CHEMICAL REACTIONS & EQUATIONS

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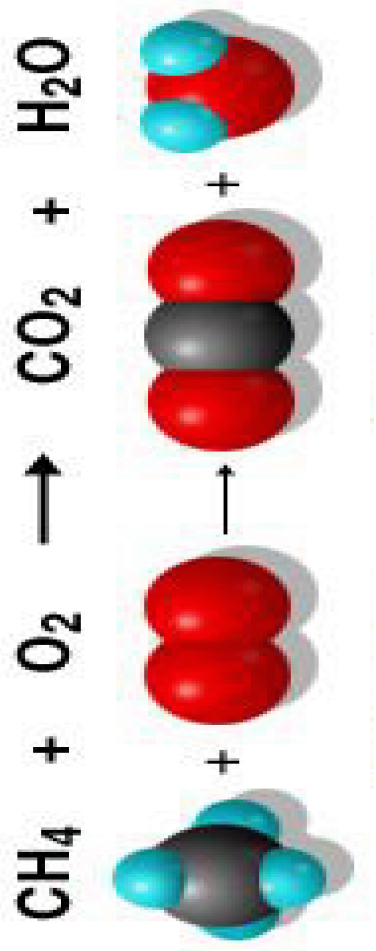
Concepts



INTRODUCTION

Change is the law of nature.

There are so many situations of daily life, where we can observe various changes.

Like,

(i) Conversion of tea into vapours from a cup of hot tea.

(ii) Corrosion of iron articles (rusting) if exposed to humid atmosphere.

(iii) Cooking of food.

(iv) Digestion of food in our body.

(v) Breaking of any article like glass.

(vi) Combustion of fuel in our vehicle.

Scientist classify these changes as

(1) Physical changes

(2) Chemical changes

1. PHYSICAL CHANGES

A change in which physical properties of a substance changes but the chemical composition do not change.

For example, Freezing, melting, boiling, condensation, etc.

Characteristic features of physical changes

(1) The identity of the substance is maintained.

(2) The change is generally temporary.

(3) Heat change may or may not take place.

(4) Only the physical state or some of the physical properties of the substances are changed.

2. CHEMICAL CHANGES

A change in which one or more substances change into new substances with a different chemical composition.

For example, Burning of a candle, rusting of iron, combustion of fuel, etc.

Characteristic features of chemical changes

(1) The identity of the original substance is completely lost.

(2) The change is generally permanent.

(3) The change is generally accompained by energy change.

(4) The change cannot be reversed generally.

Some differences between phycical and chemical changes

	Physical Change	Chemical change
1.	No new substance is formed	A new substance is formed
2.	Temporary change	Permanent change
3.	Easily reversible	Cannot be easily reversed

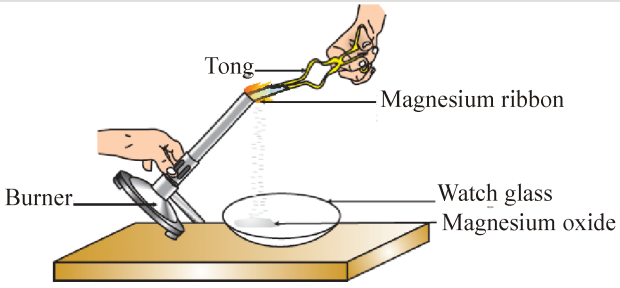
3. CHEMICAL ACTION OR REACTION

When we heat sugar crystals they melt and on further heating they give steamy vapour, leaving behind brownish black mass. On cooling no sugar crystals appear. Thus change which takes place on heating sugar is a chemical change and the process which brings about this chemical change is called chemical reaction. But how to conclude whether a chemical reaction has taken place ?
Let's discuss an activity to answer this question.

LAB TIME
Let's Do & Learn

- **Object : To study the reaction between magnesium and oxygen to form magnesium oxide.**
- **Preparation materials required :**
  Burner, tong, magnesium ribbon, sand paper, watch glass
- **Procedure :**

(i) Clean a magnesium ribbon about 2 cm long, by rubbing it with sand paper.
(ii) Hold it with a pair of tongs. Burn it using a spirit lamp or burner and collect the ash so formed in a watch glass. Burn the magnesium ribbon keeping it as far as possible from your eyes.



Burning of a magnesium ribbon in air and collection of magnesium oxide in a watch glass.

- **Observation :**

It is observed that magnesium ribbon burns with a dazzling white light and changes into a white powder. This powder is magnesium oxide.

LAB TIME
Let's Do & Learn

- **Conclusion :**

Magnesium burns in air to combine with oxygen to form magnesium oxide.

$$2Mg(s) + O_2(g) \xrightarrow{\Delta} 2MgO(s)$$

Magnesium + Oxygen (from air) → Reactants
Magnesium oxide (White powder) → Products

Focus Point

- Magnesium metal has a shining surface but due to attack of moist air, it is coated with a white layer of magnesium oxide.
  Therefore in order to use it for any chemical reaction, it is first rubbed with a sand paper.

Characteristics of a Chemical Reaction:

- In this reaction the substances which take part in bringing about chemical change are called reactants.
- The substances which are produced as a result of chemical change are called products.
- These reactions involve breaking and formation of chemical bonds.
- Product(s) of the reaction is/are new substances with new name(s) and chemical formulae.
- It is often difficult to reverse a chemical reaction.
- Properties of products formed during a chemical reaction are different from those of the reactants.
- Apart from heat other forms of energies are light and electricity which are also used in carrying out chemical changes.

In all chemical reactions, the transformation from reactants to products is accompanied by various characteristics, which are-

(i) Evolution of gas
(ii) Change of colour
(iii) Formation of precipitate
(iv) Energy changes
(v) Change in state

Focus Point

- Our body itself is a chemical laboratory where different chemical reactions take place.

3.1 EVOLUTION OF GAS

Some chemical reactions take place with the evolution of a gas.

For example,

Reaction between a metal such as zinc and dilute sulphuric acid produces hydrogen gas.

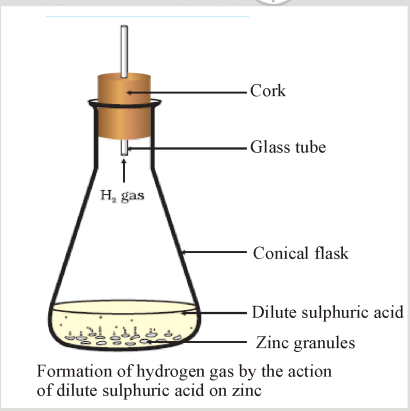
$$\underset{\text{zinc}}{Zn(s)} + \underset{\text{sulphuric acid}}{H_2SO_4(dil)} \rightarrow \underset{\text{zinc sulphate}}{ZnSO_4(aq)} + \underset{\text{hydrogen gas}}{H_2(g)}$$

An activity is given below to understand evolution of gas.

LAB TIME
Let's Do & Learn

- **Object : To study the reaction between zinc and sulphuric acid or hydrochloric acid.**
- **Preparation materials required :**
  Conical flask or test tube, zinc granules, dilute hydrochloric acid or sulphuric acid.
- **Procedure :**

(i) Take a few zinc granules in a conical flask or a test tube.
(ii) Add dilute hydrochloric acid or sulphuric acid to this.



Formation of hydrogen gas by the action of dilute sulphuric acid on zinc

- **Observation and discussion :**
  Bubbles of hydrogen gas are found to rise briskly from the surface of zinc pieces. The gas evolved can be tested by bringing a burning candle. It is found to burn with popping sound. Further, the flask is found to be, hot.

- **Conclusion :**
  Zinc reacts with dilute sulphuric acid or hydrochloric acid with the evolution of hydrogen gas and heat (i.e., reaction is exothermic).

$$Zn(s) + \text{dil. } H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)(\uparrow) + \text{Heat}$$

Zinc Sulphuric acid Zinc sulphate Hydrogen (gas)

Some more examples of characteristics of evolution of gas :

- Reaction between iron sulphide and dilute sulphuric acid produces hydrogen sulphide gas.

$$FeS(s) + H_2SO_4(dil) \rightarrow FeSO_4(aq) + H_2S(g)$$

iron sulphide ferrous sulphate hydrogen sulphide gas

- Heating a mixture of potassium chlorate ($KClO_3$) and manganese dioxide (MnO_2) gives oxygen gas.

$$2KClO_3(s) \xrightarrow[MnO_2]{\text{heat}} 2KCl(s) + 3O_2(g)$$

Potassium chlorate Potassium chloride Oxygen gas

MnO_2 is used as a catalyst in this reaction.

This reaction is used for the preparation of oxygen in the laboratory.

Focus Point

- Formation of a gaseous product is usually accompanied by bubbling in the solution.
- Think about catalyst.
- Think about industrial method for production of oxygen.

3.2 CHANGE OF COLOUR

Certain chemical reactions are characterised by the change in colour of reacting substances.
Let's understand this characteristics by following activity:

LAB TIME
Let's Do & Learn

- **Object : To study the reaction between lead nitrate solution and potassium iodie solution.**
- **Preparation materials required :**
  Test tube, lead nitrate solution, potassium iodide solution.
- **Procedure :**

(i) Take lead nitrate solution, potassium iodide solution.
(ii) Add potassium iodide solution to lead nitrate solution.

- **Conclusion :**
  Lead nitrate solution reacts with potassium iodide solution to form a yellow precipitate of lead iodide.

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

Lead nitrate	Potassium iodide	Lead (II) iodide	Potassium nirate
(Colourless)	(Colourless)	(Yellow ppt.)	(Colourless)

Some other examples of characteristics of change in colour are given below :

- When red lead oxide is heated strongly it forms yellow coloured lead monoxide and gives off oxygen gas.

$$2Pb_3O_4(s) \xrightarrow{heat} 6PbO(s) + O_2(g)$$

Lead oxide	Lead monoxide	
(Red)	(Yellow)	

- When copper carbonate (green) is heated strongly it leaves behind a black residue.

$$CuCO_3(s) \xrightarrow{heat} CuO(s) + CO_2(g)$$

Copper carbonate	Copper oxide	Carbon dioxide
(Green)	(Black)	

- When lead (II) nitrate is heated then NO_2 and O_2 gases are evolved.

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

Lead (II) nitrate	Lead (II) oxide	Nitrogen dioxide	
(White)	(Yellow)	(Brown)	

- When white sugar crystals are heated then it becomes black and water vapour is formed.

$$C_{12}H_{22}O_{11}(s) \xrightarrow{heat} 12C(s) + 11H_2O(g)$$

White sugar	Carbon black	Water

3.3 FORMATION OF PRECIPITATE

Some chemical reactions are characterised by the formation of precipitate (an insoluble substance), when the solutions of two soluble chemical compounds are mixed together.

Let's understand the formation of precipitate by following activity.

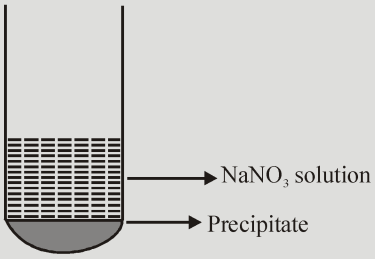
LAB TIME
Let's Do & Learn

- **Object : To study the reaction between silver nitrate solution and sodium chloride solution.**
- **Preparation materials required :**

  Test tubes, silver nitrate solution, sodium chloride solution.
- **Procedure :**

(i) Take silver nitrate solution and sodium chloride solution.

(ii) Add sodium chloride solution to silver nitrate solution.



Formation of precipitate

- **Conclusion :**

  Silver nitrate solution reacts with sodium chloride solution to form a white precipitate of silver chloride.

$$\underset{\text{Silver nitrate}}{AgNO_3(aq)} + \underset{\text{Sodium chloride (Colourless)}}{NaCl(aq)} \rightarrow \underset{\text{Sodium nitrate (Colourless)}}{NaNO_3(aq)} + \underset{\text{Silver chloride (White precipitate)}}{AgCl(s)}$$

Some other examples of characteristics of formation of precipitate are given below:

- A dirty green precipitate of ferrous hydroxide is formed, when a solution of ferrous sulphate is mixed with sodium hydroxide solution .

$$\underset{\text{Ferrous Sulphate}}{FeSO_4(aq)} + \underset{\text{Sodium hydroxide}}{2NaOH(aq)} \longrightarrow \underset{\text{Sodium sulphate}}{Na_2SO_4(aq)} + \underset{\text{Ferrous hydroxide (Green precipitate)}}{Fe(OH)_2(s)}$$

- A white precipitate of barium sulphate is formed, when dilute H_2SO_4 is added in barium chloride solution.

$$\underset{\text{Barium chloride}}{BaCl_2(aq)} + \text{dil } H_2SO_4 \longrightarrow \underset{\text{Barium sulphate (White precipitate)}}{BaSO_4(s)} + 2HCl(aq)$$

3.4 ENERGY CHANGES

Usually chemical reactions proceed either with the absorption or release of energy. On the basis of energy changes, there are two types of reactions :

(A) Endothermic reaction : A chemical reaction which is accompanied by the absorption of energy is called an endothermic reaction.

- $C(s) + 2S(s) \xrightarrow{\text{Heat}} CS_2(\ell)$
- $N_2(g) + O_2(g) \xrightarrow{\text{Heat}} 2NO(g)$

- When barium hydroxide,[$Ba(OH)_2$], is added into ammonium chloride, [NH_4Cl] , taken in a test tube, and mixed with a glass rod, then on touching the bottom of the test tube, it is found to be cooler. This is an example of endothermic reaction.
  $Ba(OH)_2 + 2NH_4Cl \longrightarrow BaCl_2 + 2NH_4OH$
- Light energy is essential for biochemical reaction, photosynthesis, by which green plants prepare their food from carbon dioxide & water.

(B) Exothermic reaction : A chemical reaction which is accompanied by the release of energy is called exothermic reaction.

- When magnesium wire is heated from its tip in a bunsen flame, it catches fire and burns with a dazzling white flame with release of heat and light energy.
  $2Mg(s) + O_2(g) \xrightarrow{Heat} 2MgO(s) + Energy$
- Burning of natural gas is exothermic reaction.
  $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$
- The decomposition of vegetable matter into compost is also an example of exothermic reaction.
- When quick lime (calcium oxide) is placed in water, the water becomes very hot and sometimes starts boiling.
  It is because of release of heat energy during the reaction.

$$\underset{\text{Calcium oxide}}{CaO(s)} + \underset{\text{Water}}{H_2O} \rightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2\,(aq)} + \text{Heat energy}$$

Focus Point

- Change in temperature during a reaction can be measured with the help of a thermometer.
- Energy change (like heat) can be shown by adding it either on reactant side or product side as per it is absorbed or released respectively.
- Think about white washing.

