AP Chemistry 2020-2021 Summer Review   (This packet is available on my website: rangerchem.online)

Welcome to AP Chemistry. Summer review work is meant to get us off to a running start when fall arrives. You should already know most of the material in this packet from your first year chemistry class. Nonetheless, START NOW to make your way leisurely through this review. Do NOT think you should wait until the very end of the summer so the concepts are "fresh in your mind." The LONGER this review swirls around in your gray cells, the better the concepts will stick. Email me with any questions or concerns. I will try to respond ASAP. Be prepared for review quizzes on this material the first weeks of school.

Please be sure you have filled out this google form **in acknowledgement of receiving this packet (same form as linked in the original email sent.**

Please ask your adult(s) at home send an email to me.

My school email is: biggss@westboroughk12.org Please ask your adult(s) to briefly introduce themselves to say hello.

Nomenclature

You will be more successful in AP chemistry if you can name chemicals from their formulas, and if you can write chemical formulas from the name of the chemical. You should be able to do this with only the assistance of a periodic table, after *memorizing* the polyatomic ions in the charts below.

Polyatomic Ions -

Memorize the shaded ions (and learn the pattern so you can easily memorize their companions)

By learning the four shaded "-ate" ions in the table to the right, **and** knowing that one less oxygen (same charge) turns the name to −*ite*, **and** two less oxygens (when possible) turns the name to *hypo*−xxx−ite **and** one more oxygen (when possible) turns the name to *per*−xxx−ate will make learning all eighteen ions in the chart below as easy as learning just four.

Polyatomic Ions to Memorize *(Use the pattern to help)*			
hypo- (2 less O)	**-ite (1 less O)**	**-ate**	**per- (1 more O)**
	nitrite NO_2^-	nitrate NO_3^-	
	sulfite SO_3^{2-}	sulfate SO_4^{2-}	
	phosphite PO_3^{3-}	phosphate PO_4^{3-}	
hypochlorite ClO^-	chlorite ClO_2^-	chlorate ClO_3^-	perchlorate ClO_4^-
hypobromite BrO^-	bromite BrO_2^-	bromate BrO_3^-	perbromate BrO_4^-
hypoiodite IO^-	iodite IO_2^-	iodate IO_3^-	periodate IO_4^-

Memorize the six extra polyatomic ions in the second table below, and don't forget ammonium in the table by itself.

Odd Companions or No Companion	
hydroxide OH^-	
cyanide CN^-	
acetate $C_2H_3O_2^-$	
carbonate CO_3^{2-}	bicarbonate HCO_3^-
permanganate MnO_4^- *purple color*	

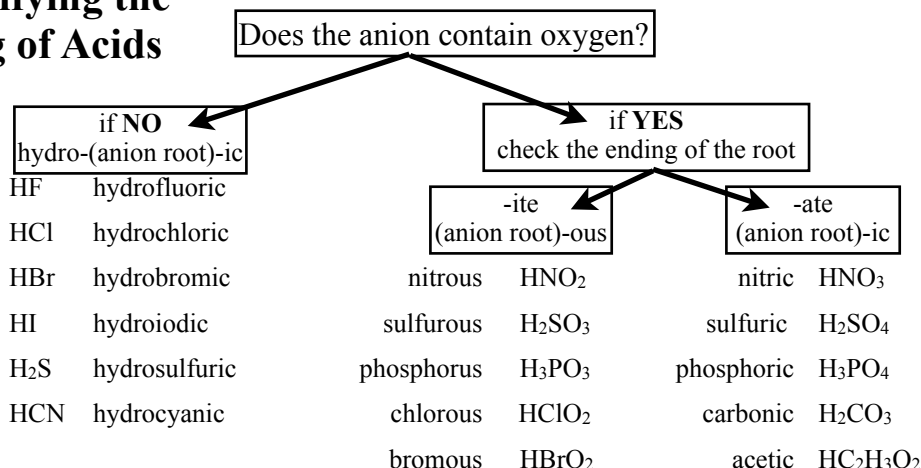| **and don't forget** |
|---|
| ammonium NH_4^+ |

> ***This packet should be review.*** *If you find yourself struggling with any of the topics in the following practices, please email me and let me know where your struggles are, so that I can guide you to more review and practice.* ***No excuses. Be ready!!***

Acids and Bases

You will find it helpful to be able to name acids. Knowing your polyatomic ions is critical in naming the acids. Use the chart below to review the pattern and method of naming.

Demystifying the Naming of Acids

Does the anion contain oxygen?

if **NO**	if **YES**
hydro-(anion root)-ic	check the ending of the root

	-ite	-ate
	(anion root)-ous	(anion root)-ic

HF	hydrofluoric			
HCl	hydrochloric			
HBr	hydrobromic	nitrous HNO_2	nitric	HNO_3
HI	hydroiodic	sulfurous H_2SO_3	sulfuric	H_2SO_4
H_2S	hydrosulfuric	phosphorus H_3PO_3	phosphoric	H_3PO_4
HCN	hydrocyanic	chlorous $HClO_2$	carbonic	H_2CO_3
		bromous $HBrO_2$	acetic	$HC_2H_3O_2$

You should memorize the seven strong acids in the table below left. The strong bases are group I and group II metal hydroxides. Hopefully you are aware that to be a strong acid or strong base means that when dissolved in water, the molecules are fully ionized. This means that the compound will dissociate completely into ions when in solution. This is important to recognize when writing *net ionic equations*.

Seven Strong Acids
memorize them
(assume all other acids are weak)

HCl	hydrochloric acid
HBr	hydrobromic acid
HI	hydroiodic acid
HNO_3	nitric acid
H_2SO_4	sulfuric acid
$HClO_3$	chloric acid
$HClO_4$	perchloric acid

Strong Bases
memorize them   *(Group I and II hydroxides)*

LiOH	lithium hydroxide	*Be & Mg hydroxides are not very*
NaOH	sodium hydroxide	*useful, since they are not soluble*
KOH	potassium hydroxide	$Ca(OH)_2$ calcium hydroxide
RbOH	rubidium hydroxide	$Sr(OH)_2$ strontium hydroxide
CsOH	cesium hydroxide	$Ba(OH)_2$ barium hydroxide

On multiple choice section of the AP exam, calculator use is NOT allowed. For many questions, this is a moot point because the question may only involve words, but for other questions, your ability to multiply and factor numbers will be very helpful.

No kidding…..
Practice your multiplication tables.
get a math facts app on your phone
and practice your multiplication/division
and from time to time, add/subtract.

This is the periodic table that you will use in AP Chemistry. Now is as good a time as any to begin to get used to it.
I apologize for the table being sideways, you can print and keep handy.

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.008																	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.30											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.97	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.95	43 **Tc**	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57–71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po**	85 **At**	86 **Rn**
87 **Fr**	88 **Ra**	89–103 †	104 **Rf**	105 **Db**	106 **Sg**	107 **Bh**	108 **Hs**	109 **Mt**	110 **Ds**	111 **Rg**	112 **Cn**	113 **Nh**	114 **Fl**	115 **Mc**	116 **Lv**	117 **Ts**	118 **Og**

*Lanthanoids

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm**	62 **Sm** 150.36	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97

†Actinoids

89 **Ac**	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lr**

This is the equations and constants info sheet that you will use on all quizzes and tests in AP Chemistry.
I apologize for the table being sideways, you can print and keep handy.

AP® CHEMISTRY EQUATIONS AND CONSTANTS

Throughout the exam the following symbols have the definitions specified unless otherwise noted.

L, mL	=	liter(s), milliliter(s)	mm Hg = millimeters of mercury
g	=	gram(s)	J, kJ = joule(s), kilojoule(s)
nm	=	nanometer(s)	V = volt(s)
atm	=	atmosphere(s)	mol = mole(s)

ATOMIC STRUCTURE

$$E = h\nu$$
$$c = \lambda\nu$$

E = energy
ν = frequency
λ = wavelength

Planck's constant, $h = 6.626 \times 10^{-34}$ J s
Speed of light, $c = 2.998 \times 10^8$ m s^{-1}
Avogadro's number $= 6.022 \times 10^{23}$ mol^{-1}
Electron charge, $e = -1.602 \times 10^{-19}$ coulomb

EQUILIBRIUM

$$K_c = \frac{[\text{C}]^c[\text{D}]^d}{[\text{A}]^a[\text{B}]^b}, \text{ where } a\,\text{A} + b\,\text{B} \rightleftarrows c\,\text{C} + d\,\text{D}$$

$$K_p = \frac{(P_C)^c (P_D)^d}{(P_A)^a (P_B)^b}$$

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

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

$$K_w = [\text{H}^+][\text{OH}^-] = 1.0 \times 10^{-14} \text{ at } 25°C$$
$$= K_a \times K_b$$

$$\text{pH} = -\log[\text{H}^+], \text{pOH} = -\log[\text{OH}^-]$$

$$14 = \text{pH} + \text{pOH}$$

$$\text{pH} = \text{p}K_a + \log\frac{[\text{A}^-]}{[\text{HA}]}$$

$$\text{p}K_a = -\log K_a, \text{p}K_b = -\log K_b$$

Equilibrium Constants
K_c (molar concentrations)
K_p (gas pressures)
K_a (weak acid)
K_b (weak base)
K_w (water)

KINETICS

$$[\text{A}]_t - [\text{A}]_0 = -kt$$

$$\ln[\text{A}]_t - \ln[\text{A}]_0 = -kt$$

$$\frac{1}{[\text{A}]_t} - \frac{1}{[\text{A}]_0} = kt$$

$$t_{1/2} = \frac{0.693}{k}$$

k = rate constant
t = time
$t_{1/2}$ = half-life

GASES, LIQUIDS, AND SOLUTIONS

$$PV = nRT$$

$$P_A = P_{total} \times X_A, \text{ where } X_A = \frac{\text{moles A}}{\text{total moles}}$$

$$P_{total} = P_A + P_B + P_C + \cdots$$

$$n = \frac{m}{M}$$

$$K = °C + 273$$

$$D = \frac{m}{V}$$

$$KE_{\text{molecule}} = \frac{1}{2}mv^2$$

Molarity, M = moles of solute per liter of solution

$$A = \varepsilon bc$$

P = pressure
V = volume
T = temperature
n = number of moles
m = mass
M = molar mass
D = density
KE = kinetic energy
ν = velocity
A = absorbance
ε = molar absorptivity
b = path length
c = concentration

Gas constant, $R = 8.314$ J mol^{-1} K^{-1}
$= 0.08206$ L atm mol^{-1} K^{-1}
$= 62.36$ L torr mol^{-1} K^{-1}

1 atm = 760 mm Hg = 760 torr
STP = 273.15 K and 1.0 atm
Ideal gas at STP = 22.4 L mol^{-1}

THERMODYNAMICS/ELECTROCHEMISTRY

$$q = mc\Delta T$$

$$\Delta S° = \sum S° \text{ products} - \sum S° \text{ reactants}$$

$$\Delta H° = \sum \Delta H_f° \text{ products} - \sum \Delta H_f° \text{ reactants}$$

$$\Delta G° = \sum \Delta G_f° \text{ products} - \sum \Delta G_f° \text{ reactants}$$

$$\Delta G° = \Delta H° - T\Delta S°$$
$$= -RT \ln K$$
$$= -nFE°$$

$$I = \frac{q}{t}$$

$$E_{cell} = E_{cell}° - \frac{RT}{nF}\ln Q$$

q = heat
m = mass
c = specific heat capacity
T = temperature
$S°$ = standard entropy
$H°$ = standard enthalpy
$G°$ = standard Gibbs free energy
n = number of moles
$E°$ = standard reduction potential
I = current (amperes)
q = charge (coulombs)
t = time (seconds)
Q = reaction quotient

