Types of Chemical Reactions

Chemical reactions can be classified on the basis of what processes occur during the reaction. You will be required to be able to identify what type of reaction has occurred and to predict the products of the reaction. There are four basic types of reactions as listed below.

1) **Direct Combination** (synthesis) $A + B \rightarrow AB$
   a) Two elements → a binary compound
   b) Two compounds (with a common ion) → one compound
   Example: $2H_2\,(g) + O_2\,(g) \rightarrow 2\,H_2O$

2) **Single Replacement** $A + BX \rightarrow AX + B$
   a) Element + compound → different element + different compound
   b) Strong metals (Groups I & IIA) + Water → metallic hydroxide + hydrogen
   Example: $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

3) Double Replacement $AX + BY \rightarrow AY + BX$
   a) Two compounds → two different compounds
   Example: $NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$
   b) Special : combustion of hydrocarbons $C_xH_y + O_2 \rightarrow CO_2 + H_2O$

4) Decomposition $AB \xrightarrow{\Delta} A + B$
   a) One compound $\xrightarrow{\Delta}$ two or more products
   b) Rules for Decomposition Rxns.
      i) Binary compounds (with heat or electricity) → free elements
         Example: $H_2O \xrightarrow{\Delta} H_2 + O_2$
      ii) Some oxides (when heated) → free elements
         Example: $2\,HgO \xrightarrow{\Delta} 2\,Hg + O_2$
      iii) Metallic carbonates (when heated) → metallic oxides + CO_2
         Example: $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
      iv) Metallic chlorates (when heated) → metallic chlorides + O_2
         Example: $2\,KClO_3 \xrightarrow{\Delta} 2\,KCl + 3\,O_2$
      v) Metallic hydroxides (when heated) → metallic oxides + H_2O
         Example: $Ca(OH)_2 \xrightarrow{\Delta} CaO + H_2O$
      vi) Oxyacids (when heated) → nonmetallic oxides + H_2O
         Example: $H_2SO_4\,(aq) \xrightarrow{\Delta} H_2O + SO_3$
   c) MEMORIZE: $NH_4OH \xrightarrow{\Delta} NH_3 + H_2O$

* Reminders: The physical state of the substance is often indicated by a letter following the formula. (s) = solid, (l) = liquid, (g) = gas, (aq) = aqueous, and (ppt) = precipitate. A precipitate is the solid formed when two liquid compounds combine and one of the resulting compounds is insoluble in the newly formed liquid.

SPECIAL REACTIONS

1) **Combustion Reactions:**
   a) combustion of a hydrocarbon (organic compound):
   hydrocarbon burning in the presence of oxygen gas yields carbon dioxide and water
   Example: $C_xH_y + O_2 \rightarrow CO_2 + H_2O$
   b) combustion of a metal:
   burning of a metal in the presence of oxygen gas yields a metal oxide
   Example: $2Mg\ (s) + O_2\ (g) \rightarrow 2\ MgO\ (s)$

2) **Precipitation Reactions:** Double Replacement Rxn : evaluate products
   a) single and double replacement reactions involving reactants that are aqueous, resulting in a product that is a solid (precipitate).
   Example: $Ag(NO_3)\ (aq) + NaCl\ (aq) \rightarrow AgCl\ (ppt) + Na(NO_3)\ (aq)$
   b) Use solubility rules to help determine which product is insoluble in water and will result in a precipitate.

3) **Ionic and Net ionic Equations:**
   a) Ionic equations write a chemical reaction by showing what ions are present on both the reactant and product sides. *Please keep in mind ions are only written if the compound is in the aqueous state.
   Example: $Ag(NO_3)\ (aq) + NaCl\ (aq) \rightarrow AgCl\ (ppt) + Na(NO_3)\ (aq)$ is written as: $Ag^{1+}\ (aq) + NO_3^{1-}\ (aq) + Na^{1+}\ (aq) + Cl^{1-}\ (aq) \rightarrow AgCl\ (s) + Na^{1+}\ (aq) + NO_3^{1-}\ (aq)$
   b) Net Ionic equations express the chemical reaction with spectator ions removed. *Spectator ions are those ions that remain in the same form before and after the reaction.
   Example: Using the equation from above the Na^{1+} and the NO_3^{1-} are spectator ions and will be removed from the equation. The resulting equation looks like:
   $Ag^{1+}\ (aq) + Cl^{1-}\ (aq) \rightarrow AgCl\ (s)$

4) **Acid – Base Reactions:**
   a) The reaction between a strong acid and a strong base will form a salt and water, also called a neutralization reaction.
   Example: $HCl\ (aq) + NaOH\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$
   b) The reactants and products can be divided into acid-base pairs. An acid-base pair can be identified by examining the movement of the hydrogen throughout the reaction. The compound that donates the hydrogen (proton) is considered the acid. The compound that accepts the hydrogen (proton) is considered the base. Also referred to as the Brønsted-Lowry model.

Practice: Change the following equations into an ionic equation and net ionic equation (if applies).

1. $Ca(NO_3)_2\,(aq) + \cancel{2\,NaClO_3}\,(aq) \rightarrow \cancel{Ca(ClO_3)_2\,(aq)} + 2\,NaNO_3\,(aq)$

$Na_2(SO_4)$ (SO_4) ppt

full ionic > $Ca^{2+} + 2(NO_3)^{1-} + 2Na^{1+} + (SO_4)^{2-} \rightarrow CaSO_4(ppt) + 2Na^{1+} + 2(NO_3)^{1-}$

Net ionic $Ca^{2+} + SO_4^{2-} \longrightarrow CaSO_4(ppt)$

Practice: Complete redox equations for the following. Remember to label LEO and GER.