3.5 CHANGE OF STATE

Some chemical reactions are characterised by a change in state - i.e. solid, liquid or gas.
Some examples of characteristics of change in state are given below:

- Two volumes of hydrogen gas react with one volume of oxygen gas to form water.
  $2H_2(g) + O_2(g) \rightarrow 2H_2O(\ell)$
  Or when electric current is passed through water it splits into its elements.
  $2H_2O(\ell) \xrightarrow{\text{Electric current}} 2H_2(g) + O_2(g)$
- Ammonia gas reacts with hydrogen chloride to form ammonium chloride in solid state.

$$\underset{\text{Ammonia}}{NH_3(g)} + \underset{\text{Hydrogen chloride}}{HCl(g)} \longrightarrow \underset{\text{Ammonium chloride (white fume)}}{NH_4Cl(s)}$$

4. CHEMICAL EQUATION

All chemical changes are accompanied by chemical reactions. These reactions can be described in sentence form, but the description would be quite long. Chemical equations have been framed to describe the chemical reactions.

"A chemical equation is a shorthand representation of a chemical reaction using the symbols and formulae of substances involved in the chemical reaction."

For example, a chemical equation for reaction between zinc and hydrochloric acid can be given as:

Zinc + hydrochloric acid ⟶ Zinc chloride + hydrogen gas

(Zinc + hydrochloric acid: Reactants; Zinc chloride + hydrogen gas: Products)

Focus Point

- A chemical reaction can be summarised by chemical equation.
- **Reactants:-** The substance/substances, which take(s) part in a chemical reaction.
- **Products:-** The new substance/substances formed as a result of a chemical reaction are called products.

4.1 WRITING OF CHEMICAL EQUATION

(i) Word equation : A word equation links together the names of the reactants with those of the products.

For example,

- When magnesium ribbon burns in oxygen to form a white powder of magnesium oxide, may be written as follows-

  Magnesium + Oxygen ⟶ Magnesium oxide (word equation)
  (Reactants) (Products)

- Granulated zinc react with sulphuric acid and form zinc sulphate and hydrogen gas, may be written as.

  Zinc + Sulphuric acid → Zinc sulphate + Hydrogen (word equation)
  (Reactants) (Products)

In a word equation

- The reactants are written on the left hand side with a plus sign (+) between them.
- The products are written on the right hand side with a plus sign (+) between them.
- An arrow (→) separates the reactants from the products.
- The direction of the arrow head points towards the products.

  Reactant → Product

Focus Point

- Although word equations are quite useful, yet they don't give the true picture of chemical reactions.

(ii) Symbol equation : A brief representation of a chemical reaction in terms of symbols and formulae of the substances involved in it is known as a symbol equation.
In a symbol equation, the symbols and formulae of the elements and compounds are written instead of their word names.
For example,

- Burning of magnesium in oxygen to form magnesium oxide may be written as follows :

$Mg + O_2 \rightarrow MgO$ (Symbol equation)

Focus Point

- Symbol equations are always written from the words equations.

5. UNBALANCED AND BALANCED CHEMICAL EQUATIONS

(a) Unbalanced chemical equation/Skeletel Equation
In an unbalanced equation, the number of atoms of different elements on both sides of the equation are not equal.
For example,
The symbol equation of reaction between magnesium and oxygen is given as:

$$Mg + O_2 \rightarrow MgO$$

In the equation given above, the number of Mg atoms on both sides of the equation is one (same), but the number of oxygen atoms are not equal. It is known as an unbalanced equation.

Focus Point

- An unbalanced equation is also called skeletel equation.
- In a skeletal equation, law of conservation of mass is not followed.

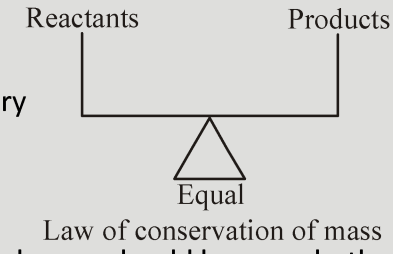
(b) Balanced chemical equation
In a balanced equation, the number of atoms of different elements on both sides of the equation are always equal.
The balanced equation for the burning of magnesium ribbon in oxygen is written as -

$$2Mg + O_2 \rightarrow 2MgO$$

In the equation given above, the number of Mg atoms on both sides of the equation is two(same), and the number of oxygen atoms on both sides are also two (same). It is known as a balanced equation.

Focus Point

- **Importance of balanced chemical equation:**
  The balancing of a chemical equation is essential or necessary to fulfil the requirement of "Law of conservation of mass".



- In balanced chemical equation number of atoms and electrical charges should be same both side.
- In a balanced chemical equation, an integer assigned with reactant and product is known as stoichiometric coefficient. If no number is there, stoichiometric coefficient is taken as 1.

6. BALANCING OF CHEMICAL EQUATIONS

Balancing of chemical equations may be defined as -
"The process of making the number of different types of elements, on both sides of the equation, equal."
The balancing of a chemical equation is done with the help of **Hit and Trial method.** In this method, the coefficients before the symbols or formulae of the reactants and products are adjusted in such a way that the total number of atoms of each element on both the sides of the arrow head become equal.
This balancing is also known as mass balancing because if the atoms of elements on both sides are equal, their masses will also be equal.
The major steps involved in balancing a chemical equation are as follows -

- Write the chemical equation in the form of a word equation. Keep the reactants on the left side and the products on the right side. Separate them by an arrow (®), whose head points from the reactants towards the products.
- Convert the word equation into the symbol equation by writing the symbols and formulae of all the reactants and products.
- Make the atoms of different elements on both sides of the equation equal by suitable method. This is known as balancing of equation.
- Do not change the formulae of the substances while balancing the equation.
- Make the equation more informative if possible. (Think about it)

Example 1

Zinc reacts with dilute sulphuric acid to give zinc sulphate and hydrogen.

Solution :

The word equation for the reaction is -
Zinc + Sulphuric acid $\rightarrow$ Zinc sulphate + Hydrogen
The symbol equation for the same reaction is -
$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
Let us count the number of atoms of all the elements in the reactants and products on both sides of the equation.

Element	No. of atoms of reactants (L.H.S.)	No. of atoms of products (R.H.S.)
Zn	1	1
H	2	2
S	1	1
O	4	4

As the number of atoms of the elements involved in the reactants and products are equal, the equation is already balanced.

Example 2

Iron reacts with water (steam) to form iron (II, III) oxide and liberates hydrogen gas.

Solution :

The word equation for the reaction is -

Iron + Water $\rightarrow$ Iron (II, III) oxide + Hydrogen

The symbol equation for the same reaction is -

$$Fe + H_2O \rightarrow Fe_3O_4 + H_2$$

The balancing of the equation is done in the following steps :

I. Let us count the number of atoms of all the elements in the reactants and products on both sides of the equation .

Element	No. of atoms of reactants (L.H.S.)	No. of atoms of products (R.H.S.)
Fe	1	3
H	2	2
O	1	4

Thus, the number of H atoms are equal on both sides. At the same time, the number of Fe and O atoms are not equal.

II. On inspection, the number of O atoms in the reactant (H_2O) is 1 while in the product (Fe_3O_4), these are 4. To balance the atoms, put coefficient 4 before H_2O on the reactant side. The partially balanced equation may be written as

$$Fe + 4H_2O \rightarrow Fe_3O_4 + H_2$$

III. In order to equate H atoms, put coefficient 4 before H_2 on the product side. As a result, the H atoms on both sides of the equation become 8 and are thus balanced. The partially balanced equation may now be written as

$$Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$$

IV. In order to balance the Fe atoms, put coefficient 3 before Fe on the reactant side. The equation formed may be written as -

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

V. On final inspection, the number of atoms of all the elements on both sides of the equation are equal. Therefore, the equation is balanced.

Focus Point

- The method of balancing the equation by using smallest natural number coefficients is called as hit and trial method.
- Chemcial equations can be balanced by using maths variable.

7. SPECIALITIES OF CHEMICAL EQUATION

(i) We get the information about the substances which are taking part and formed in the reaction.

(ii) We get the information about the number of atoms of elements or molecule of compounds which are either taking part or formed in the chemical reaction.

(iii) We also get the information of weight of reactants or products.

For example - $\underset{(100g)}{CaCO_3} \longrightarrow \underset{(56g)}{CaO} + \underset{(44g)}{CO_2}$

Total weight of reactants is equal to the total weight of products because matter is never destroyed. In the above example total weight of calcium carbonate (reactant) is 100 g and total weight of product is also 100g (56 g + 44 g).

(iv) In a chemical equation if any reactant or product is in gaseous state, then its volume can also be determined. For example in the above reaction volume of carbon dioxide is 22.4 litres at S.T.P.

(v) In a chemical equation with the help of product we can get information about the valency as well.

For example - $Mg + 2HCl \rightarrow MgCl_2 + H_2\uparrow$

In the above reaction one atom of Mg displaces two atoms of hydrogen, so valency of magnesium is two.

Focus Point

- All chemical equations are written under N.T.P. conditions (at 298 K and 1 atmosphere pressure) if conditions are not otherwise mentioned.

8. LIMITATIONS OF CHEMICAL EQUATIONS AND THEIR RECTIFICATIONS

(i) We do not get information about the physical state of reactants and products. For example solid, liquid or gas.

(ii) No information about the concentration of reactants and products is obtained .

(iii) No information about the speed of reaction and sense of timing can be obtained.

(iv) Information regarding the favourable conditions of the reactions such as pressure, temperature, catalyst etc. can't be obtained during the reaction.

(v) We do not get information whether energy is absorbed or evolved during the reaction.

(vi) We do not get information whether the reaction is reversible or irreversible.

(vii) We do not get information about the necessary precautions to be taken for the completion of reaction.

The above limitations are rectified in the following manner -

(i) The physical state of reactants and products are represented by writing them in bracket.

Writing State Symbols :

The chemical equations or symbol equations which we have enlisted don't mention the physical states of the reactant and product species involved in the reaction. In order to make the equation more informative, the physical states are also mentioned with the help of certain specific symbols known as state symbols. These symbols are

- (s) for solid state
- (l) for liquid state
- (g) for gaseous state
- (aq) for aqueous solution i.e., solution prepared in water.

Sometimes a gas if evolved in a reaction is shown by the symbol (↑) i.e., by an arrow pointing upwards. Similarly the precipitate, if formed during the reaction, is indicated by the symbol (↓) i.e., by an arrow pointing downwards.

Significance of State Symbols :

The state symbols are of most significance for those chemical reactions which are either accompanied by the evolution of heat (exothermic) or by the absorption of heat (endothermic).

For example,

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l) + 572\ kJ$

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g) + 484\ kJ$

Both these reactions are of exothermic nature because heat has been evolved in these. However, actual amounts of heat evolved are different when water is in the liquid state and when it is in the vapour state.

(ii) The precipitate formed in the reaction is represented by ↓ symbol and gaseous substance by ↑ symbol. The abbreviation 'ppt' is also used to represent the precipitate, if formed.

- $2Na(s) + 2H_2O(\ell) \rightarrow 2NaOH\ (aq) + H_2(g)$ or $H_2\uparrow$
- $Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3\downarrow + H_2O(\ell)$
- $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl\ (ppt.) + NaNO_3(aq)$

(iii) To express the concentration, dilute or conc. is written below the formula.

$$Mg + \underset{(dilute)}{H_2SO_4} \longrightarrow MgSO_4 + H_2$$

(iv) Favourable conditions required for the completion of reaction are written above and below the arrow.

$$N_2 + 3H_2 \xrightarrow[200\ atm]{500°C,Fe/Mo} 2NH_3 + 22400\ Calorie\ heat$$

$CO(g) + 2H_2(g) \xrightarrow{340\,atm} CH_3OH(l)$

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

(v) Reversible reaction is represented by ($\rightleftharpoons$) symbol and irreversible reaction by ($\rightarrow$) symbol.

(vi) The heat absorbed in the chemical reaction is written on the right side by putting negative (–) sign and heat evolved in the chemical reaction is written on the right side by putting positive (+) sign.

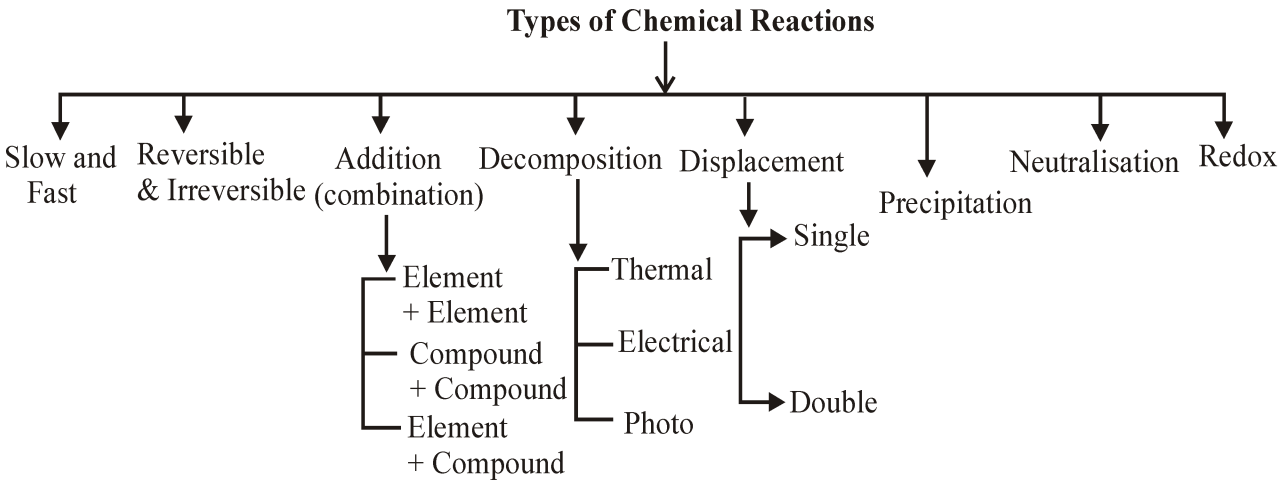
$N_2 + 3H_2 \rightarrow 2NH_3 + 22400$ Calorie (Exothermic Reaction)

$N_2 + O_2 \rightarrow 2NO - 43200$ Calorie (Endothermic Reaction)

Focus Point

- In a complete informative equation, names of all the reactants and the products can be written with their formulae.
- Chemical reaction tell us the relative number of atoms and molecules of the reactants that take part in the reaction and products formed in the reaction.

9. TYPES OF CHEMICAL REACTIONS



9.1 SLOW AND FAST REACTION

On the basis of rate of reaction, chemical reactions are of two types - slow and fast

(a) Fast reaction : These reactions take place very fast on adding reactants. Generally these reactions are ionic reactions.

For example,

- The reaction between strong acid and strong base completes in 10^{-10} sec.

  $NaOH + HCl \longrightarrow NaCl + H_2O$ (10^{-10} sec)

- The white precipitate of silver chloride (AgCl) is obtained on combination of silver nitrate and hydrochloric acid.

