AP Chemistry - Unit 2 Packet - Chapter 4
The Chemistry of Solutions

Joe Perfect

At the end of this unit I will be able to . . .

Target	Section in Text	Associated Problems
1. identify substances as either an acid, base or a salt. I will also be able to determine whether the acid or base is strong or weak.	4.1 & 4.3	35
2. predict whether a substance is a nonelectrolyte, strong electrolyte, or a weak electrolyte. I will also be able to predict the ions formed by electrolytes when they dissociate or ionize.	4.1 & 4.3	1, 3, 11, 16, 18, 38
3. use Coulomb's Law to help describe the interactions of ions during the dissolving process.	4.1	12, 13, 14
4. use solubility rules to predict whether a substance is classified as soluble or insoluble.	4.2	19, 20
5. predict the products of chemical reactions (including neutralization and precipitation reactions) and write balanced molecular and net ionic equations for them. I will also be able identify spectator ions.	4.2	7, 21, 24, 39, 40
6. be able to choose which type of equation is most appropriate (molecular, ionic or net ionic) equation for specific situations.	4.2	None
7. recognize reactions which produce either CO_2, H_2S, or NH_3 gases.	4.3	41, 43
8. determine whether a chemical reaction involves oxidation and reduction by assigning oxidation numbers to atoms in molecules and ions.	4.4	45, 46, 47, 49, 52
9. identify the applications of redox reactions.	Notes	None
10. use the activity series to predict whether a reaction will occur when a metal is added to an aqueous solution of either a metal salt or an acid; and write the balanced molecular and net ionic equations for the reaction.	4.4	55, 57, 58
11. calculate molarity, solution volume, or number of moles of solute given any two of these quantities.	4.5	59, 60, 69, 72
12. solve problems when making solutions by dilutions.	4.5	73, 74, 77
13. solve stoichiometry problems involving solutions.	4.6	81, 83, 87, 89
14. perform a titration in the lab and make stoichiometric calculations based upon my lab results.	LAB	

Target #1: I can identify substances as either an acid, base or a salt. I will also be able to determine whether the acid or base is strong or weak.

Arrhenius Acid: a substance able to donate a H^+ ion (a proton) and hence increase the H^+ ion concentration when it dissolves in water

Arrhenius Base: a substance able to produce a OH^- ion when it dissolves in water

Salt: an ionic compound made up of a one or more positive ions and negative ions; all salts are ionic compounds and all ionic compounds are salts.

Example: Circle all of the acids, box all of the bases and underline all of the salts:

$\boxed{Ca(OH)_2}$ $\boxed{KOH}$ $\underline{AlCl_3}$ H_3PO_4 HBr $\boxed{Mg(OH)_2}$ $\underline{K_2SO_4}$

How do you tell the difference between strong acids and weak acids?

There are only 7 common strong acids! H_2SO_4, HNO_3, $HClO_4$, $HClO_3$, HCl, HBr, & HI. Memorize these! Put them on a notecard!

How do you tell the difference between strong bases and weak bases?

Strong bases contain 1A or the 2A metals Ca, Sr, Ba. (Examples: NaOH, $Ca(OH)_2$, KOH)
Other common bases:

1) The most common weak base in America is ammonia (NH_3).
2) Amines are weak organic bases. CH_3NH_2 is called methylamine and is a weak base.

Acid-Base Vocabulary

Monoprotic acids = one H^+ ion molecule (HCl, HNO_3, $HC_2H_3O_2$)
Diprotic acids = two H^+ ions per molecule (H_2SO_4, H_2CO_3)
Triprotic acids = three H^+ ions per molecule (H_3PO_4, H_3AsO_4)
Polyprotic acids = diprotic and polyprotic acids
Neutralization Reaction = acid + base ➡ salt + water

Target #2: I can predict whether a substance is a nonelectrolyte, strong electrolyte, or a weak electrolyte. I will also be able to predict the ions formed by electrolytes when they dissociate or ionize.

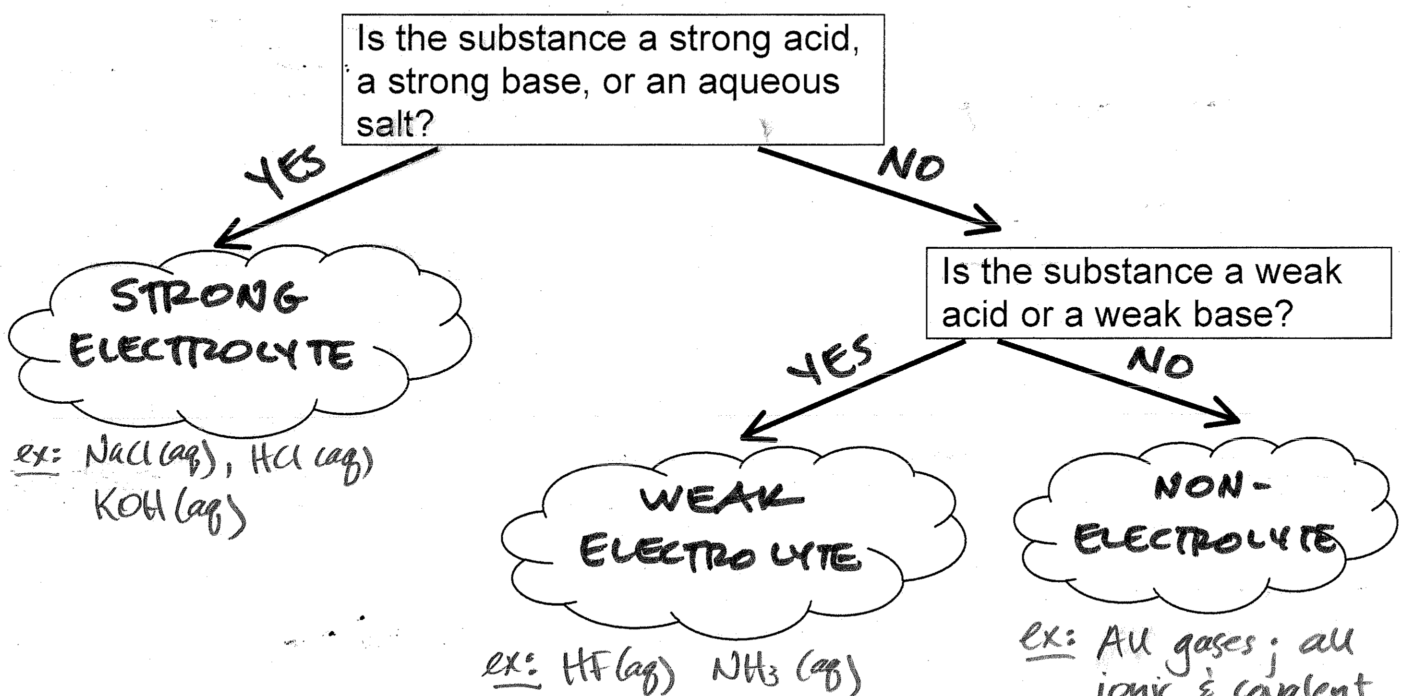
A **solution** is a homogeneous mixture made by dissolving one substance (the **solute**) in another substance (the **solvent**). An **aqueous solution** is a solution where water is the solvent. **Electrolytes** are substances which produce ions in solution. An **electrolytic solution** is a solution which conducts an electric current. **Strong electrolytes** are solutions which exist in solution completely as ions. Strong electrolytes conduct an electrical current very well as there is lots of ions available to help conduct the current. Any strong bases or strong acids are considered a strong electrolytes. **Weak electrolytes** are those solutions which exist in solution mostly as molecules with only a small fraction in the form as ions. Weak electrolytes will conduct an electrical current but not near as well as strong electrolytes! Any weak acid or weak base would be considered a weak electrolyte. Weak acids and weak bases are weak electrolytes. **Nonelectrolytes** are substances which do not ionize in water at all and consequently produce a nonconducting solution.

