CHEMISTRY 109 – Help Sheet #4
REVIEW (Part IV): Chemical Reactions
***** Review the appropriate topics for your lecture*****
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Nuggets: *Balancing Reactions; Electrolytes; Acids/Bases; Solubility Rules; Writing Molecular, Complete Ionic, and Net Ionic Reactions; Types of Reactions; Redox Reactions: assigning oxidation numbers; ID redox reactions, what is oxidized, what is reduced, what is the oxidizing and reducing agent*

CHEMICAL EQUATIONS: reactants (the starting reagents) yield products (the ending materials)
Be able to balance chemical equations; balanced reaction means the number of atoms and total charges on each side of the reaction are the same

IDENTIFYING ACIDS/BASES – STRONG and WEAK

Acids (HA): Produce H^+ in solution (e.g., $HCl \rightarrow H^+ + Cl^-$); for Chem 109, most acids begin with H in the formula (except: H_2O) or contain a –COOH group.

Strong acids: acids that *completely break up* (dissociate) into H^+ and A^-; strong electrolytes;
HCl (hydrochloric acid), HBr (hydrobromic acid), HI (hydroiodic acid), HNO_3 (nitric acid),
$HClO_4$ (perchloric acid), H_2SO_4 (sulfuric acid; $H_2SO_4 \rightarrow H^+ + HSO_4^-$) – ***best to memorize all formulas/names***

Weak acids: an acid that is not a strong acid; dissociate (break up) a little; weak electrolytes
Common weak acids (there are many weak acids): CH_3COO**H** (***best to memorize*** acetic acid; the bold **H** comes off);
H_3PO_3 (phosphoric acid); H_2CO_3 (carbonic acid); HCN (hydrocyanic); HCOO**H** (formic acid)

Bases: Produce OH^- in solution (e.g., $NaOH \rightarrow Na^+ + OH^-$)

Strong bases: bases that completely dissolve generating OH^-; strong electrolytes;
Group IA hydroxides: LiOH, NaOH, KOH; Group IIA hydroxides: $Ca(OH)_2$, $Sr(OH)_2$ and $Ba(OH)_2$ – ***best to memorize all formulas/names***

Weak bases: a base that is not a strong base; produce a little OH^-; weak electrolytes;
Common weak base (there are many weak bases): NH_3 (***best to memorize*** ammonia)

Solubility Rules

Usually Soluble	Exceptions	Usually Insoluble	Exceptions
Li^+, Na^+, K^+, Rb^+, Cs^+, NH_4^+		PO_4^{-3}	Li^+, Na^+, K^+, Rb^+, Cs^+, NH_4^+
NO_3^-		CO_3^{-2}	Li^+, Na^+, K^+, Rb^+, Cs^+, NH_4^+
Cl^-, Br^-, I^-	Ag^+, Pb^{+2}, Hg_2^{+2}	CrO_4^{-2}	Li^+, Na^+, K^+, Rb^+, Cs^+, NH_4^+, Mg^{+2}
SO_4^{-2}	Ca^{+2}, Sr^{+2}, Ba^{+2}, Pb^{+2}	OH^-	Li^+, Na^+, K^+, Rb^+, Cs^+, NH_4^+; ($Ca(OH)_2$, $Sr(OH)_2$, and $Ba(OH)_2$ are slightly soluble)
ClO_3^-, ClO_4^-		$C_2O_4^{-2}$	Li^+, Na^+, K^+, Rb^+, Cs^+, NH_4^+
CH_3COO^-		S^{-2}	Li^+, Na^+, K^+, Rb^+, Cs^+, NH_4^+; (MgS, CaS, and BaS are slightly soluble)

ELECTROLYTES: A chemical that produces ions; more ions → more electrical current/better conductor
Strong-Electrolyte: Produces large numbers of ions: *soluble ionic compounds (e.g., NaCl); strong acids (e.g., HBr); strong bases (e.g., NaOH)*
Weak-Electrolyte: Produces small quantity of ions: *weak acids (e.g., CH_3COOH); weak bases (e.g., NH_3)*
Nonelectrolyte: Produces no ions: *insoluble ionic compounds (e.g., AgCl); molecular compounds (e.g., sugar)*
(Reminder: *Ionic Compounds:* Metal + nonmetal (or polyatomic ion); *Molecular Compounds:* 2 nonmetals)

CONDUCTIVITY – how well a solution can pass an electrical current; **more ions → greater conductivity;** (molecular compounds → no ions!)

