CHEMICAL REACTION AND EQUATION

- **Chemical reactions are the processes in which new substances with new properties are formed. During a chemical reaction, atoms of one element do not change into those of another element.**

- **Only a rearrangement of atoms takes place in a chemical reaction.**
- **The substances which take part in a chemical reaction are called reactants.**
- **The new substances produced as a result of chemical reaction are called products.**

- **The burning of magnesium in air to form magnesium oxide is an example of a chemical reaction.**
- **before burning in air, the magnesium ribbon is cleaned by rubbing with a sand paper. This is done to remove the protective layer of magnesium oxide from the surface of magnesium ribbon**

SOME EXAMPLE OF CHEMICAL REACTIONS

- **Souring of milk**
- **Formation of curd from milk**
- **Cooking of food**
- **Digestion of food in our body, Process of respiration**
- **Fermentation of grapes**
- **Rusting of iron**
- **Burning of fuels**
- **Burning of candle wax**
- **Ripening of fruits,**

- **The important characteristics of chemical reactions are :**

- **Evolution of a gas,**
- **Formation of a precipitate,**
- **Change in colour,**

- **Change in temperature,**
- **Change in state.**

- **Some chemical reactions are characterised by the evolution of a gas.**

- **The chemical reaction between zinc and dilute sulphuric acid is characterised by the evolution of hydrogen gas.**

- **The chemical reaction between sodium carbonate and dilute hydrochloric acid is characterised by the evolution of carbon dioxide gas.**

- **A precipitate is a 'solid product' which separates out from the solution during a chemical reaction.**

- **Some chemical reactions are characterised by the formation of a precipitate.**

- **the chemical reaction between potassium iodide and lead nitrate is characterised by the formation of a yellow precipitate of lead iodide.**
- **The chemical reaction between sulphuric acid and barium chloride solution is characterised by the formation of a white precipitate of barium sulphate.**

- **Some chemical reactions are characterised by a change in colour.**

- **the chemical reaction between citric acid and purple coloured potassium permanganate solution is characterised by a change in colour from purple to colourless.**
- **the chemical reaction between Sulphur dioxide gas and acidified potassium dichromate solution is characterised by a change in colour from orange to green.**

- **Some chemical reactions are characterised by a change in temperature.**

- **the chemical reaction between quicklime and water to form slaked lime is characterised by a change in temperature (which is rise in temperature).**

- **the chemical reaction between zinc granules and dilute sulphuric acid is also characterised by a change in temperature (which is rise in temperature).**

- **the chemical reaction between barium hydroxide and ammonium chloride to form barium chloride, ammonia and water is characterized by a change in temperature (which is fall in temperature)**

- **Some chemical reactions are characterised by a change in state.**

- **the combustion reaction of candle wax is characterised by a change in state from solid to liquid and gas (because wax is a solid, water formed by the combustion of wax is a liquid at room temperature whereas carbon dioxide produced by the combustion of wax is a gas).**

- **There are some chemical reactions which can show more than one characteristics.**

- **The method of representing a chemical reaction with the help of symbols and formulae of the substances involved in it is known as a chemical equation.**

- **The substances which combine or react are known as reactants.**
- **The new substances produced in a reaction are known as products.**

- **A chemical equation is a short-hand method of representing a chemical reaction.**

1. A balanced chemical equation has an equal number of atoms of different elements in the reactants and products. A balanced chemical equation has equal masses of various elements in reactants and products.

2. An unbalanced chemical equation has an unequal number of atoms of one or more elements in the reactants and products.

- **An unbalanced equation has unequal masses of various elements in reactants and products.**

"matter can neither be created nor destroyed in a chemical reaction"

- **the number of various types of atoms in reactants must be equal to the number of same type of atoms in products.**
- **the chemical equations are balanced to satisfy the law of conservation of mass in chemical reactions.**
- **we should never change the formula of an element or a compound to balance an equation.**
- **The process of making the number of different types of atoms equal on both the sides of an equation is called balancing of equation.**

- **The chemical equations can be made more informative in three ways :**

1. By indicating the "physical states" of the reactants and products.
2. By indicating the "heat changes" taking place in the reaction.
3. By indicating the "conditions" under which the reaction takes place.