Faraday's constant, F = 96,485 coulombs per mole of electrons

1 volt = $\frac{1 \text{ joule}}{1 \text{ coulomb}}$

You should learn your polyatomic ions well enough to write these names and fromulas without looking at the polyatomic ion chart. Use only the periodic table in this packet.   (ANSWERS are on the following page)

Write chemical formulas for the following names.   *Write names for the following formulas.*

1.   sodium sulfite   21. $Sn(CN)_2$

2.   copper(II) nitrate   22. H_3PO_4

3.   hydrochloric acid   23. $ZnSO_4$

4.   sodium hydroxide   24. $Cu_2(SO_3)$

5.   acetic acid   25. H_2SO_4

6.   aluminum perchorate   26. $AuOH$

7.   silver sulfide   27. K_2CO_3

8.   carbonic acid   28. $NaHCO_3$

9.   ammonium phosphate   29. $HClO_2$

10. potassium permanganate   30. $AgNO_2$

11. lead(II) cyanide   31. $HBrO$

12. calcium acetate   32. KOH

13. nitrous acid   33. $HC_2H_3O_2$

14. hydroiodic acid   34. $Ni(BrO_2)_3$

15. sodium bicarbonate   35. HBr

16. nickel(III) iodate   36. $NaMnO_4$

17. chloric acid   37. $HBrO_2$

18. aluminum sulfite   38. H_3PO_4

19. phosphorous acid   39. $(NH_4)_2SO_4$

20. barium hydroxide   40. $Ni(OH)_2$

#	Name	Formula		#	Formula	Name
1.	sodium sulfite	Na_2SO_3		21.	$Sn(CN)_2$	**tin(II) cyanide**
2.	copper(II) nitrate	$Cu(NO_3)_2$		22.	H_3PO_4	**phosphoric acid**
3.	hydrochloric acid	HCl		23.	$ZnSO_4$	**zinc sulfate**
4.	sodium hydroxide	$NaOH$		24.	$Cu_2(SO_3)$	**copper(I) sulfite**
5.	acetic acid	$HC_2H_3O_2$		25.	H_2SO_4	**sulfuric acid**
6.	aluminum perchorate	$Al(ClO_4)_3$		26.	$AuOH$	**gold(I) hydroxide**
7.	silver sulfide	Ag_2S		27.	K_2CO_3	**potassium carbonate**
8.	carbonic acid	H_2CO_3		28.	$NaHCO_3$	**sodium bicarbonate**
9.	ammonium phosphate	$(NH_4)_3PO_4$		29.	$HClO_2$	**chlorous acid**
10.	potassium permanganate	$KMnO_4$		30.	$AgNO_2$	**silver nitrite**
11.	lead(II) cyanide	$Pb(CN)_2$		31.	$HBrO$	**hypobromous acid**
12.	calcium acetate	$Ca(C_2H_3O_2)_2$		32.	KOH	**potassium hydroxide**
13.	nitrous acid	HNO_2		33.	$HC_2H_3O_2$	**acetic acid**
14.	hydroiodic acid	HI		34.	$Ni(BrO_2)_3$	**nickel(III) bromite**
15.	sodium bicarbonate	$NaHCO_3$		35.	HBr	**hydrobromic acid**
16.	nickel(III) iodate	$Ni(IO_3)_3$		36.	$NaMnO_4$	**sodium permanganate**
17.	chloric acid	$HClO_3$		37.	$HBrO_2$	**bromous acid**
18.	aluminum sulfite	$Al_2(SO_3)_3$		38.	H_3PO_4	**phosphoricacid**
19.	phosphorous acid	H_3PO_3		39.	$(NH_4)_2SO_4$	**ammonium sulfate**
20.	barium hydroxide	$Ba(OH)_2$		40.	$Ni(OH)_2$	**nickel(II) hydroxide**

Summer Review: **Understanding Net Ionic Equations**

Balanced chemical equations, written to represent chemical reactions, are an important part of chemistry.

You do *not* need to write down physical state symbols (aq, s, ppt, L, g ... etc). In fact, it's probably best if you leave them off.

The best way to prepare for writing equations is to practice writing *lots* of equations. Many of the same equation types show up year after year on the AP Exam. When you are reading the words given in a problem, and trying to write an equation, try to identify the equation as a particular type in order to help you predict the products.

Sometimes you may write overall equations in which all complete chemical formulas are shown. More often, however, equations in AP Chemistry need to be written in **net ionic** form. Net ionic is a term used for balanced equations that describe chemical reactions that occur in *aqueous* solution. All soluble ionic substances must be written as separated ions with the *spectator ions* left out. The spectator ions are left out of the equation because those ions do not change during the course of the reaction and do not need to be represented in the chemical equation. All molecular substances, weak acids (weka bases, though we will not get to them until unit G) and non-soluble compounds must be written as a molecule or formula unit (not ionized!).

Solubility Rules

In first year chemistry we used a solubility chart, however, you will not be allowed to use one in AP Chemistry. The solubility rules that you need to memorize is quite a short list.

ALWAYS SOUBLE IF IN A COMPOUND	EXCEPT WITH
Alkali ions, ammonium ion (Li^+, Na^+, K^+, Rb^+, Cs^+, Fr^+, NH_4^+)	No Exceptions (unless told otherwise in a problem)
nitrate, acetate, perchlorate ions NO_3^-, $C_2H_3O_2^-$, ClO_4^-	No Exceptions (unless told otherwise in a problem)
chloride, bromide, iodide ions Cl^-, Br^-, I^-	Pb^{2+}, Ag^+ (unless told otherwise in a problem)
sulfate ion SO_4^{2-}	Pb^{2+} (unless told otherwise in a problem)

If an ionic compound does not fit one of the rules above, assume that ionic compound is INSOLUBLE, unless you are given other information to the contrary within the problem. Non-soluble compounds must be written as a *formula unit* (not ionized). Remember, this list is just a guide, and any information given within a problem that contradicts any rules given above should be followed.

Considerations to remember when writing net ionic chemical equations.

1. Weak acids, (any acid other than the seven strong acids you need to memorize) are mostly *NOT* ionized in solution and thus must be written as molecules. (There are weak bases, you will learn about them during the year.)

2. Strong acids and bases will be considered fully ionized in solution and thus must be written as separated ions in net ionic equations.

3. Soluble salts as memorized from the table above will exist as separated ions in solution and thus must be written as separated ions in net ionic equations, with spectator ions dropping out of the equation.

4. Solids, liquids, and gases should be written as molecules.

5. When you see the words "solution of" or "aqueous" to describe an ionic compound, assume that compound is dissolved and dissociated.

6. An ionic compound in a *saturated* solution (saturated: a solution with maximum that can be dissolved) is written in ionic form, while an ionic compound in *suspension* (suspension: particles shaken up and floating, but not actually dissolved) should be written together as a molecule or "ionicule."

7. Know your *phantoms* − molecules that when formed as a product, will decompose into a gas and water as indicated below.

   • as a product of a double replacement reaction, H_2CO_3 decomposes into H_2O and CO_2 gas.

   • as a product of a double replacement reaction, NH_4OH decomposes into H_2O and NH_3 gas.
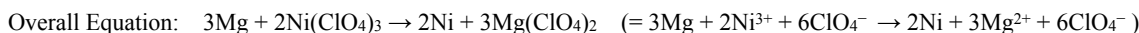
Single Replacement

• A reaction in which one element displaces another in a compound. One element is oxidized and another is reduced. In an oxidation reduction reaction, elements will change their oxidation states. All single replacement reactions are oxidation reduction (redox) reactions. You should work at being able to identify which element is oxidized, and which element is reduced.

• Generic: $A + BX \rightarrow B + AX$ or $Y + BX \rightarrow X + BY$

   • **Active metals replace less active metals or hydrogen (in acid or water).**

      The more easily oxidized metal replaces the less easily oxidized metal or hydrogen. You used an activity series in first year chem. In AP Chem, you will learn more about that chart, and other methods of predicting which metal is more active than the other. When hydrogen is replaced, the hydrogen ions will reduce into diatomic hydrogen gas.
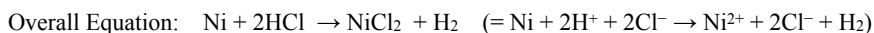
      • *Magnesium pieces are added to a solution of nickel(III) perchlorate.*

         Overall Equation: $3Mg + 2Ni(ClO_4)_3 \rightarrow 2Ni + 3Mg(ClO_4)_2$ $(= 3Mg + 2Ni^{3+} + 6ClO_4^- \rightarrow 2Ni + 3Mg^{2+} + 6ClO_4^-$)

         Net Ionic Equation: $3Mg + 2Ni^{3+} \rightarrow 2Ni + 3Mg^{2+}$

         (Note that the perchlorate compounds are soluble and thus the perchlorate ions have been removed because they are spectators − unchanged by the reaction. The nickel and magnesium are different as reactants compared to products. Pay close attention to atoms vs ions.)
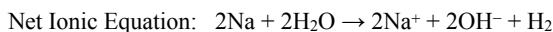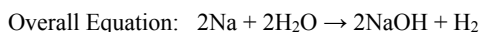   Mg is oxidized and Ni^{3+} is reduced.

      • *Nickel is added to hydrochloric acid.*

         Overall Equation: $Ni + 2HCl \rightarrow NiCl_2 + H_2$ $(= Ni + 2H^+ + 2Cl^- \rightarrow Ni^{2+} + 2Cl^- + H_2)$

         Net Ionic Equation: $Ni + 2H^+ \rightarrow Ni^{2+} + H_2$

         (Note that the chloride ions have been removed because nickel(II) chloride is soluble and the chloride ions are in the same form both as reactants and products, thus the chloride ions are spectators − unchanged by the reaction.)
         Ni is oxidized and H^+ is reduced.

      • *Sodium is added to water to produce a basic solution and an explosive gas.*

         Overall Equation: $2Na + 2H_2O \rightarrow 2NaOH + H_2$

         Net Ionic Equation: $2Na + 2H_2O \rightarrow 2Na^+ + 2OH^- + H_2$

         (Remeber basic solutions contain hydroxide ions, OH^-. Also some metals -the alkali metals and some alkaline earth metals- can replace hydrogen in water. You may find it useful to think of water as HOH. For this equation there are no ions that are removed. Na^+ and OH^- must be included as products because those products are not ions on the reactant side. The explosive gas is of course hydrogen gas.)
         Na is oxidized and H in water (oxidation number of +1) is reduced.

   • **Active nonmetals replace less active nonmetals from their compounds in aqueous solution.**

      A halogen will replace a less electronegative (lower on the Periodic table) halogen from their binary salts.