HOW TO WRITE REACTIONS

1. Overall or Molecular Reaction: All compounds are written in a molecular form; no ions.

1. If needed, given names → translate names into reactant formulas.
2. Write products by switching reactant *parts* in ionic or acid/base reactions. For combustion reactions products are CO_2 and H_2O. When writing products, ***use only one reactant part*** (anion/cation) even if there is more than one reactant part on the reactant side (i.e., *product parts* should *initially* have a subscript of 1).
3. Assign charges to *product parts*.
4. *Balance product formulas* by adding subscripts as needed.
5. *Balance the overall reaction*.

Example 1: *Calcium nitrate and sodium phosphate are mixed; write the molecular reaction.*

1. calcium nitrate + sodium phosphate: $Ca(NO_3)_2 + Na_3PO_4 \rightarrow$ (*translate names into formulas*)
2. $Ca(NO_3)_2 + Na_3PO_4 \rightarrow CaPO_4 + NaNO_3$ (*switch partners*; use only 1 reactant part in products; i.e., 3 Na on the left side but 1 Na on the right side to start)
3. $Ca(NO_3)_2 + Na_3PO_4 \rightarrow Ca^{+2}PO_4^{-3} + Na^{+1}NO_3^{-1}$ (*assign charges* to product parts)
4. $Ca(NO_3)_2 + Na_3PO_4 \rightarrow Ca_3(PO_4)_2 + Na_1(NO_3)_1$ (*balance product formulas* with subscripts using charges)
5. $3Ca(NO_3)_2 + 2Na_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6NaNO_3$ (*balance reaction* with coefficients); this is the ***molecular rxn***

Answer 1: **Molecular reaction**: $3Ca(NO_3)_2(aq) + 2Na_3PO_4(aq) \rightarrow Ca_3(PO_4)_2(s) + 6NaNO_3(aq)$

2. Complete Ionic Reaction: Break the ***appropriate*** compounds into aqueous ions

Break up into ions if chemical is: *1. Soluble Ionic (metal+nonmetal/polyatomic ion & solubility rules), 2. Strong Acid (memorized), or 3. Strong Base (memorized)*

Exception: $H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$ (used with gas-forming reactions)

Example 2: *Calcium nitrate and sodium phosphate are mixed (same as Example 1 above so start with molecular reaction); what is the complete ionic reaction?*

Molecular reaction: $3Ca(NO_3)_2(aq) + 2Na_3PO_4(aq) \rightarrow Ca_3(PO_4)_2(s) + 6NaNO_3(aq)$

$Ca(NO_3)_2$ – soluble + ionic → break-up; Na_3PO_4 – soluble + ionic → break-up;

$Ca_3(PO_4)_2$ – insoluble + ionic → don't break-up; $NaNO_3$ – soluble + ionic → break-up

Note 1: the "3" in front of $Ca(NO_3)_2$ acts on ***both*** the Ca^{+2} and the NO_3^-;

Note 2: not written as $3(NO_3)_2^-$; $(NO_3)_2$ = implies the 2 NO_3^- are bonded together (they're not bonded together!); $6NO_3^-$ = implies 6 separate NO_3^-;

Note 3: polyatomic ions are treated as a *group* and *are not broken apart*; it is $6NO_3^-$ and not 6N + 18O

Answer 2: **Complete ionic reaction**: $3Ca^{+2}(aq) + 6NO_3^-(aq) + 6Na^+(aq) + 2PO_4^{-3}(aq) \rightarrow Ca_3(PO_4)_2(s) + 6Na^+(aq) + 6NO_3^-(aq)$

3. Net Ionic Reaction: Ions that "react" are included; other ions (*Spectator Ions*) are ***not*** included

Example 3: *Calcium nitrate and sodium phosphate are mixed (same as Example 1 above so start with complete ionic reaction); what is the net ionic reaction?*

Complete ionic reaction: $3Ca^{+2}(aq) + 6NO_3^-(aq) + 6Na^+(aq) + 2PO_4^{-3}(aq) \rightarrow Ca_3(PO_4)_2(s) + 6Na^+(aq) + 6NO_3^-(aq)$

Cancel out spectator ions from Complete Ionic Reaction (Na^+ and NO_3^-); watch for H_2CO_3 (not in this reaction); if everything cancels out → No reaction!