- **Those reactions in which heat is evolved are known as exothermic reactions. The burning of carbon in oxygen is an exothermic reaction**

- **An exothermic reaction is indicated by writing "+ Heat" or "+ Heat energy" or just "+ Energy" on the products'side of an equation.**

- **The burning of natural gas is an exothermic reaction**

- **All the combustion reactions are exothermic reactions.**

- **This glucose then undergoes slow combustion by combining with oxygen in the cells of our body to produce energy in a process called respiration. In addition to other functions, this energy maintains our body heat.**

- **Respiration is an exothermic process because energy is produced during this process.**

- **The burning of a magnesium wire in air to form magnesium oxide is an exothermic reaction.**

- **Those reactions in which heat is absorbed are known as endothermic reactions.**

- **The reaction between nitrogen and oxygen to form nitrogen monoxide is an endothermic reaction**

- **An endothermic reaction is usually indicated by writing "+ Heat" or "+ Heat energy " or just "+ Energy" on the reactants' side of an equation.**

- **All the decomposition reactions are endothermic reactions.**
- **The decomposition of calcium carbonate is an endothermic reaction**
- **Photosynthesis is an endothermic reaction.**
- **The electrolysis of water to form hydrogen and oxygen is also an endothermic reaction.**

- **To Indicate the Conditions Under Which the Reaction Takes Place.**

  - **Methanol (or Methyl alcohol) is manufactured from carbon monoxide and hydrogen.**

$$CO\,(g) + 2H_2\,(g) \xrightarrow{300\ atm;\ 300^{\circ}C\ ZnO + CrO} CH_3OH\,(l)$$

  - **The green plants make food by photosynthesis.**

$$6CO_2\,(g) + 6H_2O\,(l) \xrightarrow{(Sunlight,\ Chlorophyll)} C_6H_{12}O_6\,(aq) + 6O_2\,(g)$$

  - **Iron (II) oxide, FeO. This is called iron (II) oxide because the valency of iron in it is II (two). The common name of iron (two) oxide, FeO, is ferrous oxide.**
  - **Iron (III) oxide, Fe_2O_3. This is called iron (III) oxide because the valency of iron in it is III (three). The common name of iron (three) oxide, Fe_2O_3, is ferric oxide.**

TYPES OF CHEMICAL REACTIONS

1. Combination reactions,
2. Decomposition reactions,
3. Displacement reactions,
4. Double displacement reactions,
5. Oxidation and Reduction reactions.

- **Those reactions in which two or more substances combine to form a single substance, are called combination reactions.**

- **the formation of water from hydrogen and oxygen is a combination reaction.**
- **two elements combine to form a single compound.**
- **two or more compounds combine together to form a new compound.**

(i) **H2 (g) + Cl2 (g)) ⟶ 2HCl (g)**

(ii) **3H2 + N2 ⟶ 2NH3**

(iii) **Fe (s) + S (s) ⟶ FeS (s)**

- **Those reactions in which a compound splits up into two or more simpler substances are known as decomposition reactions.**
- **a decomposition reaction is just the opposite of a combination reaction.**

- **When a decomposition reaction is carried out by heating, it is called 'thermal decomposition'.**
- **by the action of heat.**
- **by using electricity**
- **by light energy.**

$$\underset{\text{Calcium carbonate (Limestone)}}{CaCO_3\ (s)} \xrightarrow[\text{(Decomposition)}]{\text{Heat}} \underset{\text{Calcium oxide (Lime)}}{CaO\ (s)} + \underset{\text{Carbon dioxide}}{CO_2\ (g)}$$

$$\underset{\text{Ferrous sulphate (Green colour)}}{2FeSO_4\ (s)} \xrightarrow[\text{(Decomposition)}]{\text{Heat}} \underset{\text{Ferric oxide (Brown colour)}}{Fe_2O_3\ (s)} + \underset{\text{Sulphur dioxide}}{SO_2\ (g)} + \underset{\text{Sulphur trioxide}}{SO_3\ (g)}$$

$$2Pb(NO_3)_2\,(s) \xrightarrow[\text{(Decomposition)}]{\text{Heat}} 2PbO\,(s) + 4NO_2\,(g) + O_2\,(g)$$

Lead nitrate (Colourless) → Lead monoxide (Yellow) + Nitrogen dioxide (Brown fumes) + Oxygen

$$2Al_2O_3\,(l) \xrightarrow[\text{(Decomposition)}]{\text{Electricity}} 4Al\,(l) + 3O_2\,(g)$$