      • *Chlorine gas is bubbled into a solution of potassium iodide.*

         Overall Equation: $Cl_2 + 2KI \rightarrow I_2 + 2KCl$ $(= Cl_2 + 2K^+ + I^- \rightarrow I_2 + 2K^+ + 2Cl^-$)

         Net Ionic Equation: $Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$

         (Note that the potassium ions have been removed because they are spectators − unchanged by the reaction.)
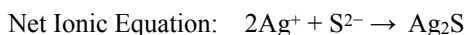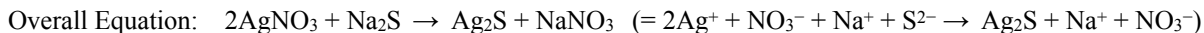 I^- is oxidized and Cl_2 is reduced

Double Replacement

Two compounds react to form two new compounds. No changes in oxidation numbers occur, thus DR reactions are not redox. Since the movement of electrons does not "push" the reaction, all double replacement reactions must have some other "driving force" that removes a pair of ions from solution. These ions may be removed by forming a precipitate, a gas, or molecular compound. If water forms, the double replacement reaction can be called an acid/base reaction. If a solid substance forms the double replacement reaction can be called a precipitation reaction. We can assume that all solutions are aqueous solutions, unless told otherwise. Double replacement reactions are NEVER redox reactions.

- **Formation of a precipitate:**

  A precipitate is an insoluble substance formed during the reaction of two aqueous substances. Two ions bond together so strongly that water can not pull them apart. Knowing your solubility rules will help you write these net ionic equations.

  - *Solutions of silver nitrate and sodium sulfide are mixed (Assume a precipitate forms).*

    Overall Equation: $2AgNO_3 + Na_2S \rightarrow Ag_2S + NaNO_3$ (= $2Ag^+ + NO_3^- + Na^+ + S^{2-} \rightarrow Ag_2S + Na^+ + NO_3^-$)

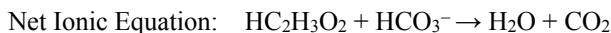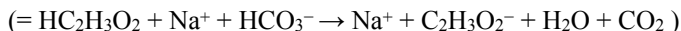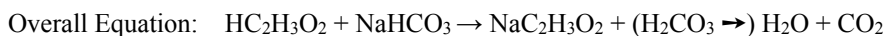   Net Ionic Equation: $2Ag^+ + S^{2-} \rightarrow Ag_2S$

    (How do you know which substance is the precipitate? By knowing alkali and nitrate salts are soluble, the precipitate must be the silver sulfide.)
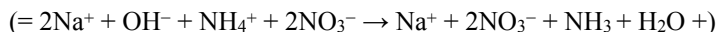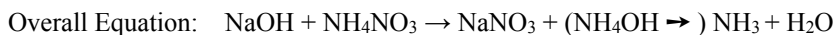
- **Formation of a gas:**

  Gases may form from the decomposition of a product such as H_2CO_3 or NH_4OH.

  - *Acetic acid solution is added to a solution of sodium bicarbonate.*

    Overall Equation: $HC_2H_3O_2 + NaHCO_3 \rightarrow NaC_2H_3O_2 + (H_2CO_3 \rightarrow) H_2O + CO_2$

    (= $HC_2H_3O_2 + Na^+ + HCO_3^- \rightarrow Na^+ + C_2H_3O_2^- + H_2O + CO_2$)

    Net Ionic Equation: $HC_2H_3O_2 + HCO_3^- \rightarrow H_2O + CO_2$

    (Note that the acetic acid must be written as a molecule because acetic acid is a *weak* acid, which you should know from the strong acid chart on page 2. Remember, if an acid is not one of the seven strong acids, you can assume that acid is weak. The carbonic acid, when formed, mostly bubbles off as carbon dioxide. You know this reaction − the classic third grade volcano trick. The sodium ions have been removed because they are spectators − unchanged by the reaction. This reaction also can be classified as an acid base neutralization.)

  - *A solution of sodium hydroxide is added to a solution of ammonium nitrate.*

    Overall Equation: $NaOH + NH_4NO_3 \rightarrow NaNO_3 + (NH_4OH \rightarrow) NH_3 + H_2O$

    (= $2Na^+ + OH^- + NH_4^+ + 2NO_3^- \rightarrow Na^+ + 2NO_3^- + NH_3 + H_2O$ +)

    Net Ionic Equation: $OH^- + NH_4^+ \rightarrow NH_3 + H_2O$

    (The ammonium hydroxide that is formed, bubbles off as ammonia with water in solution. The sodium and nitrate ions have been removed because they are spectators − unchanged by the reaction. This reaction is also an acid base neutralization, however you have not yet learned about the fact that NH_4^+ is acting as an acid.)

- **Formation of a molecular substance (often an acid base neutralization):**

  When a molecular substance such as water or a weak acid is formed, ions are removed from solution and the reaction happens. More information on the next page.
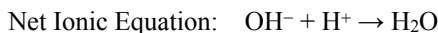
Acid base neutralization will be the focus of the next page. ➜ ➜ ➜ ➜ ➜

Acid/Base Neutralization *(a particular "flavor" of double replacement reaction)*
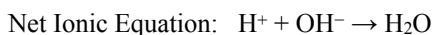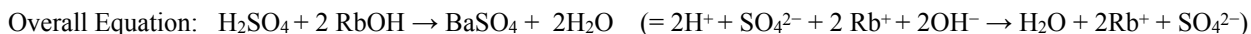
Acids react with bases to produce salts and water.

One mole of hydrogen ions react with one mole of hydroxide ions to produce one mole of water. Remember which acids are strong (and thus ionize completely) and by default, which acids are weak (should be written as a molecule). We can assume that all solutions are aqueous solutions, unless told otherwise. Acid base neutralization reactions are NEVER redox reactions.

- *Aqueous solutions of lithium hydroxide and hydrobromic acid are poured together.*

  Overall Equation: $LiOH + HBr \rightarrow H_2O + LiBr$ $(= Li^+ + OH^- + H^+ + Br^- \rightarrow H_2O + Li^+ + Br^-)$

  Net Ionic Equation: $OH^- + H^+ \rightarrow H_2O$

  (A strong acid will be completely ionized in solution. HBr is a strong acid, and of course NaOH is a strong base. Lithium bromide is a soluble ionic compound that would be separated into ions. The ions that are unchanged as reactants and products drop out of the equation as spectators.)
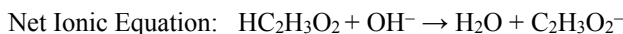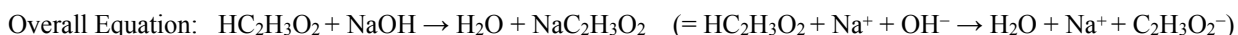
- *Aqueous solutions of sulfuric acid and rubidium hydroxide are combined.*

  Overall Equation: $H_2SO_4 + 2\ RbOH \rightarrow BaSO_4 + 2H_2O$ $(= 2H^+ + SO_4^{2-} + 2\ Rb^+ + 2OH^- \rightarrow H_2O + 2Rb^+ + SO_4^{2-})$

  Net Ionic Equation: $H^+ + OH^- \rightarrow H_2O$

  (It's true that in the "overall reaction," 2's would show up, but then drop out of the net ionic equation.)

- **Watch out for acids or bases that should be written as a molecule, such as weak acids and gases.**

  (and weak bases, but this will come later)

  - *Acetic acid solution is added to a solution of sodium hydroxide.*

    Overall Equation: $HC_2H_3O_2 + NaOH \rightarrow H_2O + NaC_2H_3O_2$ $(= HC_2H_3O_2 + Na^+ + OH^- \rightarrow H_2O + Na^+ + C_2H_3O_2^-)$

    Net Ionic Equation: $HC_2H_3O_2 + OH^- \rightarrow H_2O + C_2H_3O_2^-$
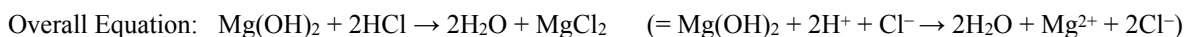
    (Remember, that weak acids are mostly not ionized in solution and thus must be represented as molecules.)

  - *Hydrogen sulfide gas is bubbled through excess potassium hydroxide solution.*

    Overall Equation: $H_2S + 2KOH \rightarrow 2\ H_2O + K_2S$ $(= H_2S + 2OH^- \rightarrow 2\ H_2O + + 2K^+ + S^{2-})$

    Net Ionic Equation: $H_2S + 2OH^- \rightarrow 2\ H_2O + S^{2-}$

    (Remember, that the gas, which is also a weak acid must be written as a molecule.)

  - *A suspension of magnesium hydroxide is added to a dilute solution of hydrochloric acid.*

    Overall Equation: $Mg(OH)_2 + 2HCl \rightarrow 2H_2O + MgCl_2$ $(= Mg(OH)_2 + 2H^+ + Cl^- \rightarrow 2H_2O + Mg^{2+} + 2Cl^-)$

    Net Ionic Equation: $Mg(OH)_2 + 2H^+ \rightarrow 2H_2O + Mg^{2+}$

    (Remember, that a suspension is not actually dissolved, not ionized, and thus must be written as a formula unit − not separated.)

- **Formation of weak acids by combining a weak base with a strong acid.**
  - *Solutions of sodium fluoride and hydrobromic acid are mixed.*

    Overall Equation: $NaF + HBr \rightarrow HF + NaBr$ $(= Na^+ + F^- + H^+ + Br^- \rightarrow HF + Na^+ + Br^-)$

    Net Ionic Equation: $F^- + H^+ \rightarrow HF$
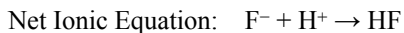
    (Remember that sodium bromide is soluble making the sodium and bromide ions the same as both reactants and products, and thus drop out as spectators. The HF is a weak acid, and thus must be represented as molecule.)

  - *Solutions of potassium acetate and sulfuric acid are mixed.*

    Overall Equation: $2KC_2H_3O_2 + H_2SO_4 \rightarrow 2HC_2H_3O_2 + K_2SO_4$ $(= 2K^+ + 2C_2H_3O_2^- + 2H^+ + SO_4^{2-} \rightarrow 2HC_2H_3O_2 + 2K^+ + SO_4^{2-})$

    Net Ionic Equation: $C_2H_3O_2^- + H^+ \rightarrow HC_2H_3O_2$

    (Remember $HC_2H_3O_2$ is a weak acid, thus a molecule is formed. Sulfate and potassium ions are spectators. Again, the 2's that show up in the overall and ionic equation will drop out of the net ionic equation.)

Remember that on the AP exam you may only use the periodic table. No solubility chart. Assume that the reaction does occur, thus if you can recognize the single replacement reaction, you do not need to check the activity series. Look for extra information embedded in the question. Answers are on the next page.

