CHEMISTRY

CHEMICAL REACTIONS & EQUATIONS

Concepts Covered

- Introduction of Chemical Reaction.
- Characteristics of Chemical Reaction.
- Chemical Equation and Balancing.
- Types of Chemical Reactions.
- Redox Reaction, Oxidizing and reducing agents, Rancidity and Corrosion.

Introduction:

Change is the law of nature. Scientist classify these changes as physical changes and chemical changes. When a chemical change occurs, a chemical reaction is said to have taken place.

Physical change: A change in which the physical properties of the substance changes but the chemical composition does not change. The substance is restored to its original state as soon as the cause of change is withdrawn.

Chemical change: In a chemical change, at least one of the reacting substance changes into a new substance with a different composition. The new substances cannot be changed back to the original substance even if the cause of change is withdrawn.

Difference between physical & chemical change

S.No.	Physical change	Chemical change
1	No new substance is produced.	A new substance is always produced.
2	The identity of the substance is maintained.	The identity of the original substance is completely lost.
3	The change is temporary, the substance returns to its original state as the cause of. change is withdrawn	The change is permanent.
4	Only the physical state or some of the physical properties of the substances are changed.	The substance after the change cannot come back to its original state even when the cause of change is withdrawn.
5	H eat change may or may not occur.	Heat change may occur.

Chemistry is defined as that branch of science which deals with the composition and properties of matter and the changes that matter undergone by various interactions. A chemical compound is formed because of a chemical change and in this process different type of energies such as heat, electrical energy, radiation etc. are either absorbed or evolved. The total mass of the substance remains the same throughout the chemical change.

Chemical Reaction:

When a chemical change occurs, a chemical action is said to have taken place. A chemical change or chemical action is represented by a chemical equation. The matter undergoing change in known as reactant and new chemical component formed is known as product.

Characteristics of a Chemical 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 appears. 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.

- In this reaction the substance which take part in bringing about chemical change are called reactants.
- The substance which are produced because of chemical change are called products.
- These reactions involve breaking and making of chemical bonds.
- Product(s) of the reaction is/are new substances with new name(s) and chemical formula.
- It is often difficult or impossible 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: Some chemical reactions are characterized by evolution of a gas.

When zinc metal is treated with dilute Sulphuric acid, hydrogen gas is evolved. The hydrogen gas burns with a pop sound.

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

When washing soda is treated with hydrochloric acid, it gives off colorless gas with lots of effervescence.

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

$$\underset{\text{Sodium hydrogen carbonate}}{2NaHCO_3\ (s)} \xrightarrow{\text{Heat}} \underset{\text{Sodium carbonate}}{Na_2CO_3\ (s)} + \underset{\text{Water}}{H_2O\ (l)} + \underset{\text{Carbon dioxide}}{CO_2\ (g)}$$

(ii) Change of colour: Certain chemical reactions are characterized by the change in colour of reacting substance.

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

$$\underset{\text{Lead oxide (Red)}}{2Pb_3O_4\ (s)} \xrightarrow{\text{heat}} \underset{\text{Lead monoxide (Yellow)}}{6PbO\ (s)} + O_2\ (g)$$

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

$$\underset{\text{Copper carbonate (Green)}}{CuCO_3\ (s)} \xrightarrow{\text{heat}} \underset{\text{Copper oxide (Black)}}{CuO\ (s)} + \underset{\text{Carbon dioxide}}{CO_2\ (g)}$$

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

(iii) Formation of precipitate: Some chemical reactions are characterized by the formation of precipitate (an insoluble substance), when the solutions of the soluble chemical compounds are mixed together.

When silver nitrate solution is mixed with a solution of sodium chloride.

