# CHEM/PHYS HIGH YIELD GUIDE

## General Chemistry

**Mass Number:** # of Protons + # of Neutrons
**Atomic Number:** # of Protons

**Mole:** How to count particles – represented by Avogadro's number which is 6.022 x 10^23 particles.

*Moles = Mass of Sample / Molar Mass*

**Isotopes:** For each element – there are multiple species of atoms with the same number of protons but different number of neutrons. Therefore, different mass numbers.

**Planck's Quantum Theory:** Energy emitted as EM radiation from matter exists in discrete bundles called quanta.

### Bohr's Model of the Hydrogen Atom

$$E = hf = \frac{hc}{\lambda}$$

h = 6.63 x $10^{-34}$ Js → Planck constant

f = frequency of photon/electromagnetic radiation

c = 3 x $10^{8}$ m/s → speed of light in a vacuum

λ = wavelength of photon/electromagnetic radiation

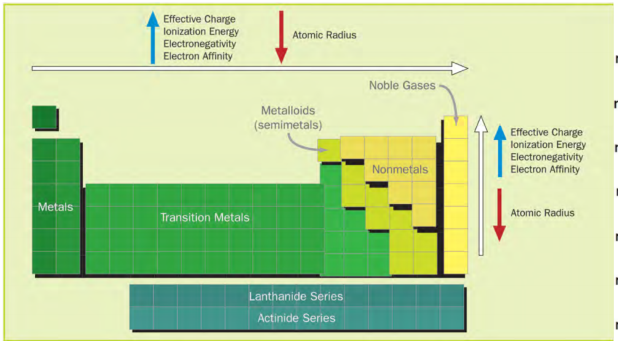
### Quantum Mechanical Models of Atoms

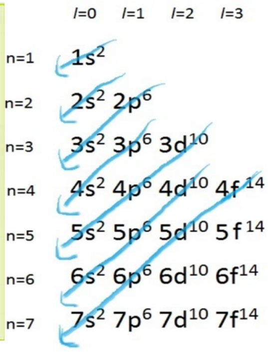
| Number | Symbol | Possible Values |
|---|---|---|
| Principal Quantum Number | $n$ | $1, 2, 3, 4, \ldots$ |
| Angular Momentum Quantum Number | $\ell$ | $0, 1, 2, 3, \ldots, (n-1)$ |
| Magnetic Quantum Number | $m_l$ | $-\ell, \ldots, -1, 0, 1, \ldots, \ell$ |
| Spin Quantum Number | $m_s$ | $+1/2, -1/2$ |

**Heisenberg Uncertainty Principle:** It's impossible to determine perfectly the momentum and position of an electron simultaneously.

### ELECTRON CONFIGURATION

**Hund's Rule:** Within a given subshell, orbitals are filled such that there are a maximum number of half-filled orbitals with parallel spins.
**Valence Electrons:** Electrons of an atom that are in its outer shell are available for bonding.





### Octet Rule Exceptions

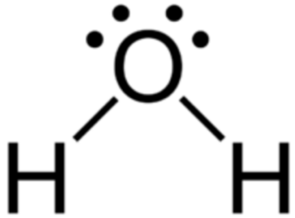
| | |
|---|---|
| **Hydrogen** | 2 Electrons (duet rule) |
| **Beryllium** | 4 Electrons |
| **Boron** | 6 Electrons |

## BONDING & CHEMICAL INTERACTIONS

Octet Rule: An atom will bond until it has a full outermost shell. An atom wants a similar configuration to Group VIII (noble gases).

## STEPS FOR DRAWING LEWIS STRUCTURES

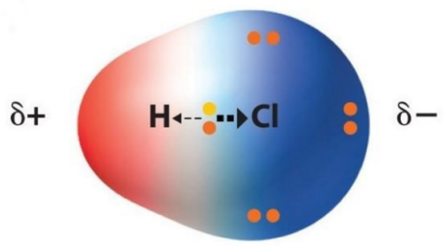
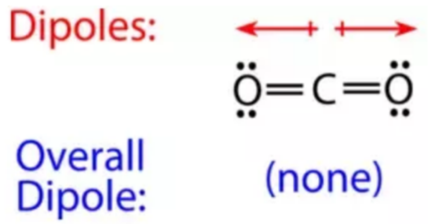
1. Count total valence electrons in the molecule.
2. Arrange atoms into a "skeleton" molecule.
3. Connect all atoms with single bonds (dashes).
4. Distribute electrons to fill octets for all atoms.
5. Make sure to check your structure.



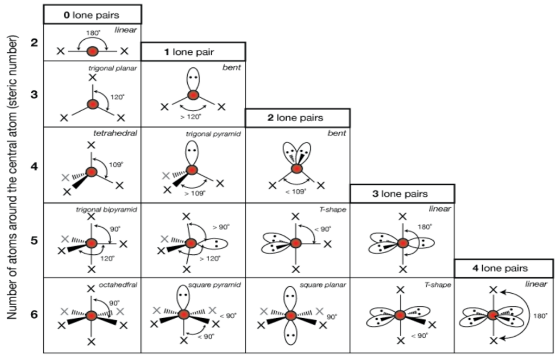
## FORMAL CHARGES

The charge an atom would have if all the electrons in the bonds were shared equally.

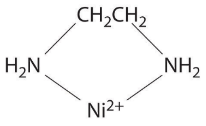
### Geometry and Polarity of Covalent Molecules

| Polar Covalent Bond | Polarity of Molecules |
|---|---|
| Bonding electron pair is not shared equally – but pulled towards the more electronegative atom.<br> | A molecule with nonpolar bonds is always nonpolar.<br>A molecule with polar bonds may be polar or nonpolar – dependent on the orientation of the bond dipoles.<br> |

## VSEPR



**Complex Ion (Coordination Compound):**
A Lewis acid-base with a cation bonded to at least one pair of electron pair donors (including water). Donor molecules are called **ligands** and use **coordinate covalent bonds**. The central cation can be bonded to the same ligand multiple times in a process called **chelation.**



