STUDENT TIPS FOR USING THE CHEMISTRY REFERENCE TABLE

TABLE A: STANDARD TEMPERATURE AND PRESSURE

Name	Value	Unit
Standard Pressure	101.3 kPa 1 atm	kilopascal atmosphere
Standard Temperature	273 K 0°C	kelvin degree Celsius

- **BACKGROUND:**
  - This table gives the values for Standard Temp. (in °C & K) & Pressure (in kPa & atm).
  - Standard Temperature and Pressure (STP) refers to normal conditions in the atmosphere. This value is important because it is used to enable comparisons/ conversions to be made between sets of data/data with different units.
- **USES:**
  - **REFERRED TO IN: MATTER, ENERGY, & GAS LAWS**
    - Use known equivalencies at STP given on Table A to **CONVERT** between units of pressure! (Remember pressure values for mmHg & torr are NOT given on the ref. table.)
    - Use when doing **GAS LAW PROBLEMS**. If a gas is said to be at STP, use the given temperature and pressure values listed on Table A as your values for temperature & pressure in the gas law problem.
      - **Ex)** 1 liter of a gas at STP is compressed to 473mL and the temperature decreases to 243K. What is the new pressure of the gas in atm?
        - Many students may read this and think, there is not enough info, BUT, since the question states that the gas is at STP, your P_1 and T_1 values are 1 atm and 273K respectively. (The rest of the question is done as a typical gas law problem, using the combined gas law eq.)

TABLE B: PHYSICAL CONSTANTS FOR WATER

Heat of Fusion	334 J/g
Heat of Vaporization	2260 J/g
Specific Heat Capacity of H_2O (ℓ)	4.18 J/g•°C

- **BACKGROUND:**
  - **Heat of Fusion (H_f)** refers to the amount of energy needed to change a substance from a solid to a liquid (**melt** a substance).
  - **Heat of Vaporization (H_v)** refers to the amount of energy needed to change a substance from a liquid to a gas (**vaporize** a substance).
  - The **Specific Heat Capacity** (**c**) of a substance refers to the amount of heat needed to raise the temperature of 1g of that substance 1°C.
  - Table B gives you these energy values for **WATER** only.
- **USES:**
  - **REFERRED TO IN: MATTER, ENERGY, & GAS LAWS**
    - Refer to values listed on Table B when doing **HEAT ENERGY EQUATIONS** involving water**!** Plug values into appropriate variable in formula.
      - **$Q=mC\Delta T$ ($C = 4.18 J/g{\cdot}°C$)**
      - **$Q = mH_f$ ($H_f = 334 J/g$)**
      - **$Q=mH_v$ ($H_v = 2260 J/g$)**

TABLE C: SELECTED PREFIXES

Factor	Prefix	Symbol
10^{3}	kilo-	k
10^{-1}	deci-	d
10^{-2}	centi-	c
10^{-3}	milli-	m
10^{-6}	micro-	μ
10^{-9}	nano-	n
10^{-12}	pico-	p

- **BACKGROUND:**
  - Shows meaning/relationships between values of different prefixes.

- **USES:**
  - **REFERRED TO IN: ALL CHAPTERS**
    - Useful as a **GUIDE FOR CONVERTING** from one unit to another if necessary.

TABLE D: SELECTED UNITS

Symbol	Name	Quantity
m	meter	length
g	gram	mass
Pa	pascal	pressure
K	kelvin	temperature
mol	mole	amount of substance
J	joule	energy, work, quantity of heat
s	second	time
L	liter	volume
ppm	part per million	concentration
M	molarity	solution concentration

- **BACKGROUND:**
  - A key that shows what the units/unit symbols are for particular quantities.
- **USES:**
  - **REFERRED TO IN: ALL CHAPTERS**
    - For example, if you give an answer for a pressure value and you happen to forget what the units are for pressure, you can look up the standard units on this chart.

TABLE E: SELECTED POLYATOMIC IONS

H_3O^+	hydronium	CrO_4^{2-}	chromate
Hg_2^{2+}	dimercury (I)	$Cr_2O_7^{2-}$	dichromate
NH_4^+	ammonium	MnO_4^-	permanganate
$C_2H_3O_2^-$ / CH_3COO^-	acetate	NO_2^-	nitrite
		NO_3^-	nitrate
CN^-	cyanide	O_2^{2-}	peroxide
CO_3^{2-}	carbonate	OH^-	hydroxide
HCO_3^-	hydrogen carbonate	PO_4^{3-}	phosphate
		SCN^-	thiocyanate
$C_2O_4^{2-}$	oxalate	SO_3^{2-}	sulfite
ClO^-	hypochlorite	SO_4^{2-}	sulfate
ClO_2^-	chlorite	HSO_4^-	hydrogen sulfate
ClO_3^-	chlorate	$S_2O_3^{2-}$	thiosulfate
ClO_4^-	perchlorate		

- **BACKGROUND:**
  - **Polyatomic ions** are multiple atoms covalently bonded together possessing an overall charge
  - Table E lists numerous polyatomic ions; including their names, formulas, and charges.
- **USES:**
  - **REFERRED TO IN: NAMING, FORMULA WRITING, BALANCING, REDOX**
    - Use table as a guide to help you when **NAMING COMPOUNDS** that include polyatomic ions.
      - Ex) Mg$\mathbf{CO_3}$ = Magnesium **Carbonate**
    - The charge of the ion is **criss-crossed** to write the formula for an ionic compound containing a polyatomic ion.
      - Ex) **Ammonium Sulfite** = $(NH_4)^+$ $(SO_3)^{2-}$ (Criss-cross charges to get formula) → $(NH_4)_2 SO_3$