$AgNO_3$ (aq)	**+**	**NaCl (aq)**	**$\longrightarrow$**	**$NaNO_3$ (aq)**	**+**	**AgCl (s)**
Silver nitrate		**Sodium chloride**		**Sodium nitrate**		**Silver chloride**
(Colourless)		**(Colourless)**		**(Colourless)**		**(White precipitate)**

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

$FeSO_4$ (aq)	**+**	**2NaOH(aq)**	**$\longrightarrow$**	**Na_2SO_4 (aq)**	**+**	**$Fe(OH)_2$ (aq)**
Ferrous sulphate		**Sodium hydroxide**		**Sodium sulpahte**		**Ferrous hydroxide**
(Light green)		**(Colourless)**		**(Colourless)**		**(Dirty green precipitate)**
$BaCl_2$ (aq)	**+**	**dill H_2SO_4**	**$\longrightarrow$**	**$BaSO_4$ (s)**		**+ 2HCl (aq)**
Barium chloride				**Barium sulphate**		
				(White precipitate)		

(iv) Energy changes: all chemical reactions proceed either with the absorption or release of energy.

On the basis of energy changes, there are two types of reactions:

(1) Endothermic reaction:

The chemical reactions in which formation of products is accompanied by the absorption of heat are known as endothermic reactions. Some examples of endothermic reactions are:

(i) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g) - \text{Heat}$

(ii) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g) - \text{Heat}$

(iii) $C(s) + 2S(g) \rightarrow CS_2(l) - \text{Heat}$

(iv) $C(s) + H_2O(g) \rightarrow CO(g) + H_2(g) - \text{Heat}$

(2) Exothermic reaction: Exothermic Reactions: The chemical reactions in which formation of products, is accompanied by evolution of heat are known as exothermic reactions.

Some examples of exothermic reactions are:

(i) Burning of coal:

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

(ii) Burning of natural gas:

$CH_4(g) + O_2(g) \rightarrow CO_2(g) + 2H_2O(l) + \text{Heat}$

(iii) Formation of slaked lime from quick lime:

$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq) + \text{Heat}$

DID you KNOW

Respiration is also an exothermic process

This energy is generally supplied by food we eat. Bread, potatoes and rice etc. which we eat all contains carbohydrates.

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

The reaction is known by a special name respiration.

(iv) Decomposition of vegetable matter on a compost heap is also an example of exothermic reaction.

(v) Change of state: Some chemical reactions are characterized by a change in state i.e. solid, liquid or gas

Two volumes of hydrogen gas react with one volume of oxygen gas to from water.

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

or when electric current is passed through water it splits into its elements.

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

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

Ammonia   Hydrochloric acid   Ammonium Chloride

Chemical Equations:

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 links together the substance which react (reactants) with the new substances that are formed (products).

Zinc + Hydrochloric acid ⟶ Zinc chloride + Hydrogen

(Reactants)   (Products)

A Chemical reaction can be summarized by chemical equation.

Types of Chemical Equations:

(i) Word equations: A word equation links together the names of the reactants with those of the products. For example, the word equation, when magnesium ribbon burns in oxygen to form a white powder of magnesium oxide, may be written as follows-

Magnesium + Oxygen ⟶ Magnesium oxide

(Reactants)   (Product)

Similarly, the word equation for the chemical reaction between granulated zinc and hydrochloric acid may be written as -

Zinc + Sulphuric acid → Zinc sulphate + Hydrogen

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 $(\rightarrow)$ separates the reactants from the products.
- The direction of the arrow head points towards the product.
- Although word equations are quite useful, yet they don't give the true picture of the chemical reactions.

(ii) Symbol equation: A brief representation of a chemical reaction in terms of symbols and formulae of the substance involved 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.

Example:

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

$$Mg + O_2 \longrightarrow MgO$$

Symbol equations are always written from the word equations.

Unbalanced and Balanced Chemical Equations:

In an unbalanced equation, the number of atoms of different elements on both side of the equation are not equal. For example, in the equation given below, 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.

$$Mg + O_2 \longrightarrow MgO$$

An unbalanced equation is also called **skeletal equation.**

In a balanced equation, the number 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 -

$$2\,Mg + O_2 \longrightarrow 2MgO$$

(i) Importance of balanced chemical equation: The balancing of a chemical equation is essential or necessary to fulfill the requirement of "Law of conservation of mass".