Answer 3: **Net ionic reaction**: $3Ca^{+2}(aq) + 2PO_4^{-3}(aq) \rightarrow Ca_3(PO_4)_2(s)$ [$Na^+(aq)$, $NO_3^-(aq)$ were canceled – spectator ions]

Example 4: Write the molecular, complete ionic, and net ionic reactions for the reaction of acetic acid with barium hydroxide.

Answer 4: **Molecular rxn:** ***Step 1:*** names → formulas: CH_3COOH (memorized) + $Ba(OH)_2$ → (assign charges, balance reactants → $H^{+1}CH_3COO^{-1} + Ba^{+2}(OH^{-1})_2$)

Step 2: switch partners; use only 1: $CH_3COOH + Ba(OH)_2 \rightarrow HOH + Ba(CH_3COO)$

Step 3: assign charges to products: $CH_3COOH + Ba(OH)_2 \rightarrow H^{+1}OH^{-1} + Ba^{+2}CH_3COO^{-1}$

Step 4: balance product formulas: $CH_3COOH + Ba(OH)_2 \rightarrow HOH (= H_2O) + Ba(CH_3COO)_2$

Step 5: balance reaction: **Molecular reaction:** $2CH_3COOH(aq) + Ba(OH)_2(aq) \rightarrow 2HOH(l) + Ba(CH_3COO)_2(aq)$

Complete ionic reaction: ***Step 1:*** break strong acids (SA), strong bases (SB), and soluble ionic compounds into ions; don't break up weak acids (WA), weak bases (WB), insoluble ionic compounds, or molecular compounds

CH_3COOH – WA → don't break up; $Ba(OH)_2$ – SB → break up; HOH = H_2O – molecular compound → don't break up;

$Ba(CH_3COO)_2$ – ionic (has a metal and a polyatomic ion) and is soluble (has CH_3COO^-) → break up:

Complete ionic rxn: $2CH_3COOH(aq) + Ba^{+2}(aq) + 2OH^-(aq) \rightarrow 2H_2O(l) + Ba^{+2}(aq) + 2CH_3COO^-(aq)$

Net ionic reaction: ***Step 1:*** cancel out ions on both sides of the reaction: $2CH_3COOH + 2OH^- \rightarrow 2H_2O + 2\ CH_3COO^-$

Simplify reaction coefficients if possible (divide all coefficients by 2): **Net ionic reaction:** $CH_3COOH(aq) + OH^-(aq) \rightarrow H_2O(l) + CH_3COO^-(aq)$

Molecular reaction: $2CH_3COOH\ (aq) + Ba(OH)_2(aq) \rightarrow 2HOH(l) + Ba(CH_3COO)_2(aq)$

Complete ionic reaction: $2CH_3COOH\ (aq) + Ba^{+2}(aq) + 2OH^-(aq) \rightarrow 2H_2O(l) + Ba^{+2}(aq) + 2\ CH_3COO^-(aq)$

Net ionic reaction: $CH_3COOH\ (aq) + OH^-(aq) \rightarrow H_2O(l) + CH_3COO^-(aq)$

TYPES OF REACTIONS and Writing Molecular, Complete Ionic, and Net Ionic Reactions

1. ***Precipitation*: 2 aqueous/soluble ionic compounds "switch" partners and produce a *solid* (precipitate)**

Example 5: Write the molecular, complete ionic, and net ionic reaction for: $Ba(NO_3)_2(aq) + K_2SO_4(aq) \rightarrow$

Answer 5: $Ba(NO_3)_2(aq) + K_2SO_4(aq) \rightarrow BaSO_4(s) + 2KNO_3(aq)$ (molecular reaction)

$Ba^{+2}(aq) + 2NO_3^-(aq) + 2K^+(aq) + SO_4^{-2}(aq) \rightarrow BaSO_4(s) + 2K^+(aq) + 2NO_3^-(aq)$ (complete ionic reaction)