Aluminium oxide (Molten) → Aluminium metal + Oxygen gas

$$2AgCl\,(s) \xrightarrow[\text{(Decomposition)}]{\text{Light}} 2Ag\,(s) + Cl_2\,(g)$$

Silver chloride (White) → Silver (Greyish white) + Chlorine (Yellowish-green)

➢ REACTIVITY SERIES OF METALS

Reactivity Series (or Activity Series) of Metals

These metals are more reactive than hydrogen	Potassium	K	(Most reactive metal)
	Sodium	Na	
	Calcium	Ca	
	Magnesium	Mg	
	Aluminium	Al	
	Zinc	Zn	
	Iron	Fe	Decreasing chemical reactivity
	Tin	Sn	
	Lead	Pb	
	[Hydrogen]	[H]	
These metals are less reactive than hydrogen	Copper	Cu	
	Mercury	Hg	
	Silver	Ag	
	Gold	Au	(Least reactive metal)

Those reactions in which one element takes the place of another element in a compound, are known as displacement reactions.

Salt solution of metal B + Metal A ⟶ Salt solution of metal A + Metal B

- **this displacement reaction takes place because zinc is more reactive than copper.**

$CuSO_4$ (aq)	+	Zn (s)	⟶	$ZnSO_4$ (aq)	+	Cu (s)
Copper sulphate (Blue solution)		Zinc (Silvery-white)		Zinc sulphate (Colourless solution)		Copper (Red-brown)

- **magnesium is able to displace copper from copper sulphate solution because magnesium is more reactive than copper.**

- **This displacement reaction occurs because iron is more reactive than copper.**

$CuSO_4$ (aq)	+	Fe (s)	⟶	$FeSO_4$ (aq)	+	Cu (s)
Copper (II) sulphate (Blue solution)		Iron metal (From iron pot)		Iron (II) sulphate (Greenish solution)		Copper metal

- **lead is able to displace copper from copper chloride solution because lead is more reactive than copper.**

$CuCl_2$ (aq)	+	Pb (s)	⟶	$PbCl_2$ (aq)	+	Cu (s)
Copper chloride (Green solution)		Lead (Bluish grey)		Lead chloride (Colourless solution)		Copper (Red-brown)

- **This displacement reaction occurs because copper is more reactive than silver.**

$$\underset{\text{Silver nitrate (Colourless solution)}}{2AgNO_3\,(aq)} + \underset{\text{Copper (Red-brown)}}{Cu\,(s)} \longrightarrow \underset{\text{Copper nitrate (Blue solution)}}{Cu(NO_3)_2\,(aq)} + \underset{\text{Silver (Greyish white)}}{2Ag\,(s)}$$

- **This displacement reaction takes place because iron is more reactive than hydrogen.**

$$\underset{\text{Iron (As iron filings)}}{Fe\,(s)} + \underset{\text{Hydrochloric acid}}{2HCl\,(aq)} \longrightarrow \underset{\text{Iron (II) chloride (Ferrous chloride)}}{FeCl_2\,(aq)} + \underset{\text{Hydrogen}}{H_2\,(g)}$$

- **This displacement reaction occurs because magnesium is more reactive than hydrogen.**

$$\underset{\text{Magnesium}}{Mg\,(s)} + \underset{\text{Hydrochloric acid}}{2HCl\,(aq)} \longrightarrow \underset{\text{Magnesium chloride}}{MgCl_2\,(aq)} + \underset{\text{Hydrogen}}{H_2\,(g)}$$

- **Those reactions in which two compounds react by an exchange of ions to form two new compounds are called double displacement reactions.**
- **Any reaction in which an insoluble solid (called precipitate) is formed that separates from the solution is called a precipitation reaction.**

- $$\underset{\text{Silver nitrate}}{AgNO_3\,(aq)} + \underset{\text{Sodium chloride}}{NaCl\,(aq)} \longrightarrow \underset{\text{Silver chloride (White ppt.)}}{AgCl\,(s)} + \underset{\text{Sodium nitrate}}{NaNO_3\,(aq)}$$
- $$\underset{\text{Barium chloride}}{BaCl_2\,(aq)} + \underset{\text{Sodium sulphate}}{Na_2SO_4\,(aq)} \longrightarrow \underset{\text{Barium sulphate (White ppt.)}}{BaSO_4\,(s)} + \underset{\text{Sodium chloride}}{2NaCl\,(aq)}$$