(ii) 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 side of the equations, equal.

The balancing of a chemical equation is done with the help of Hit and Trial method. In this method, the co-efficient 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 side of the arrow head become equal. This balancing is also known as mass balancing because the atoms of elements on both sides are equal and their masses will also be equal.

Steps involved in balancing a chemical equation are as follow –

1. Write the chemical equations in the form a word equation. Keep the reactants on the left side and the products on the right side. Separate them by an arrow whose head $(\rightarrow)$ points from the reactants towards the products.
2. Convert the word equation into the symbol equation by writing the symbols and formulae of all the reactants and products.
3. Make the atoms of different elements on both side of the equation equal by suitable method. This is known as balancing of equation.
4. Do not change the formulae of the substance while balancing the equation.
5. Make the equations more informative if possible.

Example:

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

Solution: The word equation for the reactions is -

Zinc + Sulphuric acid $\rightarrow$ Zinc sulphate + Hydrogen

The symbol equation for the same reactions 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 for the equations.

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.

(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 equations is done is 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 balance equation may be written as

$Fe + 4H_2O \rightarrow Fe_3O_4 + H_2$

III: To equate H atoms, put coefficient 4 before H_2 on the product side, as a result, the H atoms on both side on 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.

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. To make the equation more informative, the physical state is 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 $(\uparrow)$ i.e., by an arrow pointing upwards.
- Similarly, the precipitate, if formed during the reaction, is indicated by the symbol $(\downarrow)$ i.e., by an arrow pointing downwards. The abbreviation 'ppt' is also using to represent the precipitate, if formed.

$2Na(s) + 2H_2O\ (l) \rightarrow 2NaOH\ (aq.) + H_2(g)$ or $H_2\ (\uparrow)$

$Ca(OH)_2(aq.) + CO_2(g) \rightarrow CaCO_3\ (\downarrow) + H_2O\ (l)$

$AgNO_3(aq.) + NaCl(aq.) \rightarrow AgCl\ (\downarrow) + NaNO_3(aq.)$

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.

$2H_2(g) + O_2(g) \rightarrow 2H_2O\ (l) + 572\ kJ$; $2H_2\ (g) + O_2(g) \rightarrow 2H_2O(g) + 44\ kJ$

Both these reactions are of exothermic nature because heat has been evolved in these. However, actual amounts of heat are different when water is in the liquid state i.e. H_2O (l) and when it is in the vapour state.

Specialties of Chemical Equation:

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

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

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

Example:

$$\underset{(100gm)}{CaCO_3} \longrightarrow \underset{(56\ gm)}{CaO} + \underset{(44\ gm)}{CO_2}$$

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 gram and of products is also 100 g (56 gram + 44 gram).

(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 liters.

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

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.

All chemical equations are written under N.T.P. Conditions (at 273 K and 1 atmosphere pressure) if conditions are not otherwise mentioned.

Limitations of Chemical Equations:

(i) We do not get information about the physical state of reactants and products; such as 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 favorable conditions of the reactions such as pressure, temperature, catalyst etc. can't be obtained during the reaction

(v) We do not get information whether heat 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

- The physical sate of reactants and products are represented by writing them in bracket.
- The precipitate formed in the reaction is represented by $(\downarrow)$ symbol and gaseous substance by $(\uparrow)$ symbol.
- To express the concentration, dilute or conc. is written below the symbol.