Salt water has many ions in it. These ions carry the charge to conduct current.

Question: *Why does salt water conduct an electrical current and sugar water does not conduct an electrical current?*

Sugar water doesn't have ions and is therefore a non-conductor!

Flowchart of Classifying Electrolytes



Electrolyte Practice! Classify each of the following as either a strong electrolyte (SE), weak electrolyte (WE), or a nonelectrolyte (NE).

SE $NaClO_3(aq)$	NE $H_2O(l)$	WE $NH_4OH(aq)$
NE $CO_2(g)$	NE $CO_2(s)$	SE $HClO_3(aq)$
WE $H_2S(aq)$	WE $NH_3(aq)$	SE $CaBr_2$ (aq)

Assume each of the following electrolytes are dissolved in water. Once dissolved, predict the ions formed.

a) $CaCl_2$ b) $NaNO_3$ c) $HClO_3$ d) $HC_2H_3O_2$

Ca^{2+}, Cl^- Na^+, NO_3^- H^+, ClO_3^- $H^+, C_2H_3O_2^-$

SE: $CaCl_2(aq) \xrightarrow[\text{ions}]{100\%} Ca^{2+}(aq) + 2\,Cl^-(aq)$

3

WE: $HC_2H_3O_2(aq) \rightleftarrows \underbrace{H^+(aq) + C_2H_3O_2^-(aq)}_{\text{very few ions ... that's why it is WEAK}}$

Target #3: I can use Coulomb's Law to help describe the interactions of ions during the dissolving process.

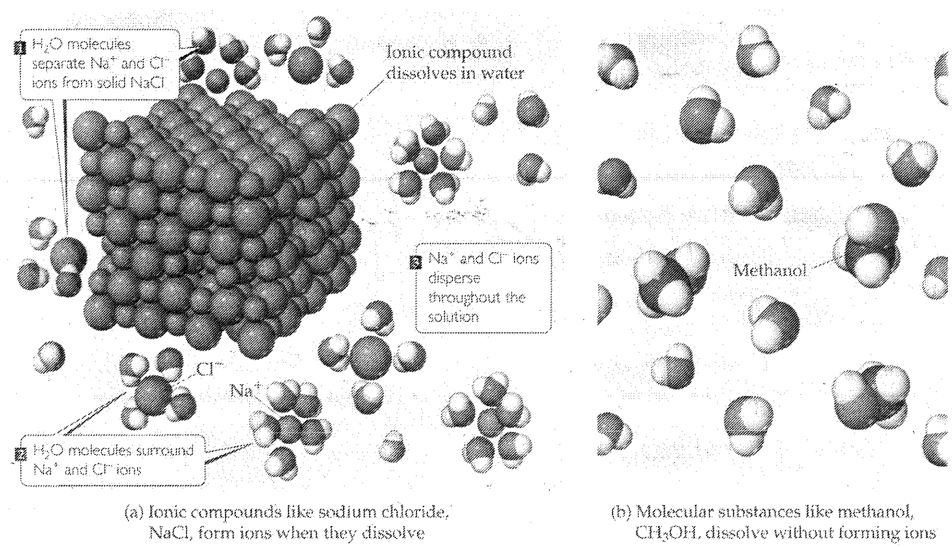
The magnitude of the electric force between two charged particles is given by **Coulomb's Law**

$$F = \frac{k \cdot Q_1 \cdot Q_2}{d^2}$$

Where: Q_1 and Q_2 = magnitude of the charges on the particles
d is the distance between their centers
k is constant determined by the units for Q and d

A negative value for the force indicates attractions whereas a positive value indicates repulsion.

The dissolving process is depicted below:



(a) Ionic compounds like sodium chloride, NaCl, form ions when they dissolve

(b) Molecular substances like methanol, CH_3OH, dissolve without forming ions

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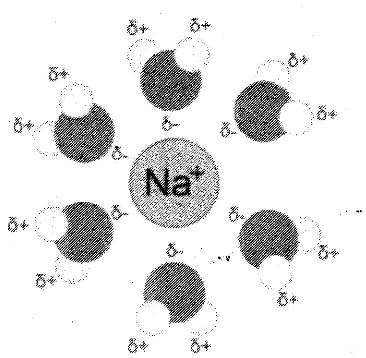
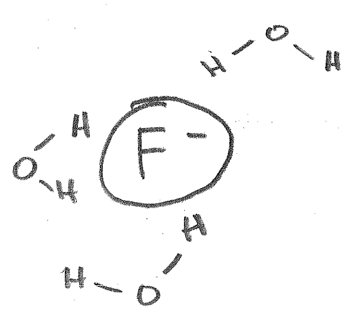
The positive regions of the water molecule are attracted to the negative ions due to Coulomb's law. The negative regions of the water molecule are attracted to the positive ions due to Coulomb's law. These attractions pull the ions apart from one another thereby dissolving the ionic solid. The aqueous ions end up with water molecules attached to them. The Na(aq) ion is shown below:



The neg. side of H_2O molecule, (oxygen side) is attracted to the positive ion.