A chelate complex

## INTERMOLECULAR FORCES

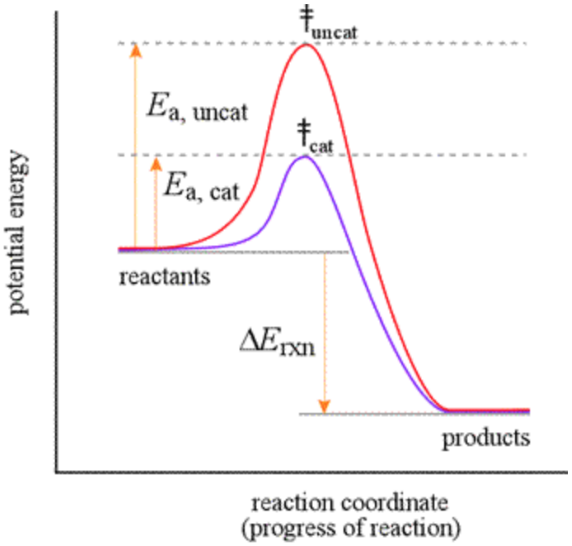
| **Hydrogen Bonding** | **Dipole-Dipole Interactions** | **Dispersion Forces** |
|---|---|---|
| Partial positive charge of hydrogen atom interacts with partial negative charge located on EN atom (F, O, N) of nearby molecules. | Polar molecules orient themselves such that the positive region of one molecule is close to the negative region of another molecule. | Bonding electrons in covalent bonds may appear to be equally shared between two atoms, but at any particular point in time they will be located randomly throughout the orbital. |

## KINETICS & EQUILIBRIUM

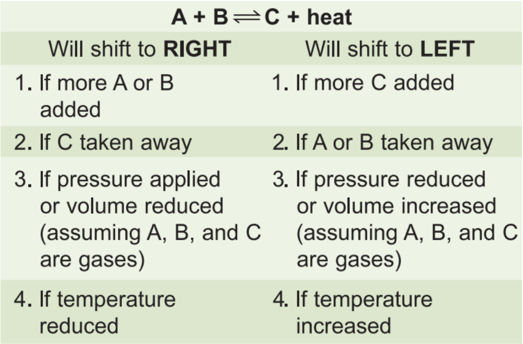
Kc = Equilibrium Constant

$$aA + bB \rightleftharpoons cC + dD$$

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$



### Properties of Equilibrium Constant

| **Keq:** Characteristic of a given system at a given temperature.<br>Pure solids and liquids don't appear in expressions. | |
|---|---|
| **Keq >> 1** | Products > Reactants |
| **Keq << 1** | Reactants > Products |
| **Keq = Close to 1** | Reactants = Products |
| **SUMMARY** |  |

**A + B ⇌ C + heat**

| Will shift to **RIGHT** | Will shift to **LEFT** |
|---|---|
| 1. If more A or B added | 1. If more C added |
| 2. If C taken away | 2. If A or B taken away |
| 3. If pressure applied or volume reduced (assuming A, B, and C are gases) | 3. If pressure reduced or volume increased (assuming A, B, and C are gases) |
| 4. If temperature reduced | 4. If temperature increased |

## COMPOUNDS & CHEMISTRY

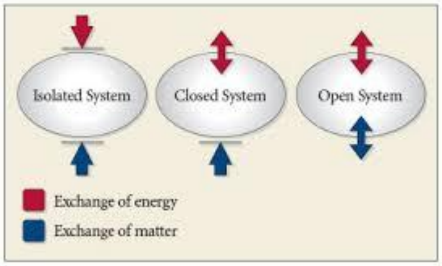
Mole is the amount of substance that contains the same number of particles that are found in a 12.000 g sample of carbon-12.

| **Reaction Type** | Explanation | General Formula |
|---|---|---|
| **Combination** | 2+ compounds combine to form one compound. | A + B -> AB |
| **Decomposition** | Complex molecule breaks down to make simpler ones. | AB -> A + B |
| **Single Displacement** | One element trades places with another element in the compound. | A + BC -> AC + B |
| **Double Displacement** | Two elements trade places with each other in two separate compounds. | AB + CD -> AC + BD |
| **Combustion** | Oxygen combines with a compound to form carbon dioxide and water. | A + O2 -> H2O + CO2 |

| | | |
|---|---|---|
| | These reactions are exothermic – giving off heat. | |
| Neutralization | An acid-base reaction. The product is generally salt and water. | Acid + Salt -> Salt + Water |
| Precipitation | Two solutions of soluble salts are mixed. Results in insoluble solid (precipitate) forming. | A + Soluble Salt B -> Precipitate + Soluble Salt C |

**Factors Affecting Reaction Rates:** Reactant concentration, temperature, medium & catalysts.
**Catalysts:** Unique substance that increase reaction rate without being consumed – they do this by lowering the activation energy.

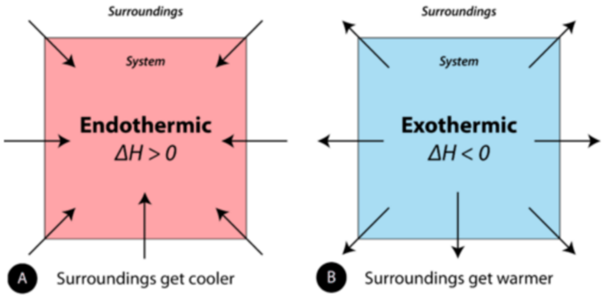
**THERMOCHEMISTRY**
**Law of Conservation of Energy:** Energy cannot be created or destroyed – all thermal/chemical/potential/kinetic energies are convertible.



**SYSTEMS:**
**Isolated:** No exchange of energy or matter.
**Closed:** Exchange of energy.
**Open:** Exchange of energy and matter.

**SYSTEM PROCESSES**

| **Isothermal** | **Temperature of system remains constant.** |
|---|---|
| **Adiabatic** | No heat exchange occurs. |
| **Isobaric** | Pressure of system remains constant. |
| **Iso-Volumetric (Isochoric)** | Volume of system remains constant. |
| **Heat** | Transfer of thermal energy from one object to another. |
| **Endothermic** | Reactions that absorb heat energy. |
| **Exothermic** | Reactions that release heat energy. |



**Constant-Volume & Constant-Pressure Calorimetry:** Conditions under which the heat changes are measured.

**$q = mc\Delta t$**

HEAT EQUATION
(in Table T)

$Q = mc\Delta t$
Q = heat energy in JOULES (J)
m = mass of the sample in GRAMS (g)
C = specific heat in J/g°C
$\Delta t$ = change in temperature (°C)
or
final temp – initial temp

**States & State Functions:** Only dependent on the initial and final states of the system – not path-dependent. Common state functions include pressure, density, temperature, volume, enthalpy, internal energy, free energy and entropy.
**Enthalpy (H):** Express heat changes at constant pressure.
**Hess's Law:** Enthalpies of reactions are additive. Reverse of any reaction has an enthalpy of the same magnitude as that of the forward reaction, but its sign is opposite.