1. $2\,Fe\,(s) + 3\,S\,(s) \rightarrow Fe_2S_3\,(s)$

2. $4\,K\,(s) + C\,(s) \rightarrow K_4C\,(s)$

3. $2\,Al\,(s) + Fe_2O_3\,(s) \rightarrow 2\,Fe\,(s) + Al_2O_3\,(s)$

Name: _____ **Period:** ___ **Date:** _____

Homework: Types of Reactions

Identify the type of reactions.

1. $3\ CaBr_2 + 2Na_3P \rightarrow Ca_3P_2 + 6\ NaBr$ — DR
2. $2\ KI + Br_2\ (g) \rightarrow 2\ KBr + I_2\ (g)$ — SR
3. $C_6H_{12}O_6 \xrightarrow{\Delta} 6\ C + 6\ H_2O$ — DEC
4. $2\ NaF \xrightarrow{\Delta} 2\ Na + F_2\ (g)$ — DEC
5. $Si + O_2\ (g) \rightarrow SiO_2$ — DC or Combustion
6. $2\ NaI + Pb(NO_3)_2 \rightarrow 2\ NaNO_3 + PbI_2$ — DR
7. $NaI + Cs \rightarrow CsI + Na$ — SR
8. $H_2\ (g) + CO + O_2\ (g) \rightarrow H_2CO_3$ — DC
9. $Li_3PO_4 \xrightarrow{\Delta} 3\ Li + P + 2\ O_2\ (g)$ — DEC
10. $CS_2 + 2\ F_2\ (g) \rightarrow CF_4 + 2\ S$ — SR

Predict the products for the following reactions, and write a balanced equation.

1. aluminum sulfate + calcium phosphate → _____

DR 2. magnesium ($2+$) chloride ($1-$) + silver ($1+$) nitrate ($1-$) → silver chloride + magnesium nitrate ($2+$, $1-$)

$$\_\ MgCl_2 + \underline{2}\ AgNO_3 \rightarrow \underline{2}\ AgCl + \_\ Mg(NO_3)_2$$

DC 4. hydrogen gas + oxygen gas → water

$$\underline{2}\ H_2(g) + \_\ O_2(g) \rightarrow \underline{2}\ H_2O$$

Diatomic molecules: H_2, N_2, O_2, F_2, Cl_2, I_2, Br_2

DEC 6. copper (II) ($2+$) hydroxide ($1-$) $\xrightarrow{\Delta}$ copper (II) oxide ($2+$, $2-$) + water

$$\_\ Cu(OH)_2 \xrightarrow{\Delta} \_\ CuO + \_\ H_2O$$

DC 8. nitrogen ($N\ 3-$) gas + hydrogen ($H\ 1+$) gas → ammonia

$$\_\ N_2(g) + \underline{3}\ H_2(g) \rightarrow \underline{2}\ NH_3$$

SR 10. sodium ($1+$) iodide ($1-$) + chlorine gas → sodium chloride + iodine gas

$$\underline{2}\ NaI + \_\ Cl_2(g) \rightarrow \underline{2}\ NaCl + \_\ I_2(g)$$

SR 12. aluminum + sulfuric acid → hydrogen gas + aluminum sulfate

$2\,Al + 3\,H_2SO_4(aq) \rightarrow 3\,H_2(g) + \_\,Al_2(SO_4)_3$

DC 14. synthesis of ammonia: (from front side)

$\_\,N_2(g) + 3\,H_2(g) \rightarrow 2\,NH_3$

DR 16. zinc sulfate + hydrogen sulfide → hydrogen sulfate + zinc sulfide

$\_\,Zn(SO_4) + \_\,H_2S \rightarrow \_\,H_2(SO_4) + \_\,ZnS$

DR 18. lead (II) chlorate + potassium chromate → potassium chlorate + lead (II) chromate

$\_\,Pb(ClO_3)_2 + \_\,K_2CrO_4 \rightarrow 2\,K(ClO_3) + \_\,PbCrO_4$

DR 20. potassium iodide + water → hydrogen iodide + potassium hydroxide

$\_\,KI + \_\,H(OH) \rightarrow \_\,HI + \_\,K(OH)$

$2AgNO_3(aq) + BaCl_2(aq) \longrightarrow Ba(NO_3)_2(aq) + 2AgCl(ppt)$

full ionic equation $2Ag^{1+} + 2(NO_3)^{-1} + Ba^{2+} + 2Cl^{1-} \longrightarrow Ba^{2+} + 2(NO_3)^{-1} + 2AgCl(ppt)$

net ionic equation $2Ag^{1+} + 2Cl^{1-} \longrightarrow 2AgCl(ppt)$

$K_2CrO_4(aq) + Pb(NO_3)_2(aq) \longrightarrow 2K(NO_3)(aq) + PbCrO_4(ppt)$

$2K^{1+} + CrO_4^{2-} + Pb^{2+} + 2NO_3^{1-} \longrightarrow 2K^{1+} + 2NO_3^{1-} + Pb(CrO_4)(ppt)$

Net ionic equation $Pb^{2+} + CrO_4^{2-} \longrightarrow Pb(CrO_4)(ppt)$

$3CuSO_4(aq) + 2Al(s) \longrightarrow Al_2(SO_4)_3 + 3Cu(s)$

$Cu^{2+} + 2e^- \longrightarrow Cu^0$