Draw a picture of an aqueous fluoride ion in the space below:



The positive end of H_2O molecule (hydrogen end) is attracted to the negative ion!

These attractions are called "ION-DIPOLE ATTRACTIONS."

Target #4: I can use solubility rules to predict whether a substance is classified as soluble or insoluble.

Precipitation Reactions

precipitation reaction - a reaction in which an insoluble product is formed
precipitate - an insoluble solid formed by a reaction in solution
solubility - the amount of substance that can be dissolved in a given quantity of solvent
insoluble - any substance which has a solubility of less than 0.01 mol/L

Memorize the solubility rules! See text page 121. Done in class!

Directions: Circle all of the compounds below which are **INSOLUBLE** in water.

KOH	$MgSO_4$	$NaCl$
$MgCO_3$	Hg_2I_2	$NaC_2H_3O_2$
$BeCl_2$	$NiCl_2$	$(NH_4)_3PO_4$
$AlPO_4$	K_3PO_4	BaS
SrS	$(NH_4)_2CO_3$	$BaSO_4$
$Ca(C_2H_3O_2)_2$	Ag_2S	$CsOH$
$PbBr_2$	$RbOH$	Hg_2Cl_2
PbI_2	$Mn_3(PO_4)_2$	$SrSO_4$
$Zn(NO_3)_2$	$Pb(C_2H_3O_2)_2$	$CaCO_3$

Target #5: I can predict the products of chemical reactions (including neutralization and precipitation reactions) and write balanced molecular and net ionic equations for them. I will also be able identify spectator ions.

Vocab For Writing Equations:

metathesis reaction (or exchange reaction) - a reaction in which 2 substances react by exchanging their component ions (examples include acid base reactions and precipitation reactions)

molecular equation - an equation showing the complete chemical formulas of the reactants and products

complete ionic equation - an equation with all strong soluble electrolytes shown as ions

net ionic equation - an ionic equation in which the spectator ions are omitted

spectator ions - ions that appear in both the reactants and products of a complete ionic equation

Practice at Writing Equations

our solubility rules tell us this is solid! (insoluble)

Write the molecular, complete ionic, and net ionic equations for each of the following:

a. $Pb(NO_3)_2(aq)$ + 2 $KBr(aq)$ → $PbBr_2(s)$ + 2 $KNO_3(aq)$

$Pb^{2+}(aq) + 2NO_3^-(aq) + 2K^+(aq) + 2Br^-(aq) \rightarrow PbBr_2(s) + 2K^+(aq) + 2NO_3^-(aq)$

NIE: $\boxed{Pb^{2+}(aq) + 2Br^-(aq) \rightarrow PbBr_2(s)}$

b. 3 $NiCl_2(aq)$ + 2 $Na_3PO_4(aq)$ → $Ni_3(PO_4)_2(s)$ + 6 $NaCl(aq)$

$3Ni^{2+}(aq) + 6Cl^-(aq) + 6Na^+(aq) + 2PO_4^{3-}(aq) \rightarrow Ni_3(PO_4)_2(s) + 6Na^+(aq) + 6Cl^-(aq)$

NIE: $\boxed{3Ni^{2+}(aq) + 2PO_4^{3-}(aq) \rightarrow Ni_3(PO_4)_2(s)}$

c. 2 $AgNO_3(aq)$ + $Ca(OH)_2(aq)$ → 2 $AgOH(s)$ + $Ca(NO_3)_2(aq)$

$2Ag^+(aq) + 2NO_3^-(aq) + Ca^{2+}(aq) + 2OH^-(aq) \rightarrow 2AgOH(s) + Ca^{2+}(aq) + 2NO_3^-(aq)$

NIE: $2Ag^+(aq) + 2OH^-(aq) \rightarrow 2AgOH(s)$

reduced... $\boxed{Ag^+(aq) + OH^-(aq) \rightarrow AgOH(s)}$

d. 2 HBr(aq) + Ba(OH)$_2$(aq) → $BaBr_2(aq) + 2\,H_2O(l)$
(strong acid) (strong base)

$2H^+(aq) + 2Br^-(aq) + Ba^{2+}(aq) + 2OH^-(aq) \rightarrow Ba^{2+}(aq) + 2Br^-(aq) + 2H_2O(l)$

You will always get this NIE for a SA + SB! → NIE: $2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(l)$

reduced... $\boxed{H^+(aq) + OH^-(aq) \rightarrow H_2O(l)}$

e. H_2CO_3(aq) + 2 KOH(aq) → $K_2CO_3(aq) + 2\,H_2O(l)$

$H_2CO_3(aq) + 2K^+(aq) + 2OH^-(aq) \rightarrow 2K^+(aq) + CO_3^{2-}(aq) + 2H_2O(l)$

Do NOT ionize weak acids or bases!

$\boxed{\text{NIE: } H_2CO_3(aq) + 2OH^-(aq) \rightarrow CO_3^{2-}(aq) + 2H_2O(l)}$

Target #6: I can choose which type of equation is most appropriate (molecular, ionic or net ionic) equation for specific situations.

molecular equation – used in stoichiometry problems in order to generate mole ratios

complete ionic equation – used to generate the net ionic equation; also used to identify spetator ions

net ionic equation – used to identify the elements/compounds/ions directly involved in the reaction

Target #7: I can recognize reactions which produce either CO_2, H_2S, or NH_3 gases.

(3) Common Types Reactions Which Produce Gases

Acids Reacting With Carbonates/Bicarbonates Produce Salts, Water, and CO_2(g)

$HCl(aq) + NaHCO_3(aq) \rightarrow NaCl(aq) + H_2CO_3(aq)$

$HCl(aq) + NaHCO_3(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$

$H^+(aq) + HCO_3^-(aq) \rightarrow H_2O(l) + CO_2(g)$ (net ionic equation!)