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

- Favorable conditions required for the completion of reaction are written above and below the arrow.

$$N_2 + 3H_2 \xrightarrow[200\ atm]{500^0 Fe / Mo} 2NH_3 + 22400 \text{ Calorie heat}$$

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

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

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

Check your Concept

(1) In the balanced equation - $aFe_2O_3 + bH_2 \longrightarrow cFe + dH_2O$

The value of a, b, c, d is respectively -

(A) 1,1,2,3 (B) 1,1,1,1

(C) 1,3,2,3 (D) 1,2,2,3

(2) Which of the following reactions is not balanced

(A) $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$ (B) $2C_4H_{10} + 12O_2 \longrightarrow 8CO_2 + 10H_2O$

(C) $2Al + 6H_2O \longrightarrow 2Al(OH)_3 + 3H_2$ (D) $4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$

(3) 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

Answer Key

(1)	(2)	(3)
(C)	(B)	(C)

Types of Chemical Reactions:

(I) Combination Reactions:

Those chemical reactions which involve the combination of two or more substances to form a single new substance are called combination reactions. Combination reactions may involve either (i) combination of two elements or (ii) combination of an element and a compound to form a new compound or (iii) combination of two compounds.

Let us now discuss all these types of combination reactions one by one.

Example:

$H_2 + Cl_2 \rightarrow 2HCl$

In the above example H_2 and Cl_2 two elements combine to from hydrogen chloride.

Addition reactions may be formed in the following conditions -

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

- Synthesis reaction: It is a type of addition reaction in which a new substance is formed by the union of its component elements.

Example:

$N_2 + 3H_2 \rightarrow 2NH_3$ (Haber's Process)

- Ammonia is synthesized from its component's nitrogen and hydrogen, so it is a synthetic reaction.
- All synthesis reaction are addition reactions, but all addition reactions are not synthesis reactions.

Other Example of synthesis reactions are -

$2H_2 + O_2 \longrightarrow 2H_2O$

$2Mg + O_2 \longrightarrow 2MgO$

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

Example:

$NH_3 + HCl \longrightarrow NH_4Cl$

$CaO + CO_2 \longrightarrow CaCO_3$

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

Example:

$2CO + O_2 \longrightarrow 2CO_2$

$2CO_2 + O_2 \longrightarrow 2CO_3$

Only single substance is formed as a product in the addition reactions.

(II) Decomposition Reaction:

(i) Those chemical reactions in which a compound breaks down to produce two or more simpler substances are known as decomposition reactions.
(ii) These reactions take place when the energy is supplied in the form of heat, light or electricity.
(iii) It may be noted that decomposition reactions are just the reverse of combination reactions.

(A) Thermal Decomposition Reactions - Chemical reactions in which the decomposition is achieved by supplying heat energy are called thermal decomposition reactions.

Example:

Decomposition of calcium carbonate

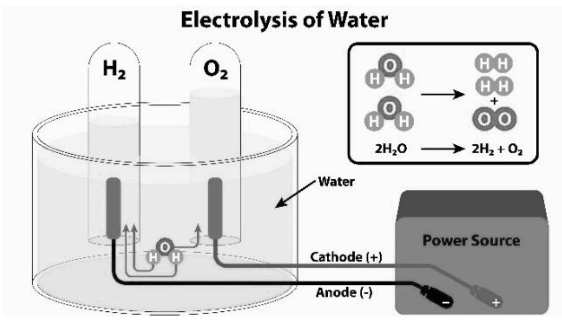
$$\underset{\text{Calcium carbonate}}{CaCO_3(s)} \xrightarrow[\text{Decomposition}]{\text{Heat}} \underset{\text{Calcium oxide}}{CaO(s)} + \underset{\text{Carbon dioxide}}{CO_2(s)}$$

Calcium oxide obtained in this process is called lime or quick lime, it has many uses.
The most important is in the manufacture of cement.

(B) Electrolytic Decomposition Reactions - Chemical reactions in which decomposition is achieved by passing electric current are called electrolytic decomposition reactions. This process of electrolytic decomposition of a substance is also known as electrolysis.

Example:

(a) Electrolytic decomposition of water: When electric current is passed through acidulated water, it decomposes to give hydrogen gas and oxygen gas.