  $AgNO_3 + HCl \longrightarrow \underset{(White\ ppt)}{AgCl} + HNO_3$

(b) Slow reaction : There are many reaction which complete in hours or days or years. These reactions are slow reactions. eg., Rusting of iron completes in years which is the best example of slow chemical reaction.

$$4Fe + 3O_2 + 6H_2O \longrightarrow \underset{\text{Rust (reddish brown)}}{2\ Fe_2O_3.3H_2O}$$

Other examples:

$$2KClO_3 \xrightarrow{\Delta} 2KCl + O_2$$

$$\underset{\text{Acetic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{C_2H_5OH} \longrightarrow \underset{\text{Ethyl acetate}}{CH_3COOC_2H_5} + H_2O$$

9.2 REVERSIBLE-IRREVERSIBLE REACTION

(a) Irreversible reactions : The reactions in which reactants form products on reaction and these reactions take place in one direction only, are called irreversible reactions.

In such reactions, the concentration of reactants goes on decreasing and concentration of products goes on increasing. When these chemical reactions are written in the form chemical equation then it is represented by sign of arrow (→)

For example,

- Coal burns in air to form carbon dioxide.
  $C + O_2 \rightarrow CO_2$
- Methane on combustion gives carbon dioxide and water
  $\underset{\text{Methane}}{CH_4} + 2O_2 \longrightarrow CO_2 + 2H_2O$

(b) **Reversible reactions :** The reaction in which reactants react to form products and at that time products on reaction in these conditions to form reactants, are called reversible reactions.

These reactions take place in both directions. The quantity of reactant is never zero in these reactions. These reactions are represented by sign of half arrow on both side in place of sign of arrow.

$$A + B \rightleftharpoons C + D$$

Reversible reactions are divided into two reactions which occur simultaneously;

(1) When reactants are converted into products, it is called forward reaction.

$A + B \rightarrow C + D$ (Forward reaction)

(2) When products are again start converted into reactants, it is called backward reaction.

$C + D \rightarrow A + B$ (Backward reaction)

Some examples of reversible reactions are given below:

(i) $N_2 + 3H_2 \rightleftharpoons 2NH_3 + 22400$ Calorie

(ii) $N_2 + O_2 \rightleftharpoons 2NO - 43200$ Calorie

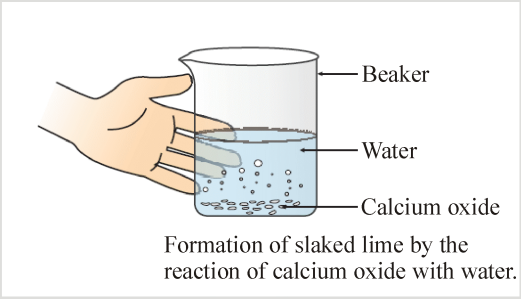
9.3 COMBINATION REACTION

The reactions in which two or more substances combine to form a single new substance are called combination reaction.

Let's discuss an activity to understand the combination reaction.

LAB TIME
Let's Do & Learn

- **Object : To study combination reaction between calcium oxide, i.e., quick lime and water.**
  Preparation materials required :
  Beaker, water, calcium oxide or quick lime
- **Procedure :**
  (i) Take a small amount of calcium oxide or quick lime in a beaker.
  (ii) Slowly add water to this.
  (iii) Touch the beaker.



Formation of slaked lime by the reaction of calcium oxide with water.

- **Observation and discussion :**
  A vigorous reaction is found to occur and the beaker is found to become very hot.
- **Conclusion**
  Calcium oxide combines with water to form calcium hydroxide (slaked lime) and this reaction is highly exothermic.

$$\underset{\text{Calcium oxide}}{CaO(s)} + \underset{\text{Water}}{H_2O(l)} \longrightarrow \underset{\text{Calcium hydroxide (Slaked lime)}}{Ca(OH)_2(aq)} + \text{Heat}$$

Combination may take place
(i) Between two or more elements. (ii) Between two or more compounds.
(iii) Between elements and compounds.

(i) When two or more elements combine to form a new compound.
For example,

- $N_2 + 3H_2 \rightarrow 2NH_3$ (Haber's Process)
- $2H_2 + O_2 \rightarrow 2H_2O$
- $2Mg + O_2 \rightarrow 2MgO$
- $2Na + Cl_2 \rightarrow 2NaCl$

(ii) When two or more compounds combine to form a new compound.
For example,

- $NH_3 + HCl \rightarrow NH_4Cl$
- $CaO + CO_2 \rightarrow CaCO_3$
- $CH_2 = CH_2 + Br_2 \longrightarrow \underset{\displaystyle CH_2 - Br}{\overset{\displaystyle CH_2 - Br}{|}}$
  1,2 – Dibromoethane

(iii) When an element and a compound combine to form a new compound.
For example,

- $2CO + O_2 \rightarrow 2CO_2$
- $2SO_2 + O_2 \rightarrow 2SO_3$

Focus Point

- Only single substance is formed as a product in the combination reactions.
- The combination reaction in which elements are combined to form single product are also known as synthesis reaction.
- In reversible types of reaction equilibrium can be established.

9.4 DECOMPOSITION REACTION

It is reciprocal of combination reaction.

The reactions in which a single compound breaks down to give two or more simpler substances, are known as Decomposition reaction.

It may be brought about by the application of heat, light, electricity etc.

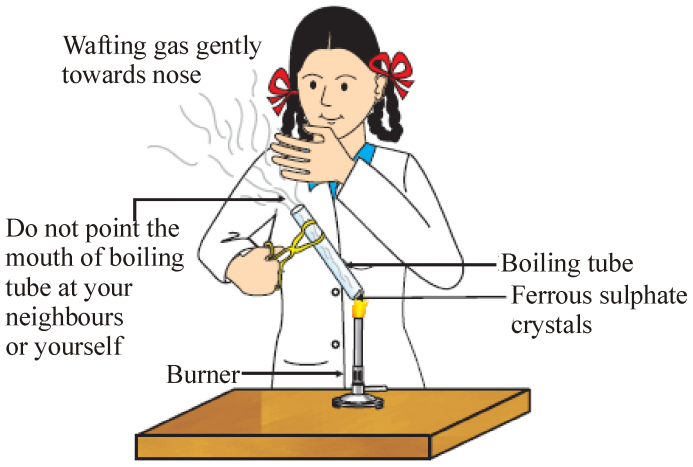
(i) Thermal decomposition reaction :

A decomposition reaction brought by absorption of heat is known as thermal decomposition.

Let's discuss an activity to understand thermal decomposition reaction.

LAB TIME
Let's Do & Learn

- **Object : To study the decomposition of ferrous sulphate on heating.**
- **Preparation materials required :**
  Burner, boiling tube, tong, ferrous sulphate crystals
- **Procedure :**
  (i) Take about 2g ferrous sulphate cystals in a dry boiling tube.
  (ii) Note the colour of ferrous sulphate crystals.
  (iii) Heat the boiling tube over the flame of a burner or spirit lamp.
  (iv) Observe the colour of the crystals after heating.



Correct way of heating boiling tube containing crystals of ferrous sulphate and of smelling the colour.

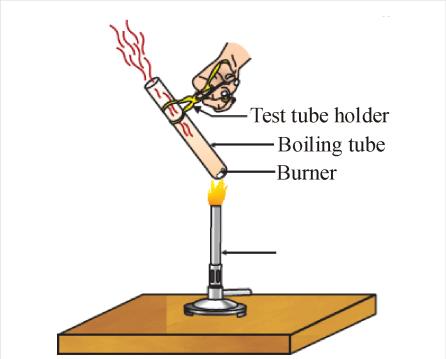
- **Observation :**
  It is observed that green coloured ferrous sulphate crystals ($FeSO_4.7H_2O$) on heating first changes colour by losing water to form $FeSO_4$ which on further heating decomposes to leave behind a reddish brown residue along with evolution of sulphur dioxide and sulphur trioxide gases.
- **Conclusion**
  The reddish brown residue is of ferric oxide. Hence, the following decomposition reaction takes place:

$$\underset{\text{Ferrous sulphate}}{FeSO_4.7H_2O(s)} \xrightarrow{\text{Heat}} \underset{\substack{\text{Anhydrous}\\\text{ferrous sulphate}\\\text{(White)}}}{FeSO_4(s)} + \underset{}{7H_2O(l)}$$

$$\underset{\substack{\text{Anhydrous ferrous}\\\text{Sulphate}\\\text{(White)}}}{2FeSO_4(s)} \xrightarrow{\text{Heat}} \underset{\substack{\text{Ferric oxide}\\\text{(Reddihs}\\\text{Brown)}}}{Fe_2O_3(s)} + \underset{\substack{\text{Sulphur}\\\text{dioxide}}}{SO_2(g)} + \underset{\substack{\text{Sulphur}\\\text{trioxide}}}{SO_3(g)}$$

LAB TIME
Let's Do & Learn

- **Object : To study the thermal decomposition of lead nitrate.**
- **Preparation materials required :**
  Burner, test tube holder/ tong, boiling tube, lead nitrate powder.
- **Procedure :**
  (i) Take about 2g lead nitrate powder in boiling tube.
  (ii) Hold the boiling tube with a pair of tongs and heat it over the flame.



Heating of lead nitrate and emission of nitrogen dioxide.

- **Observation**
  Brown fumes of nitrogen dioxide (NO_2) are found to evolve and a yellow residue is left in the test tube.
- **Conclusion**
  Solid lead nitrate decomposes on heating to give but brown fumes of NO_2 and a yellow residue of lead
  (II) oxide.

$$\underset{\substack{\text{Lead nitrate}\\\text{(white)}}}{2Pb(NO_3)_2(s)} \xrightarrow{\text{Heat}} \underset{\substack{\text{Lead (II) oxide}\\\text{(Yellow)}}}{2PbO(s)} + \underset{\substack{\text{Nitrogen dioxide}\\\text{(Brown fumes)}}}{4NO_2(g)} + \underset{\substack{\text{Oxygen}}}{O_2(g)}$$

Some more examples of thermal decompsition reaction are given below:

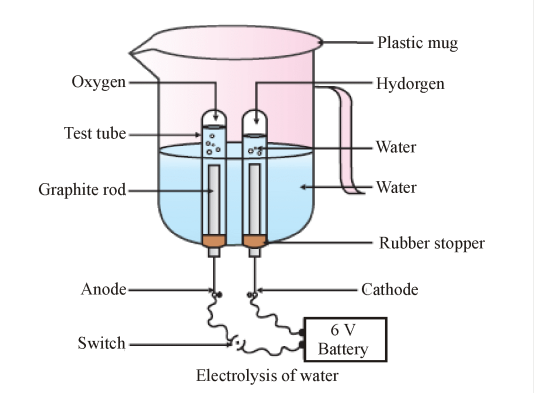
- $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
- $2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$

(ii) Electric decomposition reaction (electrolysis)

A decomposition reaction brought by electricity is known as electric decomposition or electrolysis. Let's discuss an activity to understand electric decomposition reaction.

LAB TIME
Let's Do & Learn

- **Object : To study electrolytic decomposition, i.e., electrolysis of water.**
- **Preparation materials required :**
  Plastic mug, rubber stoppers, carbon electrodes, battery, water, dilute sulphuric acid, test tubes, candle.
- **Procedure :**
  (i) Take a plastic mug. Drill two holes at its base and fit rubber stoppers in these holes. Insert carbon electrodes in these rubber stoppers and connect these electrode to a 6 volt battery.
  (ii) Fill in the mug with water such that the electrode are immersed. Add a few drops of dilute sulphuric acid to the water.
  (iii) Take two best tubes filled with water and invert them over the two carbon electrodes.
  (vi) Switch on the current and leave the apparatus undistrubed for some time.
  (v) It will be observed that formation of bubbles takes place at both the electrodes. These bubbles displace water in the test tube.
  (vii) Once the test tubes are partially filled with the respective gases, remove them carefully.
  (viii) Test these gases one by one by bringing candle close to the mouth of the test tubes.



Electrolysis of water

- **Observation and discussion:**
  It is observed that the volume of gas colected over the cathode is double than that collected over the anode.
  The gas with double volume burns with a popping sound whereas the other gas supports burning (combustion). Thus, the gas with double the volume is hydrogen whereas the gas in the other tube is oxygen.
- **Conclusion**

$2H_2O(l) \xrightarrow{\text{Electrolysis}} 2H_2(g) + O_2(g)$

Water — Hydrogen — Oxygen

Some more examples of electric decomposition or electrolysis.

- Electrolysis of molten sodium chloride.

$$\underset{\text{Sodium chloride}}{2NaCl} \xrightarrow[\text{Current}]{\text{Electric}} \underset{\text{Sodium metal}}{2Na} + \underset{\text{Chloride}}{Cl_2\uparrow}$$

- Electrolytic decomposition of molten alumina.

$$\underset{\text{Alumina (molten)}}{2Al_2O_3} \xrightarrow[\text{Current}]{\text{Electric}} \underset{\text{Aluminum}}{4Al} + \underset{\text{Oxygen}}{3O_2}$$

Focus Point

- In electrolysis, 'electro' refers to electricity 'lysis' to break down.

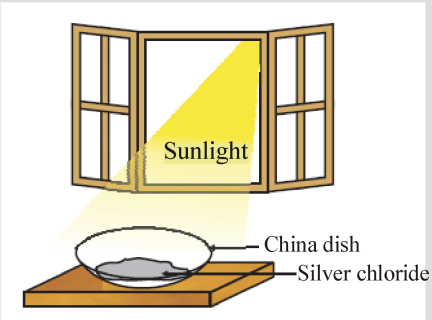
(iii) Photo decomposition reaction

A decomposition reaction brought by light is known as photo decomposition.
Let's discuss an activity to understand photo decomposition reaction.

LAB TIME
Let's Do & Learn

- **Object : To study photo-decomposition of silver chloride.**
- **Preparation materials required :**
  China dish, silver chloride
- **Procedure :**

(i) Take about 2 g of silver chloride in a china dish. Note its colour.
(ii) Place this china dish in sunlight for some time.
(iii) Observe the colour of the silver chloride after some time.



Photochemical decomposition of silver chloride to grey silver metals.
(Active chemistry)

LAB TIME
Let's Do & Learn

- **Observation**

  It is observed that white crystals of silver chloride turn grey in the sunlight.

- **Conclusion**

  Silver chloride decomposes into grey silver and chlorine in the presence of light.

$$\underset{\text{Silver chloride (white)}}{2AgCl(s)} \xrightarrow{\text{Sunlight}} \underset{\text{Silver (grey)}}{2Ag(s)} + \underset{\text{Chlorine (Greenish yellow)}}{Cl_2(g)}$$

Some more examples of photo decomposition reaction are given below:

- $2AgBr \xrightarrow{\text{Light}} 2Ag + Br_2$
- $2AgCl \xrightarrow{\text{Light}} 2Ag + Cl_2$
- $2HI \xrightarrow{\text{Light}} H_2 + I_2$
- $2H_2O_2 \xrightarrow{\text{Light}} 2H_2O + O_2$

Focus Point

- In photolysis, photo refers to light and lysis refers to break down.
- Photolysis of AgBr is used in black and white photography.
- Hydrogen peroxide is kept in amber coloured bottles so as to cut off light.

9.5 DISPLACEMENT REACTION

The reactions in which a more active element displaces a less active element from its compound, are known as Displacment reactions.

Let's discuss an activity to understand displacment reaction.