Acids Reacting With Sulfides Produce Hydrogen Sulfide Gas (*rotten egg smell)*

$2\,HCl(aq) + Na_2S(aq) \rightarrow H_2S(g) + 2\,NaCl(aq)$

$2\,H^+(aq) + S^{2-}(aq) \rightarrow H_2S(g)$ (net ionic equation!)

Strong Bases Reacting With Ammonium Salts Produce a Salt, H_2O and NH_3:

$KOH(aq) + NH_4Br(aq) \rightarrow KBr(aq) + NH_4OH(aq)$

$KOH(aq) + NH_4Br(aq) \rightarrow KBr(aq) + H_2O(l) + NH_3(g)$

$OH^-(aq) + NH_4^+(aq) \rightarrow H_2O(l) + NH_3(g)$ (net ionic equation!)

* Put these three general types of reactions on your FLASHCARDS!

Practice - Targets #1-7

True/False

T F 1. Aqueous sodium chloride and sulfuric acid are both strong electrolytes.

T F 2. The reaction between nitric acid and potassium hydroxide solutions is an example of a metathesis reaction.

↳ means exchange of double displace.

T F 3. The spectator ions in the reaction between aqueous calcium iodide and aqueous silver nitrate are the calcium ion and the nitrate ion.

$CaI_2(aq) + AgNO_3(aq) \rightarrow AgI(s) + Ca(NO_3)_2(aq)$

T F 4. Sugar is a nonelectrolyte when dissolved in water.

T F 5. When a strong acid reacts with a strong base, a salt is always produced.

T F 6. Aqueous iron(III) phosphate is not only insoluble in water, but is also considered a strong electrolyte.

↳ some of the iron (III) phosphate will actually dissolve, but very little; the portion that does dissolve will ionize completely!

Short answer

7. Rank the following 0.1 M solutions in order of increasing conductivity in water:

(NE) (SE) (WE)

$C_{11}H_{22}O_{11}$, Na_2S, H_2S

non conductor → $C_{11}H_{22}O_{11}$, H_2S, Na_2S ← great conductor!

8. Circle any of the following compounds which are soluble in water:
$PbBr_2$, $CsCl$, $Cu(C_2H_3O_2)_2$, $Mn(OH)_2$, $Ca_3(PO_4)_3$, ZnS, Ag_2SO_4

9. Which of the following metal ions form chloride compounds which are water soluble?
K^+, Ba^{2+}, Ag^+, Zn^{2+}, Pb^{2+}

10. What is/are the spectator ion(s) in a reaction between solid iron(III) hydroxide and aqueous perchloric acid. (Hint: ClO_4^- rule same as Cl^- rule)

$\boxed{ClO_4^- = \text{spec. ion!}}$

$Fe(OH)_3(s) + 3H^+(aq) + \cancel{3ClO_4^-(aq)} \rightarrow Fe^{3+}(aq) + \cancel{3ClO_4^-(aq)} + 3H_2O(l)$

NIE: $Fe(OH)_3(s) + 3H^+(aq) \rightarrow Fe^{3+}(aq) + 3H_2O(l)$

11. Classify each of the following as a strong electrolyte (SE), weak electrolyte (WE), or a nonelectrolyte (NE):

$H_2O(l)$ NE	$KCl(aq)$ SE	$HNO_3(aq)$ SE	$HC_2H_3O_2(aq)$ WE
$C_2H_5OH(l)$ NE	$NH_3(g)$ NE	$Ne(g)$ NE	$Cl_2(g)$ NE
$NaCl(aq)$ SE	$H_2SO_3(aq)$ WE	$LiNO_3(aq)$ SE	$HClO_4(aq)$ SE

12. Circle all of the following salts which are **soluble** in water?

$CaCO_3$, $Mn(OH)_2$, $ZnSO_4$, $Hg(NO_3)_2$, $Ba(C_2H_3O_2)_2$, $MgBr_2$, $(NH_4)_3PO_4$,

Na_2CO_3, $MgCO_3$, $BaSO_4$, $Mg(OH)_2$, K_2S, $Zn(C_2H_3O_2)_2$

PLEASE MEMORIZE YOUR SOLUBILITY RULES !! :)

13. Write the formula for each of the following:

H_3PO_4 a) A weak, triprotic acid.

any strong base b) A base which conducts electricity very well in solution.

H_2SO_3 c) A weak electrolyte which contains the sulfite ion.

Ba^{2+}, Sr^{2+}, Pb^{2+}, Hg_2^{2+}, Ag^+ d) A chemical that when mixed with aqueous Na_2SO_4 will form a precipitate.

14. Write the net ionic equation for the following:

a) $\underset{(WA)}{2HC_2H_3O_2(aq)} + \underset{(SB)}{Ba(OH)_2(aq)} \rightarrow Ba(C_2H_3O_2)_2\,(aq) + 2H_2O\,(l)$

Do not ionize weak acids! $2\,HC_2H_3O_2\,(aq) + 2OH^-\,(aq) \rightarrow 2\,C_2H_3O_2^-\,(aq) + 2H_2O\,(l)$

b) aqueous hydrobromic acid reacts with aqueous rubidium sulfide (Rb_2S)

$2\,HBr(aq) + Rb_2S\,(aq) \rightarrow H_2S\,(g) + 2\,RbBr(aq)$

$2H^+\,(aq) + S^{2-}\,(aq) \rightarrow H_2S(g)$ This is one of the GAS producing rxn's!! :)

c) $CaCO_3(s) + HNO_3(aq) \rightarrow Ca(NO_3)_2\,(aq) + 2H_2O\,(l) + CO_2\,(g)$

Do not ionize solids! $CaCO_3(s) + 2H^+\,(aq) \rightarrow Ca^{2+}\,(aq) + H_2O\,(l) + CO_2\,(g)$

15. Separate samples of a solution of an unknown salt are treated with dilute solutions of HBr, H_2SO_4, and NaOH. A precipitate forms only with the H_2SO_4. Which of the following cation could the solution contain: K^+; Pb^{2+}, Ba^{2+}? Please explain your answer.