1.   A strip of magnesium is added to a solution of silver nitrate

2.   Aluminum metal is dropped into an solution of zinc chloride

3.   Solid silver is dropped into an solution of gold(II) nitrate

4.   Aluminum foil is dropped into a solution of nitric acid.

5.   Solid barium is added to ~~chlorous~~ acetic acid

6.   Potassium metal is dropped into water

7.   Liquid bromine is added to an aqueous sodium iodide solution

8.   Hydrogen gas is passed over hot copper(II) oxide producing water and copper metal.

9.   Small chunks of solid sodium is added to water.

10.   Magnesium metal is added to a dilute solution of nitric acid.

11.   Chlorine gas is bubbled into a solution of potassium iodide.

1.   *The magnesium will replace the silver in solution. Remember to leave out the spectator ions.*

$$Mg + 2Ag^+ \rightarrow Mg^{+2} + 2Ag \qquad \text{(Mg is oxidized and Ag}^+ \text{ is reduced.)}$$

2.   *When you are told "solution of zinc chloride," you can assume solubility, and since zinc chloride is an ionic compound, you can assume completely ionized. Remember that zinc always forms 2+ charge. Be sure and eliminate spectator ions, and remember that charges as well as particles must always balance on both sides of the equation.*

$$2Al + 3Zn^{2+} \rightarrow 3Zn + 2Al^{3+} \qquad \text{(Al is oxidized and Zn}^{2+} \text{ is reduced.)}$$

3.   *Be sure and eliminate spectator ions, and remember that charge must also balance.*

$$2Ag + Au^{2+} \rightarrow Au + 2Ag^+ \qquad \text{(Ag is oxidized and Au}^+ \text{ is reduced.)}$$

4.   *When hydrogen ions are replaced, and "take their electron back" (reduction) hydrogen forms the diatomic H_2 molecule.*

$$2Al + 6H^+ \rightarrow 2Al^{3+} + 3H_2 \qquad \text{(Al is oxidized and H}^+ \text{ is reduced.)}$$

5.   *Be alert for weak acids which must be written as molecules.*

$$Ba + \cancel{2HClO_2} \; 2HC_2H_3O_2 \rightarrow Ba^{2+} + H_2 + \cancel{2ClO_2^=} \; 2C_2H_3O_2^- \qquad \text{(Ba is oxidized and H}^+ \text{ is reduced.)}$$
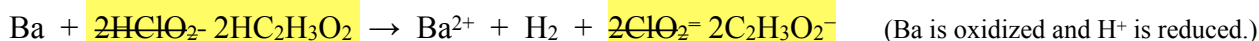
6.   *When alkali metals replace hydrogen in water, it might be easier to remember the products if you think of water as HOH, and that one H^+ that is being replaced and reduced, thus sodium hydroxide is a product, not sodium oxide.*

$$2K + 2H_2O \rightarrow 2K^+ + 2OH^- + H_2 \qquad \text{(K is oxidized and H in water is reduced.)}$$

7.   *Halogens higher on the periodic table can replace halogens lower on the periodic table.*

$$Br_2 + I^- \rightarrow I_2 + Br^- \qquad \text{(I}^- \text{ is oxidized and Br}_2 \text{ is reduced.)}$$

8.   *This reaction that should look like a single replacement, the hydrogen is more likely to behave as a positive ion, thus it will replace the copper not the oxygen.*
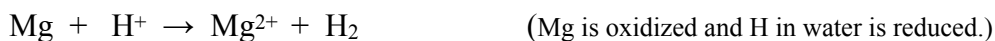
$$H_2 + CuO \rightarrow H_2O + Cu \qquad \text{(H}_2 \text{ is oxidized and Cu}^{2+} \text{ is reduced.)}$$

9.   *This is analogous to #6*

$$2Na + 2H_2O \rightarrow 2Na^+ + 2OH^- + H_2 \qquad \text{(Na is oxidized and H in water is reduced.)}$$

10.   *This is analogous to #4*

$$Mg + H^+ \rightarrow Mg^{2+} + H_2 \qquad \text{(Mg is oxidized and H in water is reduced.)}$$

11.   *This is analogous to #9*

$$Cl_2 + I^- \rightarrow I_2 + Cl^- \qquad \text{(I}^- \text{ is oxidized and Cl}_2 \text{ is reduced.)}$$

Remember that on the AP exam you may only use the periodic table. No solubility chart. Assume that the reaction does occur, thus if you can recognize the double replacement reaction, you should be able to infer the precipitate. Look for extra information embedded in the question. Answers are on the next page.

1.   Aqueous solutions of zinc sulfate and sodium phosphate are mixed.

2.   Hydrofluoric acid is combined with a solution of lead(II) nitrate.

3.   An aqueous solution of lead(II) acetate reacts with hydrochloric acid.

4.   Solid sodium carbonate is stirred into hydrobromic acid.

5.   Nitric acid is reacted with an aqueous solution of calcium acetate.

6.   Hydrochloric acid is poured over powdered potassium carbonate.

7.   An aqueous solution of cadmium chloride is reacted with an aqueous solution of potassium phosphate.

8.   A solution of hydrofluoric acid is poured over barium carbonate crystals.

9.   Hydroiodic acid is poured over solid potassium carbonate.

10.   A solution of sodium hydroxide is poured into a solution of magnesium chloride.

11.   Aqueous lead(II) nitrate is combined with potassium iodide.

Before you check the answer, read the hint and reconsider your own answer to see if you can improve it.

1.   *We can only hope for and uncomplicated precipitation reaction.*

   $3Zn^{2+} + 2PO_4^{3-} \rightarrow Zn_3(PO_4)_2$
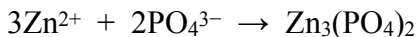
2.   *Anytime we see "acid," we know that acid is in solution, but we must decide if the acid is strong or weak. Remember to write weak acids as molecules (and strong acids as ions, and possibly the anion might be a spectator and drop out of the reaction). Fluorides are generally not particularly soluble compounds.*

   $2HF + Pb^{2+} \rightarrow PbF_2 + 2H^+$
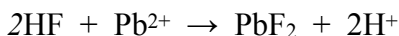
3.   *Lead ions precipitate with most everything except nitrates and acetates and thus would be a precipitate. Don't forget that weak acids should be represented as molecules, not ions. The acetic acid would be dissolved in the solution but not ionized.*

   $Pb^{2+} + 2C_2H_3O_2^- + 2H^+ + 2Cl^- \rightarrow PbCl_2 + 2HC_2H_3O_2$
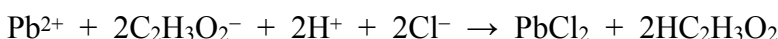
4.   *Remember that whenever carbonic acid shows up as a product, carbonic acid is a "phantom" and most of that acide would decompose into water and carbon dioxide. (Refer back to #7 under solubility rules for more on the "phantoms")*

   $2H^+ + Na_2CO_3 \ (\rightarrow H_2CO_3) \rightarrow H_2O + CO_2 + 2Na^+$
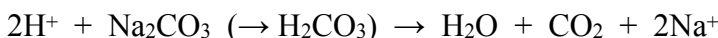
5.   *Watch for the formation of molecular weak acids − they may show up on the product side.*

   $H^+ + C_2H_3O_2^- \rightarrow HC_2H_3O_2$
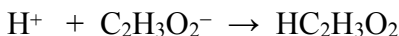
6.   *Watch for the word solid...represent as a compound (not ionized) and don't forget the decomposing of carbonic acid.*

   $2H^+ + K_2CO_3 \ (\rightarrow H_2CO_3) \rightarrow CO_2 + H_2O + 2K^+$
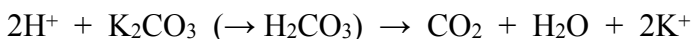
7.   *Whew, thank goodness for an uncomplicated precipitation reaction.*

   $3Cd^{2+} + 2PO_4^{3-} \rightarrow Cd_3(PO_4)_2$
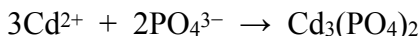
8.   *Remember that fluoride salts are often insoluble, weak acids should be represented as molecules, watch for the "phantom" − the carbonic acid that decomposes. (Refer back to #7 under solubility rules for more on the "phantoms")*

   $2HF + BaCO_3 \rightarrow H_2O + CO_2 + BaF_2$

9.   *Since the potassium carbonate is solid, the K_2CO_3 must be represented as a formula unit and not a solution. Again, watch out for the "phantom," carbonic acid which decomposes when formed. (Refer back to #7 under solubility rules for more on the "phantoms")*

   $2H^+ + K_2CO_3 \ (\rightarrow H_2CO_3) \rightarrow H_2O + CO_2 + 2K^+$
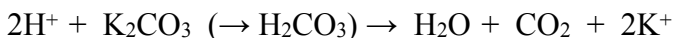
10.   *Yippee ! another uncomplicated precipitation reaction. We know that magnesium hydroxide is quite insoluble from our Milk of Magnesia demonstration.*

    $2OH^- + Mg^{2+} \rightarrow Mg(OH)_2$
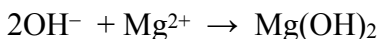
11.   *Another uncomplicated precipitation reaction.*

    $2I^- + Pb^{2+} \rightarrow PbI_2$
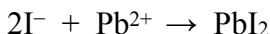
Remember that on the AP exam you may only use the periodic table. No solubility chart. Look for extra information embedded in the question. Answers are on the next page.

1.   A solution of acetic acid is reacted with a lithium hydroxide solution.

2.   A solution of nitric acid is combined with a suspension of magnesium hydroxide.

3.   A solution of sulfuric acid is poured over copper(I) hydroxide crystals.

4.   A solution of sulfuric acid is added to a solution of barium hydroxide until the same number of moles of each compound has been added. A precipitate will form.

5.   Hydrogen sulfide gas is bubbled through a solution of potassium hydroxide.

6.   Potassium hydroxide solution is added to a solution of potassium hydrogen phosphate.
        (monhydrogen phosphate: HPO_4^{2-})

7.   A solution of sodium hydroxide is added to a solution of sodium dihydrogen phosphate until the same number of moles of each compound has been added.   (dihydrogen phosphate: H$_2$PO$_4^-$) ooops should be 1− this was listed as H$_2$PO$_4^{2-}$

8.   Solutions of sulfuric acid and potassium hydroxide are combined.

9.   Hydrochloric acid solution is added to a solution of sodium dihydrogen phosphate

1.   *Pay close attention to whether or not you are working with strong or weak acids and remember that acetic acid is a weak acid and must be written as a molecule.*

$HC_2H_3O_2 + OH^- \rightarrow H_2O + C_2H_3O_2^-$
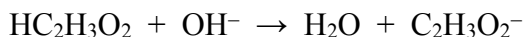
2.   *Remember to check the solubility of magnesium hydroxide − but the very fact that the prompt says "suspension," you are being told solid particles.*

$2H^+ + Mg(OH)_2 \rightarrow 2H_2O + Mg^{2+}$
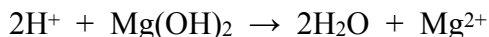
3.   *Remember that copper(I) hydroxide* **crystals** *must be written as a compound, not dissociated. Sulfuric acid is a strong acid. The reaction after splitting up the ionized species would be:* $2H^+ + SO_4^{2-} + 2CuOH \rightarrow 2H_2O + 2Cu^+ + SO_4^{2-}$ *then after eliminating the sulfate spectator ion would be* $2H^+ + 2CuOH \rightarrow 2H_2O + 2Cu^+$ *and then this would need to be reduced to whole number ratios since the directions request this, and a net ionic equation should be the same whether the acid used were a diprotic acid such as* H_2SO_4 *or a monoprotic acid such as* HNO_3.

