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CHAPTER 1

CHEMICAL REACTIONS AND EQUATIONS

Chemical Equations:-

- A complete chemical equation represents the reactants, products and their physical states symbolically.
- The simplest way to write a chemical reaction in the form of a word—equation.
- The description of a chemical reaction in a sentence form is quite long. So we use symbol to write it is called chemical equation.

Reactant:-

- The substances that undergo chemical change in the reaction are the reactant.

Product:-

- The new substance formed during the reaction, is the product.
- Example:- Mg (Magnesium) + O_2 (Oxygen) $\rightarrow$ MgO (Magnesium oxide)

  ↓ Reactant ↓ Product

- The reactants are written on the left hand side (L.H.S) with a plus sign (+) between them.
- Products are written on the right hand side (R.H.S) with a plus sign (+) between them.
- The arrow head points towards the products, and show the direction of the reaction.

Writing a Chemical Equation:-

- Chemical equation can made more concise and useful if we use chemical formula instead of words.
- A chemical equation represents a chemical reaction.
- Word form of an equation.

  Zinc + Sulphuric acid $\rightarrow$ Zinc Sulphate + Hydrogen
- The above word equation may be represented by the following symbolic equation.
- $Zn + H_2SO_4 \rightarrow Zn SO_4 + H_2$
- The unbalanced equation is known as a skeletal chemical equation for a reaction.

Balanced chemical equation:-

- The number of atoms of each element remains the same, before and after a chemical reaction.

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- The total mass of the element present in the products, of a chemical reaction has to be equal to the total mass of the element presents in reactants.
- Hence, we need to balance a skeletal chemical equation.

How to balance a chemical equation?

- To balance the following chemical equation
- $Fe + H_2O \rightarrow Fe_3O_4 + H_2$
- Steps follow while balancing chemical equation

1st Step: -

- Draw boxes around each formula.
- Do not change anything inside the box

$$\boxed{Fe} + \boxed{H_2O} \rightarrow \boxed{Fe_3O_4} + \boxed{H_2}$$

2nd Step: - List the number of atoms present in the reactants and product.

Element	No. of atoms in reactant(LHS)	No. of atoms in product(RHS)
Fe	1	3
H	2	2
O	1	4

3rd Step:-

- Start balancing with the compound that contains the maximum number of atoms.
- It may be reactant or a product.
- In the above equation oxygen has contain maximum number of atoms. To balance the oxygen atoms.

Atom of oxygen	In Reactants	In Products
Initial	1(in H_2O)	4(in Fe_3O_4)
To balance	1x4	4

- While balancing we cannot alter the formula of the compounds or elements involved in the reactions. Exp: - H_2O_4 or $(H_2O)_4$, these are incorrect we write it as $4H_2O$.
- Hence, Now partly balanced equation

$$\boxed{Fe} + 4\boxed{H_2O} \rightarrow \boxed{Fe_3O_4} + \boxed{H_2}$$

4th Step:-

- Fe and H atoms still not balanced, follow step 3. To equalize the number of H atoms.

Atom of Hydrogen	In Reactants	In Products
Initial	8(in $4H_2O$)	2(in H_2)
To balance	8	2x4

- The equation would be,

$$\boxed{Fe} + 4\boxed{H_2O} \rightarrow \boxed{Fe_3O_4} + 4\boxed{H_2} \longrightarrow \text{partly balanced equation}$$

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5th Step:-

- Check the above equation and picked up the remaining unbalanced element and follow step 3 again.
- To balance Fe (Iron) atoms

Atom of Iron	In Reactants	In Products
Initial	1(in Fe)	3(in Fe_3O_4)
To balance	1x3	3

- To equalize Fe, we take three atoms of Fe on the LHS

$$3\boxed{Fe} + 4\boxed{H_2O} \rightarrow \boxed{Fe_3O_4} + 4\boxed{H_2} \longrightarrow \text{Balanced equation}$$

6th Step:-

- Finally, to check the balanced equation, we count atoms of each element on both sides of the equation.
- Once the equation is balance we can write it in below mention form.

$$\boxed{3Fe + 4\,H_2O = Fe_3O_4 + 4H_2} \longrightarrow \text{Balanced equation}$$

- The number of atoms of element on both sides is equal. This equation is now balanced.
- This method of balancing chemical equations is called Hit-and-Trail method.

