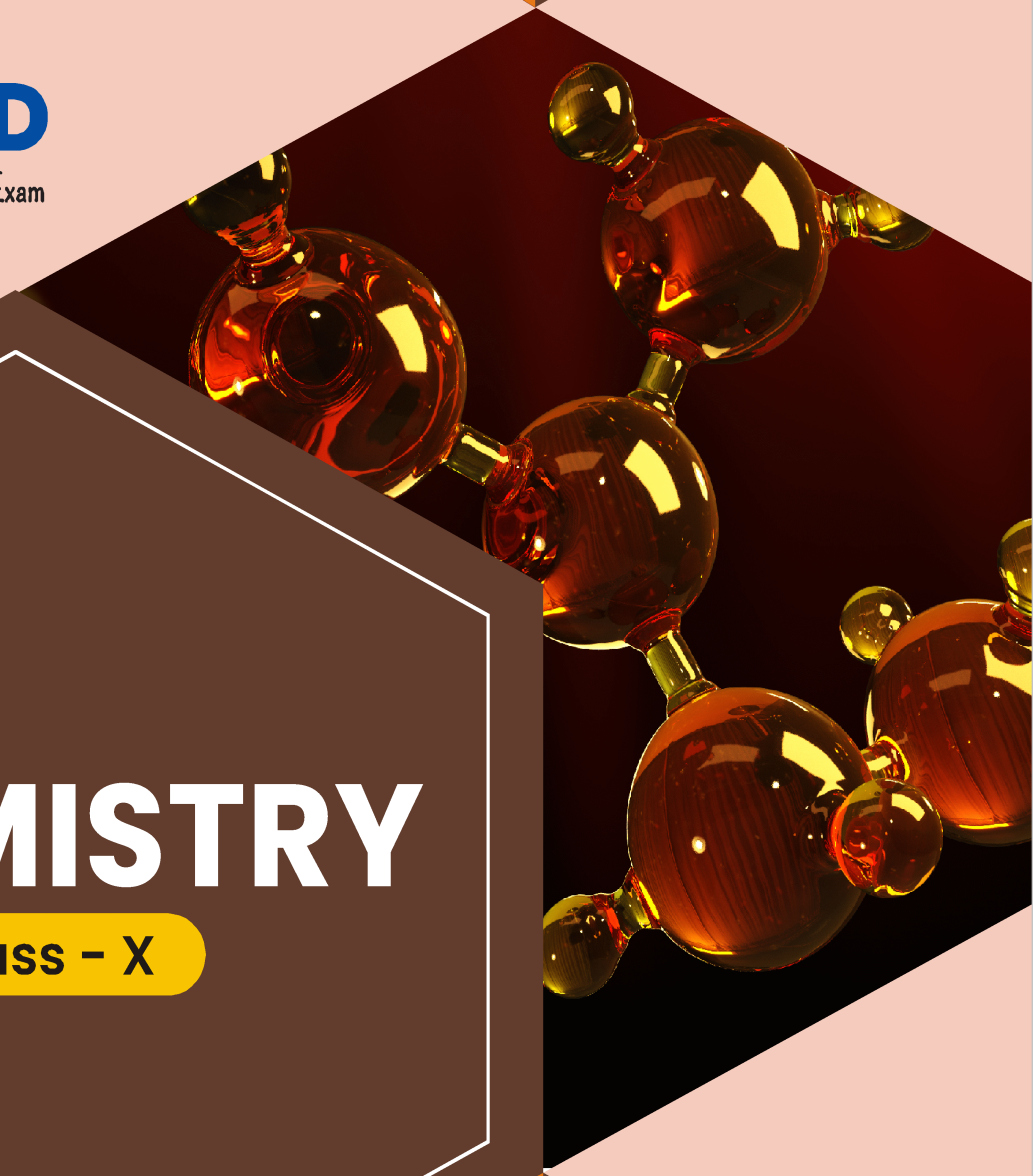
MATRIX OLYMPIAD

The Most Innovative Talent Recognition Exam



CHEMISTRY

Class - X

MATRIX

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Few words for the Readers

Dear Reader,

"*Matrix Olympiad is established to encourage school students to go a step further than their regular studies, and get a chance and exposure to competition on a wide scale. It also helps students enhance their learning of basic cognitive skills and deeper knowledge of subjects like Science, Mathematics, English, Mental Ability, Social Studies.“Matrix Olympiad helps students nurture their minds for higher targets of tomorrow and enables them to study School for JEE, NEET, CLAT, NDA, Olympiads , NSEJS, NTSE , STSE etc.*"

The above thought has been our guiding principle while designing and collating the study material for **Matrix Olympiad** . And hence, we hope that this particular material will be helpful towards your preparation for **Matrix Olympiad**.

Our team at **MATRIX** has put in their best efforts for making this particular module interesting and relevant for you. Additional efforts have been made to ensure that the content is easy to understand and error free to the extent possible. However, there might remain some inadvertent errors in answer keys and theoretical portion and we would welcome your valuable feedback regarding the same.

If there are any suggestions for corrections, please write to us at **smd@matrixacademy.co.in** and we would be highly grateful.

Finally, we would like to end this message by a famous quote by Ernest Hemingway - "*There is no friend as loyal as a book*." So, please give your study material the time and attention it deserves, and it will surely help you reach newer heights in your fight with competition examinations.

With love and best wishes !

Team MATRIX

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CHEMICAL REACTIONS & EQUATIONS

1

Concepts

Introduction

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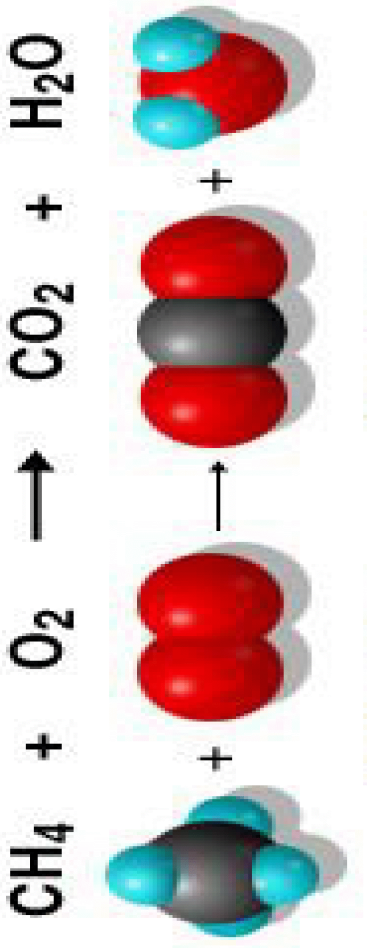
Solved Examples

NCERT Solutions

Exercise – I (Competitive Exam Pattern)

Exercise – II (Board Pattern Type)

Answer Key



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

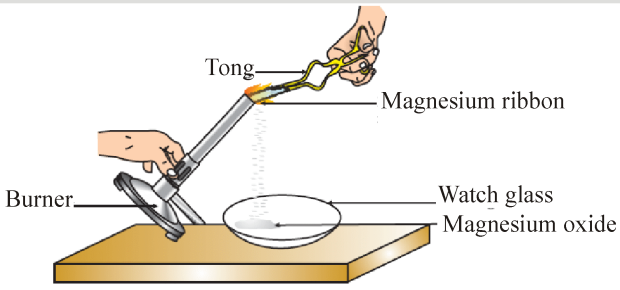
3. CHEMICAL ACTION OR REACTION

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.

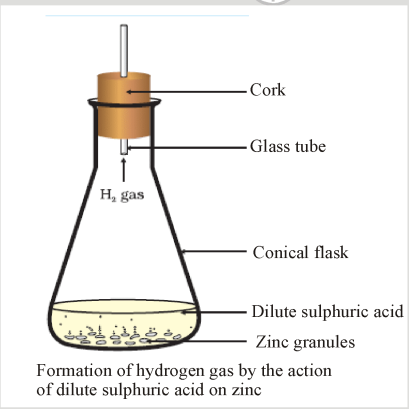
$$\underset{\text{zinc}}{Zn(s)} + \underset{\text{sulphuric acid}}{H_2SO_4(dil)} \rightarrow \underset{\text{zinc sulphate}}{ZnSO_4(aq)} + \underset{\text{hydrogen gas}}{H_2(g)}$$

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.

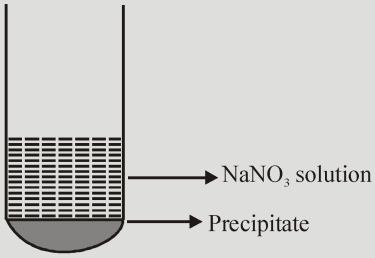
LAB TIME
Let's Do & Learn

- **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 -

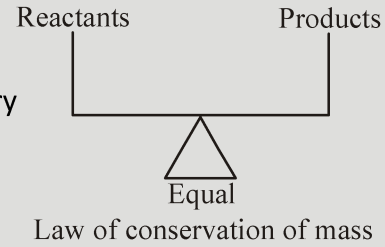
$$2Mg + O_2 \rightarrow 2MgO$$

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 → 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.

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

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

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

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

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

(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)

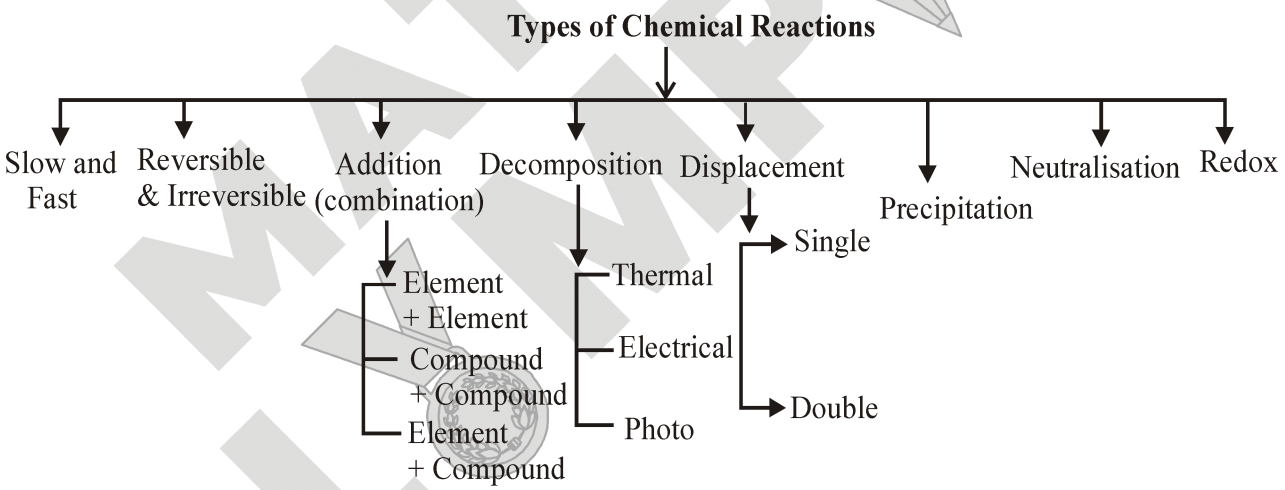
$N_2 + O_2 \rightarrow 2NO - 43200$ Calorie (Endothermic Reaction)



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 ($\rightarrow$)

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

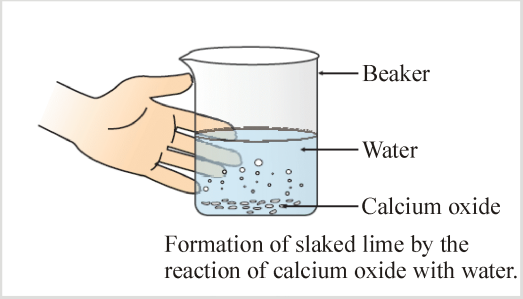
9.3 COMBINATION REACTION

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.

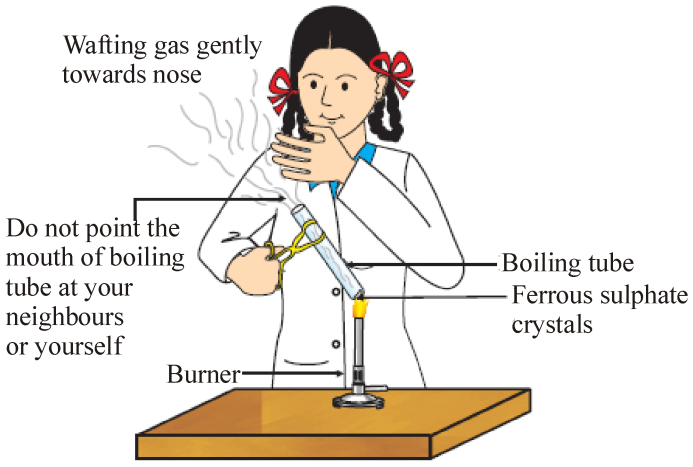
(i) Thermal decomposition reaction :

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.

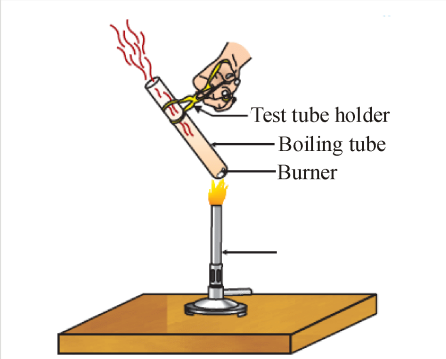
- **Observation :**
  It is observed that green coloured ferrous sulphate crystals ($FeSO_4.7H_2O$) on heating first changes colour by losing water to form $FeSO_4$ which on further heating decomposes to leave behind a reddish brown residue along with evolution of sulphur dioxide and sulphur trioxide 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:

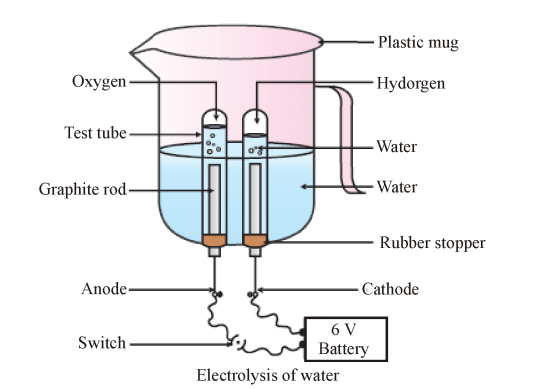
- $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
- $2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$

(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.

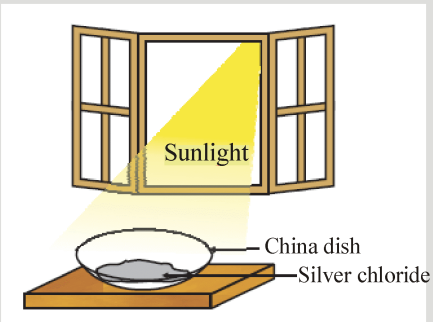
(iii) Photo decomposition reaction

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:

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



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 :**

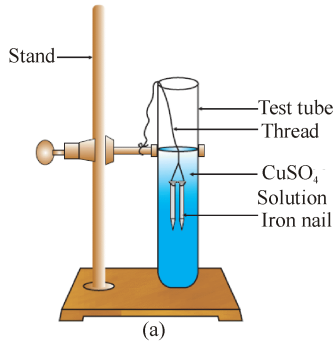
  Test tubes, iron nails, sand paper, copper sulphate solution, test tube stand.
- **Procedure :**

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

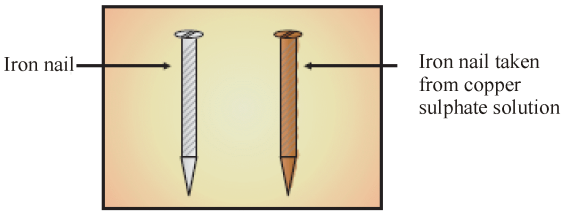
  (ii) Marked test tube as (A) and (B). In each test tube, take above 10 mL copper sulphate solution.