$H^+ + CuOH \rightarrow H_2O + Cu^+$
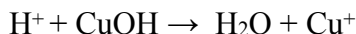
4.   *Pay close attention to whether or not you are working with strong or weak acids. This is both a precipitation adn a neutralization reaction. In this case, "until the same number of moles of each compound has been added" is a distractor and does not change how you would write the reaction.*

$H^+ + SO_4^{2-} + Ba^{2+} + OH^- \rightarrow H_2O + BaSO_4$
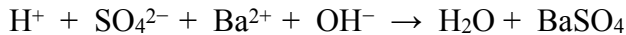
5.   *Remember that gases are always written as molecular species, which means that ions that result from them may not be eliminated as spectator ions.*

$H_2S + 2OH^- \rightarrow 2H_2O + S^{2-}$
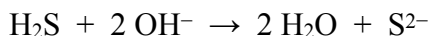
6.   *Hydrogen phosphate, in contrast to dihydrogen phosphate* $(H_2PO_4^-)$ *has only one hydrogen attached to the phosphate ion*

$OH^- + HPO_4^{2-} \rightarrow H_2O + PO_4^{3-}$
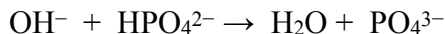
7.   *Remember that the dihydrogen phosphate ion has just that; two hydrogens attached to the phosphate ion.*
        (If extra sodium hydroxide were added, the reaction above would also proceed.)

$OH^- + H_2PO_4^- \rightarrow H_2O + HPO_4^{2-}$
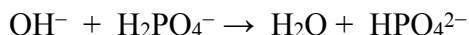
8.   *A simple strong acid/strong base neutralization.*

$H^+ + OH^- \rightarrow H_2O$

9.   *In this case acid,* H^+ *ions, are added to dihydrogen phosphate, which will form the weak acid, which will be present as molecules in solution.*

$H^+ + H_2PO_4^- \rightarrow H_3PO_4$
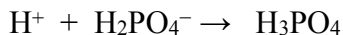
Navigating all those #'s in the Periodic Table

Atoms   When you look up an element in the periodic chart, and look up its atomic number and mass number, assume you are considering an <u>atom</u>, as opposed to an <u>ion</u>. It is very important to pay close attention to this vocabulary.

Atomic number   tells you the number of protons in an atom. Atoms are neutral in charge, which of course means that the number of protons must equal the number of electrons.

Mass number   is the average atomic mass rounded to the nearest whole number. The mass number is equal to the sum of the protons + neutrons. Thus, to determine the number of neutrons, subtract the atomic number from the mass number.

Ions   During chemical reactions, atoms can lose or gain electrons. In fact they do so on a very regular basis. Since electrons are negatively charged, when electron(s) are lost, an atom turns into an ion and ends up with a positive charge. When electrons are gained, an atom turns into an ion and ends up with a negative charge. Negatively charged ions are called ***anions***. Positively charged ions are called ***cations***.

Symbolizing atoms, isotopes, ions, molecules:

- $_3Li$ the *atomic number* is placed in front of the atom as a subscript.

- ^7Li the *mass number* is placed in front of the symbol as a superscript

- Li^+ the + as a superscript refers to the +1 charge if the atom has turned into an ion

- Li_2 the subscript 2 refers to 2 Lithium atoms that are *stuck* together

- $5\ Li$ the 5 refers to 5 lithium atoms that are NOT stuck together (used as coefficients to balance chemical equations)

  <u>**Never**</u> **would all 5 of these numbers be placed around a chemical symbol all at the same time. They would be used at different times in different contexts.**

Electron Configuration

Electron configurations are a simple way of writing down the locations of all of the electrons in an atom. Electrons stay within the atom because of their attraction to the protons, they also mutually repel each other, causing them to spread out around the nucleus in regular patterns. This results in geometric areas of probability called **orbitals** (s, p, d, and f) that represent the distinct regions of probability around the nucleus in which each electron exists. The reason that electrons tend to stay in their separate orbitals rather than piling on top of one another is the Pauli Exclusion Principle, a theorem from quantum mechanics that dictates that no two electrons can ever be in the same place. The Pauli Exclusion Principle arises from more than just the electrostatic repulsion of negative electrons: it comes from fundamental quantum mechanical principles that constrain all subatomic particles.

The orbitals represent identifiable "addresses" for each electron around an atom. Think of the electrons as people going to their favorite concert. The electrons all try to be as close to the stage (the nucleus) as possible, but there is a limited number of seats Some electrons get to be closest to the nucleus, but as the number of electrons that go the concert increases, the further out some of them need to be since the rows closest to the nucleus fill up. This describes a trend observed in the periodic table: elements with small atomic number (and thus fewer electrons) tend to have most of their electrons existing in orbitals near the nucleus. As we move further down the periodic table, orbitals and energy levels further out from the nucleus begin to fill up with electrons. In order to track down where a given electron exists in an atom, you need to know not only how far from the nucleus it is found (described as the electron's **energy level**, since electrons further out from the nucleus tend to have higher energy) but also the type of orbital that the electron is be found in.

Example: Arsenic: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^3$ OR $[Ar]\ 4s^2\ 3d^{10}\ 4p^3$ (noble gas or condensed version)

You will not need to deal with "f electrons on the AP exam.

Percent Composition

Laboratory experiments can give the masses of the various elements contained in the total mass of the compound. This common practice is called elemental analysis or mass percent composition or more simply percent composition. Example, H_2O: 2 (1.01 g/mole) + 16.00 g/mole = 18.02 g/mole total (these numbers are the molar masses from the periodic chart.)

$$H : \frac{2.02g}{18.02} \times 100 = 11.02\% \qquad O : \frac{16.00g}{18.02} \times 100 = 89.88\%$$

Thus water is 11 % hydrogen and 89 % oxygen

Empirical and Molecular Formulas

As you know, the chemical formulas for molecular compounds are not always written in the lowest whole number ratios. We have often used formaldehyde CH_2O and sugar $C_6H_{12}O_6$ as an example. Because of this, the elemental analysis to determine empirical formulas would not allow a chemist to distinguish between sugar and formaldehyde. Another analysis tool, mass spectroscopy would be needed to give one more piece of information: the molar mass of the particular compound being analyzed. So the first 4 steps below will help determine the empirical formula, steps 5-6 must be added to determine the molecular formula.

1. Divide each mass or mass percentage by the molar mass of the element, which will give the number of moles of each element.
2. Divide the results from step 1 by whichever number of moles is the smallest. This maintains the mole ratios from step 1 but bases them on the least abundant element being 1.
3. If some results are far from being whole numbers, multiply all the moles through by a common factor that will convert all the mole amounts to whole numbers or near whole numbers.
4. Round each mole amount to the nearest whole number.
5. If a molar mass is given for the compound, calculate the molar mass for the empirical formula just established from step 4. If the molar mass of the empirical formula is the same as the molar mass of the compound given in the problem, then the empirical formula and the molecular formula are one and the same.
6. If the molar mass of the empirical formula is smaller than the molar mass of the compound, divide the two to determine the whole number factor that the empirical formula must be multiplied by to determine the molecular formula.

Sample Problem

Determine the empirical formula for some compound that was analyzed to be 1.33 g of carbon,0.22 g of hydrogen, and 1.78 g of oxygen. Determine the molecular formula for this compound if the molar mass was measured and found to be 180 g/mole.

- First do step 1 as outlined above.

$$C : \ 1.33g \times \frac{1mol}{12.01g} = 0.111mol \quad H : \ 0.22g \times \frac{1mol}{1.01g} = 0.219mol \quad O : \ 1.78g \times \frac{1mol}{16.00g} = 0.111mol$$

- Proceed to step 2.

$$C : \ \frac{0.111mol}{0.111mol} = 1 \quad H : \ \frac{0.219mol}{0.111mol} = 2 \quad O : \ \frac{0.111mol}{0.111mol} = 1$$

Voilà. The empirical formula is CH_2O

- Since steps 3 and 4 are not necessary, proceed to step 5
  - For CH_2O molar mass = 30 g/mole which is of course not the same as 180 g/mole
- Proceed to step 6

$$\frac{180}{30} = 6$$

  - Therefore when the factor of 6 is distributed through the empirical formula CH_2O
  - Voilà. The empirical formula converts to $C_6H_{12}O_6$

1. Complete the following table to demonstrate your knowlege of sub atomic particles

symbol	# of protons	# of neutrons	# of electrons	atomic #	mass #	charge
		24	21			0
			18	15	31	
$^{13}_{6}C$					13	
	17				35	−1
$^{58}_{26}Fe^{3+}$			23		58	

2. Write complete electron configurations for the following particles.

    a. S

    b. Zr

    c. P^{3-}

    d. Cr^{2+}

3. Write condensed electron configurations for the following particles.

    a. Ge

    b. Pb

4. Bismuth subsalicylate, is the active ingredient in Pepto-Bismol which is used to treat upset stomachs. This chemical has the formula $C_7H_5BiO_4$.

    a. Calculate the percent composition of bismuth subsalicylate.

    b. If each tablet of the medication contains 262 milligrams of $C_7H_5BiO_4$ calculate the mass of bismuth in 2 tablets.

5. Determine the empirical and molecular formula of benzene which contains only carbon and hydrogen and is 7.74% hydrogen by mass. The molar mass of benzene is 78.1 g/mol.

6. 6.394 g of compound used as a drying agent is analyzed and determined to be 2.788 g phosphous and 3.606 g oxygen. The molar mass is approximately 284 g/mol. Determine the empirical and moleculoar formulas of this compound. What is the name of this compound.

1.   Complete the following table to demonstrate your knowlege of sub atomic particles

symbol	# of protons	# of neutrons	# of electrons	atomic #	mass #	charge
Sc	21	**24**	**21**	21	45	**0**
P^{-3}	15	16	**18**	**15**	**31**	−3
$^{13}_{6}C$	6	7	6	6	**13**	**0**
Cl^{-1}	**17**	18	18	17	**35**	−1
$^{58}_{26}Fe^{3+}$	26	32	**23**	265	**58**	3+

2.   Write complete electron configurations for the following particles.
   a.   S   1s² 2s² 2p⁶ 3s² 3p⁴
   b.   Zr 1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d¹⁰ 4p⁶ 5s² 4d²
   c.   P³⁻   1s² 2s² 2p⁶ 3s² 3p⁶
   d.   Cr²⁺ 1s² 2s² 2p⁶ 3s² 3p⁴ 3d⁴   (Cr atom will lose its valence "s" electrons because they are further from the nucleus.)

3.   Write condensed electron configurations for the following particles.
   a.   Ge   [Ar] 4s² 3d¹⁰ 4p²
   b.   Pb   [Xe] 6s² 4f¹⁴ 5d¹⁰ 6p²

4.   Bismuth subsalicylate, is the active ingredient in Pepto-Bismol which is used to treat upset stomachs. This chemical has the formula C₇H₅BiO₄.

$$C_7H_5BiO_4 \quad 7(12.01g)+5(1.008g)+(208.98g)+4(16g)=362.09g$$

   a. $C \ \dfrac{84.07}{362.09}\times100=23.22\% \qquad H \ \dfrac{5.04}{362.09}\times100=1.39\%$

   $Bi \ \dfrac{208.98}{362.09}\times100=57.71\% \qquad O \ \dfrac{64}{362.09}\times100=17.68\%$

   b. $2\times262=524gC_7H_5BiO_4 \qquad 524gC_7H_5BiO_4\times0.5771=302.4gBi$

5.   Empirical formula: CH   and molecular formula: C₆H₆
   $100\%total-7.74\%H=92.26\%C$

   $C \ \ 92.26g(\%)\times\dfrac{1mol}{12.01}=7.68mol \ \ \ Thus \ CH \ \ \ 12.01+1.008=13.018$

   $H \ \ 7.74g(\%)\times\dfrac{1mol}{1.008}=7.68mol \ \ \ \dfrac{78.1}{13.018}=6 \ \ \ Thus \ C_6H_6$

6.   Empirical formula: P₂O₅   and molecular formula: P₄O₁₀
   $100\%total-7.74\%H=92.26\%C$

   $P \ \ 2.788g\times\dfrac{1mol}{30.97}=0.090mol \ \ \ \dfrac{0.090}{0.090}=1\times2=2 \ \ \ Thus \ P_2O_5$

   $O \ \ 3.606g\times\dfrac{1mol}{16}=0.225mol \ \ \ \dfrac{0.225}{0.090}=2.5\times2=5 \ \ \ 2(30.97)+5(16)=142$

   $\dfrac{284}{142}=2 \ \ \ Thus \ P_4O_{10} \ \ \ tetraphophorous \ decoxide$

Summer Review: Energy

Energy is represented by the symbol q. This q could represent potential energy or kinetic energy

Kinetic energy transfer (when a substance changes temperature) can be calculated with

$$q = amount \times c \times \Delta T$$

Potential energy transfer (when a substance changes phase or goes through a chemical change) can be calculated with

$$q = \Delta H \times amount$$

- Energy units, q used in AP will be Joules (J) or kiloJoules (kJ)
- *Amount* units used in AP will be grams (g), kilograms (kg) or moles (mol)

> How do you know what "amount" to use? Just be sure the units match the units on "c" or "ΔH"

- *Temperature* units used in AP will be degrees Celsius (°C) or Kelvins (K), ΔT means change of temperature

- Specific heat capacity (c) is $C = \dfrac{energy}{amount \times degrees}$ $\dfrac{J}{g \cdot c}$ or $\dfrac{kJ}{mol\ K}$ or ...