LAB TIME
Let's Do & Learn

- **Object: To study displacement of copper from copper sulphate solution by iron.**
- **Preparation materials required :**

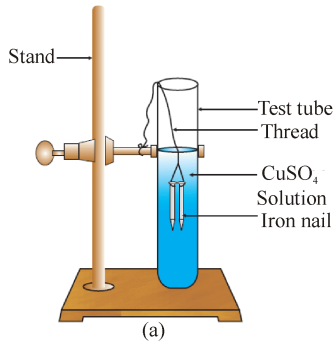
  Test tubes, iron nails, sand paper, copper sulphate solution, test tube stand.
- **Procedure :**

  (i) Take two iron nails and clean them by rubbing with sand paper.

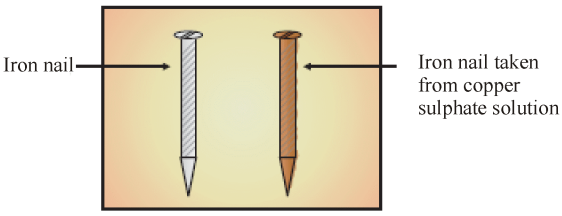
  (ii) Marked test tube as (A) and (B). In each test tube, take above 10 mL copper sulphate solution.

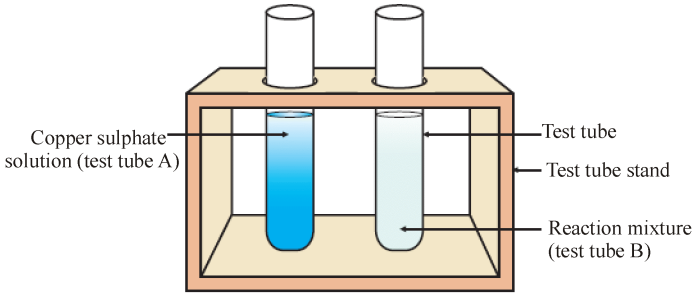
  (iii) The one iron nail with a thread and immerse it carefully in the copper sulphate solution in test tube B for about 20 minutes. Keep one iron nails aside for comparsion.

  (iv) After 20 minutes, take out the iron nail from copper sulphate solution.



(a) Iron nails dipped in copper sulphate solution





(b) Iron nails and copper sulphate solutions compared before and after experiment.

- **Observation:**

  It is observed that iron nail becomes brownish in colour and the blue colour of copper sulphate solution fades and changes to light green colour.
- **Conclusion:**

  Iron displaces copper from copper sulphate solution forming Iron (II) Sulphate in the solution, which has a light green colour. Hence, blue colour of copper sulphate solution fades.

  The displaced copper is deposited on the iron nail, giving it a brownish colour.

$$\underset{\text{Iron}}{Fe(s)} + \underset{\substack{\text{Copper sulphate}\\\text{(Blue solution)}}}{CuSO_4(aq)} \longrightarrow \underset{\substack{\text{Ferrous sulphate}\\\text{(Light green solution)}}}{FeSO_4(aq)} + \underset{\substack{\text{Copper}\\\text{(Brown)}}}{Cu(s)}$$

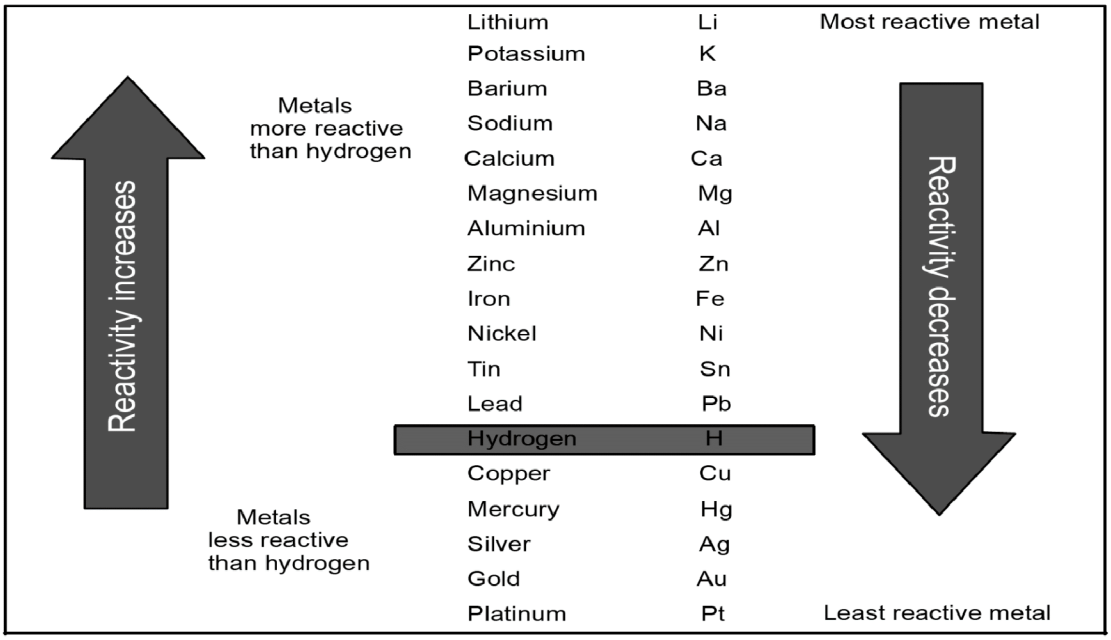
Reactivity Series of Metals

Introduction :

We have learnt that some metals are chemically very reactive while others are less reactive or do not react at all. On the basis of reactivity of different metals with oxygen, water and acids as well as displacement reactions, the metals have been arranged in the decreasing order of their reactivities.

The arrangement of metals in order of decreasing reactivities is called reactivity series or activity series of metals. The activity series of some common metals is given in Table. In this table, the most reactive metal is placed at the top whereas the least reactive metal is placed at the bottom. As we go down the series the chemical reactivity of metals decreases.

Reactivity series of metals



The element coming above in the series can displace the element coming below in this series.

Focus Point

- Among halogens, fluorine is most reactive and iodine is least reactive $F_2 > Cl_2 > Br_2 > I_2$
- Metal which is more reactive than hydrogen on reaction with acid will evolve hydrogen gas.

Types of Displacement Reactions

The displacing group may have many types of electronic configuration and hence many types of substitution reactions are possible. In general :

(i) A more active metal will displace a less active metal from compound.

(ii) Some active non-metals will displace less active non metals.

(iii) Some metals will displace a non metal.

♦ **Displacement of A Less Active Metal By A More Active Metal**

- **Reaction 1**

When an iron nail is dipped in a copper sulphate solution, it gets coated with copper.

$$\underset{\text{Iron}}{Fe(s)} + \underset{\text{Copper sulphate}}{CuSO_4(aq)} \longrightarrow \underset{\text{Iron sulphate}}{FeSO_4(aq)} + \underset{\text{Copper}}{Cu(s)}$$

In this reaction, Fe has taken the place of Cu in the compound $CuSO_4$. In other words, we say that Fe has displaced Cu from the compound $CuSO_4$.

Conclusion

From this reaction we conclude that Fe (Iron) is more reactive metal than Cu (Copper).

- **Reaction 2**

When an zinc rod is dipped in a copper sulphate solution, it gets coated with copper.

$$\underset{\text{Zinc}}{Zn(s)} + \underset{\text{Copper sulphate (blue)}}{CuSO_4(aq)} \longrightarrow \underset{\text{Zinc sulphate (white)}}{ZnSO_4(aq)} + \underset{\text{Copper}}{Cu(s)}$$

In this reaction, Zn has taken the place of Cu in the compound $CuSO_4$. In other words, we say that Zn has displaced Cu from the compound $CuSO_4$.

Conclusion

From this reaction we conclude that Zn (Zinc) is more reactive metal than Cu (Copper).

♦ **Displacement of A Non-metal By Active Metals**

- **Reaction 1**

When zinc reacts with sulphuric acid, hydrogen gas is liberated and zinc sulphate is formed.

$$\underset{\text{Zinc}}{Zn(s)} + \underset{\text{Sulphuric acid}}{H_2SO_4(aq)} \longrightarrow \underset{\text{Zinc sulphate}}{ZnSO_4(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$$

Conclusion

Zn (Zinc) is more reactive than H (hydrogen).

♦ **Displacement of A Less Active Non metal By A More Active Non metal**

- **Reaction 1**

When chlorine gas is passed through sodium bromide solution, sodium chloride and bromine are formed.

$$\underset{\text{Sodium bromide}}{2NaBr(aq)} + \underset{\text{Chlorine}}{Cl_2(g)} \longrightarrow \underset{\text{Sodium chloride}}{2NaCl(aq)} + \underset{\text{Bromine}}{Br_2(g)}$$

Conclusion

In this reaction, chlorine has displaced bromine from NaBr. Therefore, chlorine is more reactive than bromine.

- **Reaction 2**

When chlorine is bubbled through sodium iodide solution, sodium chloride and iodine are formed

$$\underset{\text{Sodium iodide}}{2NaI(aq)} + \underset{\text{Chlorine}}{Cl_2(g)} \longrightarrow \underset{\text{Sodium chloride}}{2NaCl(aq)} + \underset{\text{Iodine}}{I_2(g)}$$

Conclusion

In this reaction chlorine has displaced I_2 from sodium iodide (NaI).

Therefore, Cl_2 (chlorine) is more reactive than I_2 (Iodine).

9.6 DOUBLE DISPLACEMENT REACTION

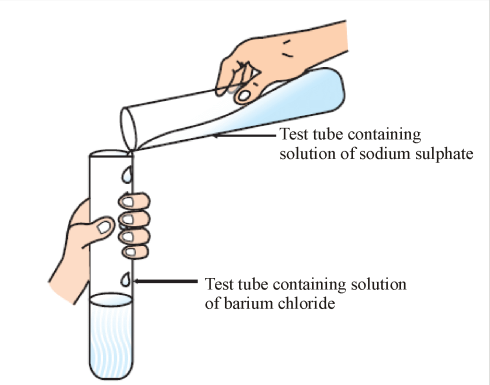
The reactions in which two ionic compounds in the solution react by exchange of their ions to form new compounds are called Double Displacement Reactions.

Let's discuss an activity to understand double displacement reaction.

LAB TIME
Let's Do & Learn

- **Object : To study double decomposition reaction between barium chloride solution and sodium sulphate solution.**
- **Preparation materials required :**
  Test tubes, sodium sulphate solution, barium chloride solution.
- **Procedure :**

(i) Take about 3 mL of sodium sulphate solution in a test tube.
(ii) In another test tube, take about 3 mL of Barium Chloride solution.
(iii) Mix the two solutions.ur of the iron nails dipped in copper sulphate solution with the one kept aside.



Formation of barium sulphate and sodium chloride. (Active chemistry)

- **Observation :**
  It is observed that a white solid insoluble substance in water is formed. This white insoluble solid is called as **precipitate**.

LAB TIME
Let's Do & Learn

- **Conclusion :**
  Barium chloride solution reacts with sodium sulphate solution to form a white precpitate of barium sulphate along with sodium chloride in the solution.

$BaCl_2(aq)$ + $Na_2SO_4(aq)$ → $BaSO_4(s)$ + $NaCl(aq)$

Barium chloride + Sodium sulphate → Barium sulphate (white precipitate) + Sodium chloride (in solution)

Some more examples of double displacement reaction are given below:
The above reaction is a double displacement reaction as well as precipitation reaction.

- $NaCl\ (aq) + AgNO_3\ (aq) \rightarrow AgCl\downarrow + NaNO_3\ (aq)$ (White)
- $NaBr\ (aq) + AgNO_3\ (aq) \rightarrow AgBr\downarrow + NaNO_3\ (aq)$ (Yellow)
- $Pb(NO_3)_2\ (aq) + 2KI\ (aq) \rightarrow PbI_2\downarrow + 2KNO_3\ (aq)$ (Yellow)

Focus Point

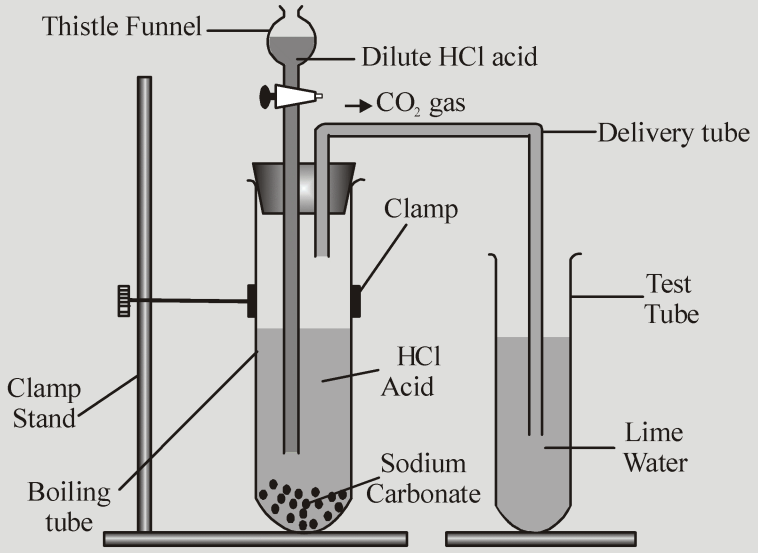
- Double displacement reactions generally takes place between two ionic compounds in the solution.
- Acid - base reactions (neutralisation) are double displacement reactions.

9.7 PRECIPITATION REACTIONS

Those reactions in which aqueous solutions of two compounds on mixing react to form an insoluble compound which separates out as a solid (called precipitate) are called precipitate reaction.

LAB TIME
Let's Do & Learn

- **Object : To study the precipitation reacton.**
- **Preparation materials required:**
  Sodium carbonate, hydrochloric acid, clamp, stand, boiling tube, lime water, test tube, delivery tube, thistle funnel.
- **Procedure:**
  (i) Take about 1 g of sodium carbonate in a boiling tube fitted with a delivery tube and a thistle funnel (dropping funnel). Clamp it in the clamp stand as shown in figure.
  (ii) Immerse the other end of the delivery tube in lime water taken in a test tube.
  (iii) Now through the thistle funnel, add dilute hydrochloric acid into the tube.
  (iv) A gas is evolved with brisk effervescence which passes through lime water as shown in figure.



Carbon dioxide formed by action of dilute hydrochloric acid on sodium carbonate and passed through lime water

- **Observation :**
  We observe that lime water turns milky. This shows that the gas evolved is carbon dioxide.
  Hence, the following reactions take place :

$Na_2CO_3(s)$ + $2HCl(aq)$ → $2NaCl(aq)$ + $H_2O(l)$ + $CO_2(g)$

Sodium carbonate — Hydrochloric acid — Sodium chloride — Water — Carbon dioxide

$Ca(OH)_2(aq)$ + $CO_2(g)$ → $CaCO_3(s)$ + $H_2O(l)$

Lime water — Carbon dioxide — Calcium carbonate (Milky suspension) — Water

- **Conclusion :**
  Here, calcium carbonate formed is an insoluble white solid which gives a milky suspension. For this reason, this reaction is used for testing carbon dioxide gas.