7th Step: - Writing symbols of physical states:-

- The above balanced equation does not tell us anything about the physical state of each reactant and product.
- To make a chemical equation more informative, the physical States of the reactants and products are mentioned along with their chemical formula.
- The state of reactants and products are represented by the following notations.
- a. Gaseous (g) b. Liquid (l) c. Aqueous (aq.) and d. Solid (s)
- Now the above balanced equation becomes—
- $3Fe\,(s) + 4\,H_2O\,(g) = Fe_3O_4\,(s) + 4H_2\,(g)$
- Here symbol (g) with H_2O indicates that in this reaction water is used in the form of steam.
- Physical states are not included in a chemical equation unless it is necessary to specify them.
- The reaction conditions, such as temperature, pressure, catalyst etc. included above or below the arrow in the equation.
- $CO\,(g) + 4H_2\,(g) \xrightarrow{340\ atm.} CH_3OH\,(l)$
- $6CO_2\,(aq.) + 12H_2O\,(l) \xrightarrow[chlorophyll]{sunlight} C_6H_{12}O_6\,(aq.) + 6O_2\,(aq.) + 6H_2O\,(l)$

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Chemical reaction:-

- It is a process in which one or more substance formed new substance.
- It can't reversed by physical method.

Chemical reaction involves:-

- Change in state
- Change in colour
- Change in temperature
- Evolution of gas

Chemical reaction happen in our daily life:-

- Digestion of food
- Respiration
- Rusting of iron
- Formation of curd

Types of chemical reaction:-

1. Combination reaction:-

- When two or more substances (element and compounds) combine to form a single products reactions are called combination reactions.
- Example of combination reactions—

Burning of Coal:-

- $C(s) + O_2(g) = CO_2(g)$

Formation of water from H_2 (g) and O_2 (g):-

- $2H_2(g) + O_2(g) = 2H_2O(l)$
- Calcium oxide reacts vigorously with water to produced slaked lime (calcium hydroxide) releasing a large amount of heat.
- $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq.)$

Quick lime Slaked lime

- Slaked lime is produced by the reaction used for white washing walls.
- Slaked lime 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 or three days of white washing and gives a shinny finish to the walls.

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- The chemical formula of marble is also $CaCO_3$.
- $Ca(OH)_2$ (aq.) + CO_2 (g) → $CaCO_3$ + H_2O (l)

  Calcium hydroxide calcium carbonate
- As we observed in the above equation large amount heat release.
- Reaction in which heat is released along with the formation of product is called **exothermic chemical reaction.**
- Other example of exothermic reaction:-

Burning of natural gas:-

- CH_4 (g) + $2O_2$ (g) → CO_2 (g) + $2H_2O$ (g)
- **Respiration is also an exothermic reaction:-**
- Carbohydrates are broken down to form glucose. This glucose combines oxygen in the cell of our body and provides energy. The special name of this reaction is respiration.
- $C_6H_{12}O_6$ (aq.) + $6O_2$ (aq.) → $6CO_2$ (aq.) + $6H_2O$ (l) + Energy

2. Decomposition reaction:-

- A single reactant breaks down to give two or more products. This is known as decomposition reaction.
- Example :- $2FeSO_4$ (s) $\xrightarrow{Heat}$ Fe_2O_3 (s) + SO_2 (g) + SO_3 (g)
- Ferrous Sulphates crystals ($FeSO_4.7H_2O$) lose water when heated and the green colour of the crystals changes.
- It than decomposes to ferric oxide (Fe_2O_3), sulphur dioxide (SO_2) and sulphur trioxide (SO_3).
- Ferric oxide is a solid while SO_2 and SO_3 are gases.
- Types of decomposition reaction:-
  a. Thermal decomposition
  b. Electrolytic decomposition
  c. Photolysis decomposition

Thermal decomposition:-

- When a decomposition reaction is carried out by heating, it is called thermal decomposition.
- Example:- $CaCO_3$ (s) $\xrightarrow{Heat}$ CaO (s) + CO_2 (g)
- Decomposition of calcium carbonate to calcium oxide and carbon dioxide on heating is an important decomposition reaction.
- Calcium oxide is called lime or quick lime.
- It is use in the manufacturing of cement.
- Another example of thermal decomposition.