**Bond Dissociation Energy:** Average of the energy required to break a particular type of bond in one mole of gaseous molecules.

**Bond Enthalpy:** Standard heat of reaction can be calculated using the values of bond dissociation energy of particular bonds.

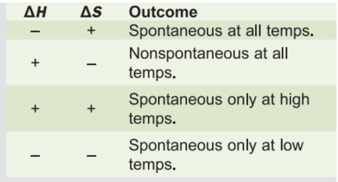
$$\Delta H^\circ_{rxn} = \sum \Delta H_{\text{bonds broken}} - \sum \Delta H_{\text{bonds formed}}$$

**Entropy (S):** Measure of the distribution of energy/randomness throughout a system.

$$\Delta S_{universe} = \Delta S_{system} + \Delta S_{surroundings}$$

**Gibbs Free Energy (G):** Combines the two factors that affect the spontaneity of a reaction – changes in enthalpy, ΔH, and changes in entropy, ΔS.

$$\Delta G = \Delta H - T\Delta S$$



| ΔH | ΔS | Outcome |
|---|---|---|
| – | + | Spontaneous at all temps. |
| + | – | Nonspontaneous at all temps. |
| + | + | Spontaneous only at high temps. |
| – | – | Spontaneous only at low temps. |

**-ΔG** = Spontaneous Reaction

**+ΔG** = Non-Spontaneous Reaction

**ΔG = 0** = State of Equilibrium.

$$aA + bB \rightleftharpoons cC + dD$$

$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

**Reaction Quotient (Q):** Once a reaction commences, the standard state conditions no longer hold.

## THE GAS PHASE

**1 atm = 760 mmHg = 760 torr = 101,325 PA**

| | |
|---|---|
| **STP Conditions**<br>Gas Law Calculations | O C or 273K & 1 atm. |
| **Standard Conditions**<br>Standard enthalpy, entropy, Gibbs Free energy & EMF | 25 C or 298 K, 1 atm & 1 M concentrations. |

**Gas Law Formula**

| **Gas Law** | **Formula** | **Description** |
|---|---|---|
| **Boyle's Law** | $P_1V_1 = P_2V_2$ | At constant *T*, as pressure increases, volume decreases. |
| **Charles' Law** | $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ | At constant P, as volume increases, temperature increases. |
| **Gay-Lussac's Law** | $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ | At constant V, as pressure increases, temperature increases. |
| **Combined Law** | $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ | Obtained by combining Boyle's Law, Charles' Law and Gay-Lussac's Law. |
| **Ideal Gas Law** | $PV = nRT$ | |
| *V* = volume in $dm^3$<br>T = temperature in K | P = pressure in kPa<br>n = number of moles | R = ideal gas constant |

## REAL GASES

Decreasing the volume of a sample of gas makes it behave less ideally because the individual gas particles are in closer proximity in a smaller volume. Increasing intermolecular interactions.
Increasing Pressure: Makes individual gas particles act less ideally.
High or Low Temperature: Makes individual gas particles act less ideally.
**1 mole of gas at STP = 22.4 L**

## DALTON'S LAW OF PARTIAL PRESSURES

States that the total pressure of a gaseous mixture is equal to the sum of the partial pressures of the individual components.

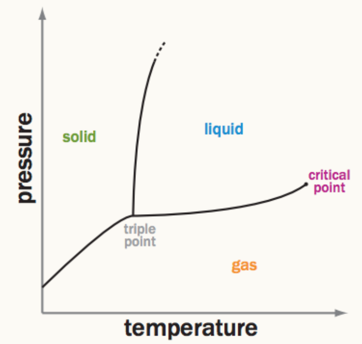
$$P_T = P_A + P_B + P_C + \ldots$$

$$P_A = P_T X_A$$

$$\text{where } X_A = \frac{n_A}{n_T} \; \frac{\text{(moles of A)}}{\text{(total moles)}}$$

## PHASES & PHASE CHANGES

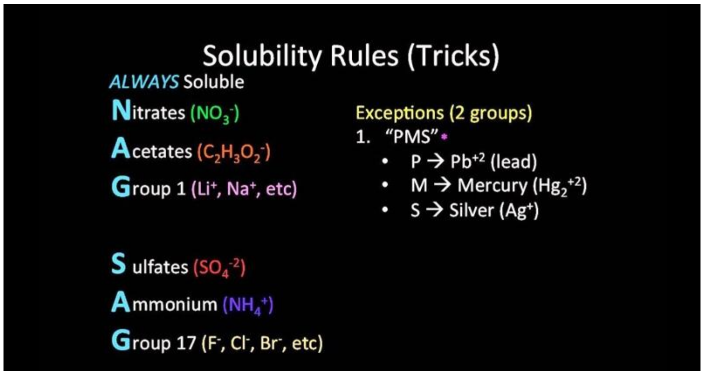
**Colligative Properties:** Physical properties (dilute solutions)
Molality (m) & van't Hoff factor (*i*) for ionic compounds used.



| Freezing Point Depression | Boiling Point Elevation | Osmotic Pressure |
|---|---|---|
| $\Delta T_f = iK_f m$ | $\Delta T_b = K_b m i$ | $\pi = iMRT$ |

| Graham's Laws | |
|---|---|
| **Diffusion** | **Effusion** |
| Gas molecules distribute through volume by random motion. | Gas particles flow under pressure from one compartment to another through small opening. |

## SOLUBILITY RULES



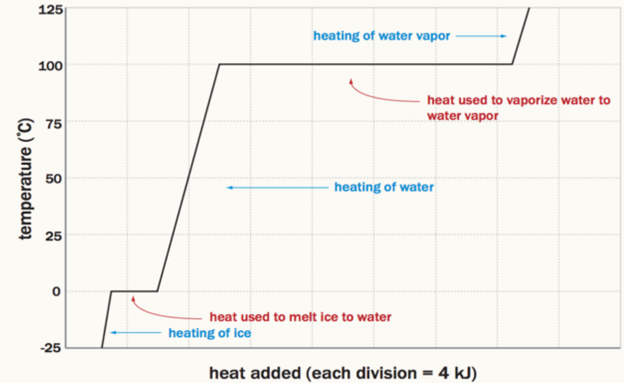
Solubility Rules (Tricks)