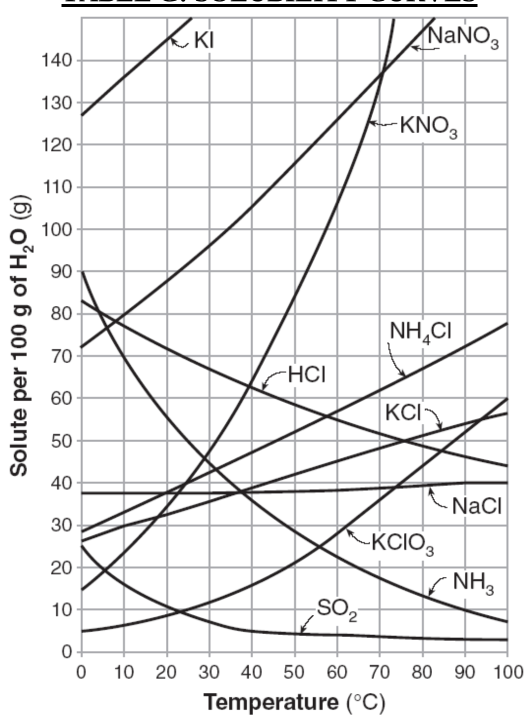
TABLE F: SOLUBILITY GUIDELINES FOR AQUEOUS SOLUTIONS

Ions That Form *Soluble* Compounds	Exceptions
Group 1 ions (Li^+, Na^+, etc.)	
ammonium (NH_4^+)	
nitrate (NO_3^-)	
acetate ($C_2H_3O_2^-$ or CH_3COO^-)	
hydrogen carbonate (HCO_3^-)	
chlorate (ClO_3^-)	
perchlorate (ClO_4^-)	
halides (Cl^-, Br^-, I^-)	when combined with Ag^+, Pb^{2+}, and Hg_2^{2+}
sulfates (SO_4^{2-})	when combined with Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, and Pb^{2+}

Ions That Form *Insoluble* Compounds	Exceptions
carbonate (CO_3^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
chromate (CrO_4^{2-})	when combined with Group 1 ions, Ca^{2+}, Mg^{2+}, or ammonium (NH_4^+)
phosphate (PO_4^{3-})	when combined with Group 1 ions or ammonium (NH_4^+)
sulfide (S^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
hydroxide (OH^-)	when combined with Group 1 ions, Ca^{2+}, Ba^{2+}, Sr^{2+}, or ammonium (NH_4^+)

- **BACKGROUND:**
  - Table F is used to determine if a compound is soluble (dissolves well) or insoluble (does not dissolve) in H_2O!
- **USES:**
  - **REFERRED TO IN: SOLUTIONS**
    - **Left side of table →** Lists ions that form **SOLUBLE** compounds!
      - If ions present in the formula are present in the column of soluble ions, and *none* of the exceptions are present, the substance is **soluble!**
    - **Right side of table →** Lists ions that form **INSOLUBLE** compounds**!**
      - If ions present in the formula are in the column of insoluble ions, and *none* of the exceptions are present, the substance is **insoluble!**
    - Soluble Compounds = **Electrolytes**
    - Insoluble Compounds = **Nonelectrolytes**
    - **BEWARE OF EXCEPTIONS**!

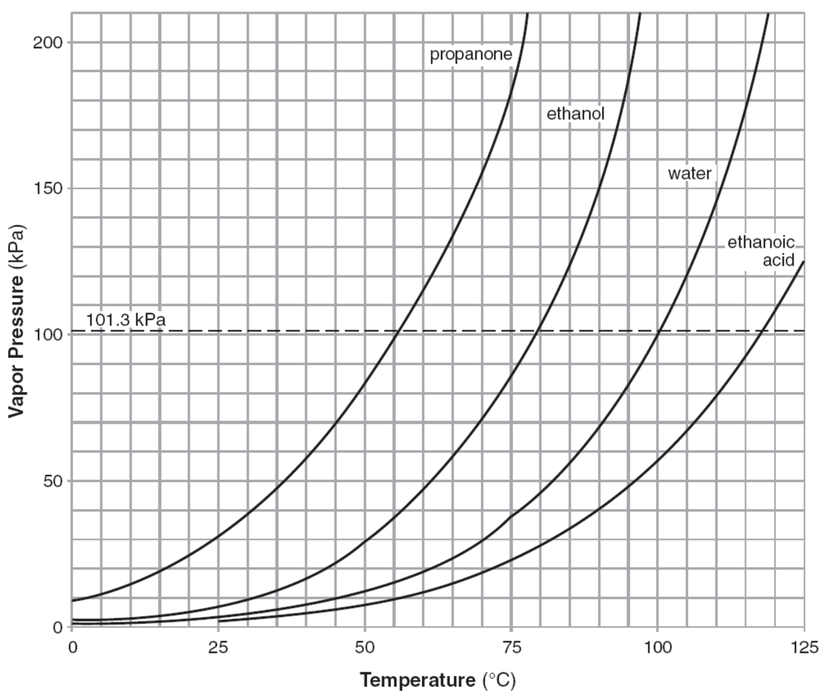
TABLE G: SOLUBILITY CURVES



- **BACKGROUND:**
  - Table G is a graph that shows the solubility of numerous solutes and their ability to dissolve in **100g of H_2O.**
  - H_2O is the **solvent** (the substance that does the dissolving)
  - Each curve represents the **greatest** amount of **solute** that can dissolve at given temperatures!

- **USES:**
  - **REFERRED TO IN: SOLUTIONS**
    - **Ex 1)** Based on the graph, how much **KNO_3** can dissolve in **100g of H_2O** at 20°C?
      - **100g of H_2O** stated in question, SO: you can read graph **literally**. (See above)
      - Find curve for KNO_3. How much solute (KNO_3) will dissolve at 20°C?
      - **Answer: ~ 35g of KNO_3**
    - **Ex 2)** Based on the graph, how much **KNO_3** can dissolve in **50g of H_2O** at 60°C?
      - **50g of H_2O** stated in question**,** therefore after you read the graph literally, you need to cut that # in **HALF**, since graph is per **100g of H_2O!!!!**
      - **Answer: ~ 107g/2 = 53.5g of KNO_3**
    - **Ex 3)** Based on the graph, how much **KCl** can dissolve in **200g of H_2O** at 90°C?
      - **200g of H_2O** stated in question, therefore after you read the graph literally, you need to **DOUBLE that #**!!
      - **Answer: ~54g x 2 = 108g of KCl**
    - **Ex 4)** In **100g of H_2O,** how many grams of **NH_4Cl** will precipitate out of solution if the temperature decreases from 80°C to 50°C?
      - Read the curve at each temperature value and take the **difference**!
      - **Answer: 67 – 52 = 15g of NH_4Cl**
    - **Ex 5)** In **200g of H_2O,** how many grams of **$NaNO_3$** will precipitate out of solution if the temperature decreases from 40°C to 10°C?
      - Read the curve at each temperature value and take the **difference**!
      - **DOUBLE THAT #** b/c questions states "per 200g of H_2O"
      - **Answer: 106 – 80 = 26 x 2 = 52g of $NaNO_3$**
    - **Ex 6)** Based on Table G, which compound's solubility decreases most rapidly as the temperature increases?
      - Look for the solute with the **steepest declining** curve
      - **Answer: NH_3**
    - **Ex 7)** 72g of NH_4Cl at 90°C represents what type of solution?
      - **Answer: SATURATED solution** (b/c that point falls **ON** NH_4Cl curve)
    - **Ex 8)** 10g of NH_3 at 70°C represents what type of solution?
      - **Answer: UNSATURATED solution** (b/c that point falls **BELOW** NH_3 curve)
    - **Ex 9)** 90g of HCl at 50°C represents what type of solution?
      - **Answer: SUPERSATURATED solution** (b/c that point falls **ABOVE** HCl curve)

TABLE H: VAPOR PRESSURE OF FOUR LIQUIDS



- **BACKGROUND:**
  - **Vapor Pressure** can be defined as the pressure that a vapor exerts on the walls of the container it's in.
  - The Table H graph shows the relationship between the temperature and the vapor pressures of 4 different liquids.

