

Name: \_\_\_\_\_ Date: \_\_\_\_\_  
Chemistry

Class Notes



# Predicting Reactions

In order to successfully predict reactions, you need to know the following:

- Nomenclature
- Types of Reactions
- Solubility Rules
- How to write net ionic equations

## Rules for Reaction Prediction:

1. Always write balanced net ionic equations (based on solubility rules),
2. Metals are insoluble and written as solids (s) in equations.
3. Gases such as CO<sub>2</sub> or H<sub>2</sub>S are written as gases (g) and will not dissociate into ions.
4. Water is written as a liquid (l) and does not dissociate.
5. Ionic compounds may or may not dissociate depending on solubility rules.
6. Even a soluble ionic compound may NOT dissociate if it is in solid form.
7. Weak acids and bases partly dissociate or ionize and are written with a reversible arrow.
8. Remember H N O F Cl Br I are diatomic. Phosphorus is P<sub>4</sub> and Sulfur is S<sub>8</sub>.
9. Remember the difference between Zn and Zn<sup>2+</sup> and Cl<sub>2</sub> and 2 Cl<sup>-</sup>.
10. Strong acids (HCl, HBr, HI, HNO<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub>) first dissociation only!), HClO<sub>4</sub> and HClO<sub>3</sub>) and strong bases (Group 1 alkali metal hydroxide and Ca, Ba, Sr hydroxides from group 2) dissociate in aq. Solutions. Weak acids and bases are **NOT** dissociated in net ionic equations.

## Types of Reactions:

### I. Synthesis Reaction

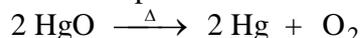
A single compound is formed:  $A + B \rightarrow C$

1. Metal + Nonmetal  $\rightarrow$  Ionic Compound  
 $\text{Na(s)} + \text{Cl}_2(\text{g}) \rightarrow 2\text{NaCl}(\text{aq})$
2. Nonmetal + Nonmetal  $\rightarrow$  Molecular Compound  
 $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$
3. Special Case:  $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$
4. Metal Oxide + Water  $\rightarrow$  Metal Hydroxide  
 $\text{Li}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{LiOH}$
5. Nonmetal Oxides + water  $\rightarrow$  Acid  
 $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$        $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$
6. Metal Oxide + CO<sub>2</sub>  $\rightarrow$  Metal Carbonate  
 $\text{CaO} + \text{CO}_2 \rightarrow \text{CaCO}_3$

## II. Decomposition Reaction

A single compound breaks down into two or more products:  $A \rightarrow B + C$

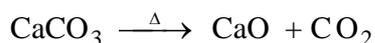
1. Binary Ionic Compound  $\xrightarrow{\Delta}$  Metal + Nonmetal



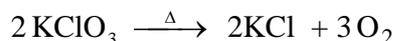
2. Metal Hydrogen Carbonates  $\xrightarrow{\Delta}$  Metal Carbonates and  $\text{CO}_2$  and  $\text{H}_2\text{O}$



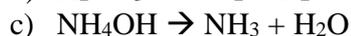
3. Metal Carbonate  $\xrightarrow{\Delta}$  Metal Oxide +  $\text{CO}_2$



4. Metal Chlorates  $\xrightarrow{\Delta}$  Metal Chloride + Oxygen



5. Special Cases: Unstable compounds, upon formation as products, decompose:



**Decomposition of:**

- Carbonates  $\rightarrow \text{CO}_2 + \text{Oxide}$
- Chlorates  $\rightarrow \text{chloride compound} + \text{O}_2$
- Ammonium carbonates  $\rightarrow \text{NH}_3 + \text{H}_2\text{O} + \text{CO}_2$
- Binary compound  $\rightarrow \text{Two elements}$
- Hydrogen peroxide  $\rightarrow \text{H}_2\text{O} + \text{O}_2$
- Bicarbonates  $\rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{metal carbonate}$

**Practice Problems:**

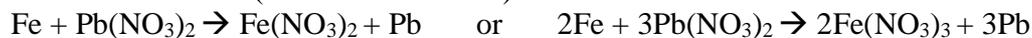
1. Ammonium carbonate is strongly heated.
2. Potassium Chlorate is strongly heated.
3. Sodium bicarbonate is strongly heated.

## III Single Replacement Reactions

Single replacement reactions are always between an element and a compound. The products are also an element and a compound. Driving force: Element with higher order of reactivity or activity series.

**Examples:**

1.  $A + BC \rightarrow AC + B$  (A and B are metals)



2.  $D + EF \rightarrow ED + F$  (D and F are halogens)



3. Metal + Water → Hydroxide + Hydrogen \*(if metal is higher than H in activity series)  
e.g.  $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$

4. Metal + Acid → Salt + Hydrogen  
e.g.  $\text{Ca} + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2$

**More examples:**

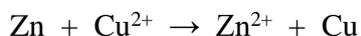
Single replacement reactions are always redox reactions.

➤ “Solid zinc strips are added to a solution of copper(II) sulfate.”



On the AP test, all reactions must be written as net ionic equations. The words from the instructions are “Omit formulas for any ions or molecules that are unchanged by the reaction.”

Therefore, this reaction becomes



➤ “Solid calcium is added to warm water.”