- Enthalpy (ΔH) is $\Delta H = \dfrac{energy}{amount}$ $\dfrac{J}{g}$ or $\dfrac{kJ}{mol}$ or ...

> when you see the work "magnitude" in a problem, that is AP code for "don't worry about the sign, just get the right number.

Paying attention be sure your units match and can cancel out is very important.

Sample Problem

Calculate the magnitude of energy required to heat a 55.0 g piece of aluminum from 20.0°C up to 500.°C. The specific heat capacity of aluminum is 0.890 J/(g×°C)

$q = amount \times c \times \Delta T$ $q = 55 g \times \dfrac{0.89 J}{g \cdot c} \times (500 - 20 °C)$ $q = 234965$ ⇒ **23.5 kJ**

Sample Problem

Calculate the amount of energy required to vaporize 250. g of water at 100°C. $\Delta H_{vaporization}$ for H_2O is 40.5 kJ/mol

$q = \Delta H \times amount$ $q = \dfrac{40.5\ kJ}{mol} \times \left(250 g \times \dfrac{1 mol}{18.02 g}\right)$ $q = 562\ kJ$

amount!

These two equations can be put together if we assume that heat lost equals heat gained. $q_{lost} = q_{gained}$

Sample Problem

What mass of ice stored in the freezer at 0.0°C is required to cool 125 g of water at 35.0°C down to 0.0°C.

The ΔH_{fusion} of H_2O is 334 J/g

$q_{gained\ by\ ice} = q_{lost\ by\ water}$ $\Delta H_{fusion} \times amount_{ice} = amount_{water} \times C_{water} \times \Delta T_{water}$

$amount_{ice} = \dfrac{125 g \times \dfrac{4.18 J}{g \cdot c} \times (35 - 0 °C)}{334 \dfrac{J}{g}}$ ⇒ 54.8 ⇒ **55 g ice**

Sample Problem

How much energy is released when 5.0 g of isoproyl alcohol, C_3H_7OH is burned? $\Delta H_{combustion}$ of C_3H_7OH is −2021 kJ/mol

$q = \Delta H \times amount$ $q = \dfrac{2021\ kJ}{1 mol} \times 5 g \times \dfrac{1 mol}{60.1 g}$ ⇒ **168 kJ**

Remember that units must match to cancel out. The negative sign on the simlpy indicates that energy is released.

Gas Laws

Gas pressure, volume, temperature and amount (moles) are related to each by the combined gas law

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

- In AP, volume, V will be measured in liters (L) or milliliters (mL)
- In AP, pressure, P will be measured in mmHg = torr or atmospheres (atm)   1 atm = 760 torr
- Temperature, T may be measured in ºC, but must always be converted to Kelvin before using in the gas equations ºC + 273 = K
- n represents numbers of particles or moles (not mass)

Further we know that 1 mole of any gas at standard conditions, 0ºC and 1 atm pressure will be a volume of 22.4 L. Plugging these known values into one side of the combined gas law equation above will produce the ideal gas constant which allows us to produce Ideal Gas Law

$$PV = nRT$$

$$\frac{PV}{nT} \rightarrow \frac{1\,atm \times 22.4\,L}{1\,mol \times 273\,K} \Rightarrow 0.0821 \frac{atm\,L}{mol\,K}$$

we call this R the ideal gas constant

$$and \quad \frac{760\,torr \times 22.4\,L}{1\,mol \times 273\,K} \Rightarrow 62.4 \frac{torr\,L}{mol\,K}$$

Sample Problem

If 250. ml of helium in a glass flask at 20.ºC at 625 torr was heated to 40.ºC, what would be the pressure after heating?

- *The gas is in a rigid glass flask, thus the volume is constant and cancels out of the equation.*
- *We can assume the flask is sealed, thus the number of moles (n) cancels out of the equation.*

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2} \qquad P_2 = \frac{P_1 \cancel{V_1} \cancel{n_2} T_2}{\cancel{n_1} T_1 \cancel{V_2}} \qquad P_2 = \frac{625\,torr \times 293\cancel{K}}{313\cancel{K}} \qquad P_2 = 585\,torr$$

Sample Problem

What is the mass of 275 ml of oxygen gas in a sealed flask at 35ºC at 5 atm of pressure?

$$PV = nRT$$

$$\frac{Mass\,(m)}{Molar\,mass\,(MM)} = moles\,(n) \quad \underset{\text{substitute}}{\longrightarrow} \quad PV = \frac{m\,RT}{MM} \qquad m = \frac{PV\,MM}{RT} \qquad m = \frac{5\,atm \times 0.275\cancel{L} \times 32 \frac{g}{\cancel{mol}}}{0.0821 \frac{\cancel{L}\,atm}{\cancel{mol}\,\cancel{K}} \times 308\,\cancel{K}} \qquad m = 1.74g\ O_2$$

A Typical Plan for Solving Stoichiometry Problems

There is a basic pattern to all stoichiometry problems, with variations depending on what information is given and what questions must be answered. You are using dimensional analysis so be sure to set up you calculations with the starting units on top and bottom so it will cancel out and with the desired substance on the top.

A. You must start with a <u>balanced </u>equation.

B. Convert the units of any starting substances into moles. (USE Molar Mass (g/mol) complete this calculation) Since the stoichiometric LINK or RATIO – coefficients from the balanced equation – is in moles, you must work the problem in moles.

C. Reread the problem to determine the information that you need to calculate. Use the stoichiometric LINK to convert from a known substance to a desired substance that you need to answer the question. Note that the LINK is set up with the known substance on the bottom (so it will cancel out) and with the desired substance on the top.

D. If necessary, convert any answers back into grams.

If your problems only involve only moles, then you can skip steps B and E

Sample Problem

Lithium hydroxide is used in space vehicles to remove exhaled carbon dioxide from the living environment by forming solid lithium carbonate and liquid water. What mass of gaseous carbon dioxide can be absorbed by 1.00. kg of lithium hydroxide?

STEP A. balanced equation: $2\ LiOH\ +\ CO_2\ \rightarrow\ Li_2CO_3\ +\ H_2O$

Notice that the starting info is given in kilograms, so 1.00 kg should be converted to grams.

$$1.00 \times 10^3\,gLiOH \times \frac{1mol}{23.99g} \times \frac{1CO_2}{2LiOH} \times \frac{44.01gCO_2}{1molCO_2} = 917\,gCO_2$$

Steps in the dimensional analysis: B.   C.   D.

STEP B. Change to moles using the molar mass of LiOH

STEP C. Change from moles of LiOH to moles of CO_2 using the coefficients from the balanced equation.

STEP D. Change from moles of CO_2 back to grams of CO_2 using the molar mass of CO_2.

Problem Solving Plan - Limiting Reactant and Percent Yield

For limiting reactant problems, the problem will give you information about two reactants as opposed to information given for only reactant and an assumption that the other reactant is present in excess.

A. You must always start with a balanced equation.

B. If it is a limiting reactant problem.... Determine which reactant LIMITS

C. First you *must* change your mass values to moles. NOTE: The mathematical trick to determine which reactant limits is to divide the moles of each reactant by the coefficient (from the balanced equation) associated with that reactant. The number that comes out the smallest indicates which reactant is the limiting one. The limiting reactant is the one that you must base all your other calculations on because it is the substance that limits how much of everything else can be made or is needed.

D. Solve the problem using the same steps for stoichiometry problems above based on the LR.

E. Of course, the other reactant (if there's only two) will be the excess reactant, and some of it will be left over. (Knowing which reactant limits and which is excess, use the limiting reactant to set up a stoichiometric LINK to determine the mass of the excess reactant that is actually needed to do the reaction. Then, subtract the mass of reactant that you just calculated was needed from the amount of excess reactant started with to determine the mass of excess reactant that is left over.

F. Determining Percent Yield- After determining the LR, use the link to calculate the theoretical amount of the product for which you need a yield.

G. The experimental amount actually produced will be given in the problem. Use it to set up the equation below and determine the percent yield:

$$\frac{Experimental}{Theoretical} \times 100 = PercentYield$$

Molarity (M):

This is the most common method of reporting concentration used in AP chemistry.

Molarity is the number of moles of solute per liter of solution. $Molarity = \dfrac{Moles\,of\,Solute}{Liters\,of\,Solution}$

When a more concentrated solution is diluted, the moles of the solute will be the same before and after the dilution. This gives rise to the dilution equation, which is just a variation of the molarity equation. $M_c V_c = M_d V_d$

Sample Problems

1. What is the molarity of a solution that contains 6.57 g of magnesium chloride in 250. mL of solution?

    - *First you need to be able to write out the chemical formula for maganesium chloride, and calculate the molar mass.*
        - $MgCl_2$ $24.31 + 2 \times 35.45 = 95.21$ g/mol

    - *Next, convert the mass of magnesium chloride to moles.* $6.57\,g\,MgCl_2 \times \dfrac{1\,mol\,MgCl_2}{95.21\,g\,MgCl_2} = 0.0690\,mol\,MgCl_2$

    - *Next apply the molarity equation.* $\dfrac{0.069\,mol}{0.25\,L} = 0.276\,M$

   > **Hey look!** Molarity which is moles per liter, is also millimoles per milliliter!!
    >
    > $\dfrac{5\,mol}{1L} \times \dfrac{1000\,millimol}{1\,mol} \times \dfrac{1L}{1000\,mL} = \dfrac{5\,millimol}{1\,mL}$

2. Given 25.0 mL of a 0.05 M of aluminum sulfate solution.

    (a) How many millimoles of aluminum sulfate does this solution contain?

    (b) How many millimoles of sulfate does this solution contain?

