

PREDICTING REACTION PRODUCTS

Five Types of Reactions:

I. Combination Rxn: Single compound is formed; $A + B \rightarrow C$

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

II. Decomposition Rxn: Single compound breaks down into 2 or more products; $A \rightarrow B + C$

1. Binary Ionic Compound $\xrightarrow{\Delta}$ Metal + Nonmetal
e.g. $2\text{HgO} \xrightarrow{\Delta} 2\text{Hg} + \text{O}_2$
2. Metal Hydrogen Carbonates $\xrightarrow{\Delta}$ Metal Carbonates and CO_2 and H_2O
e.g. $2\text{NaHCO}_3 \xrightarrow{\Delta} \text{Na}_2\text{CO}_3 + \text{CO}_2 + \text{H}_2\text{O}$
3. Metal Carbonate $\xrightarrow{\Delta}$ Metal Oxide + CO_2
e.g. $\text{CaCO}_3 \xrightarrow{\Delta} \text{CaO} + \text{CO}_2$
4. Metal Chlorates $\xrightarrow{\Delta}$ Metal Chloride + Oxygen
e.g. $2\text{KClO}_3 \xrightarrow{\Delta} 2\text{KCl} + 3\text{O}_2$
5. Special Cases: Unstable compounds, upon formation as products, decompose:
 - i) $\text{H}_2\text{SO}_3 \rightarrow \text{SO}_2 + \text{H}_2\text{O}$
 - ii) $\text{H}_2\text{CO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
 - iii) $\text{NH}_4\text{OH} \rightarrow \text{NH}_3 + \text{H}_2\text{O}$

III. Single-Replacement Rxn: Atoms of 1 element replace atoms of a second element in a compound. Driving force: Element with higher order of reactivity

1. $A + BC \rightarrow AC + B$ (A and B are metals)
e.g. $\text{Fe} + \text{Pb}(\text{NO}_3)_2 \rightarrow \text{Fe}(\text{NO}_3)_2 + \text{Pb}$ or $2\text{Fe} + 3\text{Pb}(\text{NO}_3)_2 \rightarrow 2\text{Fe}(\text{NO}_3)_3 + 3\text{Pb}$
2. $D + EF \rightarrow ED + F$ (D and F are halogens)
e.g. $\text{Cl}_2 + 2\text{KI} \rightarrow 2\text{KCl} + \text{I}_2$
3. Metal + Water \rightarrow 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 \rightarrow Salt + Hydrogen
e.g. $\text{Ca} + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2$

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.

1. $AB + CD \rightarrow AD + CB$
e.g. $\text{K}_2\text{CO}_3(\text{aq}) + \text{BaCl}_2(\text{aq}) \rightarrow 2\text{KCl}(\text{aq}) + \text{BaCO}_3(\text{s})$
2. Metal Oxide + Acid \rightarrow Salt + Water
e.g. $\text{Li}_2\text{O} + 2\text{HCl} \rightarrow 2\text{LiCl} + \text{H}_2\text{O}$
3. Acid + Base \rightarrow Salt + Water
e.g. $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$

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

1. Nonmetal + Oxygen \rightarrow Nonmetal Oxide
e.g. $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$
1. Metal + Oxygen \rightarrow Metal Oxide
e.g. $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$
2. Hydrocarbon $\text{C}_x\text{H}_y + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$ for complete combustion
e.g. $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$
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
e.g. $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O}$