Focus Point

- If excess of carbon dioxide gas is passed through lime water, the milkiness disappears and the solution again becomes clear. This is due to the change of insoluble calcium carbonate into soluble calcium bicarbonate as follows :

$CaCO_3$ + CO_2 + $H_2O(g)$ ⟶ $Ca(HCO_3)_2$

Calcium carbonate — Carbon dioxide — Water — Calcium bicarbonate (soluble)

9.8 NEUTRALIZATION REACTIONS

A reaction in which an acid reacts with a base to form salt and water is called neutralization reaction, i.e.,

Acid + Base ⟶ Salt + Water

In fact, these reactions are also double displacement reactions.

Examples.

(i) $NaOH$ + HCl ⟶ $NaCl$ + H_2O

Sodium hydroxide (Base) — Hydrochloric acid (Acid) — Sodium Chloride — Water

(ii) $2\ NaOH$ + H_2SO_4 ⟶ Na_2SO_4 + $2\ H_2O$

Sodium hydroxide — Sulphuric acid — Sodium sulphate — Water

(iii) KOH + HCl ⟶ KCl + H_2O

Potassium hydroxide (Base) — Hydrochloric acid (Acid) — Potassium Chloride — Water

(iv) NH_4OH + HCl ⟶ NH_4Cl + H_2O

Ammonium hydroxide (Base) — Hydrochloric acid (Acid) — Ammonium Chloride — Water

9.9 REDOX REACTIONS

In our daily life we come across processes like rusting of objects made of iron, fading of the colour of the clothes, burning of the combustible substances such as cooking gas, wood, coal, etc. All such processes fall in the category of specific type of chemical reactions called oxidation - reduction reactions or redox reactions.

Most of the elements are reactive and react with oxygen and hydrogen. Initially, on the basis of addition of oxygen and hydrogen, the chemical reactions were considered as oxidation and reduction reactions but afterwards, the definition was expanded, on the basis of addition or displacement of other elements except O_2 and H_2, which are as follows -

Oxidation :

Definitions : The oxidation of a substance takes place when :

(A) There is addition of oxygen to a substance.

Examples

(1) $C(s) + O_2(g) \longrightarrow CO_2(g)$
Oxidation of C
(Due to addition of O_2)

(2) $2Mg(s) + O_2(g) \longrightarrow 2MgO(g)$
Oxidation of Mg
(Due to addition of O_2)

(3) $P_4(s) + 5O_2 \longrightarrow 2P_2O_5(s)$
Oxidation of P_4
(Due to addition of O_2)

(4) $2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$
Oxidation of H_2
(Due to addition of O_2)

(B) There is removal of hydrogen from a substance

The chemical reactions in which hydrogen is lost from a substance.

(1) $2H_2O \xrightarrow{\text{electricity}} 2H_2 + O_2$
Oxidation of H_2O
(Due to removal of H_2)

(2) $2HI \xrightarrow{\text{Sunlight}} H_2 + I_2$
Oxidation of HI
(Due to removal of H_2)

(C) There is addition of an electronegative element to a substance

Examples

(1) $2Fe + 3Cl_2 \longrightarrow 2FeCl_3$
Oxidation of Fe
(Due to addition of Cl_2)

(2) $SnCl_2 + Cl_2 \longrightarrow SnCl_4$
Oxidation of $SnCl_2$
(Due to addition of Cl_2)

In these reactions, numbers of atoms of electronegative element chlorine is increased in Fe and $SnCl_2$ and forms $FeCl_3$ and $SnCl_4$ respectively

(D) There is removal of electropositive element from a substance

Examples

(1) $2NaCl \xrightarrow{\text{electricity}} 2Na + Cl_2$
Oxidation of NaCl
(Due to removal of Na)

(2) $MgCl_2 \xrightarrow{\text{electricity}} Mg + Cl_2$
Oxidation of $MgCl_2$
(Due to removal of Mg)

Focus Point

- In short oxidation is a chemical reaction in which substances combine with oxygen or an electronegative element or lose hydrogen or an electropositive element.

Reduction :

Definitions : The reduction of a substance takes place when :

(A) There is addition of hydrogen to a substance.

Examples

(1) $H_2 + Cl_2 \longrightarrow 2HCl$
Reduction of Cl_2
(Due to addition of H_2)

(2) $C_2H_4 + H_2 \longrightarrow C_2H_6$
Reduction of C_2H_4
(Due to addition of H_2)

(B) There is removal of oxygen from a substance

Examples :

(1) $2H_2O \xrightarrow{\text{electricity}} 2H_2 + O_2$

Reduction of H_2O (Due to removal of O_2)

(2) $2Al_2O_3 \xrightarrow{\text{electricity}} 4A1 + 3O_2$

Reduction of Al_2O_3 (Due to removal of O_2)

(3) $2MgO \longrightarrow 2Mg + O_2$

Reduction of MgO (Due to removal of O_2)

(C) There is addition of an electropositive element to a substance

Examples

(1) $2Na + Cl_2 \longrightarrow 2NaCl$

Reduction of Cl_2 (Due to addition of Na)

(2) $Zn + S \longrightarrow ZnS$

Reduction of S (Due to addition of Zn)

(D) There is removal of electronegative element from a substance

Examples

(1) $FeS \longrightarrow Fe + S$

Reduction of FeS (Due to removal of S)

(2) $2FeCl_3 \longrightarrow 2FeCl_2 + Cl_2$

Reduction of $FeCl_3$ (Due to removal of Cl_2)

Focus Point

- In short reduction is a chemical reaction in which substances combine with hydrogen or an electropositive element or lose oxygen or an electronegative element.

Oxidising agent and reducing agent:

A substance that brings about oxidation that is addition of oxygen or an electronegative element and removal of hydrogen or an electropositive element is called oxidising agent.

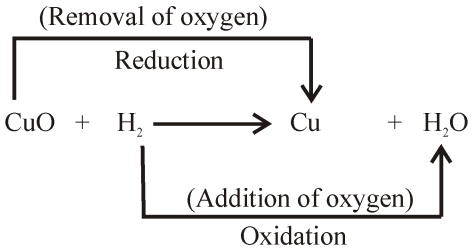
On the other hand, a substance that brings about reduction, that is removal of oxygen or an electronegative element and addition of hydrogen or an electropositive element is called reducing agent.

Consider the reaction

$$CuO + H_2 \rightarrow Cu + H_2O$$

In this reaction, hydrogen removes oxygen from copper oxide. Thus, CuO is reduced and hydrogen behaves as reducing agent.

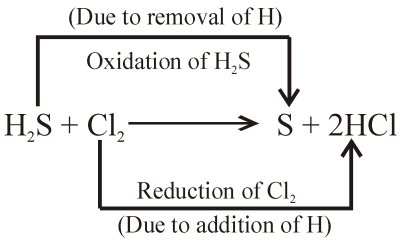
Copper oxide gives oxygen to hydrogen and hydrogen is oxidised to water by CuO. Therefore, CuO is acting as oxidising agent

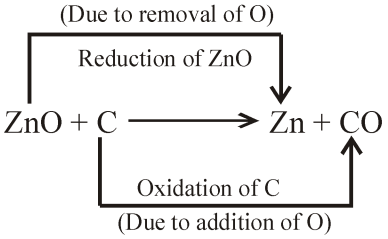


CuO makes oxidation to occur → Oxidising agent

H_2 makes reduction to occur → Reducing agent

Some examples of redox reactions are given below :

1. 

2. 

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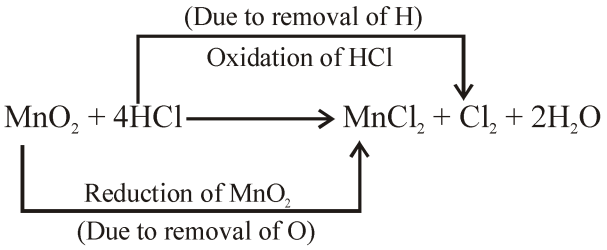

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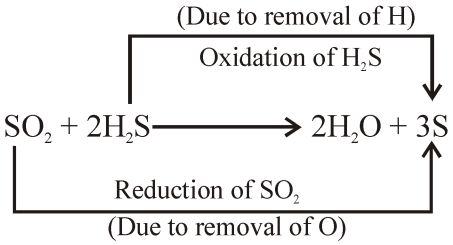

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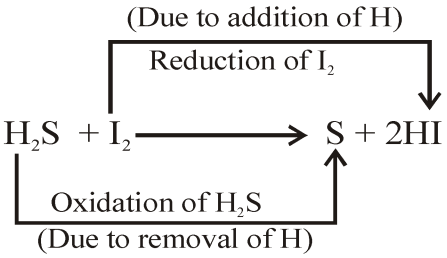


Focus Point

- The substance to which oxygen is added or substance from which hydrogen is removed is said to be oxidised.
- The substance from which oxygen is removed or substance to which hydrogen is added is said to be reduced.
- The substance which gets oxidised acts as reducing agent.
- The substances which gets reduced acts as an oxidising agent.

10. MODERN CONCEPT OF OXIDATION AND REDUCTION

Besides earlier concepts of oxidation and reduction, two modern concepts of oxidation and reduction are more common.

(i) Electronic concept

(ii) Oxidation number concept

Oxidation

According to electronic concept, those chemical reactions in which an atom, ion or molecule loses electron are known as Oxidation reaction. This is also known as **de-electronation**.

(i) Oxidation of atom

$Na \rightarrow Na^+ + e^-$

$Ca \rightarrow Ca^{2+} + 2e^-$

$Zn \rightarrow Zn^{2+} + 2e^-$

(ii) Oxidation of ion (Cation)

$Fe^{2+} \rightarrow Fe^{3+} + e^-$

$Sn^{2+} \rightarrow Sn^{4+} + 2e^-$

$Cu^{+} \rightarrow Cu^{2+} + e^-$

(iii) Oxidation of ion (Anion)

$2Cl^- \rightarrow Cl_2 + 2e^-$

$MnO_4^{2-} \rightarrow MnO_4^- + e^-$

$2O^{2-} \rightarrow O_2 + 4e^-$

In oxidation reaction, electrons are lost due to which, positive charge on substance is increased and negative charge on substance is decreased.

Reduction

Reduction is the chemical reaction in which an atom, ion or molecule gains one or more electron. This is also known as electronation.

(i) Reduction of atom

$Cl + e^- \rightarrow Cl^-$

$S + 2e^- \rightarrow S^{2-}$

(ii) Reduction of ion (cation)

$Mg^{2+} + 2e^- \rightarrow Mg$

$Pb^{4+} + 2e^- \rightarrow Pb^{2+}$

In reduction reaction, gain of electrons takes place due to which there is increase in negative charge or decrease in positive charge.

Some examples of redox reactions are given below:

Example :

(1) $2Mg + O_2 \longrightarrow 2MgO \quad (Mg^{2+}O^{-2})$

(Loss of electrons) (oxidation)

Gain of electrons (Reduction)

(2) $Fe + S \xrightarrow{\Delta} FeS\ (Fe^{2+}S^{-2})$

(Loss of electrons) (oxidation)

Gain of electrons (Reduction)

(3) $Cu + I_2 \xrightarrow{\Delta} CuI_2\ (Cu^{+2}2I^-)$

(Loss of electrons) (oxidation)

Gain electrons (Reduction)

(4) $2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$

OR

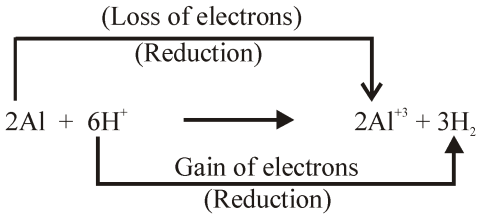


TABLE : COMPARATIVE STUDY OF OXIDATION AND REDUCTION REACTIONS

	Oxidation	Reduction
1.	Combination of substance with oxygen	Combination of substance with hydrogen
2.	Combination of substance with electronegative element	Combination of substance with electropositive element
3.	Loss of hydrogen from substance	Loss of oxygen from substance
4.	Loss of electropositive element from substance	Loss of electronegative element from substance
5.	Loss of electron from an atom or ion.	Gain of electron by an atom or ion.

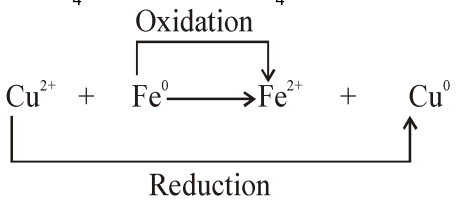
Oxidizing agent according to electronic concept

Those substances which gain electrons or get reduced are known as oxidizing agent.

Reducing agent according to electronic concept

Those substances which lose electrons or get oxidised are known as reducing agent,

$CuSO_4 + Fe \rightarrow FeSO_4 + Cu$



In this reaction, Fe loses electrons and get oxidised so it is reducing agent, while $CuSO_4$ gains electrons and get reduced, so clearly it is an oxidizing agent.

11. EFFECT OF OXIDATION REACTIONS IN DAILY LIFE

We are all aware of the fact that oxygen is most essential for sustaining life. One can live without food or even water for a number of days but not without oxygen. It is involved in a variety of actions which have wide range of effects on our daily life. Most of them are quite useful while a few may be harmful in nature.

Some of these effects are briefly discussed.

11.1 COMBUSTION REACTIONS

A chemical reaction in which a substance burns or gets oxidised in the presence of air or oxygen is called combustion reaction.

For example,

- Kerosene, coal, charcoal, wood etc. burn in air and thus, undergo combustion.
- Methane (CH_4) a major constituent of natural gas undergoes combustion in excess of oxygen upon heating.

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(\ell) + \text{energy}$
Methane

- Butane (C_4H_{10}), the main constituent of L.P.G. also undergoes combustion.

$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 5H_2O(g) + \text{energy}$
Butane

Focus Point

- All combustion reactions are of exothermic nature and are accompanied by release of heat energy.
- The human body may be regarded as a furnace or machine in which various food stuffs that we eat undergo oxidation. The heat energy evolved keeps our body working. Carbohydrates such as glucose, fructose, starch etc. are the major source of energy to the human body. They undergo oxidation with the help of oxygen that we inhale to form carbon dioxide and water. For example.

  $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(\ell) + \text{energy}$

11.2 RESPIRATION

Respiration is the most important biochemical reaction which releases energy in the cells. When we breathe in air, oxygen enters our lungs and passes into thousands of small air sacs (alveoli). These air sacs occupy a large area of membranes and oxygen diffuses from the membranes into blood. It binds itself to haemoglobin present in red blood cells and is carried to millions of cells in the body. Respiration occurs in these cells and is accompanied by the combustion of glucose producing carbon dioxide and water. Since the reaction is of exothermic nature, the energy released during respiration carry out many cell reactions and also keeps our heart and muscles working. It also provides the desired warmth to the body. Both carbon dioxide and water pass back into the blood and we ultimately breathe them out. Respiration takes place in the cells of all living beings.

Focus Point

- Fish take up oxygen dissolved in water through their gills while plants take up air through small pores (stomata) present in their leaves.