3 ppt's $\left\{ \begin{array}{l} Pb^{2+} + NaOH \rightarrow ppt. \\ Pb^{2+} + H_2SO_4 \rightarrow ppt. \\ Pb^{2+} + HBr \rightarrow ppt. \end{array} \right.$

$\left. \begin{array}{l} Ba^{2+} + NaOH \rightarrow \text{soluble} \\ Ba^{2+} + HBr \rightarrow \text{soluble} \\ Ba^{2+} + H_2SO_4 \rightarrow ppt. \end{array} \right\}$ 1 ppt ... must be Ba^{2+}

K^+ is soluble w/ everything!

Fun Practice Problem!

A chemist found four bottles of aqueous solutions numbered 1-4. She knew that the identities were KI, $Pb(NO_3)_2$, HNO_3, and Na_2CO_3. She just didn't know which chemical was in each bottle. The chemist mixed the chemicals together in all possible combinations and her results are below. It's your job to analyze her results and determine the identity of the chemical in each bottle.

		HNO_3	$Pb(NO_3)_2$	Na_2CO_3	KI
		1	2	3	4
HNO_3	1	X	No reaction	Bubbles	No reaction
$Pb(NO_3)_2$	2	X	X	White precipitate	Yellow precipitate
Na_2CO_3	3	X	X	X	No reaction
KI	4	X	X	X	X

Show your work in the space below and fill in the chart with the correct identities!

$HNO_3 + Na_2CO_3 \rightarrow CO_2(g)$ BUBBLES!

$HNO_3 + Pb(NO_3)_2 \rightarrow$ N.R.

$HNO_3 + KI \rightarrow$ N.R.

$Pb(NO_3)_2 + Na_2CO_3 \rightarrow$ PPT! $PbCO_3$ = white ppt.

$Pb(NO_3)_2 + KI \rightarrow$ PPT! PbI_2 = yellow ppt.

$Na_2CO_3 + KI \rightarrow$ N.R.

Identities of the chemicals:

Number	Identity	
1	HNO_3	— Bubbles
2	$Pb(NO_3)_2$	— 2 PPT's
3	Na_2CO_3	— 1 PPT & bubbles
4	KI	— 1 ppt.

Target #8: I can determine whether a chemical reaction involves oxidation and reduction by assigning oxidation numbers to atoms in molecules and ions. I can also identify an oxidizing agent and a reducing agent in a redox reaction.

Oxidation-Reduction Reactions: reactions where electrons are transferred between reactants

OXIDATION = lose of electrons by a substance
REDUCTION = gain of electrons by a substance

"LEO the lion goes GER"

LEO - lose of electrons, oxidation
GER - gain of electrons, reduction

* Oxidation is *always* accompanied by reduction.

Example: $2\,\overset{0}{Ca}(s) + \overset{0}{O_2}(g) \rightarrow 2\,\overset{+2}{Ca}\overset{-2}{O}(s)$

- * Calcium starts as Ca (neutral) and ends up as Ca^{2+} ion. Calcium is oxidized! When the oxidation # increases, it is oxidation.
- * Oxygen starts as O_2 (neutral) and ends up as O^{2-} ion. Oxygen is reduced! When the oxidation # is decreased, it is reduction.

Rules for determining the oxidation number of a substance:

1. All elements have an oxidation number of zero. (Na, N_2, P_4, Zn)
2. Monatomic ions have an oxidation number equal to its charge. (Na^+, S^{2-})
3. The oxidation number of oxygen in compounds is -2 (except in peroxides when it is -1 and in superoxides when it is -1/2)
   K_2O, CO_2, H_2O_2, KO_2
4. The oxidation number of hydrogen is +1 when bonded to nonmetals and -1 when bonded to metals.
   HCl, HNO_3, CaH_2
5. Halogens have an oxidation number of -1 except when in a polyatomic ion where they have a positive oxidation number.

6. The sum of oxidation numbers in compounds is equal to zero. The sum of oxidation numbers in polyatomic ions is equal to the charge on the ion.

Practice 1: Indicate the oxidation number of each element in the following:

a) $\overset{+1}{K}\overset{+7}{Mn}\overset{-2}{O_4}$ b) $\overset{+1}{Na}\overset{-2}{O}\overset{+1}{H}$ c) $\overset{+2}{Pb}(\overset{+6}{S}\overset{-2}{O_4})_2$ d) $\overset{0}{N_2}$ e) $\overset{+1}{Na}\overset{-1}{H}$

Practice 2: Identify the element oxidized and the element reduced in the following reaction.

$$2\,\overset{0}{Na}(s) + 2\,\overset{+1}{H_2}\overset{-2}{O}(l) \rightarrow 2\,\overset{+1}{Na}\overset{-2}{O}\overset{+1}{H}(aq) + \overset{0}{H_2}(g)$$

OXIDIZED: Na
REDUCED: H

Practice 3: Which of the following are redox reactions?

ppt. reaction

NO: Reaction 1: $Ba(NO_3)_2 + K_2SO_4 \rightarrow BaSO_4(s) + 2\ KNO_3$

YES: Reaction 2: $2\ \overset{+1\ -2}{H_2O} \rightarrow 2\ \overset{0}{H_2} + \overset{0}{O_2}$

YES: Reaction 3: $2\ \overset{0}{Ni} + \overset{+1\ +6\ -2}{H_2SO_4} \rightarrow \overset{+2\ +6\ -2}{NiSO_4} + \overset{0}{H_2}$

If ox. # changes during the reaction, it is a REDOX reaction!!

Target #9: I can identify the applications of redox reactions.

A) Combustion Reactions $\overset{-4\ +1}{CH_4} + 2\overset{0}{O_2} \rightarrow \overset{+4\ -2}{CO_2} + 2\overset{+1\ -2}{H_2O}$

B) Metabolism of Sugars: Metabolism of glucose is the combustion of glucose!

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

C) Hydrolysis Fats & Proteins

The hydrolysis of fats & proteins involves the cleavage of chemical bonds by the addition of water; Fat oxidation (called beta oxidation) breaks down large molecules into smaller ones to be used for energy!

D) Some Titrations

→ We will do a REDOX titration in which we will determine the % of NaClO in household bleach!

E) Chemical Reactions in Batteries

$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$ Connect a wire between the zinc & copper electrodes and you will get a current! We will do a lab in which we make batteries.

F) Photography

→ Silver halide crystals are converted to metallic silver by the developer solution.
→ This is commonly used in black & white photography.

G) Electroplating (making jewlery, mirrors, etc)

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$; You can "plate" one metal onto another.

