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CHEMICAL REACTIONS AND EQUATIONS

- A complete chemical equation represents the **reactants**, **products** and their **physical state symbolically.**
- Following observations helps us to determine whether a chemical reaction has taken place:
  - Change in state
  - Change in colour
  - Evolution of a gas
  - Change in temperature.
- Some of the **examples of chemical reactions** in everyday life:
  - Photosynthesis
  - Aerobic Cellular Respiration
  - Combustion of wood
  - Rusting of iron
  - Metathesis
  - Digestion
  - Cooking an egg
  - Souring of milk
  - Rotting bananas
- **Exothermic reactions** are reactions or processes that release energy, usually in the form of heat or light.
- Reactions in which **energy is absorbed** are known as **endothermic reactions**.

Balanced Chemical Equations

- Mass can neither be created nor destroyed in a chemical reaction. That is, the total mass of the elements present in the products of a chemical reaction has to be equal to the total mass of the elements present in the reactants.
- The number of atoms of each element remains the same, before and after a chemical reaction. Some of the examples of balanced equations:

  $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$

  $3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$

Types Of Chemical Reactions

Combination Reaction

- In a combination reaction two or more substances combine to form a new single Substance. Example of combination reaction:

Calcium oxide reacts vigorously with water to produce **slaked lime (calcium hydroxide)** Releasing a large amount of heat

$CaO\ (s) + H2O\ (l) \rightarrow Ca\ (OH)_2 + Heat$

- A solution of **slaked lime** produced by the above reaction is used for **white washing wall.**

NOTE: **Calcium hydroxide** reacts slowly with the **carbon dioxide** in air to form a thin layer of calcium carbonate on the walls. **Calcium carbonate** is formed after two to three days of **whitewashing** and gives a shiny finish to the walls. It is interesting to note that the **chemical formula** for **marble is also $CaCO_3$.**

$$Ca\ (OH)_2 + CO2\ (g) \rightarrow CaCO3\ (s) + H2O\ (l)$$

(Calcium hydroxide) (Calcium Carbonate)

Decomposition Reaction

- Decomposition reactions are opposite to combination reactions. In a decomposition reaction, a single substance decomposes to give two or more substances.
- In this reaction, you can observe that a single reactant breaks down to give simpler products. This is a decomposition reaction.

  $2FeSO_4(s)\ Heat \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$
- Decomposition of Silver bromide into silver and chlorine by light.

$$2AgBr(s) \xrightarrow{\text{Sunlight}} 2Ag(s) + Br_2(g)$$

- **Silver bromide** used in black and white **photography.**
- Decomposition of calcium carbonate to calcium oxide and carbon dioxide on heating is an important decomposition reaction used in various industries. **Calcium oxide** is called **lime or quick lime**. It has many uses – one is in the **manufacture of cement.** When a **decomposition reaction is carried out by heating**, it is called **thermal decomposition.**

$$CaCO_3\ (s) \xrightarrow{\text{Heat}} CaO(s) + CO_2\ (g)$$

(Limestone)

Displacement Reaction

- It is a reaction between an element and a compound. When they react, one of the elements of the compound- reactant is replaced by the element-reactant to form a new compound and an element.

  $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$
- In this reaction, iron has displaced or removed another element copper from copper sulphate solution. This reaction is known as displacement reaction.

Double Displacement Reactions

- When two compounds react, if their ions are interchanged, then the reaction is called double displacement reaction. The ion of one compound is replaced by the ion of another compound.

  Na_2SO_4 (aq) + $BaCl_2$ (aq) ⟶ $BaSO_4$ (s) + 2NaCl (aq)

Precipitation Reactions

- When aqueous solutions of two compounds are mixed, if they react to form an insoluble compound and a soluble compound, then it is called precipitation reaction. Because the insoluble compound, formed as one of the products, is a precipitate and hence the reaction is so called.
- Precipitation reactions produce insoluble salts.

Neutralisation Reaction

- When an acid and a base react together to form salt and water, it is known as neutralization reaction.

  HCl + NaOH ⟶ H_2O + NaCl

Oxidation and Reduction

Oxidation

- The chemical reaction which involves addition of oxygen or removal of hydrogen or loss of electrons is called oxidation.

  2 Mg + O_2 ⟶ 2MgO (addition of oxygen)

  CaH_2 ⟶ Ca + H_2 (removal of hydrogen)

  Fe^{2+} ⟶ Fe^{3+} + e− (loss of electron)

Reduction

- The chemical reaction which involves addition of hydrogen or removal of oxygen or gain of electrons is called reduction.