12. HARMFUL EFFECT OF OXIDATION

We have discussed the utility of oxidation in releasing energy which our body needs to keep warm and working. However, oxidation has harmful effects also.

12.1 POLLUTION

The environmental pollution is basically due to combustion. Poisonous gases like carbon monoxide (CO), sulphur dioxide (SO_2), sulphur trioxide (SO_3) and oxides of nitrogen (N_xO_y) etc. are being released into the atmosphere as a result of variety of combustion reaction which are taking place. They pollute the atmosphere and make our lives miserable.

12.2 CORROSION

The process of slowly eating up of the metals due to attack of atmospheric gases such as oxygen, carbon dioxide, hydrogen sulphide, water vapour etc. on the surface of the metals so as to convert the metal into oxide, carbonate, sulphide etc. is known as **Corrosion**.

- **Corrosion of iron (Rusting of iron)**

The most common example of corrosion is rusting i.e. corrosion of iron. When an iron article remains exposed to moist air for a long time, its surface is covered with a brown, flaky (non-sticky) substance called rust. Rust is mainly hydrated ferric oxide ($Fe_2O_3.xH_2O$). It is formed due to attack of oxygen gas and water vapour present in the air on the surface of iron.

$$2Fe(s) + 3/2O_2(g) + xH_2O(l) \longrightarrow \underset{\text{hydrate ferric oxide (Rust)}}{Fe_2O_3.xH_2O(s)}$$

- **Corrosion of copper**

Copper objects lose their lustre or shine after some time. The surface of these objects acquire a green coating of basic carbonate, $CuCO_3.Cu(OH)_2$ when exposed to air. This is due to attack of O_2, CO_2 and water vapour present in the air on the surface of copper.

$$\underset{\text{Copper}}{2Cu(s)} + \underbrace{CO_2(g) + O_2(g) + H_2(O)\ (l)}_{\text{From moist air}} \longrightarrow \underset{\text{Basic copper carbonate (Green)}}{CuCO_3.\ Cu(OH)_2}$$

- **Corrosion of silver**

The surface of silver metal gets tarnished (i.e. loses lustre and becomes dull) on exposure to air. This is due to the formation of a coating of black silver sulphide (Ag_2S) on its surface by the action of H_2S present in the air.

$$\underset{\text{Silver}}{2Ag(s)} + \underset{\text{Hydorgen sulphide (From air)}}{H_2S(g)} \longrightarrow \underset{\text{Silver sulphide (Black)}}{Ag_2S(s)} + H_2\ (g)$$

Focus Point

- Rusting is a serious problem it weakens the structure of bridges, iron railings, automobile parts etc. Every year a large amount of money is spent to replace rusted iron and steel structures. The reason is that the reddish brown crust of rust does not stick to the surface. It peels off (or falls down) exposing fresh surface for rusting. Thus, corrosion of iron is a continuous process which ultimately eats up the whole iron object.

Methods to prevent rusting. Rusting can be prevented if iron objects are not allowed to come in contact with the damp air. Some common methods generally used are given below.

(i) By painting the iron articles such as window grills, iron gates, steel furniture, railway coaches, bodies of cars, buses etc.

(ii) By greasing and oiling the iron articles such as mechanical tools, machine parts etc.

(iii) By galvanisation, i.e. coating the surface of iron objects with a thin layer of zinc.

Focus Point

• Unreactive metals such as gold, platinum, palladium, titanium, etc.corrode negligibly and thus are called native metals.

12.3 RANCIDITY

Oxidation also has damaging effect on foods containing fats and oils. When the food materials prepared in fats and oils are kept for a long time, they start giving unpleasant smell and taste, this is called rancidity. This happens as follows :

When the fats and oils present in food materials get oxidised by the oxygen (of air), their oxidation products have unpleasant smell and taste. The condition produced by aerial oxidation of fats and oils in foods marked by unpleasant smell and taste is called rancidity. Rancidity spoils the food materials prepared in fats and oils which have been kept for a considerable time and makes them unfit for eating.

The development of rancidity of food can be prevented or retarded (slowed down) in the following ways :

1. **Rancidity can be prevented by adding anti-oxidants to foods containing fats and oils :**
   Anti-oxidant is a substance (or chemical) which prevents oxidation. Anti-oxidants are actually reducing agents. When anti-oxidants are added to foods, then the fats and oils present in them do not get oxidised easily and hence do not turn rancid. So the foods remain good to eat for a much longer time. The two common anti-oxidants used in foods to prevent the development of rancidity are BHA (Butylated Hydroxy-Anisole) and BHT (Butylated Hydroxy Toluene).
2. **Rancidity can be prevented by packaging fat and oil containing foods in nitrogen gas :**
   When the packed food is surrounded by an unreactive gas like nitrogen, there is no oxygen (of air) to cause its oxidation and make it rancid. The manufacturers of potato chips (and other similar food products) fill the plastic bags containing chips with nitrogen gas to prevent the chips from being oxidised and turn rancid.

3. **Rancidity can be retarded by keeping food in a refrigerator :**
   The refrigerator has a low temperature inside it. When the food is kept in a refrigerator, the oxidation of fats and oils in it is slowed down due to low temperature. So, the development of rancidity due to oxidation is retarded.
4. **Rancidity can be retarded by storing food in air-tight containers :**
   When food is stored in air-tight containers, then there is little exposure to oxygen of air. Due to reduced exposure to oxygen, the oxidation of fats and oils present in food is slowed down and hence the development of rancidity is retarded.
5. **Rancidity can be retarded by storing foods away from light :**
   In the absence of light, the oxidation of fats and oils present in food is slowed down and hence the development of rancidity is retarded.

Focus Point

- There is a luminous bog found at the lower obdomen of fire files. The light emits from this because of secretion of luciferase enzyme. This enzyme when reacts with luciferin, light is emited because of the presence of magnesium and oxygen due to oxidation of magnesium.
- Common antioxidants are :
  (a) BHA (Butylated Hydroxy Anisole)
  (b) BHT (Butylated Hydroxy Toluene)
  (c)Vitamin-E(Tocopherol) and vitamin-C (ascorbic acid) are the two naturally occuring antioxidants.

SOLVED EXAMPLES

SE. 1

Write the balanced chemical equations for the following reactions and identify the type of reaction in each case.

(a) Nitrogen gas is treated with hydrogen gas in the presence of a catalyst at 773 K to form ammonia gas.

(b) Sodium hydroxide solution is treated with acetic acid to form sodium acetate and water.

(c) Ethanol is warmed with ethanoic acid to form ethyl acetate in the presence of concentrated H_2SO_4.

(d) Ethene is burnt in the presence of oxygen to form carbon dioxde, water and releases heat and light.

Ans. Chemical Reaction and Equations

(a) $N_2(g) + 3H_2(g) \underset{773\ K}{\overset{Catalyst}{\rightleftharpoons}} 2NH_3(g)$

This is an example of combination reaction.

(b) $NaOH(aq) + CH_3COOH(aq) \longrightarrow CH_3COONa(aq) + H_2O(l)$

This is an example of neutralisation reaction between a strong base and weak acid.

(c) $C_2H_5OH(aq) + CH_3COOH(aq) \longrightarrow CH_3COOC_2H_5(aq) + H_2O(l)$

This is an example of neutralisation reaction as well as double displacement reaction.

(d) $C_2H_4(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(g)$ + Heat + Light

This is an example of oxidation reaction.

SE. 2

Complete the missing components/ variables given as x and y in the following reactions.

(a) $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(x) + 2KNO_3(y)$

(b) $Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + x(s)$

(c) $Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(x) + H_2(y)$

(d) $CaCO_3(s) \xrightarrow{x} CaO(s) + CO_2(g)$

Ans. (a) $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

(b) $Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)$

(c) $Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$

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

SE. 3

Which among the following changes are exothermic or endothermic in nautre ?

(a) Decomposition of ferrous sulphate

(b) Dilution of sulphuric acid

(c) Dissolution of sodium hydroxide in water

(d) Dissolution of ammonium chloride in water

Ans. (a) Endothermic reaction

(b) Exothermic reaction

(c) Exothermic reaction

(d) Endothermic reaction

SE. 4

Identify the oxidising agent (oxidant) in the following reactions.

(a) $Pb_3O_4 + 8HCl \rightarrow 3PbCl_2 + Cl_2 + 4H_2O$

(b) $2Mg + O_2 \rightarrow 2MgO$

(c) $CuSO_4 + Zn \rightarrow Cu + ZnSO_4$

(d) $V_2O_5 + 5Ca \rightarrow 2V + 5CaO$

(e) $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

(f) $CuO + H_2 \rightarrow Cu + H_2O$

Ans. (a) Pb_3O_4 (b) O_2

(c) $CuSO_4$ (d) V_2O_5

(e) H_2O (f) CuO

SE. 5

A solution of potassium chloride when mixed with silver nitrate solution, and insoluble white substance is formed. Write the chemical reaction involved and also mention the type of the chemical reaction ?

Ans. $KCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + KNO_3(aq)$

This is a double displacement and precipitation reaction.

SE. 6

Ferrous sulphate decomposes with the evolution of a gas having a characteristic odour of burning sulphur. Write the chemical reaction involved and identify the type of reaction.

Ans. $2FeSO_4 \rightarrow Fe_2O_3 + SO_2 + SO_3$

This is a decomposition reaction.

SE. 7

Why do fire flies glow at night ?

Ans. Fire flies produces an enzyme called as luciferase which carries oxidation of magnesium. Because of oxidation of Magnesium in presence of atmospheric oxygen fireflies glows in the night.

SE. 8

Grapes hanging on the plant do not ferment but after being plucked from the plant can be fermented. Under what conditions do these grapes ferment ? Is it a chemical or a physical change ?

Ans. Grapes on the plant do not ferment because of defense mechanism of plants. When grapes are plucked from plant. Grapes reacts with yeast to carry out fermentation. Here sugar change to alcohol and it is a chemical change.

SE. 9

Which among the following are physical or chemical changes ?

(a) Evaporation of petrol

(b) Heating of an iron rod to red hot.

(c) Burning of Liquefied Petroleum Gas (LPG)

(d) Curdling of milk

(e) Sublimation of solid ammonium chloride

Ans. Physical changes

(a) Evaporation of petrol

(b) Heating of an iron rod to red hot.

(e) Sublimation of solid ammonium chloride.

Chemical changes

(c) Burning of Liquefied Petroleum Gas (LPG)

(d) Curdling of milk

SE. 10

During the reaction of some metals with dilute hydrochloric acid, following observations were made.

(a) Silver metal does not show any change

(b) The temperature of the reaction mixture rises when aluminium (Al) is added.

(c) The reaction of sodium metal is found to be highly explosive.

(d) Some bubbles of a gas are seen when lead (Pb) is reacted with the acid.

Explain these observations giving suitable reasons.

Ans. (a) There will not be any reaction between silver and dilute HCl as silver lies lower in reactive series of metals.

(b) Because it is an exothermic reaction temperature increases.

(c) Sodium is highly reactive metal, it catches fire in presence of atmospheric oxygen.

(d) When lead reacts with acid it produces hydrogen gas which are responsible for the formation of bubbles.

SE. 11

A substance X, which is an oxide of a group 2 element, is used intensively in the cement industry. This element is present in bones also. On treatment with water if forms a solution which turns red litmus blue. Identify X and also write the chemical reactions involved.

Ans. Compound X is calcium oxide. CaO is extensively used in cement industry. On treatment with water CaO produces $Ca(OH)_2$ which is alkaline in nature and turns red litmus to blue color.

$CaO + H_2O \longrightarrow Ca(OH)_2$

SE. 12

Why do we store silver chloride in dark coloured bottles ?

Ans. Silver chloride decomposes into silver and chloine gas when exposed to sunlight. Hence Silver chloride is stored in dark colored bottles.

SE. 13

Balance the following chemical equations and identify the type of chemical reaction.

(a) $Mg(s) + Cl_2(g) \longrightarrow MgCl_2(s)$

(b) $HgO(s) \xrightarrow{Heat} Hg(l) + O_2(g)$

(c) $Na(s) + S \xrightarrow{Fuse} (s)\ Na_2S(s)$

(d) $TiCl_4(l) + Mg(s) \longrightarrow Ti(s) + MgCl_2(s)$

(e) $H_2O_2(I) \xrightarrow{UV} H_2O(l) + O_2(g)$

Ans. (a) $Mg(s) + Cl_2(g) \longrightarrow MgCl_2(s)$

This type of reaction is called a combination reaction or a synthesis reaction.

(b) $2HgO \xrightarrow{Heat} 2Hg(l) + O_2(g)$

This is an example of thermal decomposition reaction.

(c) $2Na(s) + S(s) \xrightarrow{Fuse} Na_2S(s)$

This is an example of a Combination reaction.

(d) $TiCl_4(l) + Mg(s) \longrightarrow Ti(s) + 2MgCl_2(s)$

This reaction falls under the category of displacement reactions.

(e) $H_2O_2(l) \xrightarrow{UV} H_2O(l) + O_2(g)$

This is a Photolytic decomposition reaction.

SE. 14

A magnesium ribbon is burnt in oxygen to give a white compound X accompanied by emission of light. If the burning ribbon is now placed in an atmosphere of nitrogen. It continues to burn and forms a compound Y.

(a) Write the chemical formulae of X and Y.

(b) Write a balanced chemical equation, when X is dissolved in water.

Ans. $2Mg + O_2 \longrightarrow 2MgO$

Compound X $\longrightarrow$ MgO[Magnesium oxide]

Compound Y $\longrightarrow$ Mg_3N_2[Magnesium Nitride]

If magnesium oxide is dissolved in water, the product is magnesium hydroxide.

$MgO + H_2O \longrightarrow Mg(OH)_2$

SE. 15

Zinc liberates hydrogen gas when reacted with dilute hydrochloric acid, whereas copper does not. Explain why ?

Ans. Zinc is more reactive than copper as Zinc is placed above hydrogen and copper is placed below hydrogen in the activity series of metals. Because of this Zinc reacts with HCl whereas copper will not react.

SE. 16

A silver article generally turns black when kept in the open for a few days. The article when rubbed with toothpaste again starts shining.

(a) Why do silver articles turn black when kept in the open for a few days ? Name the phenonmenon involved.

(b) Name the black substance formed and give its chemical formula.

Ans. (a) Silver reacts with H_2S present in the atomsphere to form a black colour compound silver sulphide. This phenomenon is called as corrosion.

(b) Black color compound formed is silver sulphide

$2Ag + H_2S \longrightarrow Ag_2S + H_2$

SE. 17

On heating blue coloured powder of copper (II) nitrate in a boiling tube, copper oxide (black), oxygen gas and a brown gas X is formed.

(a) Write a balanced chemical equation of the reaction.

(b) Identify the brown gas X evolved.

(c) Identify the type of reaction.

(d) What could be the pH range of aqueous solution of the gas X ?