($Ba(NO_3)_2 \rightarrow$ soluble ionic $\rightarrow$ break up; $K_2SO_4 \rightarrow$ soluble ionic $\rightarrow$ break up; $KNO_3 \rightarrow$ soluble ionic $\rightarrow$ break up; $BaSO_4 \rightarrow$ insoluble ionic $\rightarrow$ don't break up)

$Ba^{+2}(aq) + SO_4^{-2}(aq) \rightarrow BaSO_4(s)$ (net ionic reaction)

2. ***Acid/Base (neutralization)*: Acid + Base $\rightarrow$ H_2O + salt** (salt = ionic compound that is usually soluble)

Example 6: Write the molecular, complete ionic, and net ionic reaction for: $2HNO_3(aq) + Ba(OH)_2(aq) \rightarrow$ (strong acid + strong base)

Answer 6: $2HNO_3(aq) + Ba(OH)_2(aq) \rightarrow 2H_2O(l) + Ba(NO_3)_2(aq)$ (molecular reaction)

$2H^+(aq) + 2NO_3^-(aq) + Ba^{+2}(aq) + 2OH^-(aq) \rightarrow 2H_2O(l) + Ba^{+2}(aq) + 2NO_3^-(aq)$ (complete ionic reaction)

($HNO_3 \rightarrow$ strong acid $\rightarrow$ break up; $Ba(OH)_2 \rightarrow$ strong base $\rightarrow$ break up; $Ba(NO_3)_2 \rightarrow$ soluble ionic $\rightarrow$ break up; $H_2O \rightarrow$ molecular $\rightarrow$ don't break up)

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ (net ionic reaction; this net ionic reaction is for SA + SB; not WA or WB)

Example 7: Write the molecular, complete ionic, and net ionic reaction for: $2CH_3COOH(aq) + Sr(OH)_2(aq) \rightarrow$ (weak acid + strong base)

Answer 7: $2CH_3COOH(aq) + Sr(OH)_2(aq) \rightarrow 2H_2O(l) + Sr(CH_3COO)_2(aq)$ (molecular reaction)

$2HF(aq) + Sr^{+2}(aq) + 2OH^-(aq) \rightarrow 2H_2O(l) + Sr^{+2}(aq) + 2CH_3COO^-(aq)$ (complete ionic reaction)

($CH_3COOH \rightarrow$ weak acid $\rightarrow$ don't break up; $Sr(OH)_2 \rightarrow$ strong base $\rightarrow$ break up; $Sr(CH_3COO)_2 \rightarrow$ soluble ionic $\rightarrow$ break up; $H_2O \rightarrow$ molecular $\rightarrow$ don't break up)

$HF(aq) + OH^-(aq) \rightarrow H_2O(l) + CH_3COO^-(aq)$ (net ionic reaction for weak acid + strong base)

3. ***Gas-Forming*: produces a gas**

- **Carbon dioxide gas**, CO_2: acid (H^+) + $CO_3^{-2}(aq) \rightarrow H_2O(l) + CO_2(g)$
- **Sulfur dioxide gas**, SO_2: acid (H^+) + $SO_3^{-2}(aq) \rightarrow H_2O(l) + SO_2(g)$
- **Dihydrogen sulfide gas**, H_2S: acid (H^+) + $S^{-2}(aq) \rightarrow H_2S(g)$
- **Hydrogen gas**, H_2: metal(s) + $H_2O(l)$ or acid (H^+) $\rightarrow M^+(aq) + OH^-(aq) + H_2(g)$ (this is also a redox reaction)

Example 8: Write the molecular, complete ionic, and net ionic reaction for: $2HCl(aq) + Na_2CO_3(aq) \rightarrow$

Answer 8: $2HCl(aq) + Na_2CO_3(aq) \rightarrow H_2CO_3(aq) + 2NaCl(aq)$ (molecular reaction not yet finished)

the $H_2CO_3(aq)$ breaks up: $H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$ to yield an overall molecular reaction:

$2HCl(aq) + Na_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g) + 2NaCl(aq)$ (molecular reaction finished)

$2H^+(aq) + 2Cl^-(aq) + 2Na^+(aq) + CO_3^{-2}(aq) \rightarrow H_2O(l) + CO_2(g) + 2Na^+(aq) + 2Cl^-(aq)$ (complete ionic reaction)