H) All Single Displacement, Synthesis and Decomposition Reactions

I) Food Spoilage the oxidation of food happens when the chemicals in the food are exposed to the oxygen in the air; a sliced apple turning brown is an example of the apple being oxidized.

Target #10: I can use the activity series to predict whether a reaction will occur when a metal is added to an aqueous solution of either a metal salt or an acid; and write the balanced molecular and net ionic equations for the reaction.

General Rule: A single displacement reaction will take place if the element which is doing the "replacing" is more reactive than the element that it is replacing!

Example: $Fe(s) + Ni(NO_3)_2(aq) \rightarrow Fe(NO_3)_2(aq) + Ni(s)$

This reaction will occur because Fe is more reactive than nickel!

The following reaction will **NOT** take place:

$$Ni(s) + Fe(NO_3)_2(aq) \rightarrow Fe(s) + Ni(NO_3)_2(aq)$$

ACTIVITY SERIES (see table 4.5 on page 136) Some metals are more easily oxidized (more reactive). You do not have to memorize the activity series. But, you should memorize the following general trends:

- Active metals are the 1A and 2A metals. 1A metals are generally more reactive than 2A metals.
- Transition metals are less reactive than either 1A and 2A metals.
- Ag, Au, and Pt are very unreactive!
- Any metal on the activity series can be oxidized by the ions below it.

Practice: Will the following single displacement reaction take place?

$Ag(s) + Ca(NO_3)_2(aq) \rightarrow$???? NO :(

↳ Silver is LESS reactive than calcium!

Target 11: I can calculate molarity, solution volume, or number of moles of solute given any two of these quantities.

Concentrations of Solutions

Molarity (M) is the most commonly used unit of concentration. Molarity is defined as the number of moles of solute per liters of solution

$$M = \frac{\text{moles}}{L}$$

Example #1: Calulate the molarity of a NaCl solution made by dissolving 2.0 moles of NaCl in enough water to make 6.0 L of solution?

$$M = \frac{mol}{L} = \frac{2.0\ mol}{6.0\ L} = 0.33\ M$$

Example #2: How many grams of $Ca(OH)_2$ crystals are needed in order to make 2.00 liters of 0.100 M $Ca(OH)_2$?

$$x\text{ g } Ca(OH)_2 = \frac{2.00\text{ L}}{} \left| \frac{0.100 \text{ mol } Ca(OH)_2}{1\text{ L}} \right| \frac{74.10\text{ g } Ca(OH)_2}{1 \text{ mol } Ca(OH)_2} = 14.8\text{ g } Ca(OH)_2$$

Example #3: What is the molarity of each ion present in 50.0 mL of . . .

a) 0.200 M KCl? $0.200\text{ M } K^+$ & $0.200\text{ M } Cl^-$

b) 0.200 M $Ni_2(SO_4)_3$? $0.400\text{ M } Ni^{2+}$
$0.600\text{ M } SO_4^{2-}$

$$\underset{0.200\text{ M}}{Ni_2(SO_4)_3} \rightarrow \underset{0.400\text{ M}}{2Ni^{2+}} + \underset{0.600\text{ M}}{3SO_4^{2-}}$$

Example #4: Assume you mixed 2.00 liters of 0.100 M NaCl with 5.00 liters of 0.200 M $SrCl_2$. What is the concentration of each ion present after the two chemicals are mixed?

(YOU GET A TOTAL VOL. OF 7.00 L AFTER MIXING!)

$$[Cl^-] = \frac{\text{mol}}{\text{L}} = \frac{0.200\text{ mol} + 2.00\text{ mol}}{7.00\text{ L}} = 0.314\text{ M } Cl^-$$

$$[Sr^{2+}] = \frac{\text{mol}}{\text{L}} = \frac{1.00\text{ mol}}{7.00\text{ L}} = 0.143\text{ M } Sr^{2+}$$

$$[Na^+] = \frac{\text{mol}}{\text{L}} = \frac{0.200\text{ mol}}{7.00\text{ L}} = 0.0286\text{ M } Na^+$$

Example #5: Assume that you mixed 2.00 liters of 0.300 M $Pb(NO_3)_2$ with 8.00 liters of 0.100 M NaCl.

a) Write a balanced equation for this reaction.

excess LR

$$\underset{[0.600\text{ mol}]}{Pb(NO_3)_2\,(aq)} + \underset{[0.800\text{ mol}]}{2NaCl\,(aq)} \rightarrow PbCl_2\,(s) + 2NaNO_3\,(aq)$$

b) Write the net ionic equation for this reaction.

Spec. ions: Na^+ & NO_3^-

excess L.R.

$$\underset{[0.600\text{ mol}]}{Pb^{2+}\,(aq)} + \underset{[0.800\text{ mol}]}{2Cl^-\,(aq)} \rightarrow PbCl_2\,(s)$$

c) Determine the limiting reactant.

Cl^- is limiting reactant ... bal. eq. says you need 2 mol of Cl^- for every 1 mole of Pb^{2+} ... you don't have 2x Cl^- :(

d) Calculate the grams of the precipitate formed.

$$x\text{ g } PbCl_2 = \frac{0.800\text{ mol NaCl}}{} \left| \frac{1\text{ mol } PbCl_2}{2\text{ mol NaCl}} \right| \frac{278.1\text{ g}}{1\text{ mol } PbCl_2} = 111\text{ g } PbCl_2$$

e) Calculate the concentration (in molarity) of each ion present after the reaction is complete.

• You have 3 ions left ... the 2 spec. ions (Na^+ & NO_3^-) and the excess ion (Pb^{2+}). You have no Cl^- ion left in solution!

$[Na^+] = \frac{0.800 \text{ mol}}{10.0 \text{ L}} = 0.0800 \text{ M}$ || $[NO_3^-] = \frac{2(0.600 \text{ mol})}{10.0 \text{ L}} = 0.120 \text{ M}$

(initial moles) (moles reacted)

$$[Pb^{2+}] = \frac{0.600 \text{ mol} - 0.400 \text{ mol}}{10.0 \text{ L}} = 0.0200 \text{ M } Pb^{2+}$$

Target 12: I can solve problems when making solutions by dilutions.

