Synthesis Reactions – "building up"

Synthesis Reactions occur when an element or compound reacts with another element or compound to form a new compound.

$$A + BC \rightarrow ABC$$

Type of Synthesis Reaction	Example
Combination of two elements	$C_{(s)} + O_{2(g)} \rightarrow CO_{2\,(g)}$
Non-metal oxide + water ⟶ oxyacid	$SO_{3\,(g)} + H_2O_{(l)} \rightarrow H_2SO_{4\,(aq)}$
Metal oxide + water ⟶ base	$Li_2O_{(s)} + H_2O_{(l)} \rightarrow 2LiOH_{(aq)}$
Metal oxide + non-metal oxide ⟶ polyatomic salt	$CaO_{\,(s)} + CO_{2(g)} \rightarrow CaCO_{3\,(s)}$

When a polyatomic ion is formed in a reaction, always assume the -ate ion is present as it is the most common form. If the reaction cannot balance, then try the -ite ion.

Decomposition Reactions – "breaking down"

Decomposition Reactions occur when a compound breaks down into smaller compounds or elements.

$$ABC \rightarrow A + BC$$

Type of Decomposition	Example
a compound into its elements or smaller compounds	$2H_2O_{(l)} \rightarrow 2H_{2\,(g)} + O_{2\,(g)}$
oxyacid ⟶ non-metal oxide + water	$H_2SO_{4\,(aq)} \rightarrow SO_{3\,(g)} + H_2O_{(l)}$
base ⟶ metal oxide + water	$2LiOH_{(aq)} \rightarrow Li_2O_{(s)} + H_2O_{(l)}$
polyatomic salt ⟶ metal oxide + non-metal oxide	$CaCO_{3\,(s)} \rightarrow CaO_{\,(s)} + CO_{2(g)}$

Chlorates typically decompose to produce a metal chloride and oxygen gas.

Single Displacement Reactions

Single Displacement happens when an element replaces a *like* element in a compound.

$$A + BC \rightarrow AC + B$$

When you mix two chemicals together, a reaction *may* or *may not* occur.

Single displacement reactions occur when the element that is by itself, is higher in its activity series than the like element in the compound.

Type of Single Displacement	Example
displacement of a metal by another metal	$2\,Na + MgCl_2 \rightarrow 2NaCl + Mg$
displacement of a halogen by another halogen	$Cl_2 + MgBr_2 \rightarrow MgCl_2 + Br_2$

Double Displacement Reactions

Double Displacement Reactions occur when an element in one compound, replaces a *like* element in a compound.

$$AB + CD \rightarrow AD + CB$$

When you mix two solutions together, a reaction *may* or *may not* occur.

Generally double displacement reactions occur when:

1. Both reactants are *soluble* (there are some exceptions)
2. At least *one* product is a *precipitate*, a *gas*, or *water*.

Type of Double Displacement	Example
Formation of a Precipitate	$Pb(NO_3)_{2(aq)} + 2KI_{(aq)} \rightarrow PbI_{2(aq)} + 2KNO_{3(aq)}$
Production of a Hydrogen Gas Hydrides react with water to produce hydrogen gas.	$LiH_{(s)} + H_2O_{(l)} \rightarrow LiOH_{(aq)} + H_{2(g)}$
Many hydrides are insoluble in water but will still react with water to produce hydrogen gas.	
Production of Hydrogen Sulphide Gas Sulphides react with acids to produce hydrogen sulphide gas.	$K_2S_{(aq)} + 2HCl_{(aq)} \rightarrow 2KCl_{(aq)} + H_2S_{(g)}$
Many sulphides are insoluble in water but will still react with acids to produce hydrogen sulphide gas.	
Production of Carbon Dioxide Gas Carbonic acid readily decomposes into a carbon dioxide and water.	$Na_2CO_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + H_2CO_{3(aq)}$ $H_2CO_{3(aq)} \rightarrow CO_{2(g)} + H_2O_{(l)}$ Adding the two reactions above gives the net reaction: $Na_2CO_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$
Many carbonates are insoluble in water but will still react with acids to produce carbonic acid which decomposes to produce carbon dioxide gas.	
Production of Sulphur Dioxide Gas Sulphurous acid readily decomposes into sulphur dioxide gas and water.	$Na_2SO_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + H_2SO_{3(aq)}$ $H_2SO_{3(aq)} \rightarrow SO_{2(g)} + H_2O_{(l)}$ Adding the two reactions above will give the net reaction: $Na_2SO_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + SO_{2(g)} + H_2O_{(l)}$
Production of Ammonia Gas Ammonium hydroxide readily decomposes into ammonia gas and water.	$NH_4Cl_{(aq)} + NaOH_{(aq)} \rightarrow NH_4OH_{(aq)} + NaCl_{(aq)}$ $NH_4OH_{(aq)} \rightarrow NH_{3(g)} + H_2O_{(l)}$ Adding the two reactions above will give the net reaction: $NH_4Cl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + NH_{3(g)} + H_2O_{(l)}$
Formation of Water (Neutralization Reactions) Acids and bases react to form a salt and water.	$H_2SO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$

Combustion Reactions

Combustion reactions occur when a substance is burned in the presence of oxygen.

Type of Combustion Reaction	Example
Burning of a metal produces a metal oxide	$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$
Burning of a non-metal produces a non-metal oxide	$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$

non-metal oxides are based on familiarity and cannot otherwise be easily predicted.

Hydrocarbon Combustion Reactions

Hydrocarbon combustion reactions occur when a chemical made up of hydrogen and carbon (and sometimes oxygen) is burned in the presence of oxygen.

Produces carbon dioxide and water	$CH_{4\,(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$

If *combustion is incomplete, products may also include carbon (soot) & carbon monoxide.*

Net Ionic Equations

Ionic equations are chemical equations that show all the individual ions in solution. Compounds that are aqueous separate into their ions.

Balanced Chemical equation: $NaOH_{(aq)} + HCl_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$

Ionic equation: $Na^+_{(aq)} + OH^-_{(aq)} + H^+_{(aq)} + Cl^-_{(aq)} \rightarrow H_2O_{(l)} + Na^+_{(aq)} + Cl^-_{(aq)}$

Spectator Ions are not involved in the reaction. They are found on both sides of the equation.

In the equation above, $Na^+_{(aq)}$ and $Cl^-_{(aq)}$ are spectator ions.

Net Ionic Equation is the equation that results when the spectator ions are removed.

$$OH^-_{(aq)} + H^+_{(aq)} \rightarrow H_2O_{(l)}$$