  2 Na + H_2 ⟶ 2 NaH (addition of hydrogen)

  CuO + H_2 ⟶ Cu + H_2O (removal of oxygen)

  Fe^{3+} + e− ⟶ Fe^{2+} (gain of electron)

Redox Reactions

- Generally, the oxidation and reduction occurs in the same reaction (simultaneously). If one reactant gets oxidized, the other gets reduced. Such reactions are called oxidation-reduction

reactions or Redox reactions.

$2\ PbO + C \longrightarrow 2\ Pb + CO_2$

$Zn + CuSO_4 \longrightarrow Cu + ZnSO_4$

Oxidation	Reduction
Addition of oxygen	Removal of oxygen
Removal of hydrogen	Addition of hydrogen
Loss of electron	Gain of electron

Oxidation and Reduction Agents

- Substance that loses oxygen or gains hydrogen is known as an oxidizing agent.
- Substance that loses hydrogen or gains oxygen is known as a reducing agent.
- Compounds with oxygen atom are called oxidizing agent and compounds with hydrogen atom are called reducing agent.
- Some compounds can act as either oxidizing agents or reducing agents. One example is hydrogen gas, which acts as an oxidizing agent when it combines with metals and As a reducing agent when it reacts with non- metals.

Oxidation reactions in daily life

- The shining surface of metals tarnishes due to the formation of respective metal oxides on their surfaces. This is called corrosion.
- The freshly cut surfaces of vegetables and fruits turn brown after some time because of the oxidation of compounds present in them.

Rancidity

- When oils and fats or foods containing oils and fats are exposed to air, they get oxidized due to which the food becomes stale and gives a bad taste or smell. This is called Rancidity.
- Following ways to **preventing rancidity:**
    - Adding antioxidants
    - Refrigerating
    - Storing food in airtight containers with nitrogen gas

Common Name and Formula of Chemical Compounds

Chemical Compounds	Chemical formula	Common names
Calcium oxide	Cao	Quick lime
Calcium hydroxide	$Ca(OH)_2$	Slaked lime
Calcium carbonate	$CaCO_3$	Limestone

Trichloro Methane	$CHCl_3$	Chloroform
Calcium Oxychloride	CaOCl2	Bleaching powder
Sodium hydrogencarbonate	$NaHCO_3$	Baking soda
Sodium carbonate	Na_2CO_3	Washing soda
Calcium sulphate hemihydrate	$CaSO_4$ .1/2H_2O	Plaster of paris
calcium sulfate dihydrate	CaSO .2H_2O	Gypsum
Acetic acid	CH_3COOH	Vinegar
Silicon Oxide	SiO_2	Sand
Methane	CH_4	Marsh Gas
Nitrous oxide	N_2O	Laughing Gas
Deuterium Oxide	D_2O	Heavy water
Solid Carbondioxide	CO_2	Dry ice
Calcium Carbonate	$CaCo_3$	Chalk
Sulphuric Acid	H_2SO_4	Oil of vitriol
Zinc sulphate	$ZnSO_4$	White Vitriol
Copper sulphate	$CuSO_4.5H_2O$	Blue Vitriol
Sodium hydroxide	NaOH	Caustic Soda
Potassium carbonate	K_2CO_3	Potash Ash
Mercurous chloride	Hg_2Cl_2	Calomel
Sucrose	$C_{12}H_{22}O_{11}$	Sugar
Silver nitrate	$AgNO_3$	Lunar caustic
Ethyl Alcohol	C_2H_6O	Alcohol
Hydrochloric acid	HCl	Muriatic acid

Chemical Compounds and Formula

Chemical Compounds	Chemical formula
Sodium chloride	NaCl
Zinc sulphate	$ZnSO_4$
Glucose	$C_6H_{12}O_6$
Ferric oxide	Fe_2O_3
Ferrous sulphate	$FeSO_4$
Lead oxide	PbO
Lead nitrate	$Pb(NO_3)_2$
silver chloride	AgCl
Silver bromide	AgBr
Sodium sulphate	Na_2SO_4

Chemical Bonding

Attraction between atoms, ions or molecules that enables the formation of chemical compounds is called chemical bonding.

Types Of Chemical Bonding

- **Ionic bond** - Chemical bond formed between two atoms due to transfer of electron from one atom to the other atom.
- **Covalent bond** - A covalent bond is a chemical bond that involves the sharing of electron between two atoms.
- **Metallic bond** - Metallic bond is the force of attraction between metal ions to a number of electrons within its sphere of influence.