Dilutions - preparing a solution from a concentrated stock solution

Use the equation: $M_1 \times V_1 = M_2 \times V_2$

where . . . M_1 = initial concentration of stock solution
V_1 = volume of stock solution needed
M_2 = molarity of the more dilute solution
V_2 = volume of the more dilute solution

Example: Assume that you needed 400. mL of 0.500 M sulfuric acid. The only sulfuric acid that you had in the storeroom was 16.0 M. How could you make the 0.500 M sulfuric acid from the stock solution?

M_1 = 16.0 M
V_1 = ?
M_2 = 0.500 M
V_2 = 400.0 mL

$$V_1 = \frac{M_2 V_2}{M_1} = \frac{(0.500 \text{ M})(400.0 \text{ mL})}{16.0 \text{ M}} = 12.5 \text{ mL}$$

Steps:
1. Obtain 400-mL container.
2. Add some distilled water.
3. Use pipette to add 12.5 mL of 16.0 M H_2SO_4.
4. Dilute w/ dist. H_2O to 400-mL mark.
5. Mix!

Practice: How would you make 100-mL of 0.100 M HCl from a 12.0 M stock solution of HCl?

$M_1 = 12.0\ M$
$V_1 = ?$
$M_2 = 0.100\ M$
$V_2 = 100.0\ mL$

$$V_1 = \frac{(0.100\ M)(100.\ mL)}{12.0\ M} = 0.833\ mL \text{ of stock HCl}$$

Put some dist. H_2O in 100-mL volumetric flask. Use pipette to add 0.833 mL of 12.0 M HCl. Dilute to 100-mL w/ dist. water. Mix!

Target #13: I can solve stoichiometry problems involving solutions.

Solution Stoichiometry (TITRATIONS!)

We will use stoichiometry to experimentally determine the concentration of an unknown solution. An experimental process, called a **titration**, uses a **standard solution** (a solution of known concentration) and adds it to the solution of unknown concentration. By using a balanced equation, one can determine the concentration of the unknown.

Example: Assume that it takes 50.0 mL of 0.138 M HCl to neutralize 65.0 mL of $Ca(OH)_2$. What is the concentration of the calcium hydroxide?

$$Ca(OH)_2\,(aq) + 2\,HCl\,(aq) \rightarrow CaCl_2\,(aq) + 2\,H_2O\,(l)$$

$$X\ \frac{mol}{L}\ B = \frac{0.0500\ \cancel{L\ A}}{} \left| \frac{0.138\ \cancel{mol\ A}}{1\ \cancel{L\ A}} \right| \frac{1\ mol\ B}{2\ \cancel{mol\ A}} \left| \frac{1}{0.0650\ L\ B} \right| =$$

$$= 0.0531\ M\ Ca(OH)_2$$

AP Chemistry
Chapter 4 Test Review

Name ______________________________

Directions: Answer each of the following.

1. Identify the oxidation state of manganese in each of the following:

+2	+7	+4	+7	0
MnO	$KMnO_4$	MnO_2	Mn_2O_7	Mn

2. Name the element being oxidized and the element being reduced in the following reaction:

$$\underset{+3\ -2}{Fe_2O_3} + \underset{+2\ -2}{3\ CO} \rightarrow \underset{0}{2\ Fe} + \underset{+4\ -2}{3\ CO_2}$$

OX: C
RED: Fe

3. Determine the following for a sucrose solution ($C_{12}H_{22}O_{11}$, molar mass = 342 g/mol)
   a) The number of moles of sucrose in exactly 200 mL of a 0.100 M solution.

$M = \frac{mol}{L}$; $mol = M \times L = (0.100\ M)(0.200\ L) = 0.0200$ moles

   b) The volume of a 1.25 M solution containing 0.100 moles of sucrose.

$L = mol/M = 0.100\ mol / 1.25\ M = 0.0800\ L$

4. Assume you had a large jug of 10.0 M NaOH. How would you make 100-mL of 0.30 M NaOH from the more concentrated base?

$M_1 = 10.0\ M$ $M_2 = 0.30\ M$
$V_1 = ?$ $V_2 = 100.\ mL$

$V_1 = \frac{(0.30\ M)(100.\ mL)}{10.0\ M} = 3.00\ mL$

Place 3.00 mL of 10.0 M NaOH in 100-mL vol. flask. Dilute to 100-mL mark. Mix!

5. Which of the following aqueous solutions has the greatest total concentration of ions?
   a) 0.08 M HCl 0.16 M
   b) 0.04 M $Ca(NO_3)_2$ 0.12 M
   c) 0.05 M $CaBr_2$ 0.15 M
   d) 0.03 M $Al(NO_3)_3$ 0.12 M

6. What is the molarity of a nitric acid solution if 45.00 mL of it reacts completely with 1.00 gram of $Ca(OH)_2$? $2\ HNO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)_2 + 2\ H_2O$

$$x\ \frac{mol}{L}\ A = \frac{1.00\ g\ Ca(OH)_2}{} \cdot \frac{1\ mol\ Ca(OH)_2}{74.1\ g\ Ca(OH)_2} \cdot \frac{2\ mol\ HNO_3}{1\ mol\ Ca(OH)_2} \cdot \frac{1}{0.04500\ L\ HNO_3} = 0.600\ M\ HNO_3$$

7. Assume 50.0 mL of 0.300 M aqueous silver nitrate react with 40.0 mL of 0.200 M barium bromide. Calculate the mass (in grams) of the precipitate formed. Calculate the concentration (in molarity) of all remaining ions present after the reaction is complete.