(a) $2H_2O \xrightarrow{\text{Electricity}} 2H_2 + O_2$

(b) $2NaCl \xrightarrow{\text{Electricity}} 2Na + Cl_2$

(c) $2Al_2O_3 \xrightarrow{\text{Electricity}} 4\,Al + 3O_2$

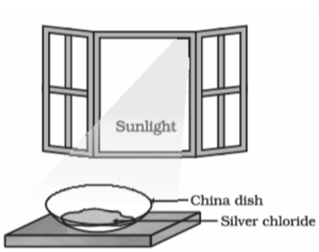
(C) A decomposition reaction brought by light is known as photo decomposition.

Example:

$2AgBr \xrightarrow{\text{Light}} 2Ag + Br_2$

$2AgCl \xrightarrow{\text{Light}} 2Ag + Cl_2$

Take about 2 g silver chloride in a china dish. What is its colour? Place this china dish in sunlight for some time (Fig)
Observe the colour of the silver chloride after some time.



(D) Decomposition reaction in which a compound decomposes into its elements is known as analysis reaction.

Example:

$2HgO \xrightarrow{\Delta} 2Hg + O_2$

$2HI \xrightarrow{\Delta} H_2 \uparrow + I_2 \downarrow$

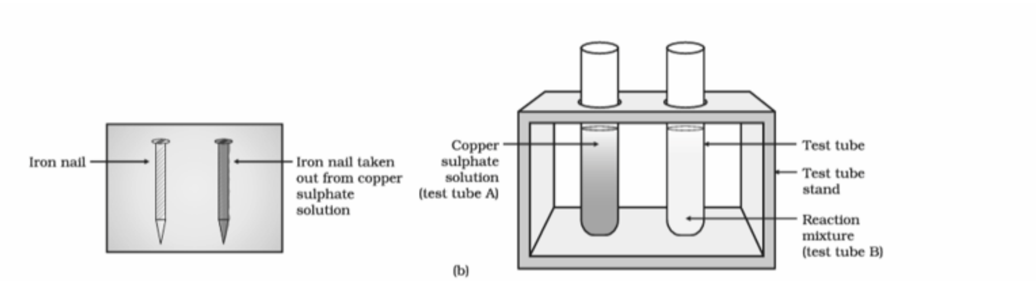
- All analysis reactions are decomposition reactions, but all decomposition reactions are not analysis reactions.
- Decomposition reactions are generally endothermic in nature
- Decomposition reaction is just opposite of the addition reaction.

(III) Displacement Reactions:

A displacement reaction is the one wherein the atom or a set of atoms is displaced by another atom in a molecule. For instance, when iron is added to a copper sulphate solution, it displaces the copper metal.

A + B-C → A-C + B

The above equation exists when A is more reactive than B.



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

Example:

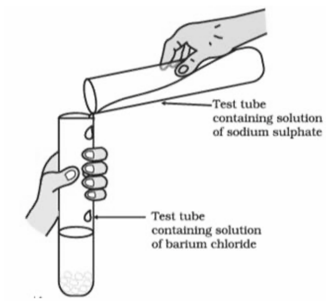
(a) Displacement of copper by iron: When a piece of iron metal is dipped in a solution of copper sulphate, deep blue colour of copper sulphate starts fading and starts converting into green colour. This is due to displacement of copper from copper sulphate solution by more reactive iron metal which results in the formation of green coloured ferrous sulphate solution along with the deposition of reddish-brown copper metal on the surface of iron metal.

$$Fe\,(s) + CuSO_4(aq) \longrightarrow FeSO_4\,(aq) + Cu$$

(IV) Double Displacement:

It is mutual exchange of the radicals of two compounds taking part in the reaction and results in the formation of two new compounds.

Take about 3 mL of sodium sulphate solution in a test tube. In another test tube, take about 3 mL of barium chloride solution. Mix the two solutions (Fig). What do you observe?



$$NaCl\,(aq) + AgNO_3\,(aq) \longrightarrow AgCl \downarrow + NaNO_3\,(aq)$$

$$BaCl_2\,(aq) + Na_2SO_4\,(aq) \longrightarrow BaSO_4 \downarrow + 2NaCl\,(aq)$$

Acid base neutralization reactions are double displacement reactions.