- $AlCl_3\ (aq) + 3NH_4OH\ (aq) \longrightarrow Al(OH)_3\ (s) + 3NH_4Cl\ (aq)$
  Aluminium chloride — Ammonium hydroxide — Aluminium hydroxide (White ppt.) — Ammonium chloride

  $Pb(NO_3)_2\ (aq) + 2KI\ (aq) \longrightarrow PbI_2\ (s) + 2KNO_3\ (aq)$
  Lead nitrate — Potassium iodide — Lead iodide (Yellow ppt.) — Potassium nitrate

Oxidation :

(i) **The addition of oxygen to a substance is called oxidation.**

(ii) **The removal of hydrogen from a substance is also called oxidation.**

Reduction :

(i) **The addition of hydrogen to a substance is called reduction.**

(ii) **The removal of oxygen from a substance is also called reduction.**

- **the process of reduction is just the opposite of oxidation.**
- **oxidation and reduction occur together.**

Oxidising agent :
(*i*) The substance which gives oxygen for oxidation is called an oxidising agent.
(*ii*) The substance which removes hydrogen is also called an oxidising agent.

Reducing agent :
(*i*) The substance which gives hydrogen for reduction is called a reducing agent.
(*ii*) The substance which removes oxygen is also called a reducing agent.

- **The oxidation and reduction reactions are also called redox reactions.**

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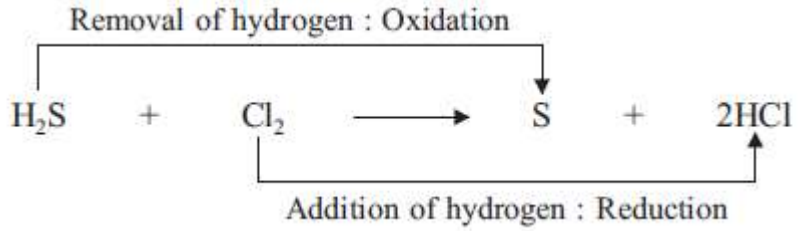

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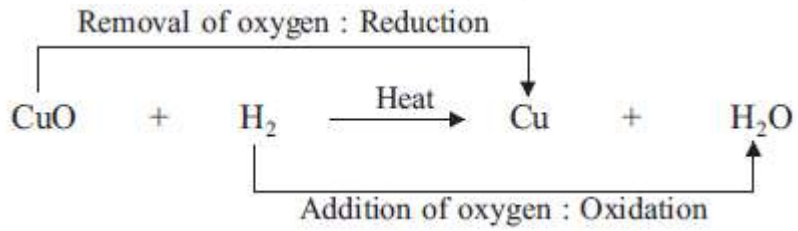

- **There is another concept of oxidation and reduction in terms of metals and non-metals.**

- **The addition of non-metallic element (or removal of metallic element) is called oxidation.**

- **The addition of metallic element (or removal of non-metallic element) is called reduction.**

there are two common effects of oxidation reactions which we observe in daily life.

These are :

1. Corrosion of metals ,

2. Rancidity of food.

Corrosion

Corrosion is the process in which metals are eaten up gradually by the action of air, moisture or a chemical (such as an acid) on their surface.

- **Rusting of iron metal is the most common form of corrosion.**
- **The rusting of iron is a redox reaction**

$$\underset{\text{Iron}}{4Fe} + \underset{\text{Oxygen}}{3O_2} + \underset{\text{Water}}{2xH_2O} \longrightarrow \underset{\text{Hydrated iron (III) oxide (Rust)}}{2Fe_2O_3.xH_2O}$$

- **Corrosion weakens the iron and steel objects and structures such as railings, car bodies, bridges and ships, etc., and cuts short their life.**

Rancidity

The condition produced by aerial oxidation of fats and oils in foods marked by unpleasant smell and taste is called rancidity.

1. Rancidity can be prevented by adding anti-oxidants to foods containing fats and oils.

2. Rancidity can be prevented by packaging fat and oil containing foods in nitrogen gas.

3. Rancidity can be retarded by keeping food in a refrigerator

4. Rancidity can be retarded by storing food in air-tight containers.

5. Rancidity can be retarded by storing foods away from light.