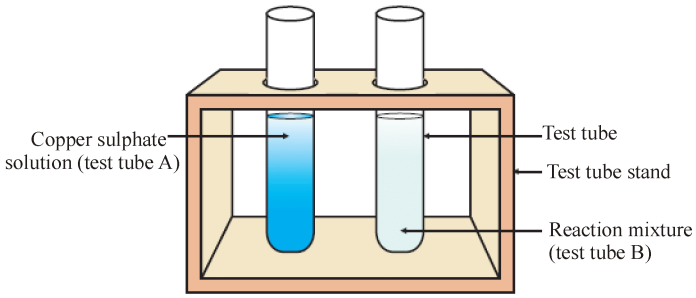
  (iii) The one iron nail with a thread and immerse it carefully in the copper sulphate solution in test tube B for about 20 minutes. Keep one iron nails aside for comparsion.

  (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.

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

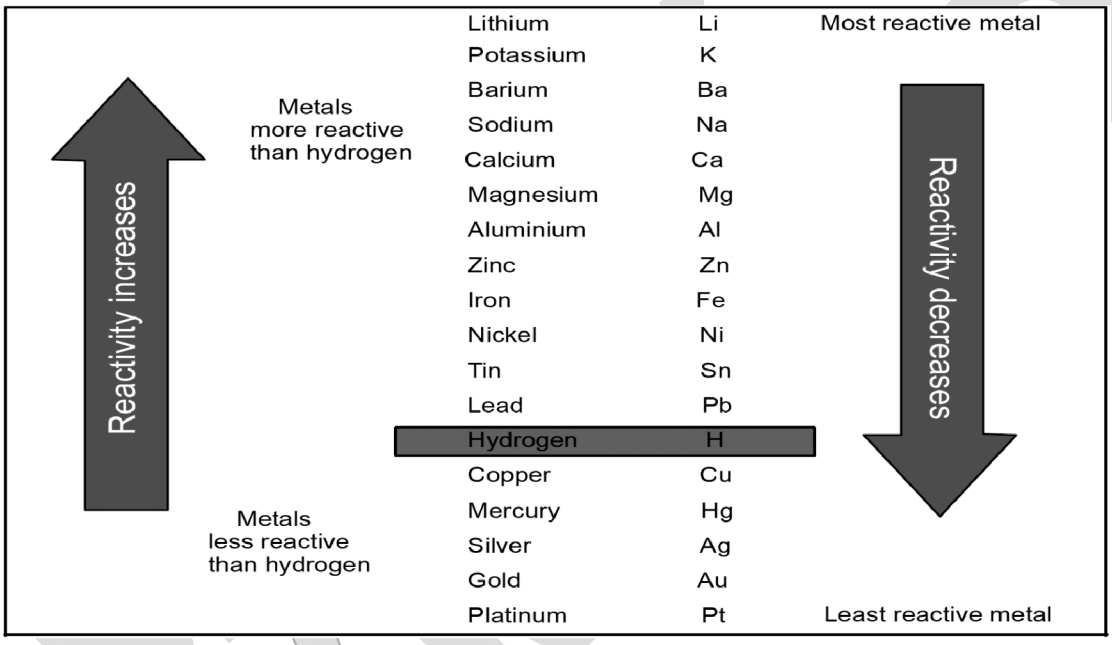
Reactivity Series of Metals

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

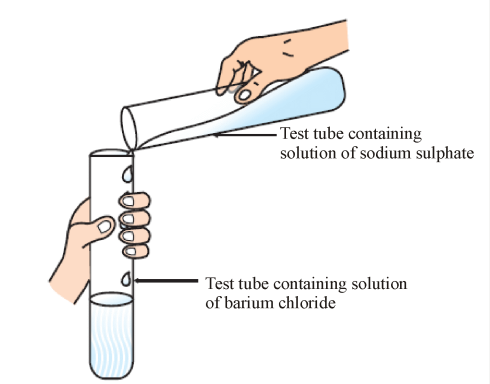
The reactions in which two ionic compounds in the solution react by exchange of their ions to form new compounds are called Double Displacement Reactions.

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

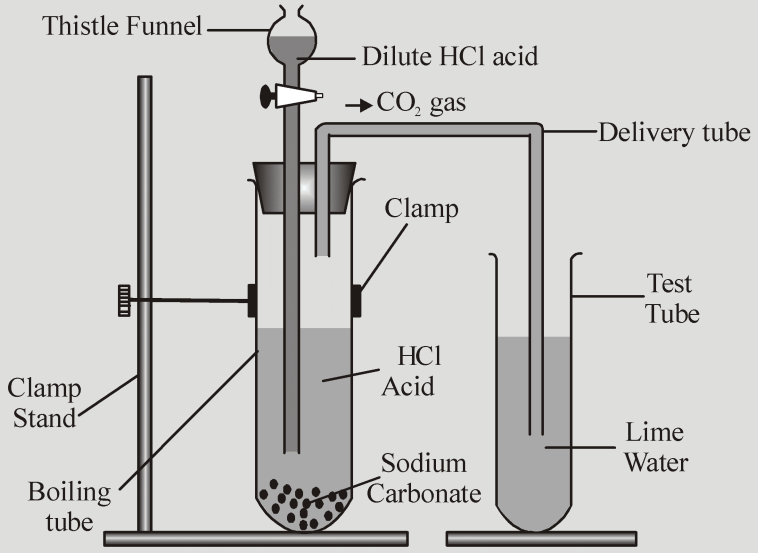
- Double displacement reactions generally takes place between two ionic compounds in the solution.
- Acid - base reactions (neutralisation) are double displacement reactions.

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

(2) $MgCl_2 \xrightarrow{electricity} Mg + Cl_2$
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) $2Al_2O_3 \xrightarrow{\text{electricity}} 4Al + 3O_2$

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.

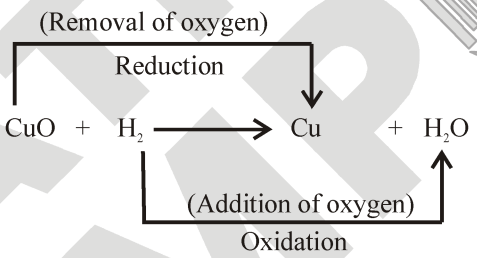
On the other hand, a substance that brings about reduction, that is removal of oxygen or an electronegative element and addition of hydrogen or an electropositive element is called reducing agent.

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

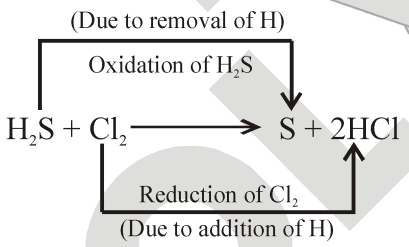


CuO makes oxidation to occur → Oxidising agent

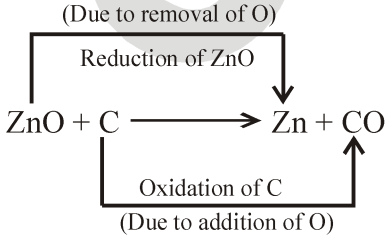
H_2 makes reduction to occur → Reducing agent

Some examples of redox reactions are given below :

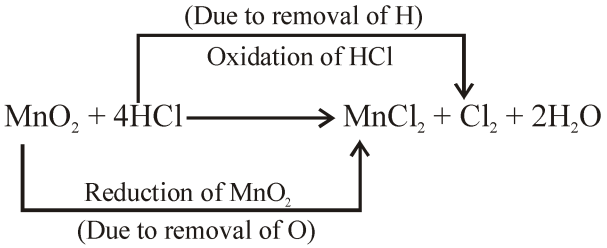
1.



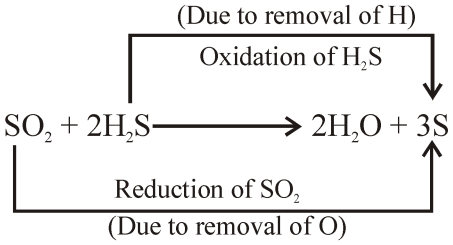
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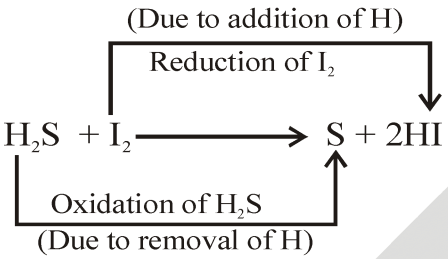
3.



4.



5.





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

(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

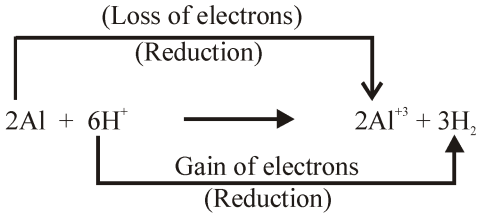


TABLE : COMPARATIVE STUDY OF OXIDATION AND REDUCTION REACTIONS

	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.

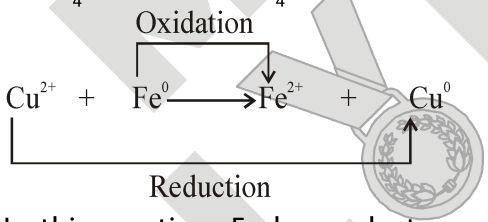
Oxidizing agent according to electronic concept

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 :

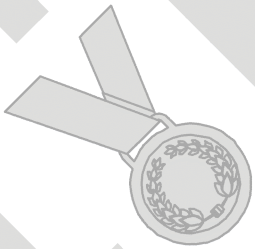
1. **Rancidity can be prevented by adding anti-oxidants to foods containing fats and oils :**
   Anti-oxidant is a substance (or chemical) which prevents oxidation. Anti-oxidants are actually reducing agents. When anti-oxidants are added to foods, then the fats and oils present in them do not get oxidised 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) $2HgO$ is $\xrightarrow{Heat} 2Hg(l) + O_2(g)$

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

MATRIX OLYMPIAD

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 :

ACIDS, BASES & SALTS 2

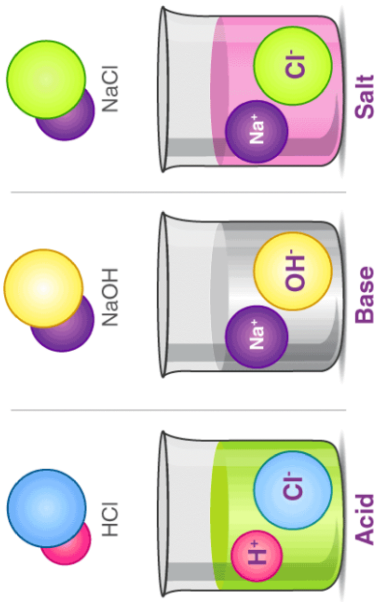
Concepts

Introduction

1. Acids
   - 1.1 Classification of acids
2. Bases
   - 2.1 Classification of bases
3. Chemical properties of acids
   - 3.1 Action with metals
   - 3.2 Action with metal oxides
   - 3.3 Action with metal carbonates and metal hydrogen carbonates
4. Chemical properties of bases
   - 4.1 Action with metals
   - 4.2 Action with non-metallic oxides
5. Conducting nature of acids and bases
6. Role of water in ionisation in acids and bases
7. Dilution of acids and bases
8. Reaction between acids and bases (Neutralisation reaction)
9. Indicators
   - 9.1 Natural indicators
   - 9.2 Synthetic indicators
   - 9.3 Olfactory indicators
10. How strong are acid or base solutions : pH scale
11. Importance of pH in everyday life
12. Salts
    - 12.1 Formations of salts
    - 12.2 Families of salts
    - 12.3 Classification of salts
13. Some commercialy important chemical compound
    - 13.1 Common salt
    - 13.2 Caustic soda
    - 13.3 Washing soda
    - 13.4 BAKING SODA
    - 13.5 Bleaching powder
    - 13.6 Plaster of paris
14. Are the crystalline salts really dry? – Anhydrous and hydrated salts

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Solved Examples
NCERT Solutions
Exercise – I (Competitive Exam Pattern)
Exercise – II (Board Pattern Type)
Answer Key



INTRODUCTION

The chemicals which we come across are usually categorised as acids, base and salts. Earlier this classification was based on different taste of chemicals.

Acids were first recognized as substances that taste sour. Vinegar tastes sour because it is a dilute solution of acetic acid. Citric acid is responsible for the sour taste of a lemon.

Bases, sometimes called alkalis, are characterised by their bitter taste and they are soapy to feel. Most hand soaps and commerical preparation for unclogging drains are highly basic.

Substances having taste similar to that of common salt are called salts.

However, some substances have very unpleasant taste and even may be poisonous. Usually salts are prepared by chemical reaction between acids and bases.

Now, the question arises – how to test that the given substance is an acid or a base without tasting it ?

In this chapter, we shall discuss the common characteristics of acid and bases and their chemical nature. We shall also discuss how salts are produced and important applications of some these salts.

1. ACIDS

Substances with sour taste are regarded as acids. Lemon juice, vinegar, grape fruit juice and spoilt milk etc. taste sour since they are acidic. Many substances can be identified as acids based on their taste but some of the acids like sulphuric acid have very strong action on the skin which means that they are corrosive in nature.

According to Arrhenius – "An acid may be defined as a substance which releases one or more H^+ ions in aqueous solution".

For example,

HCl and H_2SO_4 release one and two H^+ ions respectively into water, hence they are acids.

$$HCl(aq) \longrightarrow H^+(aq) + Cl^-(aq)$$

Hydrochloric acid — Hydrogen ion — Chloride ion

$$H_2SO_4(aq) \longrightarrow 2H^+(aq) + SO_4^{2-}(aq)$$

Sulphuric acid — Hydrogen ion — Sulphate ion

Focus Point

- The term 'acid' is derived from the latin word 'acidus' meaning sour to taste.
- H^+ ions is unstable, in nature and cannot exist independently, so it combine with water molecule and form hydronium ion.

  $H^+ + H_2O \longrightarrow H_3O^+$

1.1 CLASSIFICATION OF ACIDS

Classification of acids can be done in different ways as given below :

(A) Classification of on the basis of their Source

(B) Classification on the basis of their basicity.

(C) Classification on the basis of their strength

(D) Classification on the basis of their concentration

(A) Classification of acids on the basis of their Source

On the basis of their source, acids can be classified in two categories :

(i) Organic acids **(ii)** Inorganic acids

(i) Organic acids :

The acids which are usually obtained from living organisms are known as **organic acids.**

Oxalic acid [$(COOH)_2$], acetic acid (CH_3COOH) etc. are very common examples of organic acids. Some other organic acids with their natural sources are given in the following Table.

Some Organic Acids with Their Natural Sources

S.No.	Organic acid	Natural sources
1.	Acetic acid	Micro-organism (bacteria)
2.	Citric acid	Citrus fruits (like orange and lemon)
3.	Butyric acid	Rancid butter
4.	Formic acid	Sting of bees and ants
5.	Lactic acid	Sour milk
6.	Malic acid	Apples
7.	Oleic acid	Olive oil
8.	Stearic acid	Fats
9.	Amino acid	Proteins
10.	Uric acid	Urine
11.	Tartaric acid	Tamarind
12.	Oxalic acid	Tomatoes

(ii) Inorganic Acids.

The acids which are usually obtained from minerals are known as **inorganic acids.** Since the acids are obtained from minerals, therefore, these acids are also called **mineral acids.**

Some common examples of inorganic acids are :

Hydrochloric acid HCl

Sulphuric acid H_2SO_4

Nitric acid HNO_3

Phosphoric acid H_3PO_4

Carbonic acid H_2CO_3

(B) Classification of acids on the basis of their Basicity :

Basicity of acid : The basicity of an acid is defined as the number of hydronium ions [H_3O^+ (aq.)] that can be produced by the complete ionisation of one molecule of that acid in aqueous solution.

For example,

Basicity of HCl, H_2SO_4, H_3PO_4 is 1, 2 and 3 respectively because one molecule of these acids, on ionisation, produces 1, 2 and 3 hydronium ions in aqueous solution respectively.

On the basis of basicity, the acids can be classified as under :

(i) Monobasic Acids :

When one molecule of an acid on complete ionisation produces one hydronium ion (H_3O^+) in aqueous solution, the acid is said to be a **monobasic acid.**

Examples of Monobasic Acids.