($HCl \rightarrow$ strong acid $\rightarrow$ break up; $Na_2CO_3 \rightarrow$ soluble ionic $\rightarrow$ break up; $NaCl \rightarrow$ soluble ionic $\rightarrow$ break up; $H_2O \rightarrow$ molecular $\rightarrow$ don't break up; $CO_2 \rightarrow$ molecular $\rightarrow$ don't break up)

$2H^+(aq) + CO_3^{-2}(aq) \rightarrow H_2O(l) + CO_2(g)$ (net ionic reaction)

4. ***Combustion: a type of redox rxn:*** Hydrocarbon (hydrogen + carbon) reacting with O_2 to form H_2O and CO_2

$C_xH_y + O_2(g) \rightarrow CO_2(g) + H_2O(g)$ (unbalanced)

Example 9: Write the molecular, complete ionic, and net ionic reaction for: $2C_8H_{18}(g) + 25O_2(g) \rightarrow$

Answer 9: $2C_8H_{18}(g) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$ (molecular reaction)

$2C_8H_{18}(g) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$ (complete ionic reaction)

(C_8H_{18}, O_2, H_2O, $CO_2 \rightarrow$ molecular $\rightarrow$ don't break up)

$2C_8H_{18}(g) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$ (net ionic reaction)

5. ***Redox*: oxidation numbers change** as elements go from reactants to products (see below)

Displacement: metal + (acid or metal salt) $\rightarrow$ metal/element + metal salt

$A + BX \rightarrow AX + B$

Example 10: Write the molecular, complete ionic, and net ionic reaction for: $Mg(s) + 2HCl(aq) \rightarrow$

Answer 10: $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ (molecular reaction)

$Mg(s) + 2H^+(aq) \rightarrow Mg^{+2}(aq) + H_2(g)$ (net ionic reaction)

(Note: When an acid is in a redox reaction and forms $H_2(g)$, this reaction is sometimes classified as a gas-forming reaction!)

REDOX – **Red**uction-**Ox**idation; ***redox reactions occurs when there is a change in oxidation number***

Oxidation reaction ***cannot*** occur without reduction reactions and vice-versa

LEO the lion goes GER (LEO - **L**ose **E**lectrons **O**xidation; GER - **G**ain **E**lectrons **R**eduction)

Reducing agent - that which causes something else to be reduced;

reducing agent is the chemical that is oxidized

Oxidizing agent - that which causes something else to be oxidized;

oxidizing agent is the chemical that is reduced

1. ASSIGNING OXIDATION NUMBERS - Bookkeeping of electrons

1. Elements in elemental form 0
2. In a ***compound***:
   - a. Group 1A (Li,Na,...) +1 (always)
   - b. Group 2A (Be, Mg,...) +2 (always)
   - c. F -1 (always)
   - d. H +1 (usually; can also be –1 with MH_x; (e.g., NaH))
   - e. O -2 (usually; can also be: –1 with O_2^{-2}, e.g., H_2O_2; $-^1/_2$ with O_2^-, e.g., KO_2; +1 with F, e.g., F_2O_2)
3. Sum Rule: *Sum of all the oxidation numbers = total charge on compound*

Example 11: Assign oxidation numbers to all atoms in N_2O_4.

Answer 11: Assign **O = -2** → Sum Rule: 2(N) + 4(-2) = 0; 2(N) + (-8) = 0; 2N = +8; **N = +4**

Example 12: Assign oxidation numbers to all atoms in PO_4^{-3}.

Answer 12: Assign **O = -2** → Sum Rule: 1(P) + 4(-2) = -3; 1(P) + (-8) = -3; **P = +5**

Example 13: Assign oxidation numbers to all atoms in $CuSO_4$.