*ALWAYS* Soluble

Nitrates ($NO_3^-$)
Acetates ($C_2H_3O_2^-$)
Group 1 ($Li^+$, $Na^+$, etc)

Sulfates ($SO_4^{-2}$)
Ammonium ($NH_4^+$)
Group 17 ($F^-$, $Cl^-$, $Br^-$, etc)

Exceptions (2 groups)
1. "PMS"
   - P → $Pb^{+2}$ (lead)
   - M → Mercury ($Hg_2^{+2}$)
   - S → Silver ($Ag^+$)



| Units of Concentration | |
|---|---|
| **% Composition By Mass** | (Mass of Solute / Mass of Solution) x 100% |
| **Mole Fraction** | # of mol of compound / total # of moles in system |
| **Molarity** | # of mol of solute / liter of solution |
| **Molality** | # of mol of solute / kg of solvent |
| **Normality** | # of gram equivalent weights of solute / liter of solution |

## ACIDS & BASES

$$pH = -\log[H^+] = \log\left(\frac{1}{[H^+]}\right)$$

$$pOH = -\log[OH^-] = \log\left(\frac{1}{[OH^-]}\right)$$

$$H_2O\ (l) \rightleftharpoons H^+\ (aq) + OH^-\ (aq)$$

$$K_w = [H^+][OH^-] = 10^{-14}$$

$$pH + pOH = 14$$

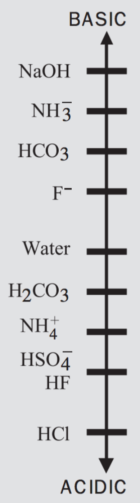
$$HA\ (aq) + H_2O\ (l) \rightleftharpoons H_3O^+\ (aq) + A^-\ (aq)$$

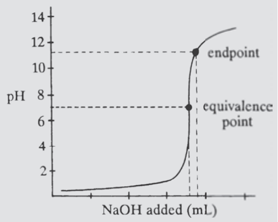
$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

$$K_b = \frac{[B^+][OH^-]}{[BOH]}$$

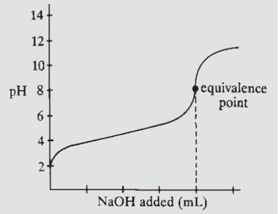
| | Acid | Base |
|---|---|---|
| Arrhenius | n $H_2O$ | $OH^-$ in $H_2O$ |
| ry | donor | Accepts $H^+$ |
| | Accepts e- pair | e- pair donor |

| Salt Formation | HA + BOH -> BA + H2O |
|---|---|
| **Hydrolysis** | BA + H20 -> HA + BOH |
| **Amphoteric Species** | Can act as an acid or base (dependent on chemical environment). |





strong acid and strong base



## TITRATIONS & BUFFERS

Determine molarity of an acid or base by reacting a known volume of a solution of unknown concentration with a known volume of a solution of known concentration.
Half equivalence point defined: *pH = pKa*

**Henderson-Hasselbach Equation**: Estimate pH of a solution in a buffer region.
*pH = pKa + log [conjugate base] / [weak acid]*
*pOH = pKb + log [conjugate acid] / [weak base]*

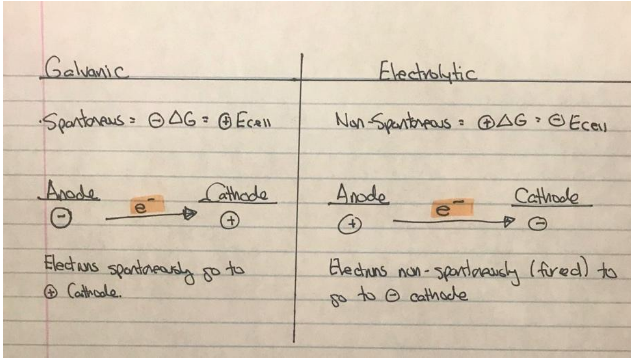
## REDOX REACTIONS & ELECTROCHEMISTRY

LEO says GER
Oxidation: Loss of Electrons (reducing agent)
Reduction: Gain of Electrons (oxidizing agent)

## GALVANIC VS ELECTROLYTIC CELL

**Reduction Potential:** Tendency of a species to gain electrons (reduced).

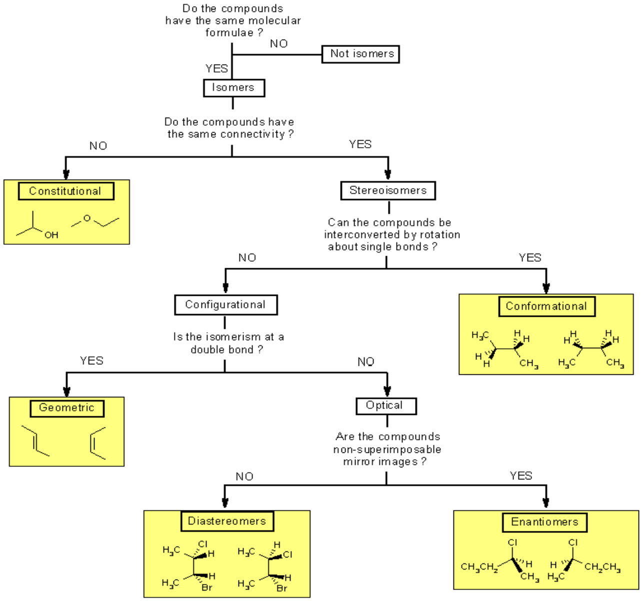
| Standard Reduction Potentials | Gibbs Free Energy |
|---|---|
| $emf = E^\circ_{\text{red, cathode}} - E^\circ_{\text{red, anode}}$ | $\Delta G = -nFE_{\text{cell}}$ |



| Galvanic | Electrolytic |
|---|---|
| ·Spontaneous = ⊖ΔG = ⊕Ecell | Non-Spontaneous = ⊕ΔG = ⊖Ecell |
| Anode ⊖ $\xrightarrow{e^-}$ Cathode ⊕ | Anode ⊕ $\xrightarrow{e^-}$ Cathode ⊖ |
| Electrons spontaneously go to ⊕ Cathode. | Electrons non-spontaneously (fired) to go to ⊖ cathode |