Some examples of monobasic acids are :

(i) Hydrochloric acid (HCl) (ii) Hydrobromic acid (HBr)

(iii) Nitric acid (HNO_3) (iv) Acetic acid (CH_3COOH)

(v) Formic acid (HCOOH)



Focus Point

- A monobasic acid ionises in one step in aqueous solution.
  For example,

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^- \quad \text{(Single step ionisation)}$$

(ii) Dibasic Acids :

When one molecule of an acid on complete ionisation produces two hydronium ions (H_3O^+) in aqueous solution, the acid is said to be a **dibasic acid.**

Examples of Dibasic Acids :

Some examples of dibasic acids are :

(i) Sulphuric acid (H_2SO_4) (ii) Sulphurous acid (H_2SO_3)
(iii) Carbonic acid (H_2CO_3) (iv) Oxalic acid [$(COOH)_2$]
(v) Hydrofluoric acid (HF)



Focus Point

- A dibasic acid ionises in two steps in aqueous solution.
  For example, sulphuric acid which is a dibasic acid ionises to produce bisulphate ion (Hydrogen sulphate ion) (HSO_4^-) in the first step which further ionises to produce sulphate ion (SO_4^{2-}) in the second step.

$$H_2SO_4 + H_2O \rightleftharpoons H_3O^+ + HSO_4^-$$

Sulphuric acid Bisulphate ion

$$HSO_4^- + H_2O \rightleftharpoons H_3O^+ + SO_4^{2-}$$

Sulphate ion

(iii) Tribasic Acids :

When one molecule of an acid on complete ionisation produces three hydronium ions (H_3O^+) in aqueous solution, the acid is said to be a **tribasic acid.**

An example of tribasic acids is Phosphoric acid (H_3PO_4).



Focus Point

- A tribasic acid ionises in three steps in aqueous solution.
  For example,

$$H_3PO_4 \rightleftharpoons H_3O^+ + H_2PO_4^-$$

$$H_2PO_4^- \rightleftharpoons H_3O^+ + HPO_4^{2-}$$

$$HPO_4^{2-} \rightleftharpoons H_3O^+ + PO_4^{3-}$$

(C) Classification of acids on the basis of their strength :

(i) Strong Acids : The acids which undergo almost complete ionisation in a dilute aqueous solution, thereby producing a high concentration of hydronium ions (H_3O^+) are known as **strong acids.**

Examples of strong acids :

Some examples of strong acids are :

(i) Hydrochloric acid (HCl) (ii) Sulphuric acid (H_2SO_4) (iii) Nitric acid (HNO_3)

All these three mineral acids are considered to be strong acids because they ionise almost completely in their dilute aqueous solutions.

(ii) Weak Acids : The acids which undergo partial or incomplete ionisation in a dilute aqueous solution, thereby producing a low concentration of hydronium ions (H_3O^+) are known as **weak acids.**

Examples of weak acids :

Some examples of weak acids are :

(i) Acetic acid (CH_3COOH) (ii) Formic acid (HCOOH) (iii) Oxalic acid [$(COOH)_2$]

(iv) Carbonic acid (H_2CO_3) (v) Sulphurous acid (H_2SO_3) (vi) Hydrogen sulphide (H_2S)

(vii) Hydrocyanic acid (HCN)

The aqueous solution of weak acids contain both ions as well as undissociated molecules.

(D) Classification on the basis of Concentration of the Acid : By the term concentration, we mean the amount of water or acid present in the given sample of acid solution in water.

(i) Concentrated Acid : The sample of an acid which contains very small or no amount of water is called a **concentrated acid.**

(ii) Dilute Acid : The sample of an acid which contains very large amount of water is called a **dilute acid.**

CHEMICAL FORMULAE, TYPES AND USES OF SOME COMMON ACIDS

Name	Type	Where found or used
Carbonic acid	Mineral acid	In soft drinks and lends fizz.
Nitric acid	Mineral acid	Used in the manufacture of explosives (TNT, Calcium nitrate, Purification of Au, Ag)
Hydrochloric acid	Mineral acid	In purification of common salt, in textile industry as bleaching agent, to make aqua regia, in stomach as gastric juice, used in tanning industry.
Sulphuric acid	Mineral acid	Commonly used in car batteries, in the manufacture of fertilizers, in paints, plastics, drugs, manufacture of artificial silk, in petroleum refining.
Phosphoric acid	Mineral acid	Used in antirust paints and in fertilizers.
Formic acid	Organic acid	Found in the stings of ants and bees, used in tanning leather, in medicines for treating gout.
Acetic acid	Organic acid	Found in vinegar, used as solvent in the manufacture of dyes and perfumes.
Lactic acid	Organic acid	Responsible for souring of milk in curd.
Benzoic acid	Organic acid	Used as a food preservative.
Citric acid	Organic acid	Present in sour fruits .



Focus Point

- Aqua regia is a mixture of conc. HCl and conc. HNO_3 in 3 : 1 ratio. It can dissolve noble metals like Ag, Au and Pt.

2. BASES

The substance which are bitter in taste and soapy in touch are regarded as bases.Since many bases like sodium hydroxide and potassium hydroxide have corrosive action on the skin and can even harm the body.
According to Arrhenius – "A base may be defined as a substance which releases one or more OH^- ions in aqueous solution".
For example,
NaOH and $Ba(OH)_2$ release one and two OH^- ions respectively into water, hence they are bases.

$$NaOH\ (aq) \longrightarrow Na^+(aq) + OH^-(aq)$$
Sodium hydroxide — Sodium ion — Hydroxide ion

$$Ba(OH)_2\ (aq) \longrightarrow Ba^{2+}(aq) + 2OH^-(aq)$$
Barium hydroxide — Barium ion — Hydroxide ion

2.1 CLASSIFICATION OF BASES

Classification of bases or alkalis can be done in different ways as given below :
(A) Classification on the basis of their strength
(B) Classification on the basis of their concentration
(C) Classification on the basis of their acidity.

(A) Classification of the Bases or Alkalis on the Basis of their Strength

(i) Strong alkalis or bases :

The alkalis or bases which undergo almost complete ionisation in aqueous solution to produce high concentration of hydroxyl (OH^-) ions are known as **strong alkalis** or **strong bases.**

Example of strong alkalis or bases.

Some example of strong alkalis or bases are : Sodium hydroxide (NaOH), Potassium hydroxide (KOH) and Barium hydroxide [Ba $(OH)_2$] etc.

$$\left.\begin{aligned} NaOH(aq) &\longrightarrow Na^+(aq) + OH^-(aq) \\ KOH(aq) &\longrightarrow K^+(aq) + OH^-(aq) \\ Ba(OH)_2(aq) &\longrightarrow Ba^{2+}(aq) + 2OH^-(aq) \end{aligned}\right\} \text{(Almost completely ionised)}$$

(ii) Weak alkalis or bases :

The alkalis or bases which undergo only partial ionisation in aqueous solution to produce a relatively low concentration of hydroxyl (OH^-) ions are known as **weak alkalis** or **weak bases.**

Some examples of weak alkalis or bases are :

Ammonium hydroxide (NH_4OH), Calcium hydroxide [Ca $(OH)_2$], Magnesium hydroxide [Mg $(OH)_2$] etc.



Focus Point

- The bases which are soluble in water are known as alkalis.
  For example, bases like sodium hydroxide (NaOH), Potassium hydroxide (KOH), Ammonium hydroxide (NH_4OH) etc are soluble in water. Hence these bases are also known as alkalis.
- All alkalis are bases but all bases are not alkalis.
  For example, Zinc hydroxide $Zn(OH)_2$ is not soluble in water, so it is a base but not an alkali.
- Difference between base and alkali.

(B) Classification of Bases or Alkalis on the Basis of their Concentration :

By the term concentration, we mean the amount of water or alkali present in the given sample of alkali solution in water. On the basis of concentration, the alkalis can be classified as under :

(i) Concentrated alkali :

A solution of alkali having a relatively high percentage of alkali in its aqueous solution is known as **concentrated alkali.**

(ii) Dilute alkali :

A solution of alkali having a relatively low percentage of alkali in its aqueous solution is known as a **dilute alkali.**

(C) Classification of Bases or Alkalis on the Basis of their Acidity :

Before we discuss this classification, let us understand the meaning of the word 'acidity' of an alkali.

The number of hydroxyl (OH^-) ions produced by one molecule of an alkali on complete dissociation in water is known as **acidity** of an alkali.

On the basis of acidity, the bases can be classified as under :

(i) Monoacidic Bases (or alkalis) :

When one molecule of the base on complete ionisation produces one hydroxyl (OH^-) ion in aqueous solution, the base or alkali is said to be **monoacidic base.**

OR

A monoacidic base (or alkali) may be defined as one whose one molecule reacts with one hydrogen (H^+) ion completely to form salt and water as the only products.

Examples of Monoacidic Bases (or alkalis) :

Sodium hydroxide (NaOH), Potassium hydroxide (KOH), Ammonium hydroxide (NH_4OH). All these substances produce only one hydroxyl ion on complete ionisation in aqueous solution.

$$NaOH(aq.) \longrightarrow Na^+(aq) + OH^-(aq)$$
$$KOH(aq.) \longrightarrow K^+(aq) + OH^-(aq)$$

The dissociation of monoacidic bases or alkalis takes place in a single step.

(ii) Diacidic Bases (or alkalis) :

When one molecule of a base or alkali on complete ionisation produces two hydroxyl (OH^-) ions in aqueous solution, the base or alkali is said to be **diacidic base.**

OR

A diacidic base (or alkali) may be defined as one whose one molecule reacts with two hydrogen (H^+) ions completely to form salt and water as the only products.

Examples of Diacidic Bases

Calcium hydroxide [$Ca(OH)_2$] and Magnesium hydroxide [$Mg(OH)_2$]

$Ca(OH)_2(aq) \longrightarrow Ca^{2+}(aq) + 2OH^-(aq)$

$Mg(OH)_2(aq) \longrightarrow Mg^{2+}(aq) + 2OH^-(aq)$

One molecule of both the bases are producing $2OH^-$ ions in aqueous solution, therefore, these are termed as diacidic bases.

(ii) Triacidic Bases :

When one molecule of a base or alkali on complete ionisation produces three hydroxyl (OH-) ions in aqueous solution, the base or alkali is said to be **triacidic base.**

Examples of Triacidic Bases :

Aluminium hydroxide [$Al(OH)_3$], Ferric hydroxide [$Fe(OH)_3$]

$Al(OH)_3(aq) \longrightarrow Al^{3+}(aq) + 3OH^-(aq)$

In the above equations, one molecule of $Al(OH)_3$ is producing three OH^- ions therefore, it is termed as a triacidic base.

Uses of some common bases

Name	Commercial name	Chemical Formula	Uses
1. Sodium hydroxide	Caustic soda	NaOH	In manufacture of soaps, artificial fibres like rayon and in paper industry.
2. Potassium hydroxide	Caustic soda	KOH	In manufacture of soft soaps, in nickel-iron storage battery and for absorbing CO_2.
3. Calcium hydroxide	Slaked lime	$Ca(OH)_2$	In manufacture of bleaching powder, in white washing and testing of CO_2 gas.
4. Magnesium hydroxide	Milk of Magnesia	$Mg(OH)_2$	As an antacid to neutralize acid in the stomach.
5. Ammonium hydroxide	–	NH_4OH	For moving grease from clothes in dry cleaning and in cleaning window panes.

3. CHEMICAL PROPERTIES OF ACIDS

3.1 ACTION WITH METALS

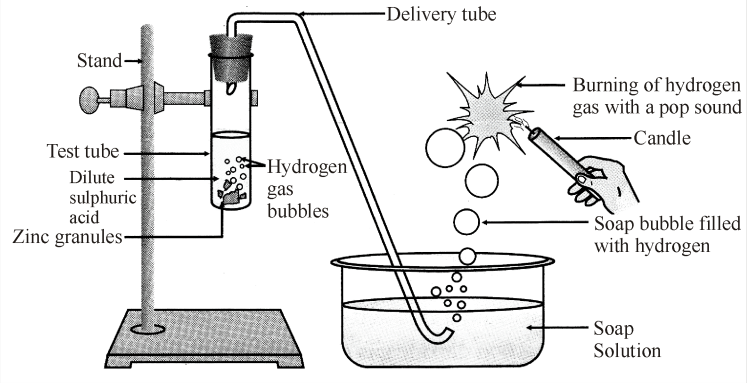
Acid + More reactive Metal than hydrogen in reactivity series $\longrightarrow$ Salt + hydrogen gas

Acid + Less reactive metal than hydrogen $\longrightarrow$ No reaction

Let's understand this property of acid by following activity.

LAB TIME
Let's Do & Learn

- **Objective : To study the reaction of acids, with metals.**
- **Materials required :** Granulated zinc, Dilute sulphuric acid, Boiling tube, Matchbox, delivery tube, test tube stand, candle, cork.
- **Procedure :**
  (i) Take about 5 ml of dilute sulphuric acid in a boiling tube.
  (ii) Add a few piece of zinc metal into it and place an inverted boiling tube over its mouth .
  (iii) You can see the bubbles of hydrogen gas coming out of the mixture in the lower tube.
  (iv) After a few minutes, remove the upper boiling tube (Keeping its mouth downwards) near to its mouth.
  (v) The gas in the upper boiling tube burns with a blue flame producing popping sound.
  (vi) Repeat similar experiment with different acids and a few other metals.



- **Observation :** Colourless, odourless gas is evolved. It burns explosively with a 'pop' sound.
  $Zn(s) + H_2SO_4$ (dil) $\rightarrow$ $ZnSO_4$ (aq) + $H_2(g)$
- **Conclusion :** Reactive metals react with dilute acid to liberate hydrogen gas.

Some more examples are given below :

$2Na + 2HCl \longrightarrow 2NaCl + H_2$

$Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2$

$Mg + 2\,HCl \longrightarrow MgCl_2 + H_2$

$Zn + 2\,HCl \longrightarrow ZnCl_2 + H_2$

$Fe + 2\,HCl \longrightarrow FeCl_2 + H_2$

$Cu + 2\,HCl \longrightarrow$ No reaction



Focus Point

- Metals which can displace hydrogen from dilute acids are known as active metals. e.g. Na, K, Zn, Fe, Ca, Mg etc.
- The active metals which lie above hydrogen in the activity series are electropositive and more reactive in nature.
- In the reaction of metals with the acid, as given above, we observe that in each reaction, hydrogen of the acid has been replaced by metal. Thus, all the above reactions are **Displacement reactions**.
- Al_2O_3 and ZnO are amphoteric oxide.

3.2 ACTION WITH METAL OXIDES

Metal oxides are basic in nature because they form basic solution on dissolving into water. So acids can easily react with metal oxides.

Metal oxide + Acid $\longrightarrow$ Salt + water

Let's discuss the following activity to understand the reaction between acid and metal oxides.

LAB TIME
Let's Do & Learn

- **Objective :**
  To study the reaction of dilute acid with metal oxides (or basic oxides).
- **Materials required :** Copper (II) oxide, Dilute hydrochloric acid , Test tube
- **Procedure :**
  (i) Take about 0.5g of copper (II) oxide (black in colour) in a test tube.
  (ii) Add dilute hydrochloric acid dropwise with occasional shaking till copper (II) oxide dissolve.
- **Observation:**
  It is observed that the colour of the solution become blue-green and the copper oxide dissolves. The blue green colour of the solution is due to formation of copper (II) chloride in the solution.
- **Conclusion :** Acids react with metal oxides to give the corresponding salt & water.

$$CuO(s) + 2HCl(aq.) \longrightarrow CuCl_2(aq) + H_2O(l)$$

(Black) (Bluish green)

Some more examples are given below :

$$ZnO(s) + 2HCl\ (aq) \longrightarrow ZnCl_2(aq) + H_2O(l)$$
$$MgO(s) + H_2SO_4(aq) \longrightarrow MgSO_4(aq) + H_2O(l)$$
$$CaO(s) + 2HCl(aq.) \longrightarrow CaCl_2(aq) + H_2O(l)$$

3.3 ACTION WITH METAL CARBONATES AND METAL HYDROGEN CARBONATES

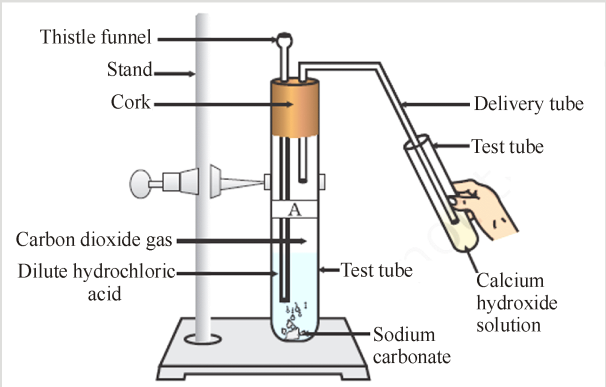
Metal carbonate/hydrogen carbonate + Acid $\longrightarrow$ Salt + water + CO_2

Both metal carbonates and bicarbonates react with acids to evolve CO_2 gas and form salts.