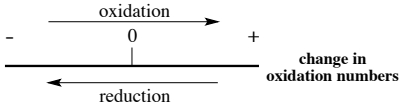
Answer 13: Two unknowns: Cu and S; break into 2 parts and look for a polyatomic ion: Cu and SO_4; assign *charge* (not oxidation numbers) to SO_4 → -2 → SO_4^{-2} *(this is memorized)*; since entire compound, $CuSO_4$, is neutral, Cu → Cu^{+2} (+2 + (-2) = 0); Cu^{+2} has ox num = +2; **Cu = +2**;

SO_4^{-2}: Assign ox num **O = -2** → Sum Rule: 1(S) + 4(-2) = -2; 1(S) + (-8) = -2; **S = +6**

2. OXIDIZED, REDUCED, OXIDIZING AGENT, REDUCING AGENT

If oxidation numbers get more positive ⇒ oxidized

If oxidation numbers get more negative ⇒ reduction



Chemical oxidized = reducing agent; Chemical reduced = oxidizing agent;

Chemical oxidized, Chemical reduced, Oxidizing agent, Reducing agent = ***reactants only; no products***

Example 14: Identify which chemical is oxidized, reduced, is the oxidizing agent, and is the reducing agent in the following reaction:

$Cu(s) + 2HNO_3(aq) \rightarrow CuO(s) + 2NO_2(g) + H_2O(l)$

Answer 14: Assign oxidation numbers to all elements in all chemicals:

$\overset{0}{Cu(s)} + \overset{1\ 5\ -2}{2HNO_3(aq)} \longrightarrow \overset{2\ -2}{CuO(s)} + \overset{4\ -2}{2NO_2(g)} + \overset{1\ -2}{H_2O(l)}$

Note where the ***change in oxidation number*** occurs as the reactants become products:

Cu: 0 → +2 → *increasing* oxidation number → ***oxidized***; N: +5 → +4 → *decreasing* oxidation number → ***reduced***

$\overset{0}{Cu(s)} + \overset{1\ 5\ -2}{2HNO_3(aq)} \longrightarrow \overset{2\ -2}{CuO(s)} + \overset{4\ -2}{2NO_2(g)} + \overset{1\ -2}{H_2O(l)}$

reduction

oxidation

The chemical that is oxidized (Cu) is also the ***reducing agent*** = Cu(s); the chemical that is reduced (HNO_3) is also the ***oxidizing agent*** = HNO_3

3. ID A REDOX RXN

Redox reaction occurs when oxidation numbers change in a reaction

- If rxn is an ***acid/base***, ***precipitation***, or ***gas-forming*** rxn (such as HCO_3^-/CO_3^{-2} + acid/H^+) – ***it's not a redox rxn***
- If rxn has an ***element*** on one side and that element ***is in a compound*** on the other side of the rxn – it's nearly ***always a redox rxn***
- If rxn is a ***combustion*** rxn – ***it's a redox rxn***

1. Balance the following equations.

a. $Mg(s) + SiO_2(s) \rightarrow MgO(s) + Si(s)$

b. $Ca(s) + N_2(g) \rightarrow Ca_3N_2(s)$

c. $CH_3OH(l) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$

d. $CaCl_2(s) + Na_2CO_3(s) \rightarrow CaCO_3(s) + NaCl(s)$

e. $P_4O_{10}(s) + H_2O(l) \rightarrow H_3PO_4(aq)$

f. $C_6H_6(l) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$

2. Write and balance a reaction from the description given (recall combustion refers to the reaction of a hydrocarbon with $O_2(g)$ to produce water, $H_2O(l)$, and carbon dioxide, CO_2). Include phases [(aq), (s), (l), (g)].

a. pentane ($C_5H_{12}(l)$) is combusted

b. ethylene ($C_2H_4(g)$) is combusted

c. sodium metal reacts with oxygen gas

d. calcium metal reacts with solid phosphorus

3. Write balanced ***molecular reactions*** for each of the following. Include phases [(aq), (s), (l), (g)].

a. $HCl(aq)$ and $Ba(OH)_2(aq)$

b. $AgNO_3(aq)$ and $NaBr(aq)$

c. $H_2O(l)$ is decomposed into its elements

4. Use the reactions below to answer the following 3 questions.

a. $HCl(aq) + KOH(aq) \rightarrow$

b. $CH_3COOH(aq) + NaHCO_3(aq) \rightarrow$

c. $NH_3(aq) + H_2SO_4(aq) \rightarrow$

d. $Pb(NO_3)_2(aq) + Na_2S(aq) \rightarrow$

e. None of the above.