(1) Classify the following reactions –

(i) $N_2 + O_2 \longrightarrow 2NO + Heat$

(ii) $2HgO \longrightarrow 2Hg + O_2$

(iii) $Na_2SO_4 + BaCl_2 \longrightarrow 2NaCl + BaSO_4$

Answer Key

(1) (i) Endothermic Reaction

(ii) Analysis reactions

(iii) Double displacement reaction

(2) Chemical reaction $2Na + Cl_2 \longrightarrow 2NaCl$ is an example of

(A) Combination reaction (B) decomposition reaction

(C) displacement reaction (D) double displacement reaction

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

Above reaction is a -

(A) precipitation reaction (B) double displacement reaction

(C) combination reaction (D) (A) and (B) both

(4) The reaction in which two compounds exchange their ions to form two new compounds is-

(A) a displacement reaction (B) A decomposition reaction

(C) an addition reaction (D) A double displacement reaction

Answer Key

(2)	(3)	(4)
(A)	(D)	(D)

Oxidation and Reduction:

Oxidation: -

(i) The addition of oxygen to an element or compound.

$2Cu + O_2 \xrightarrow{Heat} 2\,CuO$

(ii) Removal of hydrogen from a compound is known as oxidation.

$2HCl \xrightarrow{-2H} Cl_2$

Reduction: -

(i) The addition of hydrogen to an element or compound

$H_2 + O_2 \longrightarrow 2H_2O$

(i) Removal of oxygen from a compound.

$CuO + H_2 \xrightarrow{Heat} Cu + H_2O$

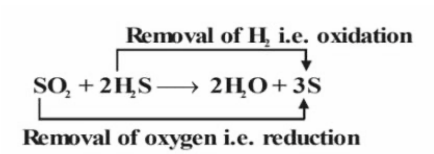
Oxidizing agent: - The substance which gives oxygen or removes hydrogen for oxidation is called oxidizing agent and the substances which gains oxygen during reaction is said to be oxidized.

Reducing agent: - The substance which gives hydrogen or removes oxygen for reduction is called reducing agent. The substance which gains, hydrogen during reaction is said to be reduced.

Those reactions in which oxidation and reduction (both) occurs simultaneously are called redox reactions.

In the name Redox the term 'red' stands for reduction and 'ox' stands for oxidation.

Example:



- SO_2 is reduced to sulphur, so it is oxidizing agent.
- H_2S is oxidized to sulphur, so it is reducing agent.

It should be noted that substance which undergoes oxidation acts as reducing agent whereas the substance undergoes reduction act as oxidizing agent.

There is another concept of oxidation and reduction in terms of metals and nonmetals. This is as follows –

- The addition of nonmetallic element (or removal of metallic element) is called oxidation.
- The addition of metallic element (or removal of nonmetallic element) is called reduction.

Electronic Concept for Oxidation and Reduction

Oxidation - The loss of an electron by atoms or ions is called oxidation.

Atom ⟶ Cation + electrons

$A \longrightarrow A^{n+} + ne^{-}$

Atom 'A' loses n electrons to become a positively changed ion an^{+}. It is called cation

Reduction: - The gain of an electron by an atom or ion is called reduction.

$B + ne^{-} \longrightarrow B^{n-}$

The atom B gains n' electrons to become negatively charged ion B^{n-}, it is called anion.

Oxidation and reduction reactions occurs simultaneously and are called as redox reactions.

Only oxidation or only reduction is called half reaction. i.e.

$A \longrightarrow A^{n+} + ne^{-}$ – Oxidation

$B + ne^{-} \longrightarrow Bn^{-}$ – Reduction

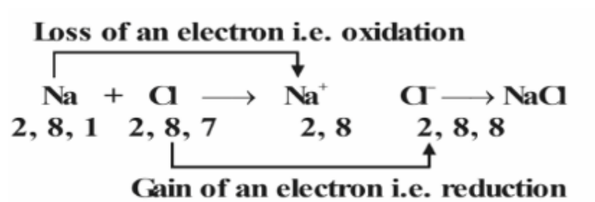
$A + B \longrightarrow A^{+}B^{-} \longrightarrow AB$ Redox

Example: Na + Cl ⟶ NaCl

In this process sodium loses one electron and oxidized to Na^{+}, chlorine gains this electron and is reduced to Cl^{-}.

