Chem 116 Notes for Sept 2 and 4, 2008 (tc)

Gases:

About Gases:

- Gases are very compressible because the particles are spread apart. There is NOTHING in between the spread out particles, therefore, compression is permitted.
- Compared to liquids and solids, gases have a lower density.
- All gas particles are spread apart and move at a rapid pace. Gas Particles are ALWAYS moving.
- Gas particles can rapidly fill any space it is put in because they move at such a fast, chaotic pace.
- Gas particles travel in straight lines and constantly collide with each other. The colliding particles either get faster in motion or slower in motion after impact with another particle or the surrounding walls.
- There are no attractive forces between gas particles; they don't attract or repel each other.
- Heavier gases move slower and lighter gases move faster.
- At standard temperatures and/or fixed/same temperatures, different gases have different average speeds.
- Gas particle speed distribution is larger when there is an increase in temperature.
- There is a wide distribution of the speed of gas particles in any given gas.
- Gas is the easiest state of matter to study.

Number of Particles, Pressure, Temperature, & Volume:

- 1) Temperature and Volume are FIXED.
  2) Add more particles.
  >>> Pressure increases in a FIXED space when extra gas particles are added to the FIXED volume.
  -or-
  >>> If the existing particles were removed instead, the pressure in the FIXED volume would drop.
  = Pressure ***-is directly proportional to-*** N (number of particles in the FIXED volume)
  => ***This is also known as*** **Avogadro's Law**.
  => ***P/N = CONSTANT***
  => $P_1/N_1 = P_2/N_2$
- 1) Number of particles and the volume are FIXED.
  2) Increase the temperature.
  >>> Pressure is increased when the temperature of the FIXED volume is raised.
  -or-
  >>> If the temperature of the FIXED volume is decreased, the pressure in the FIXED volume goes down.
  = Pressure ***-is directly proportional to-*** Temperature
  => ***This is also known as*** **Gay-Lussac's Law**.
  => ***P/T = CONSTANT***
  => $P_1/T_1 = P_2/T_2$
- 1) Temperature and the number of particles are FIXED.
  2) Decrease the volume.

>>> Pressure increases when a volume containing gas particles decreases.
-or-
>>> The pressure drops when the volume is increased.
= Pressure ***-is inversely proportional to-*** volume.
=> ***This is also known as Boyle's Law***.
=> ***PV = CONSTANT***
=> $P_1V_1 = P_2V_2$

- 1) Number of Particles and Pressure are FIXED.
  2) Increase the temperature.
  >>> The volume increases as the temperature rises.
  -or-
  >>> The volume will decrease if the temperature drops.
  = Volume ***– is directly proportional to –*** temperature
  => ***This is also known as Charles' Law***.
  => ***V/T = CONSTANT***
  => $V_1T_1 = V_2T_2$

Gas Variables:

- *Number of particles:*
  "n" = quantity in moles
  - this can be converted to and from mass (grams)
- *Volume:*
  "V" = occupied space in LITERS
  - Other units of measurement are: mL, m^3, and cm^3.
- *Temperature:*
  "T" = measured in Kelvin.
  - Other units of measurement are: Celsius/˚C.
  - To convert from Celsius to Kelvin, add 273.15 to the given Celsius amount.
    > Then, write the product as "Kelvin or (K)"
- *Pressure:*
  - "P" = 1 atm (Atmosphere)
  - Other units of measurement are: kPa, Pa, mmHg, torr (Torricelli)
  - 1 atm = 101.325 kPa
  - 1 atm = 101,325 Pa
  - 1 atm = 760 torr
  - 1 atm = 760 mmHg

"R", the Gas Constant:

- **R** =
  - 8.206×10^{-2} L·atm/mol·K
  - 8.314 L·kPa/mol·K
  - 8.314 J/mol·K
  - 62.364 L·torr/mol·K

Ideal Gas Law:

- $pV = nRT$ (The main equation)

- ***pV = nT * (A Constant called R, the gas law constant, which is always the same under any conditions for an ideal gas)***
- Ideal gases are non-existent and are mainly considered "pretend gases".
- The Ideal Gas Law is a good method to predict gas behavior under certain conditions.
- When volume, temperature, and pressure are the same, the Ideal Gas Law states that number of moles should also be the same.
- Since all gases behave similarly, the same mathematical model can be used to predict their behavior.
- You can solve the ideal gas equation for any of the variables in it using algebra:
  - ***To find "n":***
    > n = PV/RT
  - ***To find "V":***
    > V = nRT/P
  - ***To find "P":***
    > P = nRT/V
  - ***To find "T":***
    > T = PV/nR

Particle Density:

- The amount of particles (can also be expressed as moles) in a volume.
  - Example in class; using the ideal gas law, we found that there were the same number of moles of He, N_2, CO_2, SF_6 in the 4 balloons because they had the same T, P and V. Since the volumes and number of moles were the same, the particle density was the same (particle density = moles / volume).
- Although the particle densities were the same, each balloon had different masses (mass density = mass / volume) because the particles had different masses.
- The amount of particles may also change when the space it's in compresses or decompresses (syringe, canister with a piston, etc.).

Mass Density:

- Equation:

$$D = \frac{m}{V} = \frac{m}{(nRT/P)} = \frac{mp}{nRT} = (m/n)\,(P/RT) = M\,(P/RT)$$

where M = molar mass in g/mol (use the periodic table)

Standard Temperature and Pressure (STP):

- When at Standard Temperature and Pressure (STP),
  - the molar volume (which is V/n) of a gas is **22.4 L/mol**.
- Standard Temperature = 273.15 K = 0˚C
- Standard Pressure = 1.00 atm

Kinetic Molecular Theory:

- Average kinetic energy is proportional to the temperature of the gas.
- The kinetic energy of a single gas particle is greater than the attractive force between the particles.

- When gas particles collide with each other or a wall, there is no loss of energy.
- Why is it useful?
  - **Since different gases have different average speeds, the gases "effuse" differently.**
    > Effuse = the gas's escape through a tiny hole.

  ~ *This is useful for identifying gases*.

  - In **a mixture of gases, all gases spread out to occupy an entire volume.**

  ~ *This is useful for measuring how much gas is produced during a reaction*.

Graham's Law of Effusion:

- Effusion = the gas's escape through a tiny hole.
- The escape of gas particles through a tiny hole is predicted by Kinetic Molecular Theory.
- How to read Graham's Law:
  - ***The Speed of the Particles:***
    > The ratio of speeds in inverse proportion to the square root of molar masses.
    > If the molar mass of B is greater than the molar mass of A….
      - The speed of A is faster than the speed of B by the inverse ratio of the square roots of the molar masses.
  - ***Rates of Effusion:***
    > The rate of leakage of a gas out of a hole is proportional to the R.M.S (Root Mean Square)
  - ***Time of Effusion:***
    > The faster the rate of leakage, the shorter the time.
    > Times are mathematically inverse of rate or speed.
- Equation:

$$\frac{V_A}{V_B} = \sqrt{M_B/M_A}$$