Let's discuss the following activity to understand the reaction between acid and metal carbonates or metal hydrogen carbonates.

LAB TIME
Let's Do & Learn

- **Object : To study the reaction of sodium carbonate and sodium hydrogen carbonate with dilute acids.**
- **Materials required :** Sodium carbonate (Na_2CO_3), Sodium hydrogencarbonate, Hydrochloric acid (dil), Limewater, Boiling tubes, Delivery tube.
- **Procedure :**
  (i) Take about 0.5g of sodium carbonate in a boiling tube, and 2-3 mL of freshly prepared lime water in another test tube.
  (ii) Set a delivery tube as shown in fig. given alongside.
  (iii) Add about 2mL of dilute hydrochloric acid into the boiling tube containing sodium carbonate.



LAB TIME
Let's Do & Learn

- **Observation and discussion:**
  (i) A brisk effervescence is seen in the reaction mixture.
  (ii) Pass the gas evolved through limewater with the help of a delivery tube.
  (iii) The limewater turns milky. When excess of carbon dioxide is passed, the milkyness disappears.
  (iv) Repeat similar experiemnt with sodium hydrogencarbonate ($NaHCO_3$), and if desired with other acids also.
- **Conclusion :** All acids decompose carbonates and hydrogencarbonates with the liberation of carbon dioxide gas. **e.g.**

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

Some more examples are given below:

$$Na_2CO_3(s) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$$

$$2NaHCO_3(s) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)$$

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$



Focus Point

- Limestone, chalk, marble (which are all different forms of calcium carbonate) react with the acid as follow:

  $CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$
- Egg-shells also contain calcium carbonate as the main constituent. Hence, they react with the acid as above.
- When CO_2 gas is passed through lime water [$Ca(OH)_2$] then milkiness appears due to formation of calcium carbonate.

  $Ca(OH)_2 + CO_2 \longrightarrow \underset{\text{Milkiness}}{CaCO_3} + H_2O$
- If excess of CO_2 gas is passed through lime water, milkiness disappears and the solution becomes clear due to the formation of soluble calcium bicarbonate as follows:

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

4. CHEMICAL PROPERTIES OF BASES

4.1 ACTION WITH METALS

Some bases like sodium hydroxide and potassium hydroxide react with active metals like zinc and aluminium to liberate hydrogen gas along with the formation of salt.

Metals + base $\longrightarrow$ Salt + hydrogen gas

This property of base can be understood by following activity.

LAB TIME
Let's Do & Learn

- **Object : To study the reaction of a base with metal.**
- **Materials required:** Test tube, granulated zinc, NaOH solution, burner.
- **Procedure :**
  (i) Place a few pieces of granulated zinc metal in a test tube.
  (ii) Add 2mL of NaOH (Sodium hydroxide) solution and warm the contents of the test tube.
  (iii) Repeat the rest of the steps as in previous activity and record you observation.
- **Observation:**
  It is observed that metals like zinc react with strong base like NaOH, KOH, etc. to liberate hydrogen gas and form the corresponding salt.
  For example,

  $\underset{\text{Zinc}}{Zn(s)} + \underset{\text{Sodium hydroxide}}{2NaOH(aq)} \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$
- **Conclusion:**

  Some metals react with bases to liberate hydrogen gas.

Some more examples are given below:

(i) $2Al(s) + 2NaOH(aq) + 2H_2O(l) \longrightarrow \underset{\text{Sodium meta aluminate}}{2NaAlO_2(aq)} + 3H_2(g)$

(ii) $Sn(s) + 2NaOH(aq) \longrightarrow \underset{\text{Sodium stannate}}{Na_2SnO_2(aq)} + H_2(g)$

(iii) $Pb + NaOH \longrightarrow \underset{\text{Sodium plumbite}}{Na_2PbO_2(aq)} + H_2(g)$

4.2 ACTION WITH NON-METALLIC OXIDES

You saw the reaction between carbon dioxide and calcium hydroxide (lime water). Calcium hydroxide, which is base, reacts with carbon dioxide to produce a salt and water. Since this is similar to the reaction between a base and an acid, we can conclude that non-metallic oxides acidic in nature.

For example,

$$2NaOH(aq) + CO_2(g) \longrightarrow Na_2CO_3(aq) + H_2O(l)$$
$$Ca(OH)_2(s) + SO_2(g) \longrightarrow CaSO_3(s) + H_2O(l)$$
$$Ca(OH)_2(s) + CO_2(g) \longrightarrow CaCO_3(s) + H_2O(l)$$

Comparison between properties of acids and bases

S.No.	Acids	Bases
(i)	Sour in taste.	Bitter in taste.
(ii)	The properties are due to the presence of hydrogen ion (H^+)in water solution of an acid.	The properties are due to the presence of hydroxide ion (OH^-) in water solution of a base.
(iii)	Turns blue litmus to red.	Turns red litmus to blue.
(iv)	Aqueous solution conducts electricity.	Aqueous solution conducts electricity.
(v)	Reacts with active metals like Na, K, Ca and Zn to give hydrogen gas.	Does not react with metals except with Zn, Al and Sn.
(vi)	Acidic properties disappear when react with bases (Neutralization).	Basic properties disappear when react with acids (Neutralization).
(vii)	Reacts with carbonates to give carbon dioxide.	Absorbs carbon dioxide to form carbonate.
(viii)	Frequently corrosive to skin.	Frequently corrosive to skin and slippery in nature.
(ix)	The pH value is less than 7 at 25°C (room temp.)	The pH value is greater than 7 at 25°C (room temp.)



Focus Point

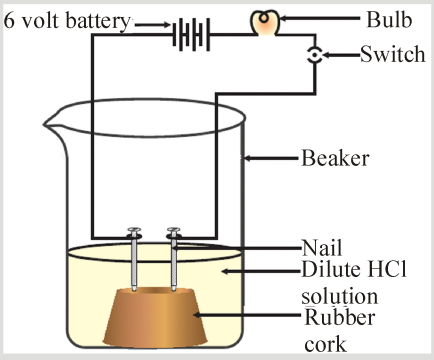
- Non- metals do not react with dilute acids as they do not have tendency to loose electrons

5. CONDUCTING NATURE OF ACIDS AND BASES

Acids are the substances which contain one or more hydrogen atoms in their molecules which they can release in water as H^+ ions. Similarly, bases are the substances which contain one or more hydroxyl groups in their molecules which they can release in water as OH^- ions . Since the ions are the carrier of charge therefore, the aqueous solutions of both acids and bases are conductors of electricity.

LAB TIME
Let's Do & Learn

- **Object: To find the characteristics common between acids and bases.**
- **Materials required :** Dilute hydrochloric acid, Dilute sulphuric acid, Dilute solution of sodium hydroxide, Ethanol, Glucose solution & Beaker, Iron nails, 6 volt Bettery, Bulb, Key etc.
- **Procedure :**
  (i) Take a beaker and place two carbon electrodes into it.
  (ii) Connect the electrodes to a battery bulb through a key and a dry cell.
  (iii) Pour dilute hydrochloric acid into the beaker and press the key.
  (iv) Perform similar experiment with all the given solutions, and record your observation



- **Observation :**

Solution	Bulb glows	Nature of solution
Dil. Hydrochloric acid	Yes	Conducting
Dil Sulphuric acid	Yes	Conducting
Dil. Sodium hydroxide	Yes	Conducting
Ethanol	No	Non- Conducting
Glucose solution	No	Non- Conducting

- **Conclusion :** The solutions of acids and bases are good conductors of electricity.

Focus Point

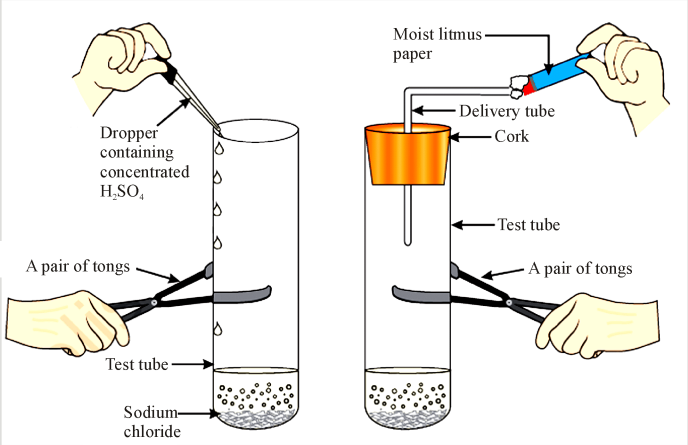
- Substances like ethyl alcohol (C_2H_5OH), glucose ($C_6H_{12}O_6$) etc. though contain hydrogen but when dissolved in water do not produce H^+ ions. This can be seen by checking the conduction of electricity through their aqueous solutions. It is observed that their solutions do not conduct electricity. Hence, they are not acidic.
- Distilled water does not contain any acid, base or salt which may dissociated to produce ions. Hence, it does not conduct electricity. Rain water contains dissolved gases like CO_2, SO_2, NO_2 etc. e.g., CO_2 dissolves in H_2O to form H_2CO_3 (carbonic acid) which dissociates to give H^+ (aq) ions and carbonate ions, CO_3^{2-} (aq). Hence, it conducts electricity.

6. ROLE OF WATER IN IONISATION IN ACIDS AND BASES

Substances can act as acids and bases only in the presence of water (in aqueous solution). In dry state which is also called anhydrous state, these characters cannot be shown. Actually, water helps in the ionisation of acid or base by separating the ions.
This can be understood by following activity.

LAB TIME
Let's Do & Learn

- **Object : To test that dry HCl gas is not acidic but its aqueous solution in acidic.**
- **Materials required :**
  Test tube, NaCl, concentrated sulphuric acid, moist blue litmus paper.
- **Procedure :**
  (i) Take about 1 g solid NaCl in a clean and dry test tube and set up the apparatus.
  (ii) Add some concentrated sulphuric acid to the test tube.
  (iii) Test the gas evolved successively with dry and wet blue litmus paper.



LAB TIME
Let's Do & Learn

- **Observation and Discussion :**
  In the presence of water, HCl dissociates to give H^+ ions.

$$HCl(g) + H_2O(l) \longrightarrow \underset{\text{Hydronium ion}}{H_3O^+} + \underset{\text{Chloride ion}}{Cl^-(aq)}$$

- **Conclusion :**
  Dry HCl gas is not acidic but HCl solution is acidic.

Similarly, when a base is dissolved in water, it forms OH^- (aq) ions.

$$NaOH(s) \xrightarrow{H_2O} Na^+(aq) + OH^-(aq)$$
$$KOH(s) \xrightarrow{H_2O} K^+(aq) + OH^-(aq)$$
$$Mg(OH)_2(s) \xrightarrow{H_2O} Mg^{2+}(aq) + 2OH^-(aq)$$

7. DILUTION OF ACIDS AND BASES

Acids and bases are mostly water soluble and can be diluted by adding the required amount of water. With the addition of water the amount of acid or base per unit volume decrease and dilution occurs. The process is generally exothermic in nature. When a concentrated acid like sulphuric acid or nitric acid is to be diluted with water, acid should be added dropwise to water taken in the container with constant stirring.

Let's discuss an activity to understand that dilution of acids and bases are exothermic in nature.

LAB TIME
Let's Do & Learn

- **Object : To test that dilution of a strong acid like H_2SO_4 and strong base like NaOH is exothermic.**
- **Materials required :**
  Beaker, water conncentrated H_2SO_4, NaOH pellets.
- **Procedure :**
  (i) Take 10 mL water in a beaker.
  (ii) Add a few drops of conncentrated H_2SO_4 to it and swirl the beaker slowly.
  (iii) Touch the base of the beaker.
  (iv) Repeat the above activity with NaOH pellets.
- **Observation and Discussion:**
  In both cases, the temperature is found to rise.
- **Conclusion:**
  Dilution of concentrated H_2SO_4 with water as well as dissolution of NaOH in water is exothermic.



Focus Point

- On dilution strength of acidic or basic solutions decrease.
- On dilution PH of acid increases.

8. REACTION BETWEEN ACIDS AND BASES (NEUTRALISATION REACTION)

Neutralization is defined a process in which an acid reacts with a base to form salt and water, i.e,
Acid + base → salt + water
Let's discuss the following activity to understand the reaction between acid and base.

LAB TIME
Let's Do & Learn

- **Object : To study a reaction of an acid say, hydrochloric acid with an alkali or base (NaOH).**
- **Materials required :** Hydrochloric acid solution, sodium hydroxide solution, phenolphthalein indicator, Boiling tube, dropper, trough.
- **Procedure :**
  (i) Take about 5 mL of dilute solution of sodium hydroxide (NaOH) in a test tube.
  (ii) Add 2 drops of phenolphthalein indicator in it. The solution in the test tube turns pink.
  (iii) Now, add dilute solution of hydrochloric acid (HCl) when the pink colour of the solution just disappears.
  (iv) Now, add a drop of sodium hydroxide solution and shake the test tube to mix the solution, it turns pink.
  (v) Add a drop of HCl solution to the solution in the test tube. The pink colour disappears.
  (vi) Keep repeating the addition of sodium hydroxide and hydrochloric acid solution one after the other and watch the appearance and disappearance of pink colour.
- **Observation:** HCl and NaOH both react together to form salt and water.
- **Conclusion :** This experiment show that the addition of HCl solution destroys the alkaline nature of NaOH. On the other hand , the addition of NaOH solution destroys the acidic nature of HCl.
  That is, both NaOH and HCl appear to cancel the effect of each other. Such a reaction between an acid and alkali is called neutralisation.

$$HCl\ (aq) + NaOH(aq) \longrightarrow NaCl + H_2O$$

9. INDICATORS

- An indicator is a substance which changes colour when added to an acid or a base. The change in colour indicates whether the substance is acidic or basic. If there is no change in the colour of the indicator, the substance is called a neutral substance.
- Indicators can be natural dyes extracted from plants or chemical compounds.

9.1 NATURAL INDICATORS

The indicators which are obtained from natural resources known as natural indicators. Some examples of natural indicators are given below :

(A) Litmus :

- Litmus is a natural dye which is extracted from lichens. Litmus solution is prepared from this extract. It is also used in the form of litmus paper which is prepared by absorbing litmus solution on filter paper.
- Litmus is available in the form of blue litmus paper and red litmus paper.
- Acidic substances change blue litmus paper to red while basic substances change red litmus paper to blue.
- Substances which do not change the colour of the litmus paper are known as neutral substances.

(B) China rose:

- China rose makes another natural indicator which is prepared by soaking the petals of the flower in water.
- Acidic substances change China rose indicator into dark pink or magenta while basic substances turn China rose indicator into green.
- Substances which do not change the colour of China rose indicator are neutral in nature.

(C) Turmeric :

- Turmeric or haldi powder is another natural indicator.
- Turmeric paste made by adding water to turmeric powder is used as an indicator for making turmeric paper.
- With acidic or neutral substances turmeric paper remains yellow. Turmeric paper changes to red colour in basic solutions.

(D) Red Cabbage :

- Red cabbage can also be used for making a natural indicator to test acids and bases.
- Red cabbage indicator can be prepared by boiling chopped red cabbage in water.
- Acidic solutions change purple colour of red cabbage indicator to red while basic solutions change purple colour of red cabbage to green.
- Neutral substances do not change the colour of red cabbage indicator.



Focus Point

- Litmus solution itself is neither acidic nor basic. It is neutral and has a purple colour. To use it as indicator, it is made acidic to give it red colour or alkaline to give it blue colour.
- Instead of blue litmus or red litmus solution, paper strips soaked in these solutions are also sometimes used. These are called litmus papers.
- Turmeric (haldi) used in the kitchen can also be used to test a basic solution. The basic substances turn yellow turmeric into brown colour. For example, while eating food, if curry falls on the white clothes, a yellow stain is produced on the clothes. When we apply soap solution on the cloth, the yellow stain becomes reddish brown because soap solution is basic in nature. On washing with excess of water, it turns yellow again because soap is washed away.