- **USES:**
  - **REFERRED TO IN: GAS LAWS, BONDING**
    - **Shows relationship btwn. Temperature and (Vapor) Pressure:**
      - As temp. **increases,** vapor pressure **increases! (direct relationship)**
    - **Relationship btwn. Vapor Pressure and Intermolecular Forces:**
      - **Lowest** Vapor Pressure = **Strongest** Intermolecular Forces
      - **Highest** Vapor Pressure = **Weakest** Intermolecular Forces
    - **Dotted Line: 101.3kPa = Standard Atmospheric Pressure** (The amount of pressure that the atmosphere exerts on the objects in it.
    - Therefore, **when vapor pressure = atmospheric pressure, a substance BOILS!!**
    - In other words, the temp. point at which the curve for each liquid touches the **dotted line** = the **Boiling Point** of that liquid!! (See above)

TABLE I: HEATS OF REACTION AT 101.3kPa and 298K

Reaction	ΔH (kJ)*
$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(\ell)$	–890.4
$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(\ell)$	–2219.2
$2C_8H_{18}(\ell) + 25O_2(g) \longrightarrow 16CO_2(g) + 18H_2O(\ell)$	–10943
$2CH_3OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(\ell)$	–1452
$C_2H_5OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(\ell)$	–1367
$C_6H_{12}O_6(s) + 6O_2(g) \longrightarrow 6CO_2(g) + 6H_2O(\ell)$	–2804
$2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$	–566.0
$C(s) + O_2(g) \longrightarrow CO_2(g)$	–393.5
$4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$	–3351
$N_2(g) + O_2(g) \longrightarrow 2NO(g)$	+182.6
$N_2(g) + 2O_2(g) \longrightarrow 2NO_2(g)$	+66.4
$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$	–483.6
$2H_2(g) + O_2(g) \longrightarrow 2H_2O(\ell)$	–571.6
$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$	–91.8
$2C(s) + 3H_2(g) \longrightarrow C_2H_6(g)$	–84.0
$2C(s) + 2H_2(g) \longrightarrow C_2H_4(g)$	+52.4
$2C(s) + H_2(g) \longrightarrow C_2H_2(g)$	+227.4
$H_2(g) + I_2(g) \longrightarrow 2HI(g)$	+53.0
$KNO_3(s) \xrightarrow{H_2O} K^+(aq) + NO_3^-(aq)$	+34.89
$NaOH(s) \xrightarrow{H_2O} Na^+(aq) + OH^-(aq)$	–44.51
$NH_4Cl(s) \xrightarrow{H_2O} NH_4^+(aq) + Cl^-(aq)$	+14.78
$NH_4NO_3(s) \xrightarrow{H_2O} NH_4^+(aq) + NO_3^-(aq)$	+25.69
$NaCl(s) \xrightarrow{H_2O} Na^+(aq) + Cl^-(aq)$	+3.88
$LiBr(s) \xrightarrow{H_2O} Li^+(aq) + Br^-(aq)$	–48.83
$H^+(aq) + OH^-(aq) \longrightarrow H_2O(\ell)$	–55.8

*Minus sign indicates an exothermic reaction.

- **BACKGROUND:**
  - **Heat of Reaction (ΔH)**: The amount of heat given off or absorbed during a chemical reaction. It is the difference in heat content/potential energy between the products and the reactants.
    - **ΔH = Energy of products – Energy of reactants**
  - Table I lists multiple reactions and gives the ΔH values for each reaction.
- **USES:**
  - **REFERRED TO IN: KINETICS & EQUILIBRIUM**
    - The ΔH value given for each reaction allows you to determine whether each particular reaction is endothermic or exothermic.
      - **Negative** ΔH value = **exothermic (spontaneous)** rxn (happen automatically)
      - **Positive** ΔH value = **endothermic (nonspontaneous)** rxn (have to *make* them happen)
    - How much heat is needed to produce **2 moles** of HI? **Answer: + 53kJ**
      - **Thought Process:**
        1. Find reaction on Table I that produces HI.
        2. How many moles of HI did that rxn yield? (Remember # of mol. = coefficient)
        3. How much heat was required for the reaction?
    - How much heat is needed to produce **1 mole** of HI? **Answer: 53/2 = 26.5kJ**

TABLE J: ACTIVITY SERIES

Table J
Activity Series**

Most ↓ Least	Metals	Nonmetals
Most	Li	F_2
	Rb	Cl_2
	K	Br_2
	Cs	I_2
	Ba	
	Sr	
	Ca	
	Na	
	Mg	
	Al	
	Ti	
	Mn	
	Zn	
	Cr	
	Fe	
	Co	
	Ni	
	Sn	
	Pb	
	**H_2	
	Cu	
	Ag	
Least	Au	

