Chem E-1a
Friday Review Notes
Chapter 5: Gases

The Ideal Gas Law:

PV = nRT (P = Pressure in atm, V = Volume in L, n = # of moles of gas, $R = 0.0821 \dfrac{L \bullet atm}{mol \bullet K}$, T = Temp in K = °C + 273)

Some Useful Manipulations of the Ideal Gas Law:

For any general change in a sample of gas:

$$\frac{P_iV_i}{n_iT_i} = \frac{P_fV_f}{n_fT_f} \quad (= R)$$

Calculating the density of a sample of gas:

$$\text{density} = d = \frac{\text{mass}}{\text{volume}} = \frac{\mathcal{M}n}{V} = \frac{\mathcal{M}P}{RT} \qquad (\mathcal{M} = \text{molar mass of gas} = \frac{dRT}{P})$$

Mixtures of Gasses:

Assume we are dealing with a mixture of different gasses labeled "a", "b", "c", "d", "e", . . .
We can then deal with the partial pressures of each gas alone or the total pressure of the gas mixture.

P_t = Total pressure of gas mixture	n_t = Total # of moles of all gasses combined
P_a = Partial pressure of gas "a"	n_a = # of moles of gas "a"
P_b = Partial pressure of gas "b"	n_b = # of moles of gas "b"
P_c = Partial pressure of gas "c"	n_c = # of moles of gas "c"
etc. . . .	

$\mathbf{n_t = n_a + n_b + n_c + \ldots}$
(this is obvious: the total # of moles is just the sum of # of moles of each individual gas in mixture)

$\mathbf{P_t = P_a + P_b + P_c + \ldots}$
(i.e. the total pressure of a mixture is the sum of all of the partial pressures of the individual gases)

$\mathbf{V = V_a = V_b = V_c}$ **. . . . = Volume of the container**

$\mathbf{T = T_a = T_b = T_c}$ **. . . . = Temperature of the gas mixture**

When dealing with gas mixtures, you can use the Ideal Gas Law applied to the total mixture or just one gas:

$\mathbf{P_tV = n_tRT}$ (relating total pressure and total number of moles)

$\mathbf{P_aV = n_aRT}$ (relating partial pressure of gas "a" to number of moles of gas "a")

Mole Fraction:

$$\textbf{Mole Fraction of "a"} = X_a = \frac{\textbf{\# of moles of "a"}}{\textbf{total \# of moles}}$$

(Note: Mole fraction is unitless and the mole fractions of all gasses in a mixture will add up to 1)

$$X_a = \frac{n_a}{n_t} = \frac{P_a}{P_t}$$

$X_a \cdot P_t = P_a$ (i.e. mole fraction of gas "a" times total pressure equals partial pressure of gas "a")

Vapor Pressure: (Collecting gasses over water)

Liquids will evaporate, creating a certain amount of gas that will be present over the surface of the liquid. The pressure of the gas over the surface of a liquid is called the vapor pressure of the liquid, and it depends only on temperature. When you collect a gas over water, the gas you collect will always be a mixture of the gas and water vapor. Thus, the total pressure (or the pressure at which the gas is collected) will be the sum of the pressure of the individual gas being collected and the vapor pressure of water at that temperature.

$P_{total} = P_{gas} + P_{H2O}$ (P_{H2O} = Vapor Pressure of water at given temperature)

And, we can see that:

$$P_{gas} = P_{total} - P_{H2O}$$

Kinetic Molecular Theory:

Problems dealing with the **kinetic molecular theory of gases** are usually fairly straightforward--know the formulas and then just plug in. The only tricky part involves using the correct units. For all of this material:

R = 8.314 J/(mol•K)

Molar Masses must be in kilograms per mole (kg/mol)

This will make the units work out because, by definition: $J = \frac{kg \bullet m^2}{s^2}$

Calculating the root mean squared (rms) velocity of a gas:

$$\boldsymbol{u_{RMS}} = \sqrt{\frac{\mathbf{3RT}}{\boldsymbol{M}}}$$

(u_{RMS} = root mean square speed in m/s, R = 8.314 J/mol•K,

T = Temp in K, M = Molar Mass in kg/mol)

Calculating the average kinetic energy (KE) per mole of a gas:

$$\mathbf{KE} = \frac{\mathbf{1}}{\mathbf{2}}\boldsymbol{Mu^2}$$

(KE = Kinetic Energy in J/mol, M = Molar Mass in kg/mol, u = rms speed in m/s)

A much simpler formula for the same thing illustrates that KE is just a function of Temperature:

$$\mathbf{KE} = \frac{\mathbf{3}}{\mathbf{2}}\mathbf{RT}$$

(KE = Kinetic Energy in J/mol, R = 8.314 J/mol•K, T = Temp in K)

To calculate KE per molecule, just use dimensional analysis to convert the units of KE from J/mol to J/molecule with Avogadro's Number.)