9.2 SYNTHETIC INDICATORS

- Some chemical compounds which are prepared in laboratory can also be used as indicators to identify bases and acids.

• Methyl orange and phenolphthalein are two common indicators used to test acids and bases.

(A) Phenolphthalein :

It is also an organic dye and acidic in nature. In neutral or acidic solution, it remains colourless while in the basic solution, the colour of indicator changes to pink.

(B) Methyl Orange :

Methyl orange is an orange coloured dye and basic in nature. In the acidic medium the colour of indicator becomes red and in the basic medium, colour of indicator becomes yellow and in neutral medium, its colour remains unchanged.

The colour change of various indicators in acidic or basic solution can be understood by following activity.

LAB TIME
Let's Do & Learn

- **Object : To test acids and bases in the laboratory using colour change acid-base indicators.**
- **Materials required :**Watch glass, test tube, hydrochloric acid, sulphuric acid, nitric caid, acetic acid, sodium hydroxide, calcium hydroxide, potassium hydroxide, magnesium hydroxide, ammonium hydroxide, red and blue litmus solution, phenolphthalein solution, methyl orange solution.
- **Procedure :**

(i) Collect the following samples from the science laboratory-hydrochloric acid (HCl), sulphuric acid (H_2SO_4), nitric acid (HNO_3), acetic acid (CH_3COOH), sodium hydroxide (NaOH), calcium hydroxide [$Ca(OH)_2$], potassium hydroxide (KOH), magnesium hydroxide [$Mg(OH)_2$], and ammonium hydroxide (NH_4OH).

(ii) Put a drop of each of the above solutions on a watch-glass and test with a drop of the following indicators.
Red litmus solution, Blue litmus solution, Phenolphthalein solution,Methyl orange solution.

- **Observation:** The changes observed are as follows :

Sample solution	Red litmus solution	Blue litmus solution	Phenolphthalein solution	Methyl orange solution
Hydrochloric acid (HC1)	No effect	Red	Colourless	Red
Sulphuric acid (H_2SO_4)	No effect	Red	Colourless	Red
Nitric acid (HNO_3)	No effect	Red	Colourless	Red
Acetic acid (CH_3COOH)	No effect	Red	Colourless	Red
Sodium hydroxide (NaOH)	Blue	No effect	Pink	Yellow
Calcium hydroxide [$Ca(OH)_2$]	Blue	No effect	Pink	Yellow
Potassium hydroxide (KOH)	Blue	No effect	Pink	Yellow
Magnesium hydroxide [$Mg(OH)_2$]	Blue	No effect	Pink	Yellow
Ammonium hydroxide (NH_4OH)	Blue	No effect	Pink	Yellow

- **Conclusion:**
Acids turn blue litmus red but have no effect on red litmus. Bases turn red litmus blue but have no effect on blue litmus. Phenolphthalein is colourless in acidic medium and turns pink in basic medium. Methyl orange is yellow in basic medium and red in acidic medium.

9.3 OLFACTORY INDICATORS

There are some substances whose odour changes in acidic or basic media. These are called olfactory indicators.

Chopped onion, vanilla essence and clove oil are examples of olfactory indicators.

Change in odour of these indicators can be understood by following activity.

LAB TIME
Let's Do & Learn

- **Object : To test acids and bases using olfactory indicators.**
- **Materials required:** Plastic bag, chopped onion, strips of clean cloth, dilute HC1 solution, dilute NaOH solution, test tube, vanilla essence, clove oil.
- **Procedure:**

(i) Take some finely chopped onion in a plastic bag along with some strip of clean cloth. Tie up the bag tightly and leave overnight in the fridge.The cloth strips can now be used to test for acids and bases.

(ii) Take two of these cloth strips and check their odour.

(iii) Keep them on a clean surface and put a few drops of dilute HCl solution on one strip and a few drops of dilute NaOH solution on the other.

(iv) Rinse both cloth strips with water and again check their odour.

(v) Note your observations.

(vi) Now take some dilute vanilla essence and clove oil and check their odour.

(vii) Take some dilute HCl solution in one test tube arid dilute NaOH solution in another. Add a few drops of dilute vanilla essence to both test tubes and shake well. Check the odour once again and record change in odour, if any.

(viii) Similarly, test the change in the odour of clove oil with dilute HCl and dilute NaOH solutions and record your observation.

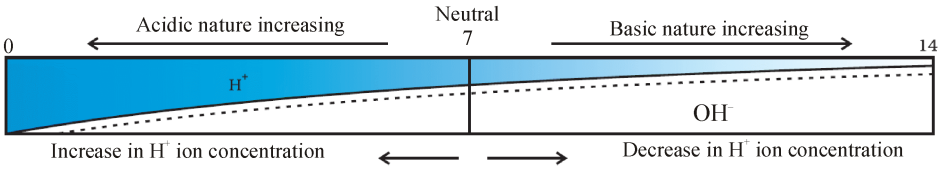
- **Observation:**
  Onion, vanilla essence and clove oil loses their smell in bases but does not change their smell in acids.
- **Conclusion:**
  A substance whose smell varies when it is mixed with an acidic or basic solution, can be used as an acid base indicator (called olfactory indicator).

10. HOW STRONG ARE ACID OR BASE SOLUTIONS: pH SCALE

We know how acid - base indicators can be used to distinguish between an acid and a base. We have also learnt in the previous section about dilution and decrease in concentration of H^+ or OH^- ions in solutions.

A scale for measuring hydrogen ion concentration in a solution, called pH scale has been developed. The p in pH stands for 'potenz' in German, meaning power. On the pH scale we can measure pH generally from 0 (very acidic) to 14 (very alkaline). pH should be thought of simply as a number which indicates the acidic or basic nature of solution. Higher the hydronium ion concentration, lower is the pH value.

The pH of a neutral solution is 7. Values less than 7 on the pH scale represent an acidic solution while pH value greater 7 represent a basic solution.





Focus Point

- According to Arrhenius theory, an acid releases H^+ ion in aqueous solution. The concentration of these ions is expressed by enclosing H^+ in square bracket i.e. as $[H^+]$. Thus, greater the $[H^+]$ ions, stronger will be the acid. However, according to pH scale, lesser the pH value, stronger will be the acid. From the above discussion, we can conclude that pH value and H^+ ion concentration are inversely proportional to each other. The relation between them can also be expressed as-

  $pH = -\log [H^+] = \log \left[\frac{1}{H^+}\right]$

  So, negative logarithm of hydrogen ion concentration is known as pH.

  On increasing $[H^+]$ value of pH will decrease.

- Just as the $[H^+]$ of a solution can be expressed in terms of pH value, the $[OH^-]$ can be expressed as pOH.

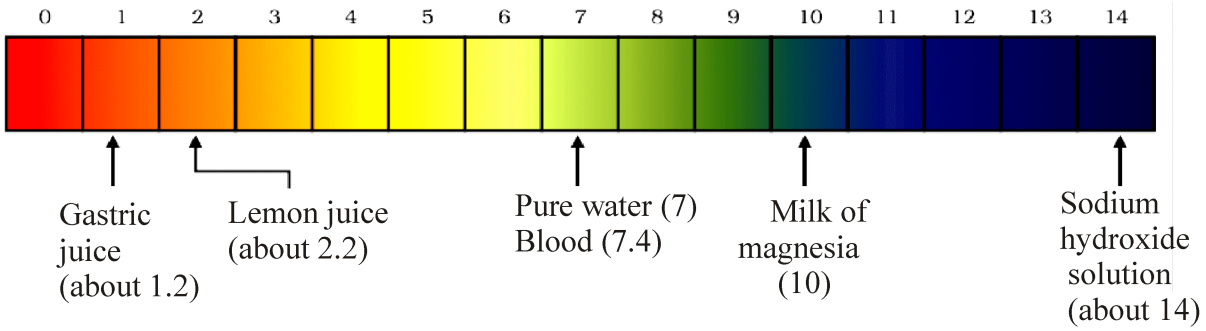
  Mathematically , $pOH = -\log [OH^-] = \log \frac{1}{[OH^-]}$

  Moreover, pH + pOH = 14. [at room temperature]

  Thus, if pH value of solution is known, its pOH value can be calculated.

♦ Universal indicator:

An indicator is a substance that changes colour in different pH environments. It is the brown coloured solution containing a mixture of indicator that can be added to any substance to determine its pH.
To measure the pH of any solution, a paper strip impregnated with the universal indicator is used. This strip is called pH paper.



For low pH ⇒ Red colour
For neutral ⇒ Green colour
For high pH ⇒ Blue or violet

LAB TIME
Let's Do & Learn

- **Object : To test the pH values of some solutions.**
- **Materials required :** pH paper, Given solutions in table.
- **Procedure :**
  (i) Test the pH values of solution given in following table.
  (ii) Record your observations.
- **Observation :** pH values of the given substances is shown in table below :

S.No.	Solution	Colur of pH paper	Approximate pH value	Nature of substance
1	Saliva (before meal)	Light green	7.4	Basic
2	Saliva (after meal)	Yellow	5.8	Acidic
3	Lemon juice	Red	2.3	Acidic
4	Colourless aerated drink	Red-orange	3	Acidic
5	Carrot juice	Yellow	6	Acidic
6	Coffee	Yellowish orange	5	Acidic
7	Tomato juice	Orange	4.1	Acidic
8	Tap water	Light green	7.4	Basic
9	1M NaOH	Dark violet	14	Basic
10	1 M HCl	Dark red	0	Acidic

- **Conclusion :**

Solutions with pH < 7 but close to 7 are weakly acidic, solutions with pH << 7 are strongly acidic, solution with pH > 7 but close to 7 are weakly basic, solutions with pH >> 7 are strongly basic.



Focus Point

- For more H^+ ions concentration, lower will be the pH.
- For more OH^- ions concentration, higher will be the pH.
- On dilution pH of acidic solution increases due to decrease in H^+ ions concentration.
- On dilution pH of basic solution decreases due to decrease in OH^- ions concentration.

11. IMPORTANCE OF PH IN EVERYDAY LIFE

♦ **Humans and animals are pH sensitive:**

Our body works within the pH range of 7.0 to 7.8. Living organisms can survive only in a narrow range of pH change. When pH of rain water is less than 5.6, it is called acid rain. When acid rain flows into the rivers. It lowers the pH of the river water. The survival of aquatic life in such rivers becomes difficult.

♦ **pH of soil :**

Plants require a specific pH range for their healthy growth. To find out the pH required for the healthy growth of a plant,you can collect the soil from various places and check the pH in the manner described below in activity.

LAB TIME
Let's Do & Learn

- **Object : To test the pH of the soil in the backyard of our home.**
- **Materials required :** Test tube, water, soil, pH paper.
- **Procedure :**
  (i) Put about 2g soil in a test tube and add 5 mL water to it.
  (ii) Shake the contents of the test tube.
  (iii) Filter the contents and collect the filtrate in the test tube.
  (iv) Check the pH of this filtrate with the help of universal indicator paper.
- **Observation and conclusion :** pH of soil is determined so that proper fertilizers can be used for growth of plants.

♦ **pH in our digestive system :**

It is very interesting to note that our stomach produces hydrochloric acid. It helps in the digestion of food without harming the stomach. During indigestion the stomach produces too much acid and this causes pain and irriation. To get rid of this pain, people use bases called antacids. One such remedy must have been suggested to you at the beginning of this Chapter. These actacids neutralise the excess acid. Magnesium hydroxide (Milk of magnesia), a mild base, is often used for this purpose.

♦ **pH change as the cause of tooth decay :**

The white enamel coating on our teeth is of insoluble calcium phosphate which is quite hard. It is not affected by water. However, when the pH in the mouth falls below 5.5 the enamel gets corroded. Water will have a direct access to the roots and decay of teeth will occur. The bacteria present in the mouth break down the sugar that we eat in one form or the other to acids, Lactic acid is one of these. The formation of these acids causes decrease in pH. It is therefore advisable to avoid eating sugary foods and also to keep the mouth clean so that sugar and food particles may not be present. The tooth pastes contain in them some basic ingredients and they help in neutralising the effect of the acids and also increasing the pH in the mouth.

♦ **Self defence by animals and plants through chemical warfare:**

The stings of bees and ants contain formic acid. Its corrosive and poisonous effect can be neutralised by rubbing soap .Sodium hydroxide present in the soap neutralises acid injected in the body and thus brings the pH back to its original level bringing relief to the person who has been stung. Similarly, the effect of stings by wasps containing alkali is neutralised by the application of vinegar which is dilute solution of ethanoic acid (or acetic acid).

Nettle is a herbaceous plant which grows in the wild. Its leaves have stinging hair, which cause painful stings when touched accidentally. This is due to the methanoic acid secreted by them. A traditional remedy is rubbing the area with the leaf of the dock plant, which often grows beside the nettle in the wild.



Focus Point

- Nettle is a herbaceous plant which grows in the wild. Its leaves have stinging hair, which cause paniful stings when touched accidentially. This is due to the methanoic acid secreted by them. A traditional remedy is rubbing the area with the leaf of the dock plant, which often grows beside the nettle in the wild.

12. SALTS

When acids and bases react together than salts are formed. Salts are the ionic compounds consisting of two parts, one part carrying a positive charge (called positive ion or cation) and the other part carrying a negative charge (called a negative ion or anion). The number of positive and negative charge is same so that the salt as a whole is the electrically neutral. The positive ion is generally a metal ion, the most common exception being that of ammonium ion, NH_4^+ . A few examples are given in Table below.

Salt	Formula	Positive ion	Negative ion
Sodium chloride	$NaCl$	Na^+	Cl^-
Sodium sulphate	Na_2SO_4	$2Na^+$	SO_4^{2-}
Sodium nitrate	$NaNO_3$	Na^+	NO_3^-
Potassium nitrate	KNO_3	K^+	NO_3^-
Copper sulphate	$CuSO_4$	Cu^{2+}	SO_4^{2-}
Zinc sulphate	$ZnSO_4$	Zn^{2+}	SO_4^{2-}
Calcium carbonate	$CaCO_3$	Ca^{2+}	CO_3^{2-}
Sodium carbonate	Na_2CO_3	$2Na^+$	CO_3^{2-}
Calcium chloride	$CaCl_2$	Ca^{2+}	$2\ Cl^-$
Aluminium sulphate	$Al_2(SO_4)_3$	$2\ Al^{3+}$	$3SO_4^{2-}$
Ammonium chloride	NH_4Cl	NH_4^+	Cl^-

12.1 FORMATIONS OF SALTS

Salts can be prepared by many reactions. Some of these are -

(1) By neutralisation of acid and bases. For example,

$NaOH + HCl \longrightarrow NaCl + H_2O$

Sodium hydroxide — Hydrochloric acid — Sodium chloride — Water

(2) By action of metals on acids. For example,

$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$

Zinc — Sulphuric acid — Zinc sulphate — Hydrogen

(3) By action of acids on metal carbonates and bicarbonates. For example,

$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

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

(4) By action of metals on alkails. For example,

$2NaOH + Zn \xrightarrow{Heat} Na_2ZnO_2 + H_2$

Sodium hydroxide — Zinc — Sodium zincate — Hydrogen

12.2 FAMILIES OF SALTS

Salts are generally formed by reaction between an acid and base. And on the basis of kind of acid and base used they contain specific cation or anion. So we can divide salts in different on the basis of cation or anion present.

The salts having the same positive radical (or cation) are said to belong to the same family. Or we can say, salts can be classified into different families based on the common ion present.



Focus Point

- **Object : Write the formulae of the salts and to identify their acids and bases and their families.**
- **Procedure :**

(i) Write down the formulae of the salts given below : (1) Potassium sulphate (2) Sodium sulphate (3) Calcium sulphate (4) Magnesium sulphate (5) Copper sulphate (6) Sodium chloride (7) Sodium nitrate (8) Sodium carbonate (9) Ammonium chloride.

(ii) Identify the acids and bases from which the above salts may be obtained.