**Activity Series based on hydrogen standard
Note: H_2 is *not* a metal

- **BACKGROUND:**
  - Lists various metals/nonmetals in order of reactivity.
  - Metals/Nonmetals at the **top** of the chart are **most active.**
  - Metals/Nonmetals at the **bottom** of the chart are **least active.**
- **USES:**
  - **REFERRED TO IN: TYPES OF REACTIONS, REDOX**
    - Metals *above* H_2 on Table J **WILL** react with acids to produce $H_{2(g)}$ and a salt!
      - **Ex1)** $Mg + 2HCl \rightarrow MgCl_2 + H_2$ (Rxn. takes place b/c Mg is above H_2 on table)
      - **Ex2)** $Cu + HCl \rightarrow$ No Reaction! (b/c Cu is **not** above H_2)
    - Table J is also used to predict whether a reaction is spontaneous or not spontaneous/if a single replacement reaction will take place!
    - **RULE:** Metals that are **more active** (**higher on Table J)** will **REPLACE** metals below them from compounds. In other words, if a metal is higher on Table J than the **ion** or **metal in the compound**, then the reaction **WILL** occur (i.e. it is **spontaneous)**
    - The same rules apply for nonmetals!
      - **Ex1)** $\mathbf{F_2}$ + 2Na**Cl** → 2NaF + Cl_2 (Spontaneous) (Single Replacement takes place)
        (This is b/c $\mathbf{F_2}$ (the nonmetal by itself) is **more active** than **Cl** (the nonmetal in cmpd.)
      - **Ex2)** $\mathbf{Cl_2}$ + 2Na**F** → No Reaction (Not Spontaneous)
        (This is b/c Cl_2 is **less active** than F)
      - **Ex3)** **Ca** + **Mg**CO_3 → $CaCO_3$ + Mg (Spontaneous) (Single Replacement takes place)
        (This is b/c Ca (the metal by itself) is **more active** than **Mg** (the metal in cmpd.)
      - **Ex 4)** Fe^{2+} + Cu → No Reaction (Not Spontaneous)
        (This is b/c Cu is **less active** than the ion (Fe^{2+})
    - Table J is also used for electrochemical cell interpretation.

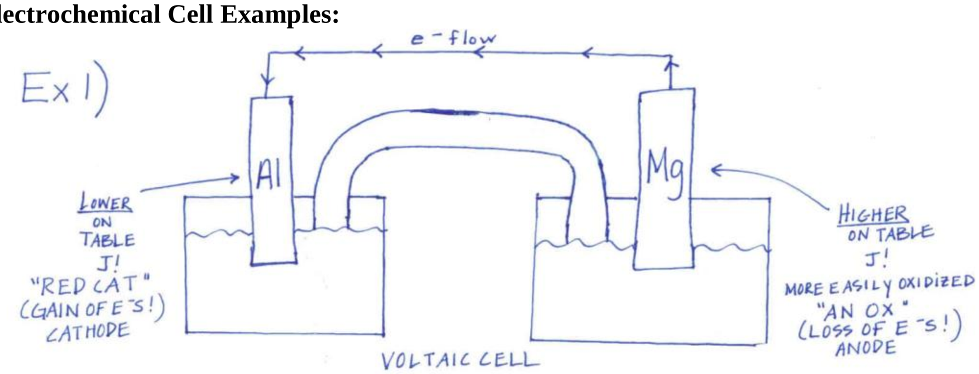
- **Metals** at top are **most easily oxidized** — **Nonmetals** at top **are most easily reduced**

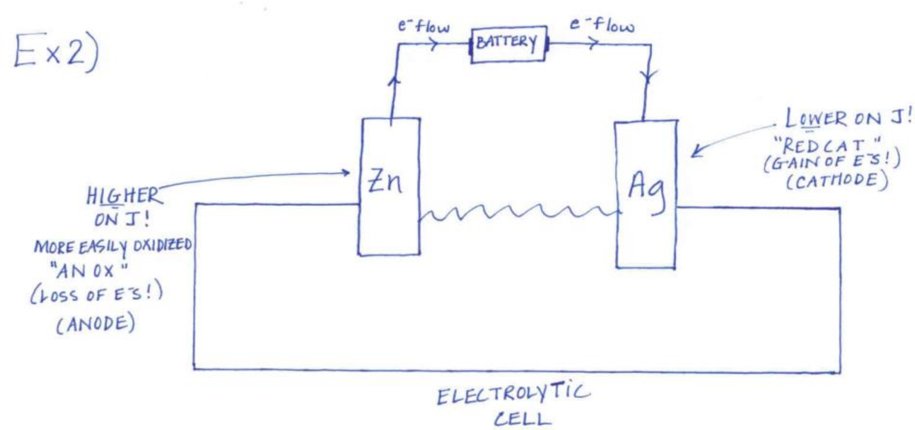
Table J
Activity Series**

Metals (Most → Least)	Nonmetals (Most → Least)
Li	F_2
Rb	Cl_2
K	Br_2
Cs	I_2
Ba	
Sr	
Ca	
Na	
Mg	
Al	
Ti	
Mn	
Zn	
Cr	
Fe	
Co	
Ni	
Sn	
Pb	
**H_2	
Cu	
Ag	
Au	

**Activity Series based on hydrogen standard
Note: H_2 is *not* a metal

- **Metals** at bottom are **least easily oxidized** — **Nonmetals** at bottom are **least easily reduced**
- **Electrochemical Cell Examples:**





- The metals **HIGHER** on J (**Mg/Zn**) → more easily oxidized **("AN OX")**
  - SO: these electrodes = **ANODES** (where **oxidation (loss of e^-s)** takes place)
- The metals **LOWER** on Table J (**Al/Ag)** are therefore the **CATHODES** (**"RED CAT")** (where **reduction (gain of electrons)** takes place)

TABLE K: COMMON ACIDS

Formula	Name
$HCl(aq)$	hydrochloric acid
$HNO_3(aq)$	nitric acid
$H_2SO_4(aq)$	sulfuric acid
$H_3PO_4(aq)$	phosphoric acid
$H_2CO_3(aq)$ or $CO_2(aq)$	carbonic acid
$CH_3COOH(aq)$ or $HC_2H_3O_2(aq)$	ethanoic acid (acetic acid)

- **BACKGROUND:**
  - Table gives list of common acids
- **USES:**
  - **REFERRED TO IN: ACIDS & BASES**
  - Use list of given acids as guidelines for recognizing the general formula for any acid.
    - i.e. Look for a **H at beginning of formula**, followed by one (or more) **nonmetal(s)**.
    - **Exception**: Compounds that end in –COOH (Organic Acids)
  - List of acids can also be used when writing Neutralization Reactions.
    - **Acid from Table K + Base from Table L → Salt + Water**
    - Be careful that **# of H^+ = # of OH^-**

TABLE L: COMMON BASES

Formula	Name
$NaOH(aq)$	sodium hydroxide
$KOH(aq)$	potassium hydroxide
$Ca(OH)_2(aq)$	calcium hydroxide
$NH_3(aq)$	aqueous ammonia

- **BACKGROUND:**
  - Table gives list of common bases
- **USES:**
  - **REFERRED TO IN: ACIDS & BASES**
  - Use list of given bases as guidelines for recognizing the general formula for any base.
    - i.e. Look for a (**Metal + OH)**
    - Exception: Ammonia (NH_3)
  - List of bases can also be used when writing Neutralization Reactions.