Ans. (a) $\underset{\text{Copper (II) nitrate}}{2Cu(NO_3)_2(s)} \xrightarrow{Heat} \underset{\text{(Black)}}{2CuO(s)} + \underset{\text{(Brown) (X)}}{4NO_2(g)} + \underset{\text{Oxygen}}{O_2}$

(b) NO_2 gas.

(c) Thermal decomposition reaction.

(d) Less than 7.

SE. 18

Give the characteristic tests for the following gases.

(a) CO_2 (b) SO_2

(c) O_2 (d) H_2

Ans. (a) Pass CO_2 into limewater which will turn water into milky. This is the confirmation test for the presence of Carbon-di-oxide.

(b) Smell is the characteristic feature of SO_2 which smell like burning sulphur.

(c) Test for oxygen involves burning of match stick near oxygen makes it burn even more brightly.

(d) When burning matchstick is brought near H_2 gas, the flame burns with pop sound. This is the test to confirm hydrogen gas.

SE. 19

What happens when a piece of -

(A) Zinc metal is added to copper sulphate solution?

(b) Aluminimum metal is added to dilute hydrochloric acid ?

(c) Silver metal is added to copper sulphate solution Also, write the balanced chemical equation if the reaction occures.

Ans. (a)When zinc is added to copper sulphate solution zinc displaces copper to form zinc sulphate.

$Zn(s) + CuSO_4(aq) \longrightarrow ZnSO_4(aq) + Cu(s)$

(b) Aluminium metals reacts with dilute HCl to form aluminium chloride and hydrogen gas is evolved in the reaction.

$2Al(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3H_2$

(c) When silver metal is added to copper sulphate solution there will not be any reaction as silver is non-reactive metal and less reactive than copper (Cu) .

SE. 20

What happens when zinc granules are treated with dilute solution of H_2SO_4, HCl, HNO_3, NaCl and NaOH, also write the chemical equations if reaction occurs.

Ans. When zinc granules reacts with dil H_2SO_4 displacement reaction takes place leading to the formation of $ZnSO_4$ liberating H_2 gas.

$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$

When zinc granules reacts with dil HCl displacement reaction take place leading to the formation fo $ZnCl_2$ liberating H_2 gas.

$Zn(s) + HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$

When zinc granules reacts with dil HNO_3 it leads to the formation of zinc nitrate evolving H_2O and nitrous oxide.

$4Zn(s) + 10HNO_3(aq) \longrightarrow 4Zn(NO_3)_2(aq) + 5H_2O(i) + N_2O(g)$

When zinc granules reacts with NaCl there will not be any reaction

When zinc granules reacts with NaOH solution.

$Zn(s) + 2NaOH(aq) \longrightarrow Na_2ZnO_2(aq) + H_2(g)$

SE. 21

On adding a drop of barium chloride solution to an aqueous solution of sodium sulphite, white precipitate is obtained.

(a) Write a balanced chemical equation of the reaction involved.

(b) What other name can be given to this precipitation reaction ?

(c) On adding dilute hydrochloric acid to the reaction mixutre, white precipitate disappears. Why ?

Ans. (a) On adding a drop of barium chloride solution to an aqueous solution of sodium sulphite, barium sulphite is obtained which is white colour precipitate.

$BaCl_2 + Na_2SO_3 \longrightarrow BaSO_3(s) + 2NaCl$

(b) In this case precipitation reaction is a double displacement reaction.

(c) When we add dilute HCl to this reaction mixture barium chloride, sulphure dioxide and water are formed Barium chloride is a soluble substance which will make the white precipitate disppear.

$BaSO_3 + 2HCl \longrightarrow BaCl_2 + SO_2 + H_2O.$

NS. 1

Which of statements about the reaction below are incorrect ?

$2PbO(s) + C(s) \rightarrow 2Pb(g) + CO_2(g)$

(a) Lead is getting reduced

(b) Carbon dioxide is getting oxidized

(c) Carbon is getting oxidized

(d) Lead oxide is getting reduced

(i) (a) and (b) (ii) (a) and (c)

(iii) (a), (b) and (c) (iv) all

Ans. Addition of oxygen is called oxidation and removal of oxygen is called reduction so statements a and b are incorrect. Hence, (i) is the correct option.

NS. 2

$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$

The above reaction is an example of

(a) Combination reaction

(b) Double displacement reaction

(c) Decomposition reaction

(d) Displacement reaction

Ans. The given equation is a displacement reaction in which Fe of Fe_2O_3 has been displaced by Al. Hence, (d) is the correct option.

NS. 3

What happens when dilute hydrochloric acid is added to iron fillings ? Choose the correct answer.

(a) Hydrogen gas and iron chloride are produced

(b) Chlorine gas and iron hydroxide are produced

(c) No reaction take place

(d) Iron salt water are produced

Ans. The following reaction take place :

$$\underset{\text{Iron}}{Fe} + \underset{\text{Hydrochloric acid}}{2HCl} \rightarrow \underset{\text{Iron chloride}}{FeCl_2} + \underset{\text{Hydrogen}}{H_2}$$

Thus, hydrogen and iron chloride are produced.

Therefore, (a) is the correct option.

NS. 4

What is a balanced chemical equation ? Why should the chemical equation be balanced ?

Ans. **Balanced chemical equation.** An equation in which the number of atoms of each element on the two sides of equation is equal is called a balanced chemical equation.

Why should chemical equation be balanced ? According to law conservation of mass, the total mass of products must be equal to total of reactants. This is possible only if the number of atoms of each element is same on the two sides of equation.

NS. 5

Translate the following statements into chemical equations and then balance them.

(A) Hydrogen gas combines with nitrogen to form ammonia.

(B) Hydrogen sulphide gas burns in air to give water and sulphur dioxide.

(C) Barium chloride reacts with aluminium sulphate to give aluminium chloride and a precipitate of barium sulphate.

(D) Potassium metal reacts with water to give potassium hydroxide and hydrogen gas.

Ans. (a) $3H_2(g) + N_2(g) \rightarrow 2NH_3(g)$

(b) $2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(l) + 2SO_2(g)$

(c) $3BaCl_2(aq) + Al_2(SO_4)_3(aq) \rightarrow 2AlCl_3(aq) + 3BaSO_4(ppt)$

(d) $2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$

NS. 6

Balance the following chemical equations.

(A) $HNO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)_2 + H_2O$

(B) $NaOH + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$

(C) $NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$

(D) $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + HCl$

Ans. (a) $2HNO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)_2 + 2H_2O$

(b) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

(c) $NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$

(d) $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$

NS. 7

Write the balanced chemical equations for the following reactions.

(A) Calcium hydroxide + Carbon dioxide → Calcium carbonate + Water

(B) Zinc + Silver nitrate → Zinc nitrate + Silver

(C) Aluminium + Copper chloride → Aluminium chloride + Copper

(D) Barium chloride + Potassium sulphate → Barium sulphate + Potassium chloride

Ans. (A) $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

(B) $Zn + 2AgNO_3 \rightarrow Zn(NO_3)_2 + 2Ag$

(C) $2Al + 3CuCl_2 \rightarrow 2AlCl_3 + 3Cu$

(D) $BaCl_2 + K_2SO_4 \rightarrow BaSO_4 + 2KCl$

NS. 8

Write the balanced chemical equation for the following and identify the type of reaction in each case.

(A) Potassium bromide (aq) + Barium iodide (aq) → Potassium iodide (aq)+ Barium bromide (s)

(B) Zinc carbonate (s) → Zinc oxide (s) + Carbondioxide (g)

(C) Hydrogen (g) + Chlorine (g) → Hydrogen chloride (g)

(D) Magnesium (s) + Hydrochloric acid (aq) → Magnesium chloride (aq) + Hydrogen (g)

Ans. (a) $2KBr(aq) + BaI_2(aq) \rightarrow 2KI(aq) + BaBr_2(s)$; In this reaction there is an exchange of ions between the reactant so it is double displacement reaction.

(b) $ZnCO_3(s) \rightarrow ZnO(s) + CO_2(g)$; In this reaction the single reactant breaks down to give simpler products so it is decomposition reaction.

(c) $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$; In this reaction the single product is formed from two reactants so it is combination reaction

(d) $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$; In this reaction magnesium displaced or removed H, so it is displacement reaction.

NS. 9

What does one mean by exothermic and endother-mic reactions? Give examples.

Ans. **Exothermic reaction:** Those reactions in which heat is evolved during the reaction are called exothermic reactions.

For example,

Burning of coke.

$C(s) + O_2(g) \rightarrow CO_2(g) + Heat$

Endothermic reaction: Those reactions in which heat is absorbed during the reaction are called

endothermic reactions.

For example,

$N_2(g) + O_2(g) + Heat \rightarrow 2NO(g)$

NS. 10

Why is respiration considered an exothermic reaction? Explain.

Ans. The carbohydrates are broken down to form glucose. This glucose combines with oxygen in the cell of our body and provides energy so it is a exothermic reaction.

$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l) +$ energy

(Glucose)

NS. 11

Why are decomposition reactions called the opposite of combination reactions? Write equations for these reactions.

Ans. Decomposition reactions are those in which a compound breaks down to form two or more substances.While in the combination reaction single product is formed from two or more reactants. Thus decomposition reaction is exact opposite of combination reactions.

For example,

$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$ (decomposition)

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l) +$ energy (combination)

NS. 12

Write one equation each for decomposition reactions where energy is supplied in the form of heat, light or electricity.

Ans. (a) Thermal decomposition of ferrous sulphate:

$$2FeSO_4(s) \xrightarrow{\Delta} Fe_2O_3(s) + SO_2(g) + SO_3(g)$$

Ferrous sulphate — Ferric oxide — sulphur dioxide — sulphur trioxide

(b)Decomposition of AgCl in presence of light:

$$2AgCl(s) \xrightarrow{Light} 2Ag(s) + Cl_2(g)$$

Silver chloride — Silver — Chlorine

(c)Decomposition of AgBr in presence of light:

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

Silver bromide — Silver — Bromine

(d)Decomposition by electricity:

$$2Al_2O_3(aq) \xrightarrow{Electricity} 4Al(s) + 3O_2(g)$$

Aluminium oxide — Aluminium — Oxygen

NS. 13

What is the difference between displacement and double displacement reactions? Write equations for these reactions.

Ans. **Displacement reaction:** A more reactive element replaces a less reactive element from a compound.

Example of displacement reaction:

$CuSO_4(aq) + Zn(s) \rightarrow ZnSO_4(aq) + Cu(s)$

Zinc is more reactive metal as compare to copper so zinc displace the copper ion in copper.

Double displacement reaction:

In the double displacement reaction two compounds react and the positive ion (cation) and the negative ion (anion) of the two reactants switch place

forming two new compounds or products.

Example:

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

NS. 14

In the refining of silver, the recovery of silver from silver nitrate solution involved displacement by copper metal. Write down the reaction involved.

Ans. $2AgNO_3(aq) + Cu(s) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)$

silver Nitrate Copper — copper Nitrate — silver

NS. 15

What do you mean by a precipitation reaction? Explain by giving examples.

Ans. A reaction in which an insoluble solid (called precipitate) is formed is called a precipitation reaction.

Example:

$Na_2CO_3(aq) + CaCl_2(aq) \rightarrow CaCO_3(s) + 2NaCl(aq)$

Sodium carbonate — Calcium chloride — Calcium carbonate — Sodium chloride

In this reaction, calcium carbonate is obtained as a precipitate. Hence, it is a precipitation reaction.

$Na_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(S) + 2NaCl(aq)$

Sodium sulphate — Barium chloride — Barium sulphate — Sodium chloride

In this reaction, barium sulphate is obtained as a precipitate.

NS. 16

Explain the following in terms of gain or loss of oxygen with two examples each.

(a) Oxidation

(b) Reduction

Ans. (a) Oxidation is the gain of oxygen

Example:

(i) $2H_2 + O_2 \rightarrow 2H_2O$ (ii) $2Cu + O_2 \rightarrow 2CuO$

In equation (i), H_2 is oxidized to H_2O and in equation (ii), Cu is oxidised to CuO due to gain of oxygen.

(b) Reduction is the loss of oxygen.

Example:

(i) $CO_2 + H_2 \rightarrow CO + H_2O$

(ii) $CuO + H_2 \xrightarrow{\Delta} Cu + H_2O$

In equation (i), CO_2 is reduced to CO and in equation (i), CuO is reduced to Cu due to removal of oxygen.

NS. 17

A shiny brown coloured element 'X' on heating in air becomes black in colour. Name the element 'X'

and the black coloured compound formed.

Ans. 'X' is copper (Cu) and the black-coloured compound formed is copper oxide (CuO).

The equation of the reaction involved on heating copper is given below.

$$\underset{\text{(Shiny brown in colour)}}{2Cu} + O_2 \rightarrow \underset{\text{(Black in colour)}}{2CuO}$$

NS. 18

Why do we apply paint on iron articles?

Ans. iron, in the presence of moisture, reacts with oxygen to form hydrated iron oxide.

$$4Fe + 3O_2 + nH_2O \rightarrow \underset{\text{Hydrated iron oxide}}{2Fe_2O_3.nH_2O}$$

This hydrated iron oxide is rust Iron articles are painted because it prevents them from rusting. When painted, the contact of iron articles from moisture and air is cut off. Hence, rusting is prevented their presence is essential for using to take place.

NS. 19

Oil and fat containing food items are flushed with nitrogen. Why?

Ans. Nitrogen is an inert gas and does not easily react with these substances. On the other hand, oxygen reacts with food substances and makes them rancid. Thus, bags used in packing food items are flushed with nitrogen gas to remove oxygen inside the pack. When oxygen is not present inside the pack, rancidity of oil and fat containing food items is avoided.

NS. 20

Explain the following terms with one example each.

(a) Corrosion

(b) Rancidity

Ans. (a) Corrosion:

Corrosion is defined as a process where materials, usually metals, deteriorate as a result of a chemical reaction with air, moisture, chemicals, etc., For example, iron, in the presence of moisture, reacts with oxygen to form hydrated iron oxide.

$$4Fe + 3O_2 + nH_2O \rightarrow \underset{\text{Hydrated iron oxide}}{2Fe_2O_3.nH_2O}$$

This hydrated iron oxide is rust.

(b) Rancidity:

The process of oxidation of fats and oils that can be easily noticed by the change in taste and smell is known as rancidity.

For example, the taste and smell of butter changes when kept for long.

Rancidity can be avoided by:

1. Storing food in air tight containers
2. Storing food in refrigerators
3. Adding antioxidants
4. Storing food in an environment of nitrogen.

EXERCISE – I

ONLY ONE CORRECT TYPE

SECTION (A) : GENERAL INTRODUCTION AND CHARACTERISTICS OF CHEMICAL REACTIONS

1. Which of the following statements is/are true ?
(A) The total mass of the system remains same in a chemical change.
(B) A chemical change is permanent and irreversible.
(C) A physical change is temporary and reversible.
(D) All of these.