## ORGANIC CHEMISTRY

| Functional Group | Prefix | Suffix |
|---|---|---|
| Carboxylic Acid | N/A | -oic acid |
| Ester | Alkyl- | -oate |
| Amide | Carbamoyl- | -amide |
| Aldehyde | Oxo- | -al |
| Ketone | Oxo- | -one |
| Alcohol | Hydroxy- | -ol |



## NOMENCLATURE, BONDING, & PROPERTIES

| **Bond Order** | **Single** | **Double** | **Triple** |
|---|---|---|---|
| **Bond Type** | Sigma | Sigma + Pi | Sigma + 2 Pi |
| **Hybridization** | Sp3 | Sp2 | Sp |
| **Angles** | 109.5° | 120° | 180° |
| **Example** | C-C | C=C | C≡C |

| **Physical Properties** | **Chemical Properties** |
|---|---|
| Don’t change composition of matter – MP, BP, solubility, odor, color, and density. | Reactivity of molecule with other molecules. |

## ABSOLUTE CONFIGURATION

| **E/Z** (Highest property substituents) | **R/S** |
|---|---|
| **E:** Opposite sides.<br>**Z:** Same side. | **R:** Counterclockwise stereocenter.<br>**S:** Clockwise stereocenter. |

## ALKANES

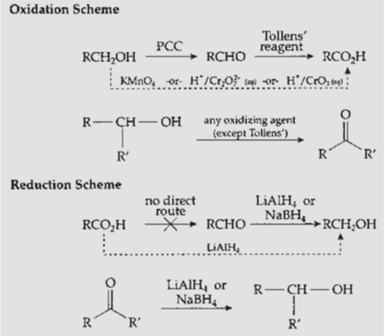
| **SN1** | **SN2** |
|---|---|
| 2 Steps | 1 Step |
| Polar Protic Solvents | Polar Aprotic Solvents |
| 3° > 2° > 1° > Methyl | Methyl > 1° > 2° >3° |
| Rate = k[RL] | Rate = k[Nu][RL] |
| Racemic Mixture | Optically Active & Inverted Products |
| Strong nucleophile not required. | Strong nucleophile favored. |

| Protic Solvents | Aprotic Solvents |
|---|---|
| Good bases pick up protons and are worse nucleophiles.<br>I-> Br-> Cl-> F- | Nucleophilicity parallels basicity.<br>F- > Cl-> Br-> I- |

| Nucleophiles (nucleus-loving) | Electrophiles (electron-loving) | Leaving Groups |
|---|---|---|
| Tend to have lone pairs or Pi bonds that can form new bonds with electrophiles.<br>4 Factors:<br>**Charge:** Increased Negative Charge = Increased Nucleophilicity.<br>**Electronegativity:** Increased EN = Decreased Nucleophilicty<br>**Steric Hindrance:** Bulkier molecules = Less nucleophilic<br>**Solvent:** Protic solvents = Decreased nucleophilicity. | Have a positive charge or positively charged polarized atom.<br><br>Most common electrophiles:<br>Carbonyl carbon<br>Substrate carbon in alkane<br>Carbocation's | Molecular fragments that retain electrons after breaking bonds. Best leaving groups will be able to stabilize the extra electrons.<br><br>Most common leaving groups:<br>Weak bases<br>Large groups w/ resonance<br>Large groups w/ electron withdrawing atoms. |

**STEPS FOR DETERMINING ORGANIC MECHANISMS**

1. Know your nomenclature.
2. Identify the functional groups.
3. Identify the other reagents.
4. Identify the most reactive functions groups.
5. Identify the first step of the reaction.
6. Consider stereoselectivity.

| Oxidizing Agents (Reduction) | Reducing Agents (Oxidation) | Summation |
|---|---|---|
| High affinity for electrons (O2, O3, Cl2) or unusually high oxidation states (Mn7+) | Low electronegativities and ionization energies (sodium, magnesium, aluminum, zinc & metal hydrides). |  |