TABLE M: COMMON ACID-BASE INDICATORS

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.2–4.4	red to yellow
bromthymol blue	6.0–7.6	yellow to blue
phenolphthalein	8.2–10	colorless to pink
litmus	5.5–8.2	red to blue
bromcresol green	3.8–5.4	yellow to blue
thymol blue	8.0–9.6	yellow to blue

- **BACKGROUND:**
  - An **indicator** is a dye that changes color in the presence of an acid or a base
  - This table gives a list of common acid-base indicators and gives the gradual color change that would be observed at an approximate pH range.
- **USES:**
  - **REFERRED TO IN: ACIDS & BASES**
    - **How to interpret Table M: Ex 1:**

bromcresol green	3.8–5.4	yellow to blue

Means: At a pH of **3.8 or lower:** bromcresol green is **yellow**
At a pH **btwn 3.8 -5.4:** bromcresol green **changes color from yellow to blue**
At pH of **5.4 or higher:** bromcresol green is **blue**

    - **How to interpret the Table M: Ex 2:**

litmus	5.5–8.2	red to blue

Means: At a pH of **5.5 or lower**: litmus is **red**
At a pH btwn **5.5 -8.2**: litmus **changes color from red to blue**
At a pH of **8.2 or higher**: litmus is **blue**

    - **Using more than one indicator and Table M to determine pH range of a substance: Ex 3:**
      - A solution turns red in litmus and yellow in methyl orange. What is the pH range of the substance?
        - **Red** in **litmus**: Means pH must be **5.5 or lower**
        - **Yellow** in **methyl orange**: Means pH must be **4.4 or higher**
        - Therefore: **pH range: btwn. 4.4 and 5.5**
        - Is this substance acidic or basic?? → **acidic!**

TABLE N: SELECTED RADIOISOTOPES

Nuclide	Half-Life	Decay Mode	Nuclide Name
^{198}Au	2.69 d	β^-	gold-198
^{14}C	5730 y	β^-	carbon-14
^{37}Ca	175 ms	β^+	calcium-37
^{60}Co	5.26 y	β^-	cobalt-60
^{137}Cs	30.23 y	β^-	cesium-137
^{53}Fe	8.51 min	β^+	iron-53
^{220}Fr	27.5 s	α	francium-220
^{3}H	12.26 y	β^-	hydrogen-3
^{131}I	8.07 d	β^-	iodine-131
^{37}K	1.23 s	β^+	potassium-37
^{42}K	12.4 h	β^-	potassium-42
^{85}Kr	10.76 y	β^-	krypton-85
^{16}N	7.2 s	β^-	nitrogen-16
^{19}Ne	17.2 s	β^+	neon-19
^{32}P	14.3 d	β^-	phosphorus-32
^{239}Pu	2.44×10^4 y	α	plutonium-239
^{226}Ra	1600 y	α	radium-226
^{222}Rn	3.82 d	α	radon-222
^{90}Sr	28.1 y	β^-	strontium-90
^{99}Tc	2.13×10^5 y	β^-	technetium-99
^{232}Th	1.4×10^{10} y	α	thorium-232
^{233}U	1.62×10^5 y	α	uranium-233
^{235}U	7.1×10^8 y	α	uranium-235
^{238}U	4.51×10^9 y	α	uranium-238

ms = milliseconds; s = seconds; min = minutes;
h = hours; d = days; y = years

- **BACKGROUND:**
  - Table N gives a **list of radioisotopes**, their **half-lives**, and their **decay modes**.
  - An isotopes' **HALF LIFE** refers to the time it takes for **HALF** of that sample to **DECAY.**
    - **Ex1)** Based on Table N, the half life for **^{42}K is 12.4 hours**.

-This means that in 12.4 hours, half of a sample of ^{42}K will decay.

-So: If you have a **50g** sample of ^{42}K, after 12.4 hours, only HALF of it will be left: i.e. **25g**

In another 12. 4 hours, only 12.5g will be left.

In another 12. 4 hours, only 6.25g will be left. Etc… etc…

  - **DECAY MODE** refers to the method by which a particular substance decays. It is dependant upon the type of particle that is given off as a result of the decay!
    - i.e. **alpha decay** = alpha particles are emitted as a result of the decay
    - i.e. **beta decay** = beta particles (electrons) are emitted as a result of the decay
    - i.e. **positron decay** = positrons are emitted as a result of the decay
    - i.e. **gamma decay** = gamma rays are emitted as a result of the decay
- **USES:**
  - **REFERRED TO IN: NUCLEAR CHEMISTRY**
    - Used to help solve **HALF LIFE PROBLEMS!**
    - Many times when solving half life problems you will need to look up the half life of a particular isotope. This table is useful to provide you with that reference.

TABLE O: SYMBOLS USED IN NUCLEAR CHEMISTRY

Name	Notation	Symbol
alpha particle	$^{4}_{2}He$ or $^{4}_{2}\alpha$	α
beta particle (electron)	$^{0}_{-1}e$ or $^{0}_{-1}\beta$	β^-
gamma radiation	$^{0}_{0}\gamma$	γ
neutron	$^{1}_{0}n$	n
proton	$^{1}_{1}H$ or $^{1}_{1}p$	p
positron	$^{0}_{+1}e$ or $^{0}_{+1}\beta$	β^+

- **BACKGROUND:**
  - Table O lists common particles associated with nuclear chemistry and nuclear reactions.
  - For each particle the notation indicates the following:
    - **Top #** = **mass** of the particle)
    - **Bottom #** = **charge** of the particle

$^{0}_{-1}\beta$	$^{4}_{2}He$	$^{0}_{+1}\beta$	$^{0}_{0}\gamma$
Beta Particle	Alpha Particle	Positron	Gamma Radiation
Mass: 0	Mass: 4	Mass: 0	Mass: 0
Charge: -1	Charge: +2	Charge: +1	Charge: 0

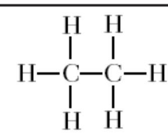
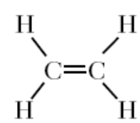
  - The symbol for each particle is also given.
- **USES:**
  - **REFERRED TO IN: NUCLEAR CHEMISTRY**
  - Used especially when writing/figuring out decay equations.
  - When writing decay equations, always remember:
    1. **Atomic #** on **left** side of arrow **MUST = the sum of the atomic #'s on right** side of arrow!!
    2. **Mass #** on **left** side of arrow **MUST = the sum of the mass #'s on the right** side of arrow!!
  - **Also Remember:** The **type of particle** emitted = **the type of decay**