(see next page :))

$$\boxed{\text{L.R.}} \qquad \boxed{\text{excess}}$$

7 $2AgNO_3(aq) + BaBr_2(aq) \rightarrow Ba(NO_3)_2(aq) + 2AgBr(s)$

0.0500 L	0.0400 L
0.300 M	0.200 M
(0.0150 mol)	(0.00800 mol $BaBr_2$)
	→ (0.0160 mol Br^-)

NET IONIC EQUATION: $2Ag^+(aq) + 2Br^-(aq) \rightarrow 2AgBr(s)$

or... $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$

(L.R.) (excess)

$$x\text{ g AgBr} = \frac{0.0150\text{ mol AgNO}_3}{} \cdot \frac{2\text{ mol AgBr}}{2\text{ mol AgNO}_3} \cdot \frac{187.77\text{ g AgBr}}{1\text{ mol AgBr}} = 2.82\text{ g AgBr precipitate}$$

SPECT. IONS: NO_3^- & Ba^{2+} EXCESS ion: Br^-

$$[NO_3^-] = \frac{M_1V_1}{V_2} = \frac{(0.0500\text{ L})(0.300\text{ M})}{0.0900\text{ L}} = 0.167\text{ M } NO_3^-$$

$$[Ba^{2+}] = \frac{M_1V_1}{V_2} = \frac{(0.200\text{ M})(0.0400\text{ L})}{0.0900\text{ L}} = 0.0889\text{ M } Ba^{2+}$$

Br^-... initial moles: 0.0160 mol
− used moles: − 0.0150 mol
excess moles: 0.0010 moles

$$[Br^-] = \frac{\text{mol}}{\text{L}} = \frac{0.0010\text{ moles}}{0.0900\text{ L}} = 0.011\text{ M } Br^-$$

$[Ag^+] = \emptyset$ as it is LIMITING REACTANT!

Solve #8 and #9 without the use of a calculator.

8. A 48.0 gram sample of metal X (that is known to form X^{2+} ions) was added to 3.0 L of 2.0 M H_2SO_4. After all of the metal was reacted, the remaining acid required 8.0 L of 1.0 M NaOH solution for neutralization. What was the identity of the metal sample? Calculate MOLAR MASS (g/mole)

a. Mg b. Mn c. Fe d. Na e. Al

$X + H_2SO_4 \rightarrow XSO_4 + H_2$; $H_2SO_4 + \underset{(8.0\ mol)}{2\,NaOH} \rightarrow Na_2SO_4 + 2H_2O$

mol $H_2SO_4 = \frac{8.0\ mol\ NaOH}{} \cdot \frac{1\ mol\ H_2SO_4}{2\ mol\ NaOH} = 4.0$ mol H_2SO_4 didn't react initially w/ "X"
∴ 2.0 mol of H_2SO_4 DID react w/ "X" !!

Since "X" & H_2SO_4 are 1:1, 2.0 mol "X" present! $MM = \frac{g}{mol} = \frac{48.0g}{2.0\ mol} = 24$ g/mole

$\boxed{Mg}$

9. 5.0 L of 2.0 M NaCl react with 2.0 L of 3.0 M $Pb(NO_3)_2$ according to the following reaction:

$$\underset{(10\ mol)}{\overset{L.R.}{2\,NaCl(aq)}} + \underset{(6.0\ mol)}{\overset{excess}{Pb(NO_3)_2(aq)}} \rightarrow PbCl_2(s) + 2\,NaNO_3(aq)$$

What is the concentration of the Pb^{2+} ion remaining in solution after the reaction is complete?

a. 0.0050 M b. 0.14 M c. 0.89 M d. 2.1 M e. 3.2 M

$Pb^{2+} + 2Cl^- \rightarrow PbCl_2(s)$

$\begin{bmatrix} 6.0\ mol \\ excess \end{bmatrix}$ $\begin{bmatrix} 10.\ mol \\ L.R. \end{bmatrix}$

Pb^{2+}: $\underset{(initially)}{6.0\ mol} - \underset{(used)}{5.0\ mol} = \underset{(excess)}{1.0\ mol}$ $M = \frac{mol}{L} = \frac{1.0\ mol}{7.0\ L} = 0.14\ M$

10. Which of the following aqueous solutions are strong electrolytes?

Na_3PO_4 $CaCl_2$ HI H_2S H_2SO_4 HF

11. Which of the following are insoluble salts?

Hg_2SO_4 AgCl ZnS $SrCO_3$ $Al(OH)_3$

12. Is the following a redox reaction? Explain. YES!

$$\overset{0}{2\,Na} + \overset{+1\ -2}{2\,H_2O} \rightarrow \overset{+1\ -2\ +1}{2\,NaOH} + \overset{0}{H_2}$$

Na = oxidized
H = reduced

13. Will the following reaction occur? Explain.

$$2\ K(s) + ZnCl_2\ (aq) \rightarrow 2\ KCl(aq) + Zn(s)$$

YES !! K is more reactive than Zn.

14. Calculate the number of sodium ions in 1.00 mL of 0.0100 M Na_3PO_4.

$$\#Na^+ = \frac{0.00100\ L\ Na_3PO_4}{} \left| \frac{0.0100\ mol\ Na_3PO_4}{1\ L\ Na_3PO_4} \right| \frac{3\ mol\ Na^+}{1\ mol\ Na_3PO_4} \left| \frac{6.02 \times 10^{23}\ ions}{1\ mol\ Na^+} \right| =$$

$= 1.81 \times 10^{19}\ Na^+$ ions

15. Assume that you had an unknown chemical that was either Na_2S or Na_2CO_3. What chemical could you add to both of these in order to identify the unknown? Explain.

HCl

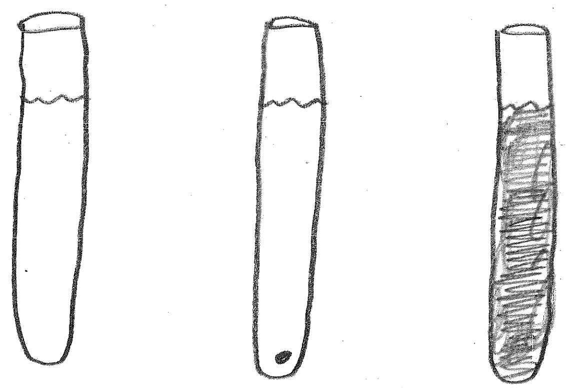
$Na_2S + HCl \rightarrow H_2S(g) + NaCl$ ⇒ rotten egg smell !!

$Na_2CO_3 + HCl \rightarrow CO_2(g) + H_2O(l) + NaCl$ ⇒ lots of BUBBLES!

or add Ca^{2+}, Sr^{2+}, Ba^{2+} ... ppt w/ Na_2S but NOT w/ Na_2CO_3

16. Given a solution, what simple test could you run to determine if the solution is saturated, unsaturated, or supersaturated?

Unsat. | sat. | super



Add 1 crystal of solute to the solution!

ESULTS! ⇒ crystal dissolves | crystal falls to bottom | all solute ppt's out!