    - *To answer (a), simply apply the molarity equation* $M \times V = moles$ $0.05\,M \times 25\,ml = 1.25\,millimol$

    - *To answer part (b) you need to write out the chemical formula for aluminum sulfate.* $Al_2(SO_4)_3$

    - *Thus you can see there are three sulfate ions per aluminum sulfate.*

        - $1.25\,mmol\,Al_2(SO_4)_3 \times \dfrac{3\,SO_4^{2-}\,ions}{1\,Al_2(SO_4)_3} = 3.75\,mmol\ SO_4^{2-}\,ions$

3. If 38.0 mL of a 6.0 M HCl solution are diluted to a final volume of 250 mL, what is the final concentration?

    - *To answer (a), simply apply the dilution equation* $M_c V_c = M_d V_d$

        - $M_c V_c = M_d V_d$ $M_d = \dfrac{M_c V_c}{V_d}$ $M_d = \dfrac{6M \times 38\,mL}{250\,ml}$ $M_d = 0.91M$

1. Solutions of nickel(II) chloride and potassium phosphate will react to produce a light green precipitate .

Solution	Concentration (Molarity)	Volume (Liters)
$Na_2S_2O_3$	0.500	250.
NOCl	2.00	150.
NaOH	0.600	175

   a) Write a balanced overall chemical equation to represent this reaction.

   b) What mass of potassium phosphate in solution would be required to react completely with 0.875 g of nickel(II) chloride in solution?

   c) Calculate the theoretical mass of nickel(II) phosphate that could be produced.

   d) Convert the overall equation to the net ionic equation.

2. Gallium metal reacts with perchloric acid. *Assume that room conditions are 20.0°C and 750 torr.*

   a) Write both overall and net ionic balanced equations to represent this reaction.

   b) If 2.25 L of hydrogen gas were collected, what mass of gallium metal was dropped into the acid solution?

3. Aluminum will cause copper to reduce from a solution of copper(II) chloride.

   a) Write a balanced net ionic chemical equation to represent this reaction.

   b) Is 5.00 g of aluminum enough aluminum to reduce all of the copper(II) ions from 750. ml of a 0.500 M solution?

   c) If 5.00 g of aluminum is more than enough, what mass would be left over? OR if 5.00 g of aluminum is not enough, what is the additional mass of aluminum that would be needed to remove all of the copper(II) ions from solution?

4. Hydrochloric acid reacts with solid magnesium hydroxide.

   a) Write a balanced overall chemical equation to represent this reaction.

   b) What volume, in milliliters, of 0.25 M hydrochloric acid solution would be required to completely react with 4.56 g of magnesium hydroxide?

   c) Convert the balanced overall equation to a net ionic equation.

5. 1.65 g of zinc is dropped into 150. ml of 0.250 M of hydrobromic acid.

   a) Write both overall and net ionic balanced chemical equations to represent this reaction.

   b) Which reactant is the limiting reactant in this chemical reaction?

   c) Calculate the theoretical mass of solid zinc bromide that should be produced.

   d) If Consuela and Pete were able to produce 3.67 g of the zinc bromide, what is their percent yield?

6. Eldon and Sally were preparing a sulfuric acid solution for a lab and they needed 500. ml of 0.045 M

   a) Calculate the volume of 3.0 M solution that Eldon and Sally should measure out into the 500. ml volumetric flask.

   b) What is the molarity of H^+ ions for the solution that Eldon and Sally prepared?

   c) What are the number of millimol of H^+ ions that are in Eldon and Sally's 500. ml of 0.045 M sulfuric acid solution?

7. Nitric acid will react with a sodium carbonate solution.

   a) Write a balanced overall equation to represent this reaction. (Hint: one of the products is a phantom, and will turn into two products. Refer to page 5 of this packet for more information.)

   b) What volume of 0.25 M nitric acid would be required to react completely with 245 ml of 0.38 M of the sodium carbonate solution.

$$Na_2S_2O_{3(aq)} + 4\ NaOCl_{(aq)} + 2\ NaOH_{(aq)} \rightarrow 2Na_2SO_{4(aq)} + 4\ NaCl_{(aq)} + H_2O_{(L)}$$
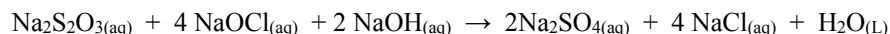
8. Answer the following questions about the balanced redox equation shown above.

   a) The student combines the solutions shown in the table to the right. Determine the limiting reactant.

   b) How many moles of water would be produced during this reaction?

   c) Convert the overall equation shown above into a net ionic equation.

Solution	Concentration (Molarity)	Volume (Liters)
$Na_2S_2O_3$	0.500	250.
NOCl	2.00	150.
NaOH	0.600	175

9. One of the main components in olive oil is oleic acid, $C_{18}H_{24}O_2$. $\Delta H_{combustion}$ for oleic acid is 11,100 kJ/mol. The molar mass of oleic acid is 272.38 g/mol.

    a) Write the balanced equation to represent this reaction.

    b) Calculate the mass of oleic acid that is combusted if 550. kJ of energy is released during a burn.

    c) Calculate the volume of oxygen gas at 25ºC and 1 atm pressure at that would be required during the same burn described in part (b).

10. The main component of gasoline is octane, C_8H_{18} which burns in the engine of your car that produces gases that expand inside the engine to produce pressure to turn the wheels. $\Delta H_{combustion}$ for octane is 5,460 kJ/mol.

    a) Write the balanced thermochemical equation to represent this reaction.

    b) Calculate the amount of energy released for every 15 g of CO_2 produced.

    c) You may be aware that some cars can operate on cooking oil. Which fuel, octane or oleic acid (from question 9) provides more energy per gram. Justify with a calculation to make the comparison.

1. Solutions of nickel(II) chloride and potassium phosphate will react to produce a light green precipitate .

   a) $2\ NiCl_2\ +\ 3\ K_3PO_4\ \rightarrow\ 6\ KCl\ +\ Ni_2(PO_4)_3$

   b) $0.875\,gNiCl_2 \times \dfrac{1mol}{129.59g} \times \dfrac{3K_3PO_4}{2NiCl_2} \times \dfrac{212.27g}{1mol} = 2.15\,gK_3PO_4$

   c) $0.875\,gNiCl_2 \times \dfrac{1mol}{129.59g} \times \dfrac{Ni_3(PO_4)_2}{2NiCl_2} \times \dfrac{366.01g}{1mol} = 1.24\,gNi_3(PO_4)_2$

   d) $Ni^{2+}\ +\ 3\ PO_4{}^{3-}\ \rightarrow\ Ni_2(PO_4)_3$

2. Gallium metal reacts with an aqueous perchloric acid solution. *At room conditions, 24.0 L is the volume of 1.00 mole of gas.*

   a) Overall: $2\ Ga\ +\ 6\ HClO_4\ \rightarrow\ 2\ Ga(ClO_4)_3\ +\ 3\ H_2$ Net: $2\ Ga\ +\ 6\ H^+\ \rightarrow\ 2\ Ga^{3+}\ +\ 3\ H_2$

   b) $PV = nRT \quad n = \dfrac{PV}{RT} \quad \dfrac{750\,torr \times 2.25\,L}{62.4\,\frac{torr\,L}{mol\,K} \times 293K} \quad n = 0.0923\,mol\,H_2 \times \dfrac{2\,Ga}{3\,H_2} \times \dfrac{69.72g}{1\,mol} = \boxed{4.29\,g\,Ga}$

3. Aluminum will cause copper to reduce from a solution of copper(II) chloride.

   a) $2\ Al\ +\ 3\ Cu^{2+}\ \rightarrow\ 2\ Al^{3+}\ +\ 3\ Cu$

   b) $0.5M \times 0.75L \times \dfrac{2Al}{3Cu^{2+}} \times \dfrac{26.98g}{1mol} = 6.745\,gAlNeeded$, thus 5.00 g of aluminum would NOT be enough.

   c) 6.745g needed − 5.00g provided = 1.74 g (or 1.75 g) more aluminum would be needed

4. Hydrochloric acid reacts with solid magnesium hydroxide.

   a) $2\ HCl\ +\ Mg(OH)_2\ \rightarrow\ 2\ H_2O\ +\ MgCl_2$

   b) $4.56\,gMg(OH)_2 \times \dfrac{1mol}{58.33g} \times \dfrac{2HCl}{1Mg(OH)_2} \times \dfrac{1L}{0.25mol} = 0.625L\ HCl$ and this is 625 ml of hydrochloric acid

   (Remember that molarity means moles/Liter, thus it is used in the dimensional analysis upside down.)

   c) $2\ H^+\ +\ Mg(OH)_2\ \rightarrow\ 2\ H_2O\ +\ Mg^{2+}$

5. 0.165 g of zinc is dropped into 150. ml of 0.250 M of hydrobromic acid.

   a) Overall: $2\ HBr\ +\ Zn\ \rightarrow\ 2\ H_2\ +\ ZnBr_2$ Net: $2\ H^+\ +\ Zn\ \rightarrow\ 2\ H_2\ +\ Zn^{2+}$

   b) $0.165g \times \dfrac{1mol}{65.41g} = \dfrac{0.0252mol}{1Zn} > 0.250M \times 0.150L = \dfrac{0.0375molHBr}{2HBr}$ Thus the HBr acid solution limits.

   c) $0.0375\,molHBr \times \dfrac{1ZnBr_2}{2HBr} \times \dfrac{225.21g}{1mol} = 4.22\,gZnBr_2$

   d) $\dfrac{3.67gZnBr_2\,Experimental}{4.22gZnBr_2\,Theoretical} \times 100 = 87.0\%$

6. Eldon and Sally were preparing a sulfuric acid solution for a lab and they needed 500. ml of 0.045 M

   a) $M_cV_c = M_dV_d \quad 3M \times V_c = 0.045M \times 500ml \quad V_c = 7.5\,ml$

   b) $0.045M\ H_2SO_4 \times \dfrac{2H^+}{1H_2SO} = 0.090M\ H^+$

   c) $0.090M\ H^+ \times 500ml = 45\,millimol$

7. Nitric acid will react with a sodium carbonate solution.

a) $2\ HNO_3 + Na_2CO_3 \rightarrow 2\ NaNO_3 + (\ H_2CO_3\ phantom \Rightarrow)\ H_2O + CO_2$
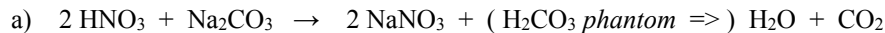
b) $0.38\dfrac{mol}{L}(M)\times 0.245L\ Na_2CO_3 \times \dfrac{2\,HNO_3}{1Na_2CO_3}\times \dfrac{1L}{0.25\,mol}=0.775L\ HNO_3$

Some of you may look at this and be confused by the single string of dimensional analysis. Perhaps you wopuld prefer to think about solving the problem in three parts as shown below:

$0.38\dfrac{mol}{L}(M)\times 0.245L\ Na_2CO_3 = 0.0931 molNa_2CO_3$ $\qquad 0.0931molNa_2CO_3 \times \dfrac{2\,HNO_3}{1Na_2CO_3}=0.1862\,molNa_2CO_3$

$Molarity = \dfrac{moles}{Liter}\qquad 0.25M = \dfrac{0.1862\,molNa_2CO_3}{xLiter}\qquad x=0.775L\ HNO_3$
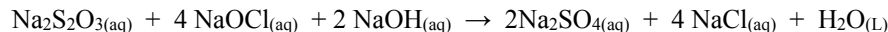
$$Na_2S_2O_{3(aq)} + 4\ NaOCl_{(aq)} + 2\ NaOH_{(aq)} \rightarrow 2Na_2SO_{4(aq)} + 4\ NaCl_{(aq)} + H_2O_{(L)}$$

8. Answer the following questions about the balanced redox equation shown above.

a)
$0.500M\times 0.250L = 0.125\,molNa_2S_2O_3 \qquad \dfrac{0.125\,molNa_2S_2O_3}{1}=0.125$

$2.00M\times 0.150L = 0.300\,molNOCl \qquad \dfrac{0.300\,molNOCl}{4}=0.075$

$0.60M\times 0.175L = 0.105\,molNaOH \qquad \dfrac{0.105\,molNaOH}{2}=0.0525\quad ThusNaOHLimits$

b) $0.105\,molNaOH \times \dfrac{1H_2O}{2\,NaOH}=0.210\,molH_2O$

c) $S_2O_3{}^{2-} + 4\ OCl^- + 2\ OH^- \rightarrow 2\ SO_4{}^{2-} + 4\ Cl^- + H_2O$

Note that the sodium spectator ions drop out of the overall equation.

