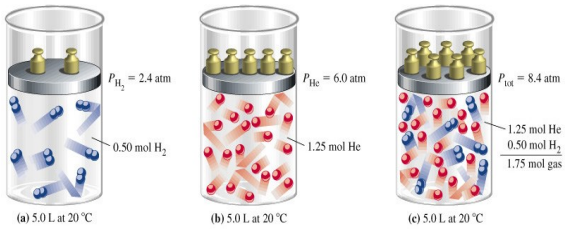
Partial Pressure, Effusion and Diffusion

Dalton's Law of Partial Pressure

It states that the total pressure of a mixture of gases is the sum of the partial pressures of the components of the mixture.



Partial Pressure

$P_{tot} = P_a + P_b + \ldots$

$V_a = n_a RT/P_{tot}$ and $V_{tot} = V_a + V_b + \ldots$

$$\frac{V_a}{V_{tot}} = \frac{n_a RT/P_{tot}}{n_{tot} RT/P_{tot}} = \frac{n_a}{n_{tot}}$$

$$\frac{P_a}{P_{tot}} = \frac{n_a RT/V_{tot}}{n_{tot} RT/V_{tot}} = \frac{n_a}{n_{tot}}$$

$$\frac{n_a}{n_{tot}} = \chi_a$$

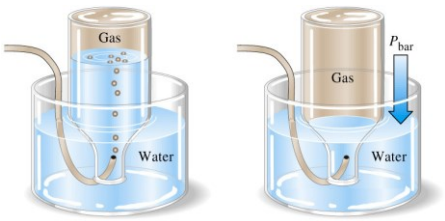
Mole fraction of component A

$P_a = \chi_a \bullet P_{tot}$ $P_b = \chi_b \bullet P_{tot}$

Problem

The percent composition of air by volume is 78.08% N_2, 20.95% O_2, 0.93% Ar and 0.036% CO_2. What are the partial pressures of these four gases in a sample of air at a barometric pressure of 748 mm Hg?

Pneumatic Trough



$$P_{tot} = P_{bar} = P_{gas} + P_{H_2O}$$

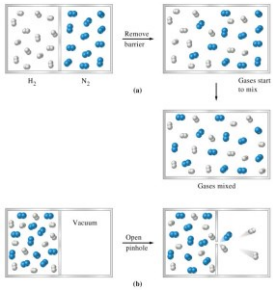
Kinetic Molecular Theory

- Particles are point masses in constant, random, straight line motion.
- Particles are separated by great distances.
- Collisions are rapid and elastic.
- No force between particles.
- Total energy remains constant.

Average kinetic energy is directly proportional to temperature!!

Gas Properties Relating to the Kinetic-Molecular Theory

- Diffusion
  - Migration of molecules that results in a homogenous mixture.
- Effusion
  - Escape of gas molecules through a tiny pinhole.



Graham's Law

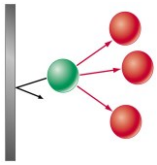
$$\frac{rate\ of\ effusion\ of\ A}{rate\ of\ effusion\ of\ B} = \sqrt{\frac{M_B}{M_A}}$$

- Only for gases at low pressure (natural escape, not a jet).
- Tiny orifice (no collisions)
- Does not apply to diffusion.

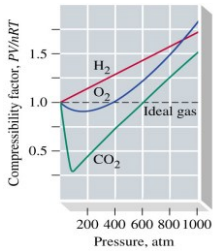
- Ratio used can be:
  - Rate of effusion (as above)
  - Molecular speeds
  - Effusion times
  - Distances traveled by molecules
  - Amounts of gas effused.

Real Gases

- Compressibility factor PV/nRT = 1
- Deviations occur for real gases.
  - PV/nRT > 1 - molecular volume is significant.
  - PV/nRT < 1 – intermolecular forces of attraction.



Real Gases



van der Waals Equation

$$\left(P + \frac{n^2 a}{V^2}\right)\left(V - nb\right) = nRT$$