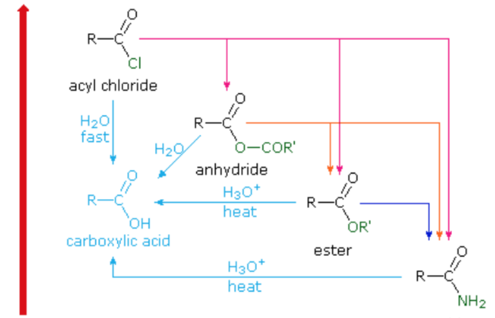
## CARBOXYLIC ACID DERIVATIVES

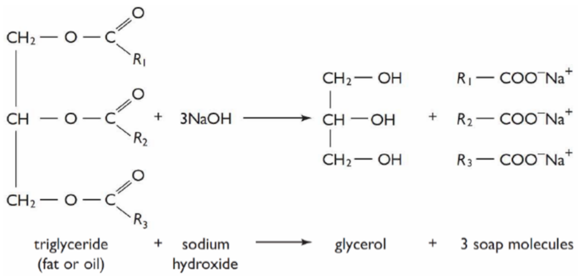
**Most to Least Reactive:**

1. Acyl Halides

**SAPONIFICATION**

2. Anhydrides
3. Carboxylic Acids & Esters
4. Amides

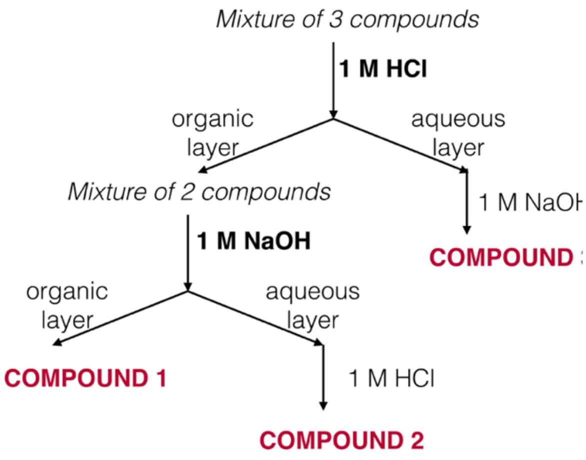




## LAB TECHNIQUES: PURIFICATION METHODS

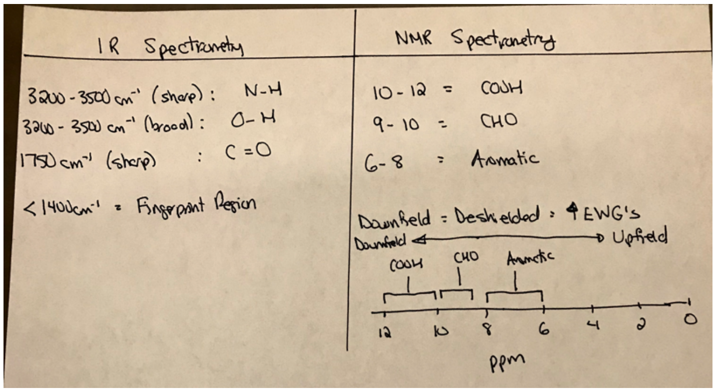
| | |
|---|---|
| **Extraction** | Separate dissolved substances based on differential solubility in aqueous vs organic solvents. |
| **Filtration** | Separate solids from liquids. |
| **Chromatography** | Use stationary phase & mobile phase to separate compounds based on polarity/size. |
| **Distillation** | Separate liquids based on boiling points – **four types.** |
| **Simple Distillation** | Two liquids with boiling points less than 150°C and at least 25°C apart. |
| **Vacuum Distillation** | Boiling points above 150°C. Lower pressure to prevent degradation of product. |
| **Fractional Distillation** | Boiling points less than 25°C apart. |
| **Recrystallization** | Separate solids based on differential solubility at different temperatures. |
| **Electrophoresis** | Separate biological macromolecules based on size/charge. |

## EXTRACTION EXAMPLE



### NMR Spectrum

| | |
|---|---|
| **Types of Protons** | Number of peaks seen in the spectrum |
| **Position of Peaks** | Left-shifted = downfield = de-shielded = electron withdrawing groups. |
| **Integration of Peaks** | Larger Integration = more protons |
| **Splitting** | Hydrogens on adjacent carbon (n+1) |



IR Spectrometry

3200-3500 cm⁻¹ (sharp) : N-H
3200-3500 cm⁻¹ (broad) : O-H
1750 cm⁻¹ (sharp) : C=O

<1400cm⁻¹ = Fingerprint Region

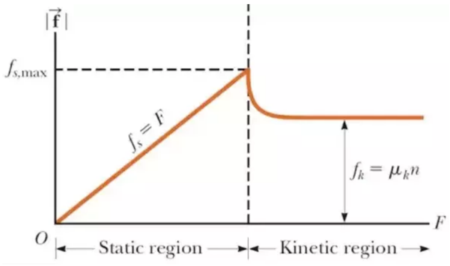
NMR Spectrometry

10-12 = COOH
9-10 = CHO
6-8 = Aromatic

Downfield = Deshielded : ↑ EWG's

# PHYSICS

**Vectors:** Magnitude & direction. (Ex. Force & velocity).
**Scalars:** Only magnitude. (Ex. Mass & speed).



## FRICTIONAL FORCES:

1. **Static Friction:** Force that must be overcome to set an object in motion.
2. **Kinetic Friction:** Opposes the motion of objects moving relative to each other.

## NEWTON'S THREE LAWS:

1. A body will remain at rest, or moving at a constant velocity, unless acted on by an unbalanced force.
2. F= ma
3. $\mathbf{F}_b = -\mathbf{F}_a$

## WORK & ENERGY

$$E_i = E_f$$
$$KE_i + PE_i = KE_f + PE_f$$

**Work:** W=Fdcosθ (SI Units = Joules)
**Power:** P = W / Δt (SI Units = Watts)
**Kinetic Energy:** K = 1/2 mv^2 (SI Units = Joules)
**Potential Energy:** U = mgh (SI Units = Joules)
**Conservation/Total Mechanical Energy:** E = ΔK + ΔU
*When there are no non-conservative forces (ex. Friction) the total mechanical energy remains constant.

## UNIFORM CIRCULAR MOTION:

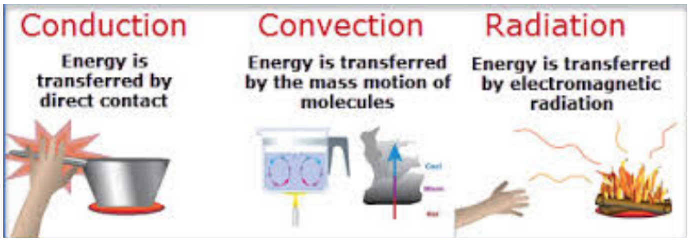
$$a_c = \frac{v^2}{r}$$
$$F_c = \frac{mv^2}{r}$$

## THERMAL EXPANSION

| Linear Expansion | Volume Expansion |
|---|---|
| Increase in length by most solids when heated.<br>$\Delta L = \alpha L \Delta T$ | Increase in volume of fluids when heated.<br>$\Delta V = \beta V \Delta T$ |

## HEAT TRANSFER

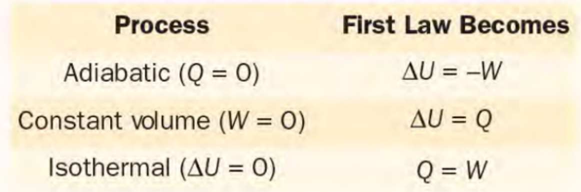
| | |
|---|---|
| **Conduction** | **Direct transfer of energy via molecular collisions.** |



| | |
|---|---|
| **Convection** | **Transfer of heat by physical motion of a fluid.** |
| **Radiation** | **Transfer of energy via EM waves.** |

## THERMODYNAMIC LAWS

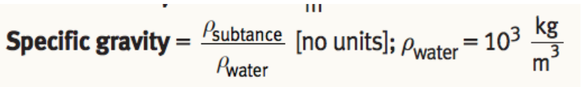
1. ΔU = Q – W
2. Entropy of the system and environment together will either increase or remain unchanged.



| Process | First Law Becomes |
|---|---|
| Adiabatic ($Q = 0$) | $\Delta U = -W$ |
| Constant volume ($W = 0$) | $\Delta U = Q$ |
| Isothermal ($\Delta U = 0$) | $Q = W$ |

