1764\ atm\ O_2$

$Ar = .789\ atm\ Ar$

More Practice

- From data gathered by Voyager 1, scientists have estimated the composition of the atmosphere of Titan. The pressure on the surface is 1220.0 torr. The atmosphere consists of 82.0 mol N_2, 12.0 mol Ar, and 6.00 mole CH_4. Calculate the partial pressure of each gas.

More Practice

- A mixture of gases contains 0.75 mol N_2, 0.30 mol O_2, and 0.15 mol CO_2. If the total pressure of the mixture is 2.15 atm, what is the partial pressure of each compound?