I. Which of the following will lead to a precipitation reaction?

II. Which of the following is an example of a weak base reacting with a strong acid?

III. Which of the following is an example of a gas-forming reaction?

5. Write the balanced ***net ionic reaction*** for each of the following. If no reaction occurs, write no reaction. (Hint: Start by writing a molecular reaction, then a complete ionic, and then a net ionic – it's long to do it this way but it also is instructive.) Include phases [(aq), (s), (l), (g)].

a. An aqueous solution of potassium chloride, $KCl(aq)$, is combined with an aqueous solution of silver(I) nitrate, $AgNO_3(aq)$, to yield an insoluble precipitate.

b. Aqueous $Pb(NO_3)_2(aq)$ and aqueous $NaI(aq)$ are combined to yield an insoluble precipitate.

c. A solution of hydrochloric acid, $HCl(aq)$, and a solution of potassium hydroxide, $KOH(aq)$ are combined.

d. A balloon containing oxygen gas and hydrogen gas is combusted.

e. Aqueous barium chloride and aqueous potassium sulfate are mixed together to yield an insoluble precipitate.

6. Identify the following chemicals when they are dissolved into water as a strong, weak, or nonelectrolytes.

a. NaCl b. HCl c. CH_3COOH d. sugar e. $BaSO_4$

f. NH_3 g. H_2SO_4 h. NaOH i. HF

7. Assign the oxidation numbers for each element present.

a. Na b. Fe c. Cl_2 d. Li^+ e. Br^- f. NO g. NO_2 h. NaCl i. $NaNO_3$ j. PO_4^{-3} k. H_2O l. NO_3^-

m. H_2SO_4 n. $Ca(NO_3)_2$ o. $S_2O_3^{-2}$ p. CO_3^{-2} q. $MnSO_4$ r. $Cr_3(PO_4)_2$ s. $CuNO_3$ t. NH_4NO_3

8. Identify what is being oxidized, reduced, what the oxidizing agent is, and what the reducing agent is. (The reactions don't need to be balanced, and don't try to balance them.)

a. $S^{2-} + NO_3^- \rightarrow NO_2 + S_8$ b. $NO_3^- + Cu \rightarrow NO + Cu^{2+}$

c. $MnO_4^- + SO_2 \rightarrow SO_4^{2-} + Mn^{2+}$ d. $Hg_2^{2+} + H_2S \rightarrow Hg + S_8$

9. A white compound is found and is either $Pb(NO_3)_2$ or $Ba(NO_3)_2$. Which one of the following compounds could be used with water and the unknown white compound to determine the identity of the unknown compound?

a. HNO_3 b. HCl c. $AgNO_3$ d. ClO_4 e. C_2H_5OH (ethanol)

10. A white compound is found and is either K_2CO_3 or $AgNO_3$. Which one of the following compounds could be used with water and the unknown white compound to determine the identity of the unknown compound?

a. $BaCl_2$ b. $NaClO_4$ c. Li_2SO_4 d. CaI_2 e. HNO_2

ANSWERS

1. a. $2Mg(s) + SiO_2(s) \rightarrow 2MgO(s) + Si(s)$
   b. $3Ca(s) + N_2(g) \rightarrow Ca_3N_2(s)$
   c. $2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$
   d. $CaCl_2(s) + Na_2CO_3(s) \rightarrow CaCO_3(s) + 2NaCl(s)$
   e. $P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$
   f. $2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(l)$

2. a. $C_5H_{12}(l) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(g)$
   b. $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(g)$
   c. $4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$
   d. $3Ca(s) + 2P(s) \rightarrow Ca_3P_2(s)$

3. a. $2HCl(aq) + Ba(OH)_2(aq) \rightarrow 2H_2O(l) + BaCl_2(aq)$
   b. $AgNO_3(aq) + NaBr(aq) \rightarrow AgBr(s) + NaNO_3(aq)$
   c. $2H_2O(l) \rightarrow O_2(g) + 2H_2(g)$

4. I. d {solubility rules: PbS insoluble}
   II. c {NH_3 is a weak base (memorized); H_2SO_4 is a strong acid (memorized)}
   III. b {an acid + $HCO_3^- \rightarrow H_2CO_3 \rightarrow H_2O(l) + CO_2(g)$; there are other gas-forming reactions besides this one}