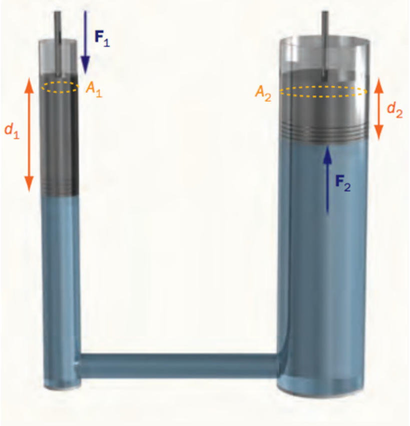
## HYDROSTATICS & FLUID DYNAMICS

Density (*p*): *p* = m/v (SI Units: kg/m^3)



$$\textbf{Specific gravity} = \frac{\rho_{\text{subtance}}}{\rho_{\text{water}}} \text{ [no units]; } \rho_{\text{water}} = 10^3\ \frac{\text{kg}}{\text{m}^3}$$

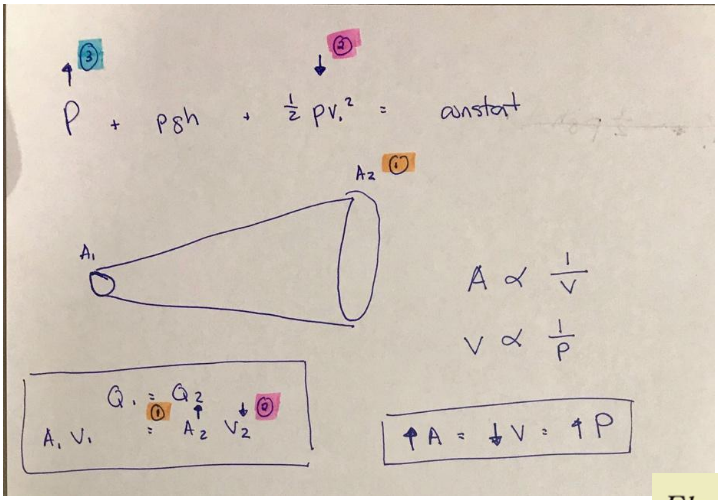
**Pascal's Principle**

| Change in pressure applied to an enclosed fluid is transmitted unchanged to every portion of the fluid and to the wall of the containing vessel. |
|---|
|  |

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2} \text{ and } A_1 d_1 = A_2 d_2$$

$$\text{so, } W = F_1 d_1 = F_2 d_2$$

**Bernoulli's Equation:**



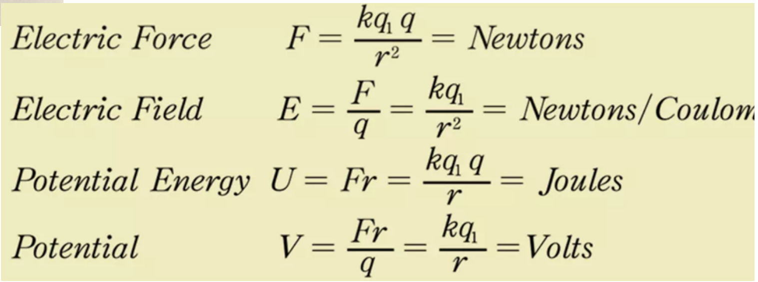
$\uparrow P + \rho g h + \downarrow \frac{1}{2}\rho v_1^2 = \text{constant}$

$A \propto \frac{1}{V}$

$V \propto \frac{1}{P}$

$\boxed{Q_1 = Q_2 \quad A_1 V_1 = \uparrow A_2 \downarrow V_2}$

$\boxed{\uparrow A = \downarrow V = \uparrow P}$



| | |
|---|---|
| *Electric Force* | $F = \frac{kq_1 q}{r^2} = Newtons$ |
| *Electric Field* | $E = \frac{F}{q} = \frac{kq_1}{r^2} = Newtons/Coulom$ |
| *Potential Energy* | $U = Fr = \frac{kq_1 q}{r} = Joules$ |
| *Potential* | $V = \frac{Fr}{q} = \frac{kq_1}{r} = Volts$ |

**ELECTROSTATICS:**

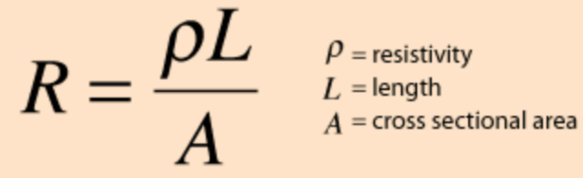
**KNOW UNITS!!!**

**CIRCUITS:**
Current ($I = Q/\Delta t$): Direction of current is the direction positive charge would flow, or from high  low potential.

**OHM'S LAW AND RESISTANCE**

**V = IR**

**Resistance:** Opposition to the flow of charge. (Resistance increases with increasing temperatures with most conductors).



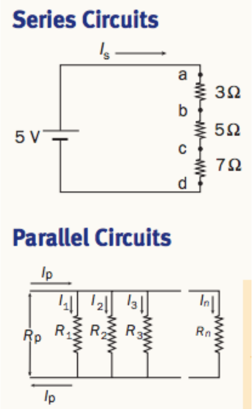
$$R = \frac{\rho L}{A}$$

$\rho$ = resistivity
$L$ = length
$A$ = cross sectional area

**KIRCHOFF'S LAWS:**

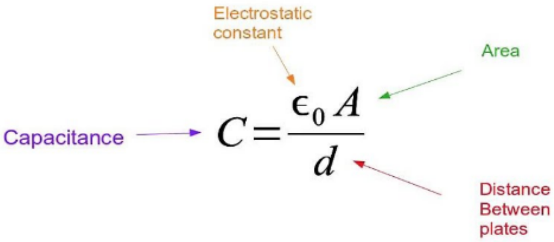
1. Current flowing into a junction must be equal to current flowing out of it.
2. Sum of all voltages around any closed loop in a circuit must equal zero.