$Na \longrightarrow N^{a+} + e^{-}$ (loss of an electron is oxidation)

$Cl + e^{-} \longrightarrow Cl^{-}$ (Gain of an electron is reduction)



Effect of Oxidation Reactions in Everyday 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 several 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. Some examples are-

(A) Combustion Reactions:

A chemical reaction in which a substance burns or gets oxidized in the presence of air or oxygen in 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 more than oxygen upon heating.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O\,(l)$$

Methane

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

$$C_4H_{10}\,(g) + 13/2O_2(g) \rightarrow 4CO_2(g) + 5H_2O(g)$$

Butane

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 combustion or oxidation. The heat energy evolved keeps our body working. Carbohydrates such as glucose, fructose, starch etc. Is the major source of energy to the human body? They undergo combustion with the help of oxygen that we inhale to form carbon dioxide and water. For example.

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

All combustion reactions are not accompanied by flame. Combustion is basically oxidation accompanied by release of energy.

(B) 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 smalls air sacs (alveoli). These air sacs occupy a large area of membranes and oxygen diffuses from the membranes into blood. It binds itself to hemoglobin 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 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. Fish takes up oxygen dissolved in water through their gills while plants take up air through small pores (stomata) present in their leaves.

(C) Corrosion:

Corrosion is the process in which metals are eaten up gradually by the action of air, moisture or a chemical (such as an acid) on their surface. Corrosion is caused mainly by the oxidation of metals by the oxygen of air. Rusting of iron metal is the most common form of corrosion. When an iron object is left in damp air for a considerable time, it gets covered with a red-brown flaky substance called rust. This is called rusting of iron.

Rust is a chemical substance brown in colour and is formed by the chemical action of moist air (containing O_2 and H_2O) on iron. It is basically an oxidation reaction and the formula of rust is Fe_2O_3, xH_2O. It is very slow in nature and once started keeps on.

Rusting involves unwanted oxidation of iron metal which occurs in nature on its own.

Rust is a soft and porous substance which gradually falls off from the surface of an iron object, and then the iron below starts rusting. Thus, rusting of iron (or corrosion of iron) is a continuous process which, if not prevented in time, eats up the whole iron object. Corrosion weakens the iron and steel objects and structures such as railings, car bodies, bridges and ships, etc., and cuts short their life. A lot of money has to be spent every year to prevent the corrosion of iron and steel objects, and to replace the damaged iron and steel structures. The black coating on silver and the green coating on copper are other examples of corrosion.

(D) Rancidity:

When the fats and oils present in food materials get oxidized 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 fats and oils which have been kept for a considerable time and makes them unfit for eating.

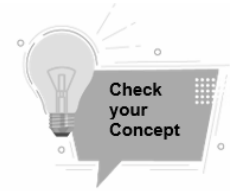
(i) Rancidity can be prevented by adding anti-oxidants to foods containing fats and oils. Anti-oxidant is a substance (or chemical) which prevents oxidation. The two common anti-oxidants used in foods to prevent the development of rancidity are BHA (Butylated Hydroxy-Anisole) and BHT (Butylated Hydroxy-Toluene).

(ii) Rancidity can be prevented by packaging fat and oil containing foods in nitrogen gas. When the packed food is surrounded by an unreactive gas 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 oxidized and turn rancid.

(iii) 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.

(iv) 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.

(v) 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.



Identify the substances that are oxidized and the substances that are reduced in the following reactions -

(a) $ZnO + C \longrightarrow Zn + CO$

(b) $MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$

(c) $2FeCl_3 + H_2S \longrightarrow 2FeCl_2 + S + 2HCl$

(d) $3Mg + N_2 \longrightarrow Mg_3N_2$

Answer Key

(b) MnO_2 is reduced and HCl is oxidized.