9. Combustion of oleic acid

a) $C_{18}H_{24}O_2 + 23\ O_2 \rightarrow 12\ H_2O + 18\ CO_2 + 11,100\ kJ$
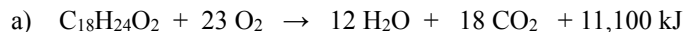
*(writing a **thermochemical** equation means putting the energy in the equation on the proper side to reflect exothermic or endothermic)*

b) $q = \Delta H \times amount \qquad \dfrac{550kJ}{11,100\ \frac{kJ}{1mol}} = 0.0495\ mol \times \dfrac{272.38g}{1mol} = 13.5g$
    (amount)

c) $0.0495\ mol\ C_{18}H_{24}O_2 \times \dfrac{23\ O_2}{1\ C_{18}H_{24}O_2} = 1.14mol \quad V = \dfrac{nRT}{P} \quad V = \dfrac{1.14\,mol \times 0.0821\,\frac{L\,atm}{mol\,K}\,298K}{1\,atm} \quad V = 27.9L\ O_2$

10. Combustion of octane.

a) $C_8H_{18} + 12\tfrac{1}{2}\ O_2 \rightarrow 9\ H_2O + 8\ CO_2 + 5,460\ kJ$
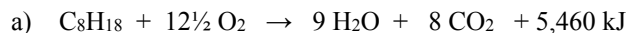
(Yes you can balance with fractions or you may convert to whole numbers, however that means you would need to adjust the energy value since the reaction shows 2 moles of octane)

$2\ C_8H_{18} + 25\ O_2 \rightarrow 18\ H_2O + 16\ CO_2 + 10,920\ kJ$
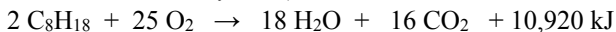
b) $15g\ CO_2 \times \dfrac{1mol}{44g} \times \dfrac{5,460kJ}{8\,CO_2} = 233\ kJ$

c) $\dfrac{5,460kJ}{mol} \times \dfrac{1mol}{114.23g} = \dfrac{44.8\,kJ}{g}\ octane > \dfrac{40.8\,kJ}{g}\ oleic\ acid = \dfrac{11,100\,kJ}{1mol} \times \dfrac{1mol}{272.38g}$
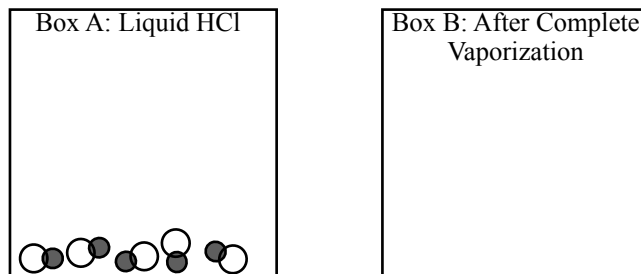
The AP Chemistry curriculum has made a point of asking students to interpret and draw particulate diagrams. A particulate diagram is a sketch that asks students conceptualize what may be happening at the atom and molecule level. You will be asked to convert between macroscopic observations in lab, to symbolic representations with chemical formulas and balanced equations, to particulate representations of the atoms, ions and molecules.

1. The picture shown to the right is a representation of a mixture of hydrogen and oxygen molecules that can be sparked to produce water. Draw a sketch that represents the resulting mixture after the reaction goes to completetion.

    Hint: write a balanced chemical equation first. Decide which molecule best represents oxygen and which best represents hydrogen.
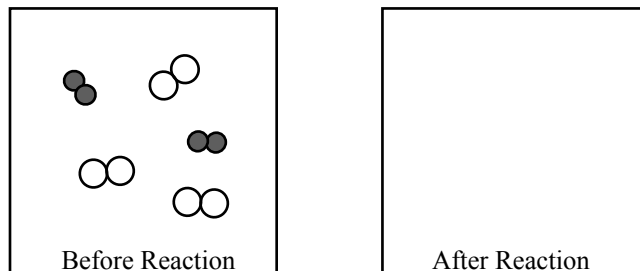

    Before Reaction

    After Reaction

2. Draw a sketch that represents five molecules of HCl in the liquid state is shown in Box A below. In Box B, draw a representation of the five molecules of HCl after complete vaporization has occurred


    Box A: Liquid HCl

    Box B: After Complete Vaporization

3. A section of a solid lithium chloride crystal is represented to the left of the box below. In the box, show the interactions of the components of a lithium chloride crystal dissolved in water by making a drawing that represents the different particles present in the solution. Include only **one formula unit** of lithium chloride and at least three, but no more than five molecules of water. Your drawing must include the following details.

    *   identify the ions (symbol and charge)
    *   the proper arrangement and orientation of the particles in the solution
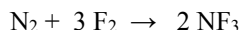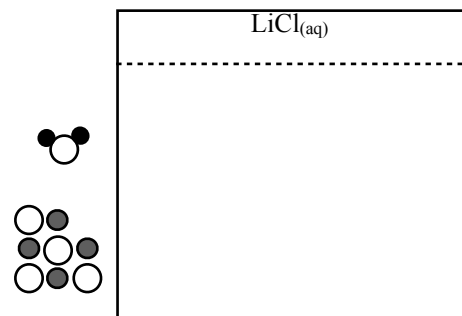
    LiCl$_{(aq)}$

    $$N_2 + \ 3\ F_2 \ \rightarrow \ \ 2\ NF_3$$

4. The picture shown to the right is a representation of a mixture of ammonia and hydrogen molecules that is a result of the completion of the reaction between N_2 and H_2 as shown in the reaction above. In the box on the left, draw the particle-level representation of the reactant mixture of N_2 and H_2 that would yield the product mixture shown in the box on the right. In your drawing, represent nitrogen atoms and hydrogen atoms as shown below


    ● = fluorine
    ○ = nitrogen

    Before Reaction
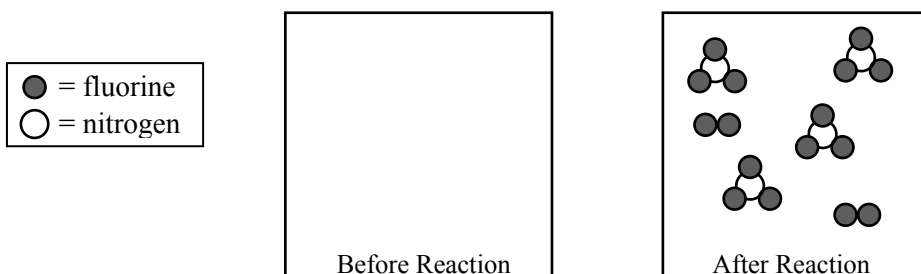
    After Reaction

1. The picture shown to the right is a representation of a mixture of hydrogen and oxygen molecules. Draw a sketch that represents the resulting mixture after the reaction goes to completetion. *Hint: write a balanced chemical equation first. Decide which molecule represents oxygen and which should represent hydrogen.*

    Hydrogen atoms are smaller, and thus H_2 should be represented by the shaded molecules, the oxygen molecules, O_2 represented by the unshaded molecules.
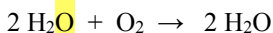
    $2 H_2O + O_2 \rightarrow 2 H_2O$

    should be: $2 H_2 + O_2 \rightarrow 2 H_2O$
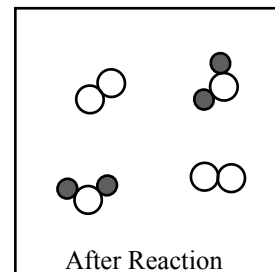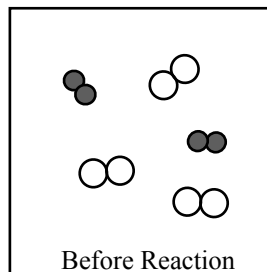
   Before Reaction   After Reaction

2. Draw a sketch that represents five molecules of HCl in the liquid state is shown in Box A below. In Box B, draw a representation of the five molecules of HCl after complete vaporization has occurred

    During vaporization, molecules do NOT break apart. The moleulecules simply separate from each other equally distributing within the box, filling the container.
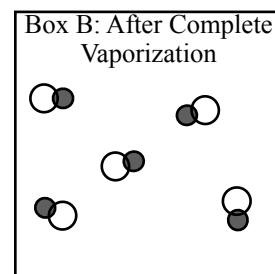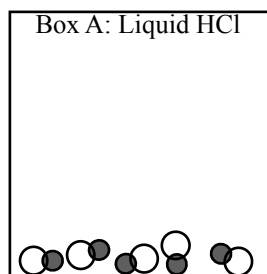
    Box A: Liquid HCl   Box B: After Complete Vaporization

3. A section of a solid lithium chloride crystal is represented to the left of the box below. In the box, show the interactions of the components of a lithium chloride crystal dissolved in water by making a drawing that represents the different particles present in the solution. Include only **one formula unit** of lithium chloride and at least three, but no more than five molecules of water. Your drawing must include the following details. The formula unit will separate when dissolved in water.

    *   Lithium ions would be smaller and positive charged. Chloride ions would be larger and negative charged. Rebresent only one formula unit (ionicule)

    *   The partially negative oxygen end of water will orient near the lithium ions. The partially positve hydrogen end of water will orient around the chloide ion
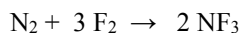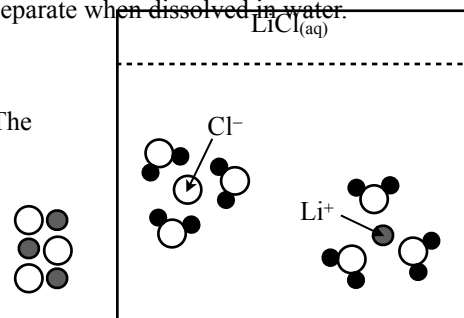
    $LiCl_{(aq)}$

    Cl^-

    Li^+

$$N_2 + 3 F_2 \rightarrow 2 NF_3$$

4. The picture shown to the right is a representation of a mixture of ammonia and hydrogen molecules that is a result of the completion of the reaction between N_2 and H_2 as shown in the reaction above. In the box on the left, draw the particle-level representation of the reactiant mixture of N_2 and H_2 that would yield the product mixture shown in the box on the right. In your drawing, represent nitrogen atoms and hydrogen atoms as shown below

    *   The arrangement of the molecules within the box is not important, what is important is the number of each molecule

    ● = fluorine
    ○ = nitrogen

    Before Reaction   After Reaction