(iii) Salts having the same positive or negative radicals belong the the same family. For example, NaCl and Na_2SO_4 belong to the family of sodium salts. Similarly, NaCl and KCl belong to the family of chloride salts.



Focus Point

- **Observation and conclusion :**

S.No.	Salt	Formula	Acid	Base
1	Potassium sulphate	K_2SO_4	H_2SO_4	KOH
2	Sodium sulphate	Na_2SO_4	H_2SO_4	NaOH
3	Calcium sulphate	$CaSO_4$	H_2SO_4	$Ca(OH)_2$
4	Magnesium sulphate	$MgSO_4$	H_2SO_4	$Mg(OH)_2$
5	Copper sulphate	$CuSO_4$	H_2SO_4	$Cu(OH)_2$
6	Sodium chloride	NaCl	HCl	NaOH
7	Sodium nitrate	$NaNO_3$	HNO_3	NaOH
8	Sodium carbonate	Na_2CO_3	H_2CO_3	NaOH
9	Ammonium chloride	NH_4Cl	HCl	NH_4OH

Families of salts :

(i) On the basis of common acids.

Sulphates $\Rightarrow$ K_2SO_4, Na_2SO_4, $CaSO_4$, $MgSO_4$, $CuSO_4$

Chlorides $\Rightarrow$ NaCl, NH_4Cl

Carbonates $\Rightarrow$ Na_2CO_3

(ii) On the basis of common bases

Sodium salts ⇒ Na_2SO_4, NaCl, $NaNO_3$, Na_2CO_3

Potassium salts ⇒ K_2SO_4

Calcium salts ⇒ $CaSO_4$

Magnesium salts ⇒ $MgSO_4$

Copper salts ⇒ $CuSO_4$

Ammonium salts ⇒ NH_4Cl

12.3 CLASSIFICATION OF SALTS

(A) Based on their Mode of Formation :

(i) Normal Salts :

The salts which are obtained by complete replacement of the ionisable hydrogen atoms of an acid by a metallic or an ammonium ion are known as normal salts. For example, normal salts NaCl and Na_2SO_4 are formed by the complete replacement of ionisable hydrogen atoms of HCl and H_2SO_4 respectively.

$$HCl + NaOH \longrightarrow \underset{\text{Sodium chloride (Normal salt)}}{NaCl} + H_2O$$

$$H_2SO_4 + 2NaOH \longrightarrow \underset{\text{Sodium sulphate (Normal salt)}}{Na_2SO_4} + 2H_2O$$

(ii) Acid Salts : The salts which are obtained by the partial replacement of ionisable hydrogen atoms of a polybasic acid by a metal or an ammonium ion are known as acid salts.

These are usually formed when insufficient amount of the base is taken for the neutralisation of the acid. For example, when insufficient amount of NaOH is taken to neutralise H_2SO_4, we get an acid salt $NaHSO_4$.

$$\underset{\text{(Limited amount)}}{H_2SO_4} + \underset{\text{(Insufficient amount)}}{NaOH} \longrightarrow \underset{\text{Sodium hydrogensulphate (Acid salt)}}{NaHSO_4} + H_2O$$

In this case, only one hydrogen atom out of two has been replaced by sodium atom. Since there is one more hydrogen atom in $NaHSO_4$ which can be replaced, therefore, it further reacts with another molecule of NaOH to produce Na_2SO_4 which is a normal salt.

$$\underset{\substack{\text{Sodium hydrogensulphate}\\ \text{(Acid salt)}}}{NaHSO_4} + NaOH \longrightarrow \underset{\substack{\text{Sodium sulphate}\\ \text{(Normal salt)}}}{Na_2SO_4} + H_2O$$

Acid salts ionise in aqueous solution to produce hydronium ions (H_3O^+), therefore, they exhibit all the properties of acids.

Some other examples of acid salts are given in Table.

SOME ACID SALTS WITH THEIR PARENT ACIDS

S. No.	Parent Acid	Acid Salts
1.	Sulphuric acid (H_2SO_4)	$NaHSO_4$, $KHSO_4$, $Ca(HSO_4)_2$
2.	Carbonic acid (H_2CO_3)	$NaHCO_3$, $KHCO_3$, $Ca(HCO_3)_2$, $Mg(HCO_3)_2$
3.	Sulphurous acid (H_2SO_3)	$NaHSO_3$, $KHSO_3$, $Ca(HSO_3)_2$, $Mg(HSO_3)_2$
4.	Phosphoric acid (H_3PO_4)	NaH_2PO_4, Na_2HPO_4, KH_2PO_4, K_2HPO_4, $Ca(H_2PO_4)_2$, $CaHPO_4$

(iii) Basic Salts : The salts which are formed by partial replacement of hydroxyl (–OH) groups of a di or a triacidic base (polyacidic base) by an acid radical are known as basic salts.

These are usually formed when an insufficient amount of acid is taken for the neutralisation of the base. For example, when insufficient amount of HCl is added to Lead hydroxide, Basic lead chloride [Pb(OH)Cl] is formed

$$\underset{\text{Lead hydroxide (Diacidic base)}}{Pb(OH)_2} + HCl \longrightarrow \underset{\text{Basic Lead chloride (Basic salt)}}{Pb(OH)Cl} + H_2O$$

Basic salts, for example, Pb(OH)Cl further reacts with HCl to form normal salts

$$\underset{\text{Basic Lead Chloride (Basic salts)}}{Pb(OH)Cl} + HCl \longrightarrow \underset{\text{Lead chloride (Normal salt)}}{PbCl_2} + H_2O$$

Some other important examples of basic salts are :

(i) Basic copper chloride, Cu(OH)Cl.

(ii) Basic copper nitrate, $Cu(OH)NO_3$

(iii) Basic lead nitrate, $Pb(OH)NO_3$.

(iv) Double Salts : The salts which are obtained by the crystallisation of two simple salts from a mixture of their saturated solutions are known as double salts.

For example,

A double salt potash alum [$K_2SO_4 . Al_2(SO_4)_3 . 24H_2O$] is prepared by mixing saturated solutions of two simple salts, K_2SO_4 and $Al_2(SO_4)_3$ and crystallization of the mixture.

$$K_2SO_4 + Al_2(SO_4)_3 + 24H_2O \xrightarrow{\text{Crystallisation}} \underset{\text{Potash alum (Double salt)}}{K_2SO_4 . Al_2(SO_4)_3 . 24\,H_2O}$$

Some other examples of double salts are :

(i) Mohr's Salt, $FeSO_4 .(NH_4)_2SO_4 . 6H_2O$

(ii) Dolomite, $CaCO_3 . MgCO_3$

(iii) Carnallite, $KCl . MgCl_2 . 6H_2O$

(B) Classification of salt solutions based on pH values :

Salts are formed by the reaction between acids and bases. Depending upon the nature of the acids and bases or upon the pH values, the salt solutions may be neutral, acidic or basic.

It can be understood by following activity.

LAB TIME
Let's Do & Learn

- **Object : To find the pH of the given salt solutions.**
- **Method :**
  (i) Colloect the following salt samples :
  (a) Sodium chloride (b) Potassium nitrate (c) Aluminium chloride
  (d) Zinc sulphate (e) Copper sulphate (f) Sodium acetate
  (g) Sodium carbonate (h) Sodium hydrogen carbonate
  (ii) Chek their solubility in water (use distilled water only).
  (iii) Check the action of these solutions on litmus and find the pH using a pH paper
  (iv) Report your observations in a tabular form.
- **Observation and conclusion :**
  The solubility of salts in water, their pH values are shown in table below :

Salt	Formula	Solubility in water	Action on litmus	pH	Acid used	Base used
Sodium chloride	NaCl	Soluble	No action	7	HCl	NaOH
Potassium nitrate	KNO_3	Soluble	No action	7	HNO_3	KOH
Aluminium chloride	$AlCl_3$	Soluble	Turns red	<7	HCl	$Al(OH)_2$
Zinc sulphate	$ZnSO_4$	Soluble	Turns red	<7	H_2SO_4	$Zn(OH)_2$ or ZnO
Copper sulphate	$CuSO_4$	Soluble	Turns red	<7	H_2SO_4	$Cu(OH)_2$ or CuO
Sodium acetate	CH_3COONa	Soluble	Turns blue	>7	CH_3COOH	NaOH
Sodium Carbonate	Na_2CO_3	Soluble	Turns blue	>7	H_2CO_3	NaOH
Sodium hydrogen carbonate	$NaHCO_3$	Soluble	Turns blue	>7	H_2CO_3	NaOH

Types of salt solutions on the basis of pH values :

(i) Neutral salt solutions : Salt solutions of strong acids and strong bases are neutral and have pH equal to 7. They do not change the colour of litmus solution.

e.g. NaCl, KCl, $NaNO_3$, Na_2SO_4 etc.

(ii) Acidic salt solutions : Salt solutions of strong acids and weak bases are of acidic nature and have pH less than 7. They change the colour of blue litmus solution to red.

e.g. $(NH_4)_2SO_4$, NH_4Cl etc.

In both these salts, the base NH_4OH is weak while the acids H_2SO_4 and HCl are strong.

(iii) Basic salt solutions : Salt solutions of strong bases and weak acids are of basic nature and have pH more than 7. They change the colour of red litmus solution to blue.

e.g. Na_2CO_3, K_3PO_4 etc.

In both the salts, bases NaOH and KOH are strong while the acids H_2CO_3 and H_3PO_4 are weak.

13. SOME COMMERCIALY IMPORTANT CHEMICAL COMPOUND

13.1 COMMON SALT

♦ **Chemical name :** Sodium chloride

♦ **Chemical formula :** NaCl

Sodium chloride (NaCl) also called common salt or table salt is the most essential part of our diet. Chemically it is formed by the reaction between solutions of sodium hydroxide and hydrochloric acid. Sea water is the major source of sodium chloride where it is present in dissolved form along with other soluble salts such as chlorides and sulphates of calcium and magnesium. It is separated by some suitable methods. Deposits of the salts are found in different parts of the world and is known as rock salt. When pure, it is a white crystalline solid, however, it is often brown due to the presence of impurities.

♦ **Uses :**

(i) Essential for life : Sodium chloride is quite essential for life. Biologically, it has a number of functions to perform such as in muscle contraction, in conduction of nerve impulse in the nervous system. When we sweat, there is loss of sodium chloride along with water. It leads to muscle cramps. Its loss has to be compensated suitably by giving certain salt preparations to the patient. Electoral powder is an important substitute of common salt.

(ii) Raw material for chemicals : Sodium chloride is also a very useful raw material for different chemicals. A few out of these are hydrochloric acid (HCl), washing soda ($Na_2CO_3.10H_2O$), baking soda ($NaHCO_3$) etc.

(iii) In leather industries : It is used in leather industry for the leather tanning.

(iv) In severe cold, rock salt is spread on icy roads to melt ice.

(v) It is also used as a fertilizer for sugar beet.

13.2 CAUSTIC SODA

♦ **Chemical name :** Sodium hydroxide

♦ **Chemical formula :** NaOH

♦ **Preparation :** It is Prepared by passing electricity through aqueous solutin of sodium chloride, commonly called brine.

$$2NaCl(aq) + 2H_2O(l) \xrightarrow[\text{Current}]{\text{Electric}} 2NaOH(aq) + Cl_2(g) + H_2(g)$$

On electrolysis, chlorine gas is formed at anode and hydrogen at cathode.

♦ **Uses :**

(i) It is used in soaps, detergents, paper and silk industries.

(ii) It is used in refining of petroleum.

(iii) It is used as a laboratory reagent.

(iv) It is used in dye industry.

(v) It is used in concentration of bauxite ore.(leaching process)

13.3 WASHING SODA

♦ **Chemical name :** Sodium carbonate decahydrate

♦ **Chemical formula :** $Na_2CO_3.10H_2O$

♦ **Preparation :** It is prepared by Recrystallization of sodium carbonate.

$$\underset{\text{Sodium carbonate}}{Na_2CO_3} + 10H_2O \longrightarrow \underset{\text{Washing Soda}}{Na_2CO_3.10H_2O}$$

♦ **Uses :**

(i) It is used as cleansing agent for domestic purposes.

(ii) It is used in softening of hard water and controlling the pH of water.

(iii) It is used in the manufacture of glass.

(iv) Due to its detergent properties, it is used as a constituent of several dry soap powders.

(v) It also finds use in photography, textile and paper industries etc.

13.4 BAKING SODA

♦ **Chemical name :** Sodium hydrogen carbonate or sodium bicarbonate

♦ **Chemical formula :** $NaHCO_3$

♦ **Preparation :**

It is obtained as an intermediate product in the preparation of sodium carbonate by Solvay process. In this process, a saturated solution of sodium chloride in water (30% NaCl solution known as brine solution) is saturated with ammonia and then carbon dioxide gas is passed into the solution. Sodium chloride is converted into sodium bicarbonate which, being less soluble, separates out from the solution.

$$NaCl + H_2O + CO_2 + NH_3 \longrightarrow \underset{\text{(Ammonium chloride)}}{NH_4Cl} + \underset{\text{(Sodium hydrogencarbonate)}}{NaHCO_3}$$

♦ **Properties :**

(i) It is a white, crystalline substance that forms an alkaline solution with water. The aqueous solution of sodium bicarbonate does not change the colour of methyl orange but gives pink colour with phenolphthalein. (Phenolphthalein and methyl orange are dyes used as acid-base indicators.)

(ii) When heated above 543 K, it is converted into sodium carbonate.

$$2NaHCO_3\ (s) \longrightarrow Na_2CO_3\ (s) + CO_2\ (g) + H_2O\ (l)$$

♦ **Uses** :

(i) For making baking powder, which is a mixture of baking soda (sodium hydrogencarbonate) and a mild edible acid such as tartaric acid. When baking powder is heated or mixed in water, the following reaction takes place.

$$\underset{\text{(From acid)}}{NaHCO_3 + H^+} \rightarrow CO_2 + H_2O + \text{Sodium salt of acid}$$

Carbon dioxide produced during the reaction causes bread or cake to rise making them soft and spongy.

(ii) Sodium hydrogencarbonate is also an ingredient in antacids. Being alkaline, it neutralises excess acid in the stomach and provides relief.

(iii) It is also used in soda–acid fire extinguisher.

13.5 BLEACHING POWDER

♦ **Chemical name :** Calcium oxychloride

♦ **Chemical formula :** $CaOCl_2$

♦ **Preparation :** Bleaching powder is prepared by passing chlorine over slaked lime at 313 K.

$$\underset{\text{Slaked lime}}{Ca(OH)_2\ (aq)} + Cl_2\ (g) \xrightarrow{313K} \underset{\text{Bleaching powder}}{CaOCl_2\ (s)} + H_2O\ (g)$$

♦ **Uses :**

(i) It is commonly used as a bleaching agent in paper and textile industries.

(ii) It is also used for disinfecting water to make it free from germs.

(iii) It is used to prepare chloroform.

13.6 PLASTER OF PARIS

♦ **Chemical name :** Calcium sulphate hemihydrate

♦ **Chemical formula :** $CaSO_4.\frac{1}{2}H_2O$

♦ **Preparation :**

It is prepared by heating gypsum ($CaSO_4.2H_2O$) at about 373 K in large steel pots with mechanical stirrer, or in a revolving furnace.

$$\underset{\text{Gypsum}}{2(CaSO_4.2H_2O)\ (s)} \xrightarrow{373K} \underset{\text{Plaster of Paris}}{(CaSO_4)_2.H_2O\ (s)} + 3H_2O\ (g)$$

or

$$\underset{\text{Gypsum}}{CaSO_4.2H_2O\ (s)} \xrightarrow[\text{heat}]{373K} \underset{\text{Plaster of Paris}}{CaSO_4.\frac{1}{2}H_2O(s)} + \frac{3}{2}H_2O\ (g)$$

♦ **Properties of Plaster of Paris**

(i) Plaster of Paris is white, odourless powder.

(ii) At ordinarty room temperature, Plaster of Paris absorbs water and a large amount of heat is liberated.

(iii) When mixed with a limited amount of water (50% by mass), it forms a plastic mass, evolves heat and quickly sets to a hard porous mass within minute. This is called the setting process.