**SERIES VS. PARALLEL CIRCUITS**



| Series Circuit | Parallel Circuit |
|---|---|
| $I_s = I_1 = I_2 = \ldots I_x$ | $I_p = I_1 + I_2 \ldots I_x$ |
| $R_s = R_1 + R_2 + \ldots R_x$ | $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots \frac{1}{R_x}$ |
| $V_s = V_1 + V_2 + \ldots V_x$ | $V_p = V_1 = V_2 = \ldots V_x$ |
| $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots \frac{1}{C_x}$ | $C_p = C_1 + C_2 + \ldots C_x$ |

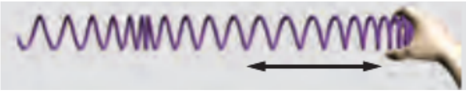
**Capacitance:** Ability to store charge per unit voltage.



$$C = \frac{\epsilon_0 A}{d}$$

$$U = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$$

**WAVES**

| Longitudinal Waves (Sound) | Transverse Waves (EM Radiation) |
|---|---|
|  |  |

V=fλ

V: velocity (of the wave)
f: frequency (of the wave)
λ: "lambda": wavelength (of the wave

**SOUND**

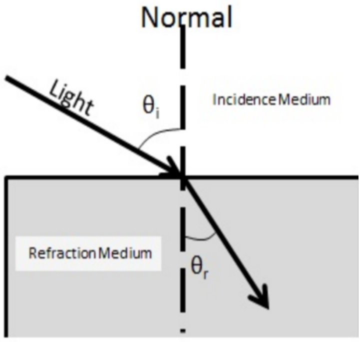
| | |
|---|---|
| **Intensity (I)** | **Intensity** $(I) = \frac{P}{A}$ [SI units: $\frac{W}{m^2}$] |
| **Sound Level (B)** | **Sound level** $(\beta) = 10 \log \left(\frac{I}{I_0}\right)$ [unit: decibel = dB] |
| **Doppler Effect** | $f' = f\frac{(v \pm v_D)}{(v \mp v_S)}$<br>**Stationary source:** $v_S = 0$<br>**Stationary detector:** $v_D = 0$ |

## REFRACTION

n = c /v (**c= speed of light = 3.0 x 10^8 m/s)**

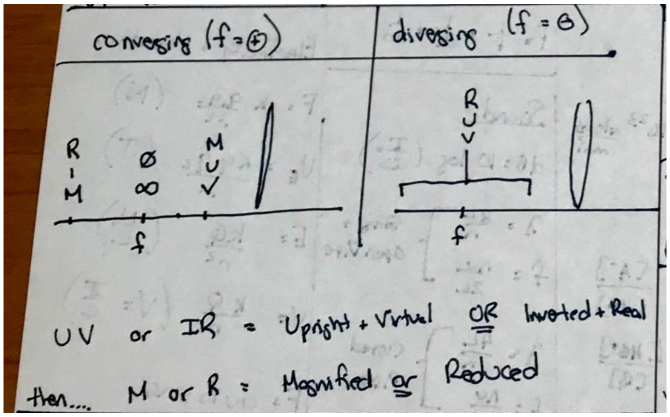
$$n_i * \sin\theta_i = n_r * \sin\theta_r$$

$n_i$ = Index of Refraction of Incidence Medium
$n_r$ = Index of Refraction of Refraction Medium
$\theta_i$ = Angle of Incidence
$\theta_r$ = Angle of Refraction



## MIRRORS & LENSES

| **ptics Equation** | $\frac{1}{o} + \frac{1}{i} = \frac{1}{f} = \frac{1}{r}$ |
|---|---|
| **lagnification**<br>I <1 = Reduced<br>I > Enlarged<br>I = 1 = Same<br>nverted = Negative m<br>pright = Positive m | $(m) = \frac{-i}{o}$ |



UV or IR = Upright + Virtual OR Inverted + Real

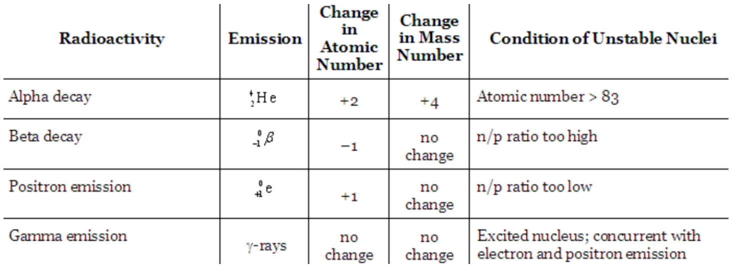
then.... M or R = Magnified or Reduced

## ATOMIC AND NUCLEAR PHENOMENA

### PHOTOELECTRIC EFFECT:

$$E = hf = \frac{hc}{\lambda}$$

### TYPES OF DECAY



| Radioactivity | Emission | Change in Atomic Number | Change in Mass Number | Condition of Unstable Nuclei |
|---|---|---|---|---|
| Alpha decay | $^4_2He$ | +2 | +4 | Atomic number > 83 |
| Beta decay | $^0_{-1}\beta$ | −1 | no change | n/p ratio too high |
| Positron emission | $^0_{+1}e$ | +1 | no change | n/p ratio too low |
| Gamma emission | $\gamma$-rays | no change | no change | Excited nucleus; concurrent with electron and positron emission |

## RESEARCH DESIGN

**Causality:**

| | |
|---|---|
| **Controls** | Experimental subjects that are maintained with similar but non-interventional treatments to establish causality. |
| **Hill's Criteria:** | Helps determine the strength of causal relationships. |

### Error Sources:

| | |
|---|---|
| **Small Sample Size** | Amplifies effects of statistical outliers. |
| **Defects in Precision/Accuracy** | Creates random & systematic variation in data. |
| **Bias** | Systematic data error. Selection Bias, Detection Bias & Hawthorne Effect. Reduced through proper participant selection, blinding, and randomization. |
| **Confounding** | Variable has a relationship with the other two variables and is overlooked. |

### Ethics:

| | |
|---|---|
| **Beneficence** | Requirement to do good. |
| **Nomaleficence** | Do no harm. |
| **Autonomy** | Right of individuals to make decisions for themselves. |
| **Justice** | Need to consider only morally relevant differences between patients and distribute healthcare resources fairly & equally. |

### Statistical Testing:

| | |
|---|---|
| **Null Hypothesis** | Hypothesis of no difference. |
| **p-Value** | Probability that results were obtained by chance given the null hypothesis is true. (Ex. $P < 0.05$) |
| **Confidence Interval** | Range of values believed to contain the true value with a given level of probability (Ex. 95% confidence) |

Remember you CAN do this!
Practice becoming the best test taker possible!
Start studying earlier and make sure every single day you put some time into studying!

We are always here for you.. at ANY time.