(c) $FeCl_3$ is reduced and H_2S is oxidized.

(d) Mg is oxidized and N_2 is reduced.

Solved Examples

(1) Why does not silver evolve hydrogen on reacting with dil H_2SO_4

Answer: Silver do not evolve hydrogen on reacting with dil. H_2SO_4 as silver is less reactive metal than hydrogen.

(2) Why do diamond and graphite are the two allotropic forms of carbon evolve different amounts of heat on combustion?

Answer: Diamond and graphite are the two allotropes of carbon, but they do not evolve same amount of heat on combustion because they differ in the arrangement of carbon atoms and their shapes are different.

(3) What is the sole of oxidizing agent is a reaction?

Answer: The oxidizing agent supply the oxygen in a reaction or it removes the hydrogen.

(4) Why a combustion reaction is/are an oxidation reaction?

Answer: Combustion reaction because it is always carried out in the presence of air or oxygen.

Example: CH_4 (g) + $2O_2$ (g) → Co_2 (g) +$2H_2O$ (l)

(5) What happens to lime water when CO_2 gas is bubbled through it in excess?

Answer: When CO_2 gas is bubbled through lime water in excess then initially it becomes milky but then its milkiness disappears.

(6) In the equations given below, state giving reasons, whether substances have been oxidized or reduced.

(i) PbO + CO → Pb + CO_2

(ii) H_2S + Cl_2 → 2HCl + S.

Answer: (i) Carbon monoxide is oxidized as it gains oxygen.

(ii) Chlorine is reduced as it gains hydrogen.

(7) A sample of water weed was placed in water and exposed to sunlight. Bubbles of a gas are seen on the surface of the leaves.

(i) Name the gas evolved.

(ii) Name the process taking place.

(iii) Write a balanced equation of reaction taking place.

Answer: (i) Oxygen

(ii) Photosynthesis

(iii) $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$.

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

(a) Magnesium ribbon is burnt in an atmosphere of nitrogen gas to form solid magnesium nitride.

Answer: (a) Magnesium ribbon is burnt in an atmosphere of nitrogen gas to form solid magnesium nitride.

It is a combination reaction of magnesium on burning reacts N_2 to form magnesium nitride.

$$3Mg_{(s)} + N_2 \longrightarrow Mg_3N_2$$

(9) What happens when a piece of

(a) zinc metal is added to copper sulphate solution?

(b) aluminum 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.

Answer: (a) The solution will become colourless due to formation of zinc sulphate and reddish brown

(b) aluminum chloride solution will be formed.

(c) No reaction will take place because silver is less reactive than copper, it cannot displace copper from copper sulphate.

(10) A white coloured water insoluble substance X on reacting with dilute H_2SO_4 released a colourless and odourless gas accompanied by brisk effervescence. When the gas was passed through water, the solution obtained turned blue litmus red. On bubbling the gas through lime water, it initially became milky and milkiness disappeared when the gas was passed in excess. Identify the substance X. Write its chemical equations of the reactions involved. [HOTS]

Answer: Calcium carbonate on reacting with dilute sulphuric acid releases a colourless and odourless gas carbon dioxide accompanied by brisk effervescence.

The chemical equation for this reaction is

$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$

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

milky

$CO_2\ (g) + CaCO_3\ (s) + H_2O\ (l) \rightleftharpoons Ca(HCO_3)_2\ (aq)$

(colourless)

(10) What happens when dilute hydrochloric acid is added to iron filling?

(A) Hydrogen gas and iron chloride are produced.

(B) Chlorine gas and iron hydroxide are produced

(C) No reaction takes place

(D) Iron salt and water are produced

Answer Key

(II) OBJECTIVE TYPE QUESTIONS

(1)	(C)	**(6)**	(C)
(2)	(B)	**(7)**	(B)
(3)	(D)	**(8)**	(B)
(4)	(C)	**(9)**	(C)
(5)	(D)	**(10)**	(A)