During setting, a slight expansion in volume occurs. It is due to this that it fills the mould completely and gives sharp impression. The reaction during process is

$$\underset{\text{Plaster of Paris}}{CaSO_4.\frac{1}{2}H_2O(s)} + \frac{3}{2}H_2O\ (l) \rightarrow \underset{\text{Gypsum}}{CaSO_4.2H_2O\ (s)}$$

♦ **Uses :**

(i) It is used in the laboratories for sealing gaps where air tight arrangement is required.

(ii) It is used for making toys, cosmetics and casts of statues.

(iii) It is used as a cast for setting broken bones.

(iv) It also finds use in making moulds in pottery.

(v) It is used for making surfaces smooth and for making designs on walls and ceilings.

14. ARE THE CRYSTALLINE SALTS REALLY DRY ? – ANHYDROUS AND HYDRATED SALTS

The chemical formula of washing soda is $Na_2CO_3.10H_2O$. Thus, one formula unit of the salt contains 10 water molecules. Similarly, there are a number of crystalline salts, each of which contains a fixed number of water molecules. For example, crystalline copper sulphate is $CuSO_4.5H_2O$, gypsum is $CaSO_4.2H_2O$, plaster of Paris is is $CaSO_4.1/2H_2O$.

The fixed number of water molecules present in one formula unit of the salt is called water of crystallisation.

LAB TIME
Let's Do & Learn

- **Object :** To test the presence of water of crystallisation in copper sulphate crystals.
- **Materials required :** Boiling tube, copper sulphate crystals, burner, water, test tube holder.
- **Procedure :**
  (i) Heat a few crystals of copper sulphate in a dry boiling tube. Note the colour of copper sulphate after heating.

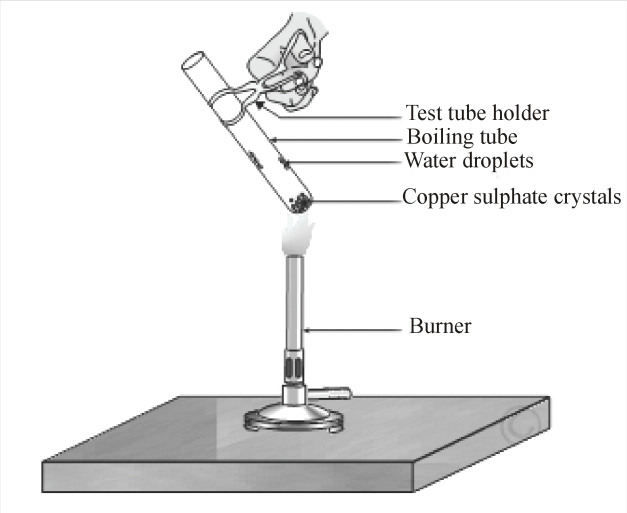
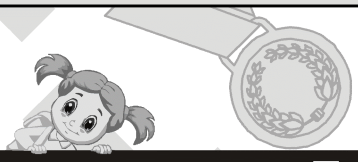


Figure. Removing water of crystallisation

- **Observation :** Blue coloured copper sulphate crystals on heating leave behind white anhydrous copper sulphate and water droplets are seen in the upper cooler parts of the boiling tube. On adding 2–3 drop of water to the white residue, blue colour reppears.
- **Conclusion :** Copper sulphate crystals on heating lose water to form white anhydrous copper sulphate which can combine again with water to form blue coloured copper sulphate crystals.



Focus Point

- **Deliquescence:** Certain crystalline substance when exposed to atmosphere absorb moisture and change into solution. The absorption of moisture from air by crystals to form a solution is called deliquescence.
  Sodium hydroxide, potassium hydroxide, calcium chloride, etc. are deliquescent substance.
- **Hygroscopic substance:** Certain substance absorb water from the atmosphere without undergoing change in physical state. Such substances are known as hygroscopic substance.
  Anhydrous sodium carbonate, anhydrous copper sulphate, concentrated sulphuric acid are examples of hygroscopic substances.

SOLVED EXAMPLES

SE. 1

You have been provided with three test tubes. One of them contains distilled water and the other two contain an acidic solution and a basic solution, respectively. If you are given only red litmus paper,how will you identify the contents of each test tube?

Ans. Few drops of each solution from the test tubes are added to red litmus paper separately.
(i) The solution which turns red litmus to blue is the basic solution. Use this blue litmus paper to test the solutions in the other two test tubes.
(ii) The solution which turns blue litmus paper to red will be the acidic solution.
(iii) The solution which does not change the colour of either red or blue litmus paper contains distilled water.

SE. 2

Why should curd and sour substances not be kept in brass and copper vessels?

Ans. Curd and sour substances contain acids. These acids can react with brass and copper vessels to form toxic compounds. This makes the substances unfit for human consumption. Hence, they should not kept in brass and copper vessels.

SE. 3

Which gas is usually liberated when an acid reacts with a metal? Illustrate with an example. How will you test for the presence of this gas?

Ans. Hydrogen gas is usually liberated when an acid reacts with a metal.
e.g., $Zn(s) + 2HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2(g)$
The equation given above ,illustrates how zinc reacts with dilute hydrochloric acid resulting in the liberation of hydrogen gas and the formation of the salt zinc chloride.
A burning match stick, when brought near the mouth of the test tube where H_2 gas is being released, makes a pop sound. This confirms the presence of hydrogen gas.

SE. 4

Metal compound A reacts with dilute hydrochloric acid to produce effervescence. The gas evolved extinguishes a burning candle. Write a balanced chemical equation for the reaction if one of the compoundsformed is calcium chloride.

Ans. Metal compound A is Calcium carbonate ($CaCO_3$). When A reacts with dilute hydrochloric acid it produces effervescence. The chemical equation is given as:
$CaCO_3(s)+2HCl(aq)\rightarrow CaCl_2(aq)+CO_2(g)+H_2O\ (l)$
The gas evolved is CO_2. CO_2 extinguishes a burning candle.

SE. 5

Why do HCl, HNO_3,etc., show acidic characters in aqueous solutions while solutions of compounds like alcohol and glucose do not show acidic character?

Ans. When HCl or HNO_3 are mixed with water, they dissolve in water to form H^+ or H_3O^+ ions which show their acidic character.
For example,
$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$
$H^+(aq) + H_2O(l) \rightarrow H_3O^+\ (aq)$
Solutions of compounds like alcohol and glucose do not dissolve to form any such ions. Hence, they do not show any acidic character.

SE. 6

Why does an aqueous solution of acid conduct electricity?

Ans. An acid dissolves in water and dissociates to form H^+ or H_3O^+ ions. Electricity is conducted through these moving ions.

SE. 7

Why does dry HCl gas not change the colour of the dry litmus paper?

Ans. Dry HCl gas does not dissociate into H^+ ions and hence, the acidic property of gas is not impaired. So dry HCl gas does not change the colour of the dry litmus paper.

SE. 8

While diluting an acid, why is it recommended that the acid should be added to water and not water to the acid?

Ans. The process of adding water to acid is highly exothermic. If not done very carefully the acid may splash, cause burns and even the bottle/container can break due to the vigorous reaction. To avoid this and to allow the heat evolved to be absorbed by water slowly, the acid is added to water for diluting it. This significantly reduces the risk of splashing.

SE. 9

How is the concentration of hydronium ions H_3O^+ affected when a solution of an acid is diluted?

Ans. When the solution of acid is diluted then the concentration of hydronium ion H_3O^+ per unit volume decreases. On adding water, the H^+ ions of the acid and hydroxyl ions of water react to form water molecules and the concentration of hydronium ions decreases.

SE. 10

How is the concentration of hydroxide ions OH^- affected when excess base is dissolved in a solution of sodium hydroxide?

Ans. When the base is mixed with sodium hydroxide solution there is an increase in the number of hydroxide ions whereas the volume remains almost the same. This leads to an increase in the concentration of OH^- ions per unit volume.

SE. 11

You have two solutions, A and B. The pH of solution A is 6 and pH of solution B is 8. Which solution has more hydrogen ion concentration? Which of this is acidic and which one is basic?

Ans. Solutions with pH < 7 are said to be acidic.
Solutions with pH = 7 are neutral and pH > 7 are basic.
Therefore, Solution A with pH = 6 is acidic and Solution B with pH = 8 is basic.
So 'A' has more hydrogen ion concentration.

SE. 12

What effect does the concentration of $H^+(aq)$ ions have on the nature of the solution?

Ans. The higher the concentration of $H^+(aq)$ ions, the more is its acidic nature.

SE. 13

Do basic solutions also have $H^+(aq)$ ions? If yes, then why are these basic?

Ans. Yes, basic solutions also have H^+ ions, but they are basic in nature due to a greater number of OH^- ions than the H^+ ions.

SE. 14

Under what soil condition do you think a farmer would treat the soil of his fields with quick lime (calcium oxide) or slaked lime (calcium hydroxide) or chalk (calcium carbonate)?

Ans. Quick lime (calcium oxide), slaked lime (calcium hydroxide) and chalk (calcium carbonate) are all basic in nature. When the soil becomes more acidic in nature, the farmer would add quicklime CaO or slaked lime $CaOH_2$ or chalk $CaCO_3$ to make it neutral. This helps the farmer to make the soil fit to grow his crops.

SE. 15

What is the common name of the compound $CaOCl_2$?

Ans. $CaOCl_2$ (chemical name - calcium oxychloride) is commonly called bleaching powder.

SE. 16

Name the substance which on treatment with chlorine yields bleaching powder.

Ans. Bleaching powder is prepared by treating Calcium hydroxide $Ca(OH)_2$ with chlorine. The chemical equation for the reaction is:

$$Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$$

SE. 17

Name the sodium compound which is used for softening hard water.

Ans. Sodium carbonate is commonly used for softening hard water.

SE. 18

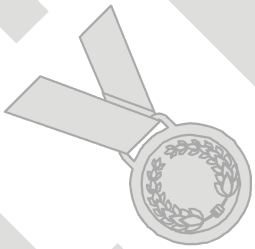
What will happen if a solution of sodium hydrogen carbonate is heated? Give the equation of the reaction involved and where it is used?

Ans. When sodium hydrogen carbonate ($NaHCO_3$) is heated, sodium carbonate, water and carbon dioxide gas are obtained. The chemical equation for the reaction is

$2\ NaHCO_3 + \text{heat} \rightarrow Na_2CO_3 + H_2O + CO_2$

it is used to make the cake soft.

Space for Notes :



MATRIX OLYMPIAD

NS. 1

A solution turns red litmus blue; its pH is likely to be:

(A) 1 (B) 4

(C) 5 (D)10

Ans. (D)

A solution which turns the colour of red litmus to blue must be basic in nature. A basic solution has a pH value of greater than 7. The only option with pH greater than 7 is 10 which will be the correct answer.

NS. 2

A solution reacts with crushed egg-shells to give a gas that turns lime-water milky. The solution contains:

(A) NaCl (B)HCl

(C) LiCl (D)KCl

Ans. (B)

Egg shells are made up of calcium carbonate, which on reaction with HCl liberates CO_2 gas. When CO_2 reacts with lime water ($Ca(OH)_2$), it forms calcium carbonate which gives the solution a milky appearance.

$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

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

NS. 3

10 ml of a solution of NaOH is found to be completely neutralized by 8 mL of a given solution of HCl. If we take 20 ml of the same solution of NaOH, the amount of HCl solution (the same solution as before) required to neutralize it will be:

(A) 4 ml (B)8 ml

(C) 12 ml (D)16 ml

Ans. (D)

The amount of Hydroxide ions and hydrogen ions are directly proportional to the volume of their respective solutions. Hence, the problem can be solved by a unitary method .Since 10 ml NaOH reacts with = 8 ml HCl.

Therefore, 20 ml NaOH react with =(8/10) × 20 = 16 ml HCl

∴ 16 ml of HCl solution will be required to completely neutralize 20 ml of NaOH solution.

NS. 4

Which of the following types of medicines is used for treating indigestion?

(A) Antibiotic (B) Analgesic

(C) Antacid (D) Antiseptic

Ans. (C)

An antacid is used for the treatment of indigestion which is caused due to excessive acidity in the stomach. The antacid chemical is basic in nature and thus, it neutralizes the acidity in the stomach.

NS. 5

Write word equations and then balanced equations for the reaction taking place when

(i) Dilute sulphuric acid reacts with zinc granules.

(ii) Dilute hydrochloric acid reacts with magnesium ribbon.

(iii) Dilute sulphuric acid reacts with aluminium powder.

(iv) Dilute hydrochloric acid reacts with iron filings.

Ans. (i) Sulphuric acid +Zinc → Zinc sulphate + Hydrogen

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

(ii) Hydrochloric acid + Magnesium → Magnesium chloride + Hydrogen

$2HCl\ (aq) + Mg(s) \rightarrow MgCl_2(aq) + H_2(g)$

(iii) Sulphuric acid + Aluminium → Aluminium sulphate + Hydrogen

$3H_2SO_4(aq) + 2Al(s) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$

(iv) Hydrochloric acid + Iron → Ferrous chloride + Hydrogen

$6HCl\ (aq) + 2Fe(s) \rightarrow 2FeCl_2(aq) + 3H_2(g)$

NS. 6

Compounds such as alcohols and glucose also contain hydrogen but are not categorized as acids. Describe an activity to prove it.

Ans. Two nails are fitted on a cork and are kept in a 100 ml beaker. The nails are then connected to the two terminals of a 6-volt battery through a bulb and a switch. Some dilute HCl is poured into the beaker and the current is switched on. The same experiment is then performed with a glucose solution and an alcohol solution.

Observations

It will be observed that the bulb glows in the HCl solution and does not glow in the glucose or alcohol solution.

Result

HCl dissociates into H^+ and Cl^- ions. These ions conduct electricity in the solution resulting in the glowing of the bulb. On the other hand, neither the glucose solution nor the alcohol solution dissociates into ions. Therefore, these two solutions do not conduct electricity.

Conclusion

From this activity, it can be concluded that all acids generate hydrogen ions but not all compounds containing hydrogen are acids.

That is why, though alcohols and glucose contain hydrogen, they are not categorized as acids.

NS. 7

Why does distilled water not conduct electricity, whereas rain water does?

Ans. Distilled water is a pure form of water and its pH is 7. Therefore, it does not conduct electricity. Rain water, being an impure form of water, contains CO_2, SO_2, N_xO_y (oxide of nitrogen) .

These oxide gases react with water and get chemically converted into acids which are responsible for the release of ions that conduct electricity.

NS. 8

Why do acids not show acidic behaviour in the absence of water?

Ans. A substance is said to be acidic when it can generate hydrogen ions (H^+). The hydrogen ion generally comes from the acid which dissociates in the presence of water. Thus, for acid to dissociate into hydrogen ion and the respective anion, water must be present. Hence, an acid fails to show its acidic behaviour in the absence of water.

NS. 9

Five solutions A, B, C, D , and E , when tested with universal indicator, showed pH as 4,1,11,7 and 9, respectively. Which solution is

(i) Neutral?

(ii) Strongly alkaline?

(iii) Strongly acidic?

(iv) Weakly acidic?

(v) Weakly alkaline?

Arrange the pH in increasing order of hydrogenion concentration.

Ans. At 25^o C pH of neutral solutions =7

As the pH falls below 7, it denotes acidic character with a pH of 0 being highly acidic. When the pH goes above 7, it implies that the solution is basic with 14 being highly basic.

(i) Neutral Solution D with pH 7

(ii) Strongly alkaline Solution C with pH 11

(iii) Strongly acidic Solution B with pH 1

(iv) Weakly acidic Solution A with pH 4

(v) Weakly alkaline Solution E with pH 9

NS. 10

Equal lengths of magnesium ribbons are taken in test tubes A and B. Hydrochloric acid (HCl) is added to test tube A, while acetic acid (CH_3COOH) is added to test tube B. Amount and concentration taken for both the acids are same. In which test tube will the fizzing occur more vigorously and why?

Ans. The fizzing will occur strongly in test tube A, in which hydrochloric acid (HCl) is added. This is because HCl is a stronger acid than CH_3COOH and therefore produces hydrogen gas at a quicker rate due to which fizzing occurs more vigorously in test tube A.

$Mg + 2HCl \rightarrow MgCl_2 + H_2\uparrow$ (faster)

$Mg + 2CH_3COOH \rightarrow Mg(CH_3COO)_2 + H_2$ (slower)

NS. 11

Fresh milk has a pH of 6. How do you think the pH will change as it turns into curd? Explain your answer.