TABLE P: ORGANIC PREFIXES

Prefix	Number of Carbon Atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

- **BACKGROUND:**
  - Lists the prefixes used in naming organic compounds.
- **USES:**
  - **REFERRED TO IN: ORGANIC CHEMISTRY**
    - Each **prefix refers to the # of carbon atoms** present in the compound.
      - Ex1) if the compound is **Pro**pane: The compound will have **3 carbons**
      - Ex2) if the compound is **Hex**yne: The compound will have **6 carbons**

TABLE Q: HOMOLOGOUS SERIES OF HYDROCARBONS

Name	General Formula	Examples	
		Name	Structural Formula
alkanes	C_nH_{2n+2}	ethane	
alkenes	C_nH_{2n}	ethene	
alkynes	C_nH_{2n-2}	ethyne	H—C≡C—H

n = number of carbon atoms

- **BACKGROUND:**
  - Table Q lists the 3 main types of hydrocarbons and gives their general formulas and structural formulas
  - **Hydrocarbons** are organic compounds that *only* contain **carbon** & **hydrogen.**
- **USES:**
  - **REFERRED TO IN: ORGANIC CHEMISTRY**
  - This table can be used alongside tables P and R to help name, recognize, & draw organic compounds. Table Q particularly helps in the naming, drawing, and recognition of **hydrocarbons** and their formulas.
  - The structural formulas on the table also indicate the **# of bonds** between carbon atoms of each specific type of hydrocarbon.
    - **Ex)** alk**anes** → **single** bond btwn carbon atoms
      alk**enes** → **double** bond btwn carbon atoms
      alk**ynes** → **triple** bond btwn carbon atoms
  - Use the general formulas listed as guides to recognize formulas for specific hydrocarbons.
    - (n = # of carbon atoms)
    - **Ex1)** C_6H_{10} → C_nH_{2n-2} (Therefore formula for an alkyne)
    - **Ex2)** C_4H_8 → C_nH_{2n} (Therefore formula for an alkene)

TABLE R: ORGANIC FUNCTIONAL GROUPS

Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	$-F$ (fluoro-) $-Cl$ (chloro-) $-Br$ (bromo-) $-I$ (iodo-)	$R-X$ (X represents any halogen)	$CH_3CHClCH_3$ 2-chloropropane
alcohol	$-OH$	$R-OH$	$CH_3CH_2CH_2OH$ 1-propanol
ether	$-O-$	$R-O-R'$	$CH_3OCH_2CH_3$ methyl ethyl ether
aldehyde	$-\overset{O}{\overset{\parallel}{C}}-H$	$R-\overset{O}{\overset{\parallel}{C}}-H$	$CH_3CH_2\overset{O}{\overset{\parallel}{C}}-H$ propanal
ketone	$-\overset{O}{\overset{\parallel}{C}}-$	$R-\overset{O}{\overset{\parallel}{C}}-R'$	$CH_3\overset{O}{\overset{\parallel}{C}}CH_2CH_2CH_3$ 2-pentanone
organic acid	$-\overset{O}{\overset{\parallel}{C}}-OH$	$R-\overset{O}{\overset{\parallel}{C}}-OH$	$CH_3CH_2\overset{O}{\overset{\parallel}{C}}-OH$ propanoic acid
ester	$-\overset{O}{\overset{\parallel}{C}}-O-$	$R-\overset{O}{\overset{\parallel}{C}}-O-R'$	$CH_3CH_2\overset{O}{\overset{\parallel}{C}}OCH_3$ methyl propanoate
amine	$-\overset{\mid}{N}-$	$R-\overset{R'}{\overset{\mid}{N}}-R''$	$CH_3CH_2CH_2NH_2$ 1-propanamine
amide	$-\overset{O}{\overset{\parallel}{C}}-\overset{\mid}{N}H$	$R-\overset{O}{\overset{\parallel}{C}}-\overset{R'}{\overset{\mid}{N}}H$	$CH_3CH_2\overset{O}{\overset{\parallel}{C}}-NH_2$ propanamide

R represents a bonded atom or group of atoms.

- **BACKGROUND:**
  - This table lists **9 other types of organic compounds** that students will need to know how to identify, draw, and name.
  - Table R gives the **functional group, general formula**, and an **example** for each family of organic compounds.
- **USES:**
  - **REFERRED TO IN: ORGANIC CHEMISTRY**
    - The **functional groups** for each type of organic compound can be recognized as **one or more atoms** that replace hydrogen in the organic compound, **define the structure of the family of compounds**, and determine the **properties** of that family.
    - The **general formulas** help you locate the **placement of the functional group** in comparison to the rest of the formula.
    - The **example column** serves as a **guide for naming** specific compounds.
    - Use each column simultaneously when attempting to recognize, draw and/or name a specific organic compound!

TABLE S: PROPERTIES OF SELECTED ELEMENTS

Atomic Number	Symbol	Name	Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling Point (K)	Density** (g/cm^3)	Atomic Radius (pm)
1	H	hydrogen	1312	2.1	14	20	0.00009	208
2	He	helium	2372	—	1	4	0.000179	50
3	Li	lithium	520	1.0	454	1620	0.534	155
4	Be	beryllium	900	1.6	1551	3243	1.8477	112
5	B	boron	801	2.0	2573	3931	2.340	98
6	C	carbon	1086	2.6	3820	5100	3.513	91
7	N	nitrogen	1402	3.0	63	77	0.00125	92
8	O	oxygen	1314	3.4	55	90	0.001429	65
9	F	fluorine	1681	4.0	54	85	0.001696	57
10	Ne	neon	2081	—	24	27	0.0009	51
11	Na	sodium	496	0.9	371	1156	0.971	190
12	Mg	magnesium	736	1.3	922	1363	1.738	160
13	Al	aluminum	578	1.6	934	2740	2.698	143
14	Si	silicon	787	1.9	1683	2628	2.329	132
15	P	phosphorus	1012	2.2	44	553	1.820	128
16	S	sulfur	1000	2.6	386	718	2.070	127
17	Cl	chlorine	1251	3.2	172	239	0.003214	97
18	Ar	argon	1521	—	84	87	0.001783	88
19	K	potassium	419	0.8	337	1047	0.862	235
20	Ca	calcium	590	1.0	1112	1757	1.550	197
21	Sc	scandium	633	1.4	1814	3104	2.989	162
22	Ti	titanium	659	1.5	1933	3580	4.540	145
23	V	vanadium	651	1.6	2160	3650	6.100	134
24	Cr	chromium	653	1.7	2130	2945	7.190	130
25	Mn	manganese	717	1.6	1517	2235	7.440	135
26	Fe	iron	762	1.8	1808	3023	7.874	126
27	Co	cobalt	760	1.9	1768	3143	8.900	125
28	Ni	nickel	737	1.9	1726	3005	8.902	124
29	Cu	copper	745	1.9	1357	2840	8.960	128
30	Zn	zinc	906	1.7	693	1180	7.133	138
31	Ga	gallium	579	1.8	303	2676	5.907	141
32	Ge	germanium	762	2.0	1211	3103	5.323	137
33	As	arsenic	944	2.2	1090	889	5.780	139
34	Se	selenium	941	2.6	490	958	4.790	140
35	Br	bromine	1140	3.0	266	332	3.122	112
36	Kr	krypton	1351	—	117	121	0.00375	103
37	Rb	rubidium	403	0.8	312	961	1.532	248
38	Sr	strontium	549	1.0	1042	1657	2.540	215
39	Y	yttrium	600	1.2	1795	3611	4.469	178
40	Zr	zirconium	640	1.3	2125	4650	6.506	160