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

Electrolytic Decomposition:-

- When decomposition is carried out by passing electricity is called Electrolytic Decomposition.
- Example:- $H_2O(l) \xrightarrow[current]{Electric} H_2(g) + O_2(g)$

Photolysis Decomposition:-

- When decomposition is carried out in presence of sunlight is called Photolysis decomposition.
- Example:- $2AgCl(S) \xrightarrow{Sunlight} 2Ag(s) + Cl_2(g)$
- White silver chloride turns grey in sunlight. This is due to the decomposition of silver chloride into silver and chlorine.
- $2AgBr(S) \xrightarrow{Sunlight} 2Ag(s) + Br_2(g)$
- Silver bromide also behaves in the same way as silver chloride.
- The above reactions are used in black and photography.
- As we seen that the decomposition reactions require energy either in the form heat, light, Electricity for breaking down the reaction.
- Reaction in which energy is absorbed is known as **endothermic reaction**.

3. Displacement reaction:-

- The reaction in which more reactive element displaces less reactive element from its solution. This reaction is known as displacement reaction.
- Example:- $Fe(s) + CuSO_4(aq.) \longrightarrow FeSO_4(aq.) + Cu(s)$

  Copper Sulphate — Iron Sulphate
- In this reaction iron has displaced or removed another element, Copper, from Copper Sulphate solution.
- $Zn(s) + CuSO_4(aq.) \longrightarrow ZnSO_4(aq.) + Cu(s)$

  Copper Sulphate — Zinc Sulphate
- $Pb(s) + CuCl_2(aq.) \longrightarrow PbCl_2(aq.) + Cu(s)$

  Copper chloride — Lead chloride
- Zinc and Lead are more reactive elements than Copper.

4. Double Displacement reaction:-

- A reaction in which there is an exchange of irons between the reactants is called double displacement reaction.

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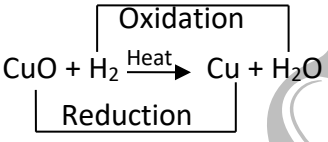
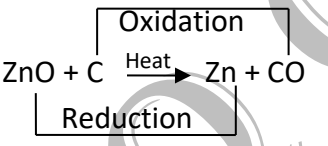
- Example:- $Na_2SO_4(aq.) + BaCl_2(aq.) \longrightarrow BaSO_4(s) + 2NaCl(aq.)$

  Sodium Sulphate Barium chloride Barium Sulphate Sodium chloride
- The white precipitate of $BaSO_4$ is formed by the reaction of SO_4^{2-} and Ba^{2+}. The other product is sodium chloride which remains in the solution.
- The white substance, which is insoluble in water, is formed. This insoluble substance formed is known as a precipitate.
- Any reaction that produces a precipitate can be called a precipitation reaction.

5. <u>Oxidation and reduction reaction:-</u>

- If a substance gains oxygen or loses hydrogen during a reaction, it is oxidized. This reaction is known as **Oxidation reaction**.
- Example:- $2Cu + O_2 \xrightarrow{Heat} 2CuO$
- The surface of copper becomes coated with black copper oxide because oxygen is added to copper and copper oxide is formed.
- If a substance loses oxygen or gains hydrogen during a reaction, it is reduced. This reaction is known as **Reduction reaction**.
- Example:- $CuO + H_2 \xrightarrow{Heat} Cu + H_2O$
- If the hydrogen gas is passed over copper oxide, the black coating on the surface turns brown as the reverse reaction take place and copper is formed.
- One reactant gets oxidized while the other gets reduced during a reaction. Such a reaction is called Oxidation-Reduction reaction or redox reaction.





<u>Effects of oxidation-reduction in everyday life:-</u>

<u>Corrosion:-</u>

- Iron articles are shiny but get coated with a redish brown powder when left outside for some time. This process is commonly known as resulting of iron.
- When a metal is attacked by substances around it. Such as moisture, acids etc. it is said to corrode and this process is called Corrosion.
- Corrosion causes damage to car bodies, bridge, iron rolling, ships and all objects made of metals, especially those of iron.
- It is a serious problem and spent huge amount every year to replaced the damaged.

<u>Rancidity:-</u>

- When fats and oil exposed to air are oxidized and this is known as Rancidity.
- It lead to change the smell and taste of food.
- Chips manufacturers use nitrogen to prevent the chips from getting oxidized.

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