**Practice Problems:**

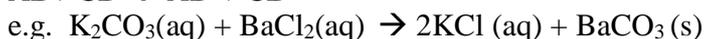
1. Solid calcium is added to hydrobromic acid solution.
2. Calcium is added to water.
3. Solid copper is added to a solution of silver nitrate.

**.IV. Double-Replacement Rxn:** exchange of positive ions between 2 *reacting* compounds

Driving force is formation of solid (precipitate), liquid (molecular compound like water), or gas.

Examples:

1.  $\text{AB} + \text{CD} \rightarrow \text{AD} + \text{CB}$



2. Metal Oxide + Acid → Salt + Water



3. Acid + Base → Salt + Water

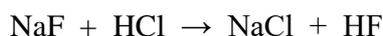


More examples:

A. Acid-Base reactions

➤ “Solutions of sodium fluoride and dilute hydrochloric acid are mixed.”

The reaction is obviously double replacement when written like this

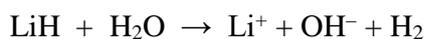


However, this reaction must be written as a net ionic equation where it looks like a combination reaction.



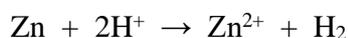
Hydrolysis reactions are a form of acid-base reaction.

- “Solid lithium hydride is added to water.”



If  $E^\circ$  for reduction of a metal ion is negative, the metal will produce hydrogen gas when mixed with acid.

- “A strip of zinc is added to a solution of 6.0-molar hydrobromic acid.”



### Acid Bases

- Salts of weak acid + strong base are basic
- Salts of strong acid + strong base are neutral
- Salts of strong acid + weak base are acidic
- Salts of weak acid + weak base can be acidic, basic or neutral depending on  $K_a$  and  $K_b$  (which ever is greater)

Sample Problems:

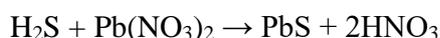
1. A solution of lead nitrate is mixed with potassium sulfate.
2. Equal volumes of 0.1 M sodium phosphate is added to hydrochloric acid.
3. Ammonia reacts with acetic acid solution.

### B. Precipitation reactions

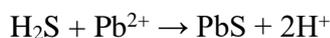
#### Know the solubility rules!

- “Hydrogen sulfide gas is bubbled through a solution of lead(II) nitrate.”

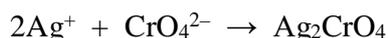
The reaction can be seen as double replacement when written like this



However, the net ionic equation is



- “Solutions of silver nitrate and sodium chromate are mixed.”



$\text{Na}^+$  and  $\text{NO}_3^-$  are not shown in the net ionic equation.

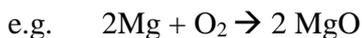
### V. Combustion Rxn: Element or compound is heated and reacts with Oxygen.; $\text{A} + \text{O}_2 \rightarrow \text{BC}$

Examples:

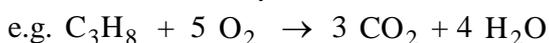
1. Nonmetal + Oxygen  $\rightarrow$  Nonmetal Oxide



1. Metal + Oxygen  $\rightarrow$  Metal Oxide



2. Hydrocarbon  $\text{C}_x\text{H}_y + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$  for complete combustion



3. Carbohydrate, alcohols  $\text{C}_x\text{H}_y\text{O}_z + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$  for complete combustion

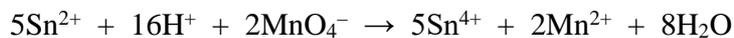


## VI. Redox reactions

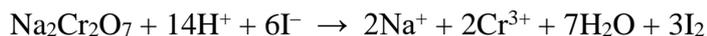
Most reactions involving permanganate, dichromate, or chromate are redox reactions.

Examples:

- “A solution of tin(II) chloride is added to an acidified solution of potassium permanganate.”



- “Solid sodium dichromate is added to an acidified solution of sodium iodide.”



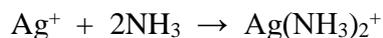
$\text{MnO}_4^{-}$ in acidic solution	$\text{Mn}^{2+}$
$\text{MnO}_2$ in acidic solution	$\text{Mn}^{2+}$
$\text{MnO}_4^{-}$ in neutral or basic solution	$\text{MnO}_2$
$\text{Cr}_2\text{O}_7^{-}$ in acidic solution	$\text{Cr}^{3+}$
$\text{HNO}_3$ concentrated	$\text{NO}_2$
$\text{H}_2\text{O}_2$	$\text{O}_2, \text{H}_2\text{O}$

## VII. Complex ions

Transition metal ions and  $\text{Al}^{3+}$  combine with ligands to completely surround the metal ion. Often you will see  $\text{NH}_3$ ,  $\text{OH}^{-}$ ,  $\text{Cl}^{-}$ ,  $\text{SCN}^{-}$ , or  $\text{CN}^{-}$ , and these will be in excess.

Examples:

- “An excess of ammonia gas is bubbled through a solution saturated with silver chloride.”



When forming complex ions, you will often add double the number of ligands than the oxidation state of the metal.

- “Concentrated (15M) ammonia solution is added in excess to a solution of copper(II) nitrate.”