Atomic Number	Symbol	Name	Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling Point (K)	Density** (g/cm^3)	Atomic Radius (pm)
41	Nb	niobium	652	1.6	2741	5015	8.570	146
42	Mo	molybdenum	684	2.2	2890	4885	10.220	139
43	Tc	technetium	702	1.9	2445	5150	11.500	136
44	Ru	ruthenium	710	2.2	2583	4173	12.370	134
45	Rh	rhodium	720	2.3	2239	4000	12.410	134
46	Pd	palladium	804	2.2	1825	3413	12.020	137
47	Ag	silver	731	1.9	1235	2485	10.500	144
48	Cd	cadmium	868	1.7	594	1038	8.650	171
49	In	indium	558	1.8	429	2353	7.310	166
50	Sn	tin	709	2.0	505	2543	7.310	162
51	Sb	antimony	831	2.1	904	1908	6.691	159
52	Te	tellurium	869	2.1	723	1263	6.240	142
53	I	iodine	1008	2.7	387	458	4.930	132
54	Xe	xenon	1170	2.6	161	166	0.0059	124
55	Cs	cesium	376	0.8	302	952	1.873	267
56	Ba	barium	503	0.9	1002	1910	3.594	222
57	La	lanthanum	538	1.1	1194	3730	6.145	138
Elements 58–71 have been omitted.								
72	Hf	hafnium	659	1.3	2503	5470	13.310	167
73	Ta	tantalum	728	1.5	3269	5698	16.654	149
74	W	tungsten	759	2.4	3680	5930	19.300	141
75	Re	rhenium	756	1.9	3453	5900	21.020	137
76	Os	osmium	814	2.2	3327	5300	22.590	135
77	Ir	iridium	865	2.2	2683	4403	22.560	136
78	Pt	platinum	864	2.3	2045	4100	21.450	139
79	Au	gold	890	2.5	1338	3080	19.320	146
80	Hg	mercury	1007	2.0	234	630	13.546	160
81	Tl	thallium	589	2.0	577	1730	11.850	171
82	Pb	lead	716	2.3	601	2013	11.350	175
83	Bi	bismuth	703	2.0	545	1833	9.747	170
84	Po	polonium	812	2.0	527	1235	9.320	167
85	At	astatine	—	2.2	575	610	—	145
86	Rn	radon	1037	—	202	211	0.00973	134
87	Fr	francium	393	0.7	300	950	—	270
88	Ra	radium	—	0.9	973	1413	5.000	233
89	Ac	actinium	499	1.1	1320	3470	10.060	—
Elements 90 and above have been omitted.								

*Boiling point at standard pressure
**Density at STP

- **BACKGROUND:**
  - This table lists all the names, symbols, densities, boiling points, etc… for all the elements in the periodic table.
  - The table is arranged in order of increasing atomic number.

- **USES:**
  - **REFERRED TO IN PACKETS PERIODIC TABLE, CHEM MATH, GRAPHING APPLICATIONS**
    - Table S is very useful as a guide to **help you recognize trends of the periodic table**: i.e. what happens to atomic number, ionization energy, electronegativity, boiling point, atomic radius, etc.. as you go down a group or across a period?
    - The **densities at STP** listed on Table S, along with the gram formula mass (not listed, but must be calculated) for a particular element, may be used to determine the volume of a particular element using the density formula.
    - **OR** you could be asked something like this:

Example:

A 10.0-gram sample of which element has the *smallest* volume at STP?

(1) aluminum (3) titanium
(2) magnesium (4) zinc

- To do *this* prob. you must look up the densities on Table S and plug them into the density equation (D=m/v) to solve the problem. **Answer: (4) zinc**

- With regard to table S, you may also be asked to **record values** for and/or **graph** any of the categories listed on the table.

TABLE T: IMPORTANT FORMULAS AND EQUATIONS

1. DENISTY FORMULA:

Density	$d = \frac{m}{V}$	d = density m = mass V = volume

2. MASS→MOLE CONVERSION FORMULA:

Mole Calculations	$\text{number of moles} = \frac{\text{given mass (g)}}{\text{gram-formula mass}}$

3. % ERROR FORMULA:

Percent Error	$\% \text{ error} = \frac{\text{measured value} - \text{accepted value}}{\text{accepted value}} \times 100$

4. % COMPOSITION FORMULA:

Percent Composition	$\% \text{ composition by mass} = \frac{\text{mass of part}}{\text{mass of whole}} \times 100$

Notes:

- For most applications, the **"mass of whole"** is the **gram formula mass** of the **entire cpd**!

5. CONCENTRATION FORMULAS:

Concentration	$\text{parts per million} = \frac{\text{grams of solute}}{\text{grams of solution}} \times 1\,000\,000$
	$\text{molarity} = \frac{\text{moles of solute}}{\text{liters of solution}}$

Notes:

- Make sure you are in **grams** for ppm formula!
- **% by mass formula** is the same as the ppm eq. except you multiply by 100 instead of 1,000,000!
- You may need to **convert from grams to moles BEFORE** using the molarity equation **OR** you may need to **convert to grams AFTER** using the molarity formula, depending on the question.

