Chemical Changes and Reactions

Chemical Change

A chemical change is a permanent change in which the chemical composition of a substance is changed and one or more substances with different chemical compositions and different properties are formed.

Characteristics of a chemical change

1. Permanent and Reversible
2. Exothermic and Endothermic
3. Total mass of Reactants is equal to total mass of Products

Necessary conditions for a chemical change

1. Mixing (close contact)

$$Pb(NO_3)_2(aq) + 2KI(aq) \longrightarrow 2KNO_3(aq) + PbI_2(s)$$

2. Solution

$$NaCl(aq) + AgNO_3(aq) \longrightarrow AgCl(s) + NaNO_3(aq)$$

3. Light

$$6CO_2 + 12H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

(glucose)

4. Electricity

$$2H_2O \xrightarrow{\text{electricity}} 2H_2 + O_2$$

5. Pressure

$$N_2 + 3H_2 \underset{}{\overset{>200\ atm}{\rightleftharpoons}} 2NH_3$$

6. Catalyst

- Positive catalyst (MnO_2)
- Negative catalyst (H_3PO_4)

Characteristics of Chemical Reactions

1. Evolution of gas

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow$$

- Effervescence: The formation of gas bubbles in liquid during a reaction is called effervescence.

2. Change of colour

$$Fe + \underset{\text{(Blue)}}{CuSO_4} \longrightarrow \underset{\text{(Green)}}{FeSO_4} + Cu$$

3. Formation of precipitates

$$AgNO_3(aq) + NaCl(aq) \longrightarrow \underset{\text{(white)}}{AgCl(\downarrow)} + NaNO_3(aq)$$

4. Change of states

$$NH_3(g) + HCl(g) \longrightarrow NH_4Cl(s)$$

Types of chemical Reactions

1. Direct combination or Synthesis Reaction

A reaction in which two or more substances combine together to form a single substance.

- Element + Element ⟶ Product
  $C(s)$ $O_2(g)$ $CO_2(g)$
- Element + Compound ⟶ Product
  $O_2(g)$ + $CO(g)$ $CO_2(g)$
- Compound + Compound ⟶ Product
  $NH_3(g)$ $HCl(g)$ $NH_4Cl(s)$

2. Decomposition Reaction

A reaction involves the breaking up of a compound either into elements or simpler compounds.

Types:

- Thermal decomposition
  $CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$
- Photolytic decomposition
  $AgCl(s) \xrightarrow{\text{Sunlight}} Ag(s) + Cl_2(g)$
- Electrolytic decomposition
  $H_2O(l) \xrightarrow[\text{current}]{\text{Electric}} H_2(g) + O_2(g)$

Thermal decomposition of metal compounds

(i) Hydroxides

K / Na $\xrightarrow{\text{Heat}}$ No change

Ca / Mg / Al etc. $\xrightarrow{\text{Heat}}$ (CaO / MgO / Al_2O_3) + H_2O

$Hg / Ag \xrightarrow{Heat} (Hg / Ag) + O_2 + H_2O$

(ii) Carbonates

$K / Na \xrightarrow{Heat}$ No change

$Ca / Mg / Al$ etc. $\xrightarrow{Heat} (CaO / MgO / Al_2O_3) + CO_2$

$Hg / Ag \xrightarrow{Heat} (Hg / Ag) + O_2 + CO_2$

(iii) Bicarbonates

$Na / Ca / Mg \xrightarrow{Heat} Na_2CO_3 / CaCO_3 / MgCO_3 + CO_2 + H_2O$

(iv) Nitrates

$K / Na \xrightarrow{Heat} (KNO_2 / NaNO_2) + O_2$

$Ca / Mg / Al$ etc. $\xrightarrow{Heat} (CaO / MgO / Al_2O_3) + NO_2 + O_2$

$Hg / Ag \xrightarrow{Heat} (Hg / Ag) + NO_2 + O_2$

Reversible Reaction :-

A reaction in which the direction of reaction can be reversed by changing the conditions under which reaction is taking place.

for example:

$$N_2O_4 \underset{Cool}{\overset{Heat}{\rightleftharpoons}} 2NO$$

3. Displacement Reaction

A reaction in which a more reactive element displace a less reactive element from its salt solution.

for example: $CuSO_4 + Zn \longrightarrow ZnSO_4 + Cu$

Reactivity / Activity series of Elements

Metals:

K > Na > Ca > Mg > Al > Zn > Fe > Pb > [H] > Cu > Hg > Ag > Au > Pt

Non-Metals:

F > Cl > Br > I

4. Double displasement Reaction

A reaction in which two compounds in a solution react to form two new compounds by mutual exchange of radicals.

Types:

(a) Precipitation Reaction

(b) Neutralization Reaction

Precipitation Reaction:

A reaction in which two compounds in their aqueous state react to form an insolable salt (a precipitate) as one of the products.

for example:

$BaCl_2(aq) + Na_2SO_4(aq) \longrightarrow BaSO_4(s) + 2NaCl(s)$
(White)

Neutralization Reaction:

A reaction in which an acid and a base react with each other to form salt and water.

for example:
$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$

Energy change in chemical Reactions

1. Exothermic Reaction
   A reaction in which heat is released during the reaction.

   for example:
   $CaO(s) + H_2O(s) \longrightarrow Ca(OH)_2(aq) + Heat$

2. Endothermic Reaction
   A reaction in which heat is absorbed during the reaction.

   for example:
   $N_2(g) + O_2(g) \xrightarrow[(3000^\circ C)]{Heat} 2NO(g)$

Photochemical Reaction

It is a reaction that occurs with the absorption of light energy.

for examples:

Photosynthesis:

$$6CO_2 + 12H_2O \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

Decomposition of Silver Nitrate

$$2AgNO_3 \xrightarrow{\text{sunlight}} 2Ag + 2NO_2 + O_2$$

Electrochemical Reactions

It is a reaction that occurs with the absorption of electrical energy.

For examples:

$$KCl_{(fused)} \xrightarrow[\text{current}]{\text{electric}} K^+ + Cl^-$$

$$2H_2O \xrightarrow[\text{current}]{\text{electric}} 2H_2 + O_2$$