2. Which of the following statements is/are correct ?
(A) A chemical equation tells us about the substances involved in a reaction.
(B) A chemical equation informs us about the symbols and formulae of the substances involved in a reaction.
(C) A chemical equation tells us about the atoms or molecules of the reactants and products involved in a reaction.
(D) All are correct

3. $Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$ is an example of -
(A) precipitation reaction
(B) endothermic reaction
(C) evolution of gas
(D) change in colour

4. Neutralization reaction is an example of -
(A) exothermic reaction
(B) endothermic reaction
(C) oxidation reaction
(D) none of these

5. Read the given statements and select the correct option.
Statement-1 : Breaking of a bone china plate is a physical change
Statement-2 : When a bone China plate breaks, the pieces can be joined to get back the original plate.
(A) Both statements 1 and 2 are true and statement-2 is the correct explanation statement-1.
(B) Both statements 1 and 2 are true but statement-2 is not the correct explanation statement-1.
(C) Statement-1 is true and statement-2 is false.
(D) Both Statement-1 is true and statement-2 is false.

SECTION (B) : CHEMICAL EQUATIONS & BALANCING :

6. The equation - $Cu + xHNO_3 \rightarrow Cu(NO_3)_2 + yNO_2 + 2H_2O$
The values of x and y are -
(A) 3 and 5 (B) 8 and 6
(C) 4 and 2 (D) 7 and 1

7. When dilute hydrochloric acid is added to iron fillings -
(A) hydrogen gas and ferric chloride are produced.
(B) chlorine gas and ferric hydroxide are produced.
(C) no reaction takes place.
(D) iron salt and water are produced.

8. In the reaction $FeSO_4 + x \rightarrow Na_2SO_4 + Fe(OH)_2$, x is -
(A) Na_2SO_4 (B) H_2SO_4
(C) NaOH (D) None of these

SECTION (C) : TYPES OF CHEMICAL REACTIONS:

9. In the reaction $Mg + Cl_2 \rightarrow MgCl_2$
Chlorine may be regarded as -
(A) an oxidising agent
(B) a reducing agent
(C) a catalyst
(D) providing an inert medium

10. Which of the following equations is representing combination of two elements ?
(A) $CaO + CO_2 \rightarrow CaCO_3$
(B) $4Na + O_2 \rightarrow 2Na_2O$
(C) $SO_2 + 1/2\ O_2 \rightarrow SO_3$
(D) $2Na + 2H_2O \rightarrow 2NaOH + H_2$

11. Which of the following statements is correct for oxidation reaction ?
(A) Gain or addition of electronegative radical or element
(B) Removal of hydrogen atom
(C) Removal or loss of electropositive radical or element
(D) All the above statements are correct.

12. $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$
Above equation is a-
(i) neutralization reaction
(ii) double displacement reaction
(iii) decomposition reaction
(iv) addition reaction
(A) (i) to (iv) all (B) (i) and (ii)
(C) (i) and (iii) (D) (ii) and (iv)

13. In the process of burning of magnesium in air, magnesium undergoes -
(A) reduction (B) sublimation
(C) oxidation (D) all of these

14. A substance which oxidises itself and reduces other is known as -
(A) an oxidising agent
(B) a reducing agent
(C) Both of these
(D) None of these

15. A redox reaction is one in which -
(A) both the substances are reduced.
(B) both the substances are oxidised.
(C) an acid is neutralised by the base.
(D) one substance is oxidised, while the other is reduced.

16. When the gases sulphur dioxide and hydrogen sulphide react, the reaction is
$SO_2 + 2H_2S \rightarrow 2H_2O + 3S$
Here hydrogen sulphide is acting as -
(A) an oxidising agent
(B) a reducing agent
(C) a dehydrating agent
(D) a catalyst

17. $CuO + H_2 \rightarrow H_2O + Cu$, reaction is an example of-
(A) Redox reaction
(B) Synthesis reaction
(C) Neutralisation
(D) Analysis reaction

18. Which of the following is an example of oxidation reaction ?
(A) $Sn^{+2} - 2e^- \rightarrow Sn^{+4}$
(B) $Fe^{+3} + e^- \rightarrow Fe^{+2}$
(C) $Cl^2 + 2e^- \rightarrow 2Cl^-$
(D) None of these

19. Oxidation is a process which involves -
(A) addition of oxygen
(B) removal of hydrogen
(C) loss of electrons
(D) All are correct

20. In the reaction $PbO + C \rightarrow Pb + CO$
(A) PbO is oxidised
(B) C acts as oxidising agent
(C) C acts as a reducing agent
(D) This reaction does not represent a redox reaction

SECTION (D) : EFFECT OF OXIDATION REACTIONS IN DAILY LIFE :

21. The antioxidant which is used to prevent rancidity in foods is
(A) butylated hydroxyl anisole.
(B) sodium hydroxide.
(C) sodium carbonate.
(D) methylated hydroxyl anisole

22. Corrosion of silver occurs due to the formation of
(A) Ag_2O
(B) AgCl
(C) Ag_2CO_3
(D) Ag_2S

23. Which of the following is a combustion reaction ?
(A) Boiling of water
(B) Melting of wax
(C) Burning of petrol
(D) None of these

24. Combination of phosphorus and oxygen is an example of -
(A) oxidation
(B) reduction
(C) rancidity
(D) none of these

25. Rancidity can be prevented by -
(A) adding antioxidants
(B) packging oily food in nitrogen gas
(C) both A and B
(D) none of these

PARAGRAPH TYPE

PARAGRAPH # 1

Corrosion is the phenomenon of deterioration of surface of metal in presence of air and moisture. It is a natural process and in the presence of a moist atmosphere, chemically active metals get corroded. This is an oxidation reaction. Rusting is the process where iron corrodes due to exposure to the atmosphere. The main circumstance of corrosion occurs with iron because it is a structural material in construction, bridges, buildings, rail transport, ships, etc. Aluminium is also an important structural metal, but even aluminium undergoes oxidation reactions. However, aluminium doesn't corrode or oxidize as rapidly as its reactivity suggests. Copper (Cu) corrodes and forms a basic green carbonate.

26. Which two metals do not corrode easily?
(A) Gold and Platinum
(B) Iron and Copper
(C) Iron and Aluminium
(D) Silver and Iron

27. In galvanisation process iron is coated with :
(A) Ag (B) Zn
(C) Al (D) Cu

28. On rusting of copper green substance formed is :
(A) Basic copper carbonate
(B) Basic copper sulphate
(C) Acidic copper carbonate
(D) Copper oxide

PARAGRAPH # 2

A chemical reaction is a representation of chemical change in terms of symbols and formulae of reactants and products. There are various types of chemical reactions like combination, decomposition, displacement, double displacement, oxidation and reduction reactions. Reactions in which heat is released along with the formation of products are called exothermic chemical reactions. All combustion reactions are exothermic reactions.

29. The chemical reaction in which a single substance breaks down into two or more simpler substances upon heating is known as
(A) thermal decomposition reaction
(B) photo decomposition reaction
(C) electric decomposition reaction
(D) both (A) and (C)

30. A white salt on heating decomposes to give brown fumes and yellow residue is left behind. The yellow residue left is of
(A) lead nitrate (B) nitrogen oxide
(C) lead oxide (D) oxygen gas

31. Complete the following statements by choosing correct type of reaction for X and Y.
Statement 1: The heating of lead nitrate is an example of 'X' reaction.
Statement 2: The burning of magnesium is an example of 'Y' reaction.
(A) X- Combination, Y- Decomposition
(B) X- Decomposition, Y-Combination
(C) X- Combination, Y-Displacement
(D) X- Displacement, Y-Decomposition

MATCH THE COLUMN TYPE

32.

Column - A Types of chemical reaction	Column - B Chemical equation
(a) Combination	(p) $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
(b) Decomposition	(q) $H_2 + Cl_2 \rightarrow 2HCl$
(c) Displament	(r) $BaCl_2 + Na_2SO_4 \rightarrow BaSO(\downarrow) + 2NaCl$
(d) Double displacement	(s) $2H_2O \xrightarrow{\text{Electricity}} 2H_2 + O_2$

(A) a-s, b-q, c - p, d-r
(B) a-q, b-p, c - s, d-r
(C) a-q, b-s, c - r, d-p
(D) a-q, b-s, c - p, d-r

33.

Column - A	Column - B
(a) $2Mg + O_2 \rightarrow 2MgO$	(p) Exothermic reaction
(b) $CaO + H_2O \rightarrow Ca(OH)_2$	(q) Dissociation
(c) $2AgCl \rightarrow 2Ag + Cl_2$	(r) Reduction
(d) $CuO + H_2 \rightarrow Cu + H_2O$	(s) Oxidation

(A) a-s, b-p, c - q, d-r
(B) a-s, b-p, c - r, d-q
(C) a-q, b-s, c - r, d-p
(D) a-p, b-s, c - q, d-r

EXERCISE – II

VERY SHORT ANSWER TYPE

1. on what basis is a chemical equation balanced.
2. what does the symbol aq represent in a chemical equatuon.
3. write down two characteristics of a chemical reaaction.
4. Define the term rancidity.
5. What type of reaction is represented by the digestion of food in our body ?
6. Why does the colour of copper sulphate solution change when an iron nail kept immersed in it ?
7. What is the general name of the chemicals which are added to fat and oil containing foods to prevent the development of rancidity ?
8. Name two anti-oxidants which are usually added to fat and oil containing foods to prevent rancidity.
9. Write one equation for the decomposition reaction where energy is supplied in the form of light.
10. State an important use of decomposition reactions.

SHORT ANSWER TYPE

1. Write the balanced chemical equations for the following reactions.
   (a) Sodium carbonate on reaction with hydrochloric acid in equal molar concentrations gives sodium chloride and sodium hydrogencarbonate.
   (b) Sodium hydrogencarbonate on reaction with hydrochloric acid gives sodium chloride, water and liberates carbon dioxide.
   (c) Copper sulphate on treatment with potassium iodide forms cuprous iodide (Cu_2I_2), liberates iodine gas and also forms potassium sulphate.
2. Balance the following chemical equations and identify the type of chemical reaction.
   (a) $Mg(s) + Cl_2(g) \rightarrow MgCl_2(s)$
   (b) $HgO(s) \xrightarrow{Heat} Hg(l) + O_2(g)$
   (c) $Na(s) + S(s) \xrightarrow{Fuse} Na_2S(s)$
   (d) $TiCl_4(l) + Mg(s) \rightarrow Ti(s) + MgCl_2(s)$
   (e) $CaO(s) + SiO_2(s) \rightarrow CaSiO_3(s)$
   (f) $H_2O_2(l) \xrightarrow{U.V.} H_2O(l) + O_2(g)$
3. A magnesium ribbon is burnt in oxygen to give a white compound X accompanied by emission of light. If the burning ribbon is now placed in an atmosphere of nitrogen, it continues to burn and forms a compound Y.
   (a) Write the chemical formulae of X and Y.
   (b) Write a balanced chemical equation, when X is dissolved in water.
4. A solution of potassium chloride when mixed with silver nitrate solution, an insoluble white substance is formed. Write the chemical reaction involved and also mention the type of the chemical reaction?
5. The color of copper sulphate solution changes when an iron nail is dipped in it. State the giving chemical equation for the reaction involved.

   Write the name of reaction involved.

LONG ANSWER TYPE

1. Identify the reducing agent and oxidising agent in the following reactions
   (a) $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
   (b) $CuO + H_2 \rightarrow Cu + H_2O$
   (c) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
   (d) $2H_2 + O_2 \rightarrow 2H_2O$
   (e) $Pb_3O_4 + 8HCl \rightarrow 3PbCl_2 + Cl_2 + 4H_2O$
   (f) $2Mg + O_2 \rightarrow 2MgO$
   (g) $CuSO_4 + Zn \rightarrow Cu + ZnSO_4$
   (h) $V_2O_5 + 5Ca \rightarrow 2V + 5CaO$
   (i) $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$
2. You are provided with two containers made up of copper and aluminium. You are also provided with solutions of dilute HCl, $ZnCl_2$ and H_2O. In which of the above containers these solutions can be kept ?
3. What happens when a piece of
   (a) Zinc metal is added to copper sulphate solution?
   (b) Aluminium metal is added to dilute hydrochloric acid?

(c) silver metal is added to copper sulphate solution? Also, write the balanced chemical equation if the reaction occurs.

4. Explain why ?
(a) Digestion of food is a decomposition reaction.
(b) All decomposition reactions are endothermic reactions.
(c) A popping sound is produced when a burning candle is brought near mouth of a test tube used in electrolysis of water.

5. A solution of a substance 'X' is used for white washing.
(a) Name the substance 'X' and write its formula
(b) Write the reaction of the substance 'X' named in (a) above with water.
(c) Write the balanced equation for the following chemical reaction:
Barium chloride + Aluminium sulphate → Barium sulphate + Aluminium chloride.

TRUE / FALSE TYPE

1. Rusting of iron is a physical change.
2. Unbalanced chemical equation is against the law of conservation of mass.
3. In general, combination reactions are exothermic.
4. When water containing dil. H_2SO_4 is electrolysed, H_2 gas is obtained at positive electrode (anode).
5. Oxidizing agent gets oxidized in a chemical reaction.

FILL IN THE BLANKS TYPE

1. Formation of Nitric oxide from nitrogen and oxygen is a _____ reaction.
2. Reaction in which energy is absorbed is known as _____ reaction.
3. The reaction in which heat is given out along with products is known as _____ reaction.
4. Digestion of food in your body is an example of _____ reaction.
5. The reaction $CaCO_3 \xrightarrow{Heat} CaO + CO_2$ is a _____ reaction.

NUMERICAL PROBLEMS

1. In the reaction

$$xPb(NO_3)_2 \xrightarrow{Heat} yPbO + zNO_2 + O_2$$

x + y + z is

2. Lime water molecular mass is
3. On reaction of metal sulphite with acid evolved gas molecular mass is
4. $MnO_4^{-2} \longrightarrow MnO_4^{-}$ in this reaction number of electron loose is
5. On electrolysis of H_2O gas evolved H_2 and O_2 volume ratio at S.T.P. is

Answer Key

EXERCISE–I

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
D	D	C	A	C	C	A	C	A	B	D	B	C	B	D
16	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
B	A	A	D	C	A	D	C	A	C	A	B	A	A	A
31	**32**	**33**												
B	D	A												

EXERCISE – II

TRUE / FALSE

1. F 2. T 3. T 4. F 5. F

FILL IN THE BLANKS

1. Combination **2.** Endothermic **3.** Exothermic

4. Decomposition **5.** Thermal decomposition

NUMERICAL PROBLEMS

1. 8 **2.** 74 **3.** 64 **4.** 1 **5.** 2 : 1

SELF PROGRESS ASSESSMENT FRAMEWORK

(CHAPTER : CHEMICAL REACTIONS & EQUATIONS)

CONTENT	STATUS	DATE OF COMPLETION	SELF SIGNATURE
Theory			
In-Text Examples			
Solved Examples			
NCERT Exercises			
Exercise I			
Exercise II			
Short Note-1			
Revision - 1			
Revision - 2			
Revision - 3			
Remark			

NOTES :

1. In the status, put “completed” only when you have thoroughly worked through this particular section.

2. Always remember to put down the date of completion correctly. It will help you in future at the time of revision.

Space for Notes :