6. COMBINED GAS LAW FORMULA:

Combined Gas Law	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	P = pressure V = volume T = temperature (K)

Notes:

- Be sure **all units** for pressure, volume, and temp are **consistent**, otherwise you must **convert**!
  - Temperature must **ALWAYS** be in **Kelvin** (See temp conversion formula below!)
    - **Know relationships** between each variable in the equation!
  - **At Constant Pressure**: **Eliminate the P variable from the equation!**

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

  - **At Constant Temp: Eliminate the T variable from the equation!**

$$P_1V_1 = P_2V_2$$

  - **At Constant Volume: Eliminate the V variable from the equation!**

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

7. TITRATION FORMULA:

Titration	$M_AV_A = M_BV_B$	M_A = molarity of H^+ V_A = volume of acid	M_B = molarity of OH^- V_B = volume of base

Notes:

- $\mathbf{M_A}$ = Molarity(Concentration) of **Acid**
- $\mathbf{M_B}$ **=** Molarity (Concentration) of **Base**
- **To Find Volume in Titration Lab Application Problem:**
  Do: **Final Volume – Initial Volume** before plugging values into the equation!

8. HEAT ENERGY FORMULAS:

Heat	$q = mC\Delta T$ $q = mH_f$ $q = mH_v$	q = heat m = mass C = specific heat capacity ΔT = change in temperature	H_f = heat of fusion H_v = heat of vaporization

Notes:

- When the substance is **water:** $\mathbf{H_f}$**,** $\mathbf{H_v}$**,** and **C** values can be found on **Table B**
  - **ΔT = Final Temp – Initial Temp**

9. TEMPERATURE CONVERSION FORMULA:

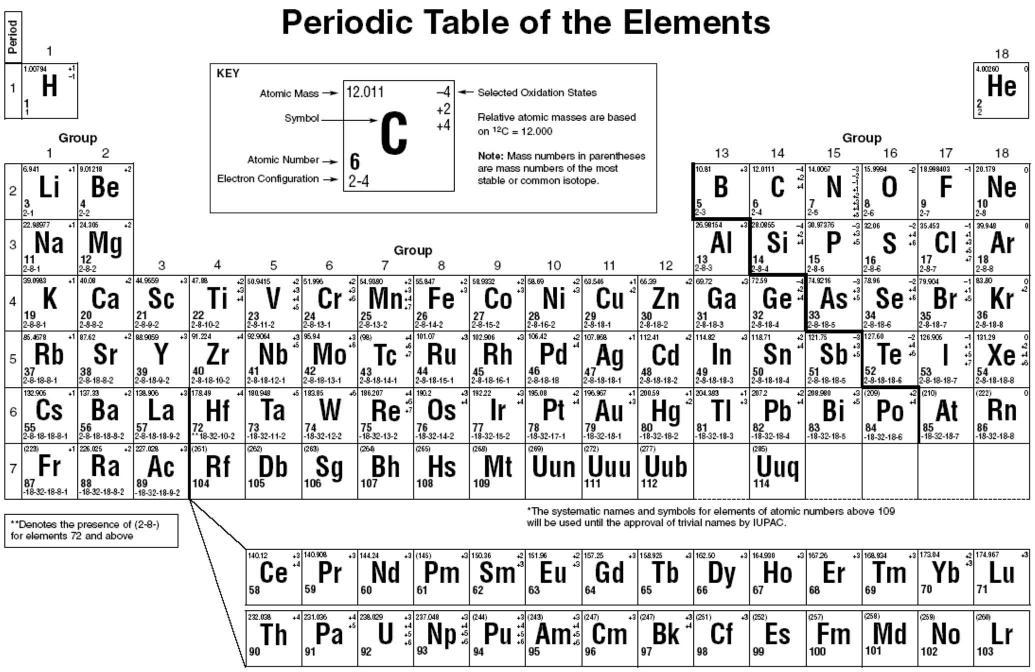
Temperature	K = °C + 273	K = kelvin °C = degrees Celsius

10. HALF LIFE FORMULAS:

Radioactive Decay	fraction remaining = $\left(\frac{1}{2}\right)^{\frac{t}{T}}$ number of half-life periods = $\frac{t}{T}$	t = total time elapsed T = half-life

Notes:

- You may need to look up the half life for a particular radioisotope on table N before plugging it into the equation.



BACKGROUND:

- The Periodic Table of Elements, first discovered in 1869 by Dmitry I. Mendeleyev gives a way of presenting and arranging all the elements in nature according to their similarities and differences.
- The elements are arranged in order of increasing atomic number as you go from left to right across the table.
- The horizontal rows = **periods**
- The vertical rows = **groups**
- **Noble Gases** = found on the right hand side of each period (**Group 18**)
- As you go from **left to right** across each period there is a progression from metals (left) to metalloids (along the zigzag line) to nonmetals (right).
- Elements found in each group (i.e. alkali metals, halogens, etc…) have similar chemical properties, and the same number of valence electrons in their outermost shell. As a result, elements in the same group react similarly.
- The block of elements in the middle of the periodic table (Groups 3-12) are called **transition metals.**
- The elements with atomic numbers larger than 92 do not occur naturally. They have all been produced artificially by bombarding other elements with particles.

USES: (Can be used as application in various chapters)

- Use **Carbon Key** at the top as a guide so you know where to find the **atomic number, atomic mass, oxidation states, electron configuration**, etc… for each element
- Use each element box to help you figure out the **number of protons, neutrons, electrons, atomic #, mass #, atomic mass, ground state electron configuration, oxidation state,** etc…
- Use the **atomic mass** as a *check* when **calculating the average atomic mass** for all the naturally occurring isotopes of a particular element.
- The **# of Principle Energy Levels** for an element = the amount of #'s in the electron configuration.
- The ***last*** # in the electron configuration = the # of ***valence electrons***
  - **Example:** Ca: (2-8-8-2) = 4 PEL's ; 2 valence electrons Ne: 2-8 = 2 PEL's ; 8 valence electrons
- Use the **ground state electron** configuration on the table to figure out the **excited state** electron config.
- Use the **oxidation state** to help you figure out an elements tendency toward losing/gaining electrons.
- Use the Periodic Table of Elements along with Table S to help you recognize ***trends*** of the Periodic Table as you go across a period and down a group.
  - i.e.
    - What happens to **atomic #?**
    - What happens to the # of **valence electrons?**
    - What happens to the **atomic radius?**
    - What happens to the **# of PEL's?** etc…
- Know where **metals, nonmetals** and **metalloids** are located on the periodic table!
- Location on the periodic table also helps you establish the **type of bond** that exists between elements in a compound.
  - **Ex 1)** Na (metal) + Cl (nonmetal) → ionic bond (transfer of electrons)
  - **Ex 2)** H (nonmetal) + Cl (nonmetal) → covalent bond (sharing of electrons)
- Use the Periodic Table to help you find the **molar mass/gram formula mass** of a molecule.