Ans. The pH of milk is 6. As it gets converted to curd the pH will reduce because curd has lactic acid which is more acidic in nature.

Thus, the pH drops below 6 when milk gets converted to curd.

NS. 12

A milkman adds a very small amount of baking soda to fresh milk.

(i) Why does he shift the pH of the fresh milk from 6 to slightly alkaline?

(ii) Why does this milk take a long time to set as curd?

Ans. (i) The milkman adds a small amount of baking soda to shift the pH of the fresh milk from 6 to slightly alkaline because in alkaline condition, milk does not set as curd easily and this helps in preventing the milk from getting converted to curd.

(ii) Since this milk is slightly basic than usual milk, acids produced to set the curd are neutralized by the base. Only when the alkalinity of milk is neutralized, the process of curd formation begins. Therefore, it takes a longer time for the curd to set.

NS. 13

Plaster of Paris should be stored in a moisture-proof container. Explain why?

Ans. Plaster of Paris (POP) should be stored in a moisture-proof container because Plaster of Paris, a powdery mass, absorbs water (moisture) to form a hard solid known as gypsum.

$CaSO_4.1/2H_2O + 3/2H_2O \rightarrow CaSO_4.2H_2O$

NS. 14

What is a neutralization reaction? Give two examples.

Ans. A reaction in which an acid and a base react with each other to give a salt and water is termed as a neutralization reaction. In this reaction, energy is evolved in the form of heat and thus, such reactions are usually exothermic by nature.

Example:

(i) $NaOH + HCl \rightarrow NaCl + H_2O$

(ii) During indigestion (caused due to the production of excess of hydrochloric acid in the stomach), we administer an antacid (generally milk of magnesia, $Mg(OH)_2$ which is basic in nature).

The antacid neutralizes the excess acid and thus gives relief from indigestion.

$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$

NS. 15

Give two important uses of washing soda and baking soda.

Ans. Two important uses of washing soda are as follows:

i. It is used in glass, soap, and paper industries.

ii. It is used to remove the permanent hardness of the water.

Two important uses of baking soda are as follows:

i. It is used in baking industries. Baking powder is a mixture of baking soda and a mild acid known as tartaric acid. When it is heated or mixed with water, it releases CO_2 that makes bread or cake fluffy.

ii. It is used in soda-acid fire extinguishers.

ONLY ONE CORRECT TYPE

SECTION(B):INTRODUCTION, CLASSIFICATION AND PROPERTIES OF ACIDS

1. H_2CO_3 is a -
(A) strong acid (B) weak acid
(C) strong base (D) weak base

2. Common name of H_2SO_4 is -
(A) Oil of vitriol
(B) Muriatic acid
(C) Blue vitriol
(D) Green vitriol

3. $CuO + (X) \longrightarrow CuSO_4 + H_2O$.
Here (X) is -
(A) $CuSO_4$ (B) HCl
(C) H_2SO_4 (D) HNO_3

4. Acids gives -
(A) H^+ in water (B) OH^- in water
(C) Both (A) & (B) (D) None of these

SECTION (B) : CLASSIFICATION AND PROPERTIES OF BASES:

5. Which of the following is the weakest base ?
(A) NaOH (B) NH_4OH
(C) KOH (D) $Ca(OH)_2$

6. Calcium hydroxide (slaked lime) is used in -
(A) Plastics and dyes (B) Fertilizers
(C) Antacids (D) White washing

7. Caustic soda is the common name for -
(A) $Mg(OH)_2$ (B) KOH
(C) $Ca(OH)_2$ (D) NaOH

8. Antacids contain -
(A) Weak base (B) Weak acid
(C) Strong base (D) Strong acid

SECTION (C) : INDICATORS AND pH SCALE:

9. pH of Blood is -
(A) 6.4 (B) 7.4
(C) 4.7 (D) 5.2

10. Nature of methyl orange is -
(A) acidic (B) basic
(C) neutral (D) none of these

11. A solution has pH 9. On dilution the pH value
(A) decreases
(B) increases
(C) remain same
(D) none of these

SECTION (D) : SALTS :

12. A salt derived from strong acid and weak base will dissolve in water to give a solution which is -
(A) acidic
(B) basic
(C) neutral
(D) none of these

13. Which of the following is an example of basic salt solution ?
(A) CH_3COONa (aq)
(B) NH_4Cl (aq)
(C) $AlCl_3$ (aq)
(D) $(NH_4)_2SO_4$ (aq)

14. Nature of the aqueous solution of NaCl towards litmus is -
(A) acidic (B) basic
(C) neutral (D) none

15. Which of the following is an acid salt ?
(A) Na_2CO_3 (B) $NaHCO_3$
(C) NH_4Cl (D) NaCl

SECTION(E):SOMECOMERCIALLY IMPORTANT CHEMICAL COMPOUND :

16. Materials used in the manufacture of bleaching powder are -
(A) lime stone and chlorine
(B) quick lime and chlorine
(C) slaked lime and HCl
(D) slaked lime and chlorine

17. Bleaching powder gives smell of chlorine because it -
(A) is unstable
(B) gives chlorine on exposure to atmosphere
(C) is a mixture of chlorine and slaked lime
(D) contains excess of chlorine

18. Plaster of paris is made from -
(A) lime stone (B) slaked lime
(C) quick lime (D) gypsum

19. Chemical formula of baking soda is -
(A) $MgSO_4$ (B) Na_2CO_3
(C) $NaHCO_3$ (D) $MgCO_3$

20. The chemical name of marble is -
(A) calcium carbonate
(B) magnesium carbonate
(C) calcium chloride
(D) calcium sulphate

21. Two colours seen at the extreme ends of pH chart are
(A) red and blue (B) red and green
(C) green and blue (D) orange and black

22. Which one of the following are the correct observations about acetic acid?
(A) It turns blue litmus red and smells like vinegar
(B) It turns blue litmus red and smells like burning sulphur
(C) It turns red litmus blue and smells like vinegar
(D) It turns red litmus blue and has a fruity smell

23. A student takes about 2 mL ethanoic acid in a dry test tube and adds a pinch of sodium hydrogen carbonate to it. He reports the following observations:
I. Immediately a colourless and odourless gas evolves with a brisk effervescence.
II. The gas turns lime water milky when passed through it.
III. The gas burns with an explosion when a burning splinter is brought near it.
IV. The gas extinguishes the burning splinter that is brought near it.
The correct observations are
(A) I, II and III (B) II, III and IV
(C) III, IV and I (D) I, II and IV

24. In a locality, hard water, required for an experiment, is not available. However, the following salts are available in the school laboratory:
1. Sodium sulphate
2. Calcium sulphate
3. Magnesium chloride
4. Sodium chloride
5. Calcium chloride
6. Potassium sulphate
Which of the above salts may be dissolved in water to obtain hard water for the experiment?
(A) 2, 3 and 5 (B) 1, 2 and 5
(C) 1, 2, 4 and 6 (D) 3 and 5 only

25. The colour of the pH paper strip turned red when it was dipped into a sample. The sample could be:
(A) Dilute sodium bicarbonate
(B) Tap water
(C) Dilute sodium hydroxide
(D) Dilute hydrochloric acid

PARAGRAPH TYPE

PARAGRAPH # 1

Metal sulphide of reaction with acid evolve gas 'X'. Which on reaction with metal 'M' forms black precipipate 'Y'.

26. In above evolve gas X is :
(A) H_2S (B) SO_2
(C) CO_2 (D) SO_3

27. In above metal M is :
(A) Cu (B) Pb
(C) Fe (D) Ag

28. In above black precipitate Y is :
(A) AgCl (B) AgS
(C) Ag_2S (D) $CuCO_3.Cu(OH)_2$

PARAGRAPH # 2

In one of the industrial processes used for manufacture of sodium hydroxide, a gas X is formed as by product. The gas X reacts with lime water to give a compound Y which is used as a bleaching agent in chemical industry. Identify X and Y giving the chemical equation of the reactions involved.

29. In above process 'X' is:
(A) Cl_2 (B) H_2
(C) N_2 (D) O_2

30. In above process 'Y' is:
(A) $CaOCl_2$ (B) $Ca(OH)_2$
(C) $Mg(OH)_2$ (D) None of these

31. Correct reaction of 'X' and 'Y' for above process
(A) $Ca(OH)_2 + CO_2 \rightarrow Ca(HCO_3)_2 + H_2O$
(B) $Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$
(C) $Ca(OH)_2 + Cl_2 \rightarrow CaOCl + H_2O$
(D) $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

MATRIX OLYMPIAD

MATCH THE FOLLOWING TYPE

In this section, each question has two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (a), (B), (C) and (D) out of which one is correct.

32.

List-I	**List-II**
(a) Quicklime	(p) Sodium hydroxide
(b) Caustic soda	(q) Magnesium hydroxide
(c) Washing soda	(r) Calcium oxide
(d) Milk of magnesia	(s) Sodium carbonate

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

33.

List-I	**List-II**
(a) Citric acid	p. Tamarind
(b) Lactic acid	q. Tomatoes
(c) Oxalic acid	r. Orange
(d) Tartaric acid	s. Sour milk

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

Space for Notes :

MATRIX OLYMPIAD

EXERCISE – II

VERY SHORT ANSWER TYPE

1. Which gas burns with pop sound?
2. Write any three chemical properties of acids.
3. What do you understand by organic acids ? Give the name of two organic acids and their sources?
4. Give the name of two mineral acids and their uses.
5. Give the name of two diacidic base and their uses.
6. Give two examples of bases which are not alkali.
7. Write any two chemical properties of base.
8. Does dry HCl(g) turn blue litmus red?
9. Give two applications of pH in our daily life.
10. What will be the colour of phenolphthalein and methyl orange in Soap solution.

SHORT ANSWER TYPE

1. Name the four chemicals which can be obtained from common salt?
2. What do you call the property of loosing water of crystallisation?
3. Write the equation show formation of plaster of paris?
4. Write two examples of each of the following :
   (i) Acidic salts (ii) Basic salts
   (iii) Double salts
5. Explain why ?
   (i) Aqueous solution of sodium acetate has pH more than 7.
   (ii)Aqueous solution of copper sulphate has pH less than 7.
   (iii) Aqueous solution of potassium nitrate has pH value 7.

LONG ANSWER TYPE

1. Give chemical names of the following compounds. Also state one use in each case.
   (i) Washing soda (ii) Baking soda
   (iii) Bleaching powder
2. A student prepared solutions of (i) an acid and (ii) a base in two separate beakers. She forgot to label the solutions and litmus paper is not available in the laboratory. Since both the solutions are colourless, how will she distinguish between the two ?
3. Salt A commonly used in bakery products on heating gets converted into another salt B which itself is used for removal of hardness of water and a gas C is evolved. The gas C when passed through lime water, turns it milky. Identify A, B and C.
4. When zinc metal is treated with a dilute solution of a strong acid, a gas is evolved, which is utilised in the hydrogenation of oil. Name the gas evolved. Write the chemical equation of the reaction involved and also write a test to detect the gas formed.
5. For making cake, baking powder is taken. If at home your mother uses baking soda instead of baking powder in cake.
   (A) How will it affect the taste of the cake and why ?
   (B) how can baking soda be converted into baking powder?
   (C) What is the role of tartaric acid added to baking soda?

TRUE OR FALSE TYPE

1. Litmus is an indicator prepared by dissolving litmus salt in water.
2. Antacids neutralise the bases present in the stomach.
3. When an acid reacts with a base, neutralisation reaction takes place to give salt and water.
4. Acids have a sour taste and they are soapy to touch.
5. All bases are alkalis but all alkalis are not bases.

FILL IN THE BLANKS

1. Non metal oxide _____ in nature.
2. Metal oxide solution converts red litmus into _____.
3. Phosphoric acid basicity is _____.
4. Strong acid aq. solution will give _____ colur with universal indicator.
5. _____ metal reaction with base evolve H_2 gas.

NUMERICAL PROBLEMS

1. Calculate basicity of boric acid.
2. Number of weak acid in HCl, $H_2C_2O_4$, HCOOH, H_2SO_4, HI, HNO_3, HBr, Citric acid, HF
3. Calculate number of water of crystallisation in green vitrol.
4. PH of 10^{-1}M H_2SO_4.[if log 2 = 0.30]
5. POH of 10^{-2}M NaOH.

Space for Notes :

MATRIX OLYMPIAD

Answer Key

EXERCISE–I

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

EXERCISE – II

TRUE / FALSE

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

FILL IN THE BLANKS

1. Acidic **2.** Blue **3.** 3 **4.** Red **5.** Amphoteric

NUMERICAL PROBLEMS

1. 1 **2.** 4 **3.** 7 **4.** 0.7 **5.** 2

MATRIX OLYMPIAD

SELF PROGRESS ASSESSMENT FRAMEWORK

(CHAPTER : ACIDS, BASES & SALTS)

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 :

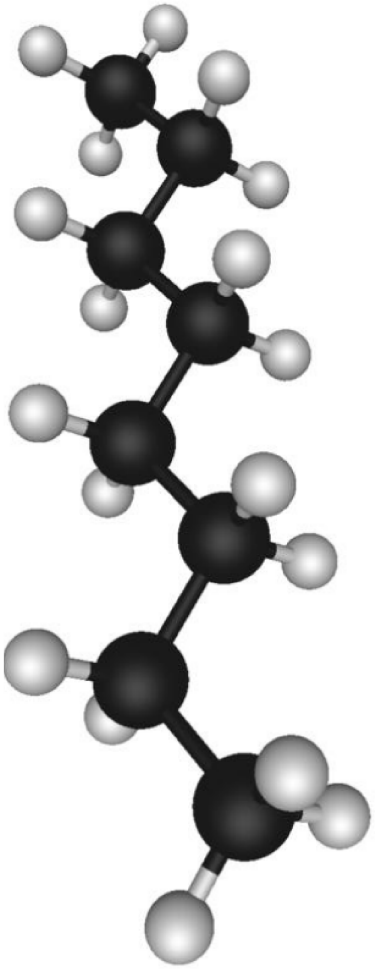
CARBON & ITS COMPOUNDS

3

Concepts

Introduction
1. Vital force theory or berzelius hypothesis
2. Wohler's synthesis
3. Modern definition of organic chemistry
   3.1 Sources of organic compounds
4. Bonding in carbon- The covalent bond
   4.1 Some Molecules Formed by the Sharing of Valence Electrons
   4.2 Different kind of covalent bonds
   4.3 Characteristic properties of covalent compounds
5. Versatile nature of carbon
6. Allotropic forms of carbon
   6.1 Diamond
   6.2 Graphite
   6.3 Fullerene
7. Classification of organic compounds
   7.1 Open chain compounds
   7.2 Closed chain or cyclic compounds
8. Hydrocarbon
   8.1 Saturated hydrocarbons
   8.2 Unsaturated hydrocarbons
9. Nomenclature of organic compounds
10. Homologous series
11. Isomerism
12. Chemical properties of carbon compounds
   12.1 Combustion reactions
   12.2 Oxidation reactions
   12.3 Substitution Reactions
   12.4 Addition reactions
13. Burning of substances with or without smoky flame
14. Catalysts and their use in reactions
15. Some important carbon compounds
   15.1 Ethanol
   15.2 Ethanoic acid
16. Soaps and detergents
   16.1 Soap
   16.2 Detergents

Solved Examples
NCERT Solutions
Exercise – I (Competitive Exam Pattern)
Exercise – II (Board Pattern Type)
Answer Key



INTRODUCTION

In this chapter we will learn about carbon, an element which is of immense significance to us in both its elemental form and in the combined form. The compounds obtained from 'Carbon' are widely used as clothes, medicines, books, food, fertilizer, fuel etc. All living structures are carbon based. Carbon is a non–metal with symbol 'C'. It has an electronic configuration 2, 4. It is the most versatile element known.

Carbon forms a large number of compounds with hydrogen which are known as hydrocarbons. In addition to hydrogen, carbon compounds may also contain some other elements such as oxygen, halogen, nitrogen, phosphorus, sulphur, etc.

The compounds like urea, sugars, fats, oils, dyes, proteins vitamins etc., which were isolated directly or indirectly from living organisms such as animals and plants were called organic compounds. The branch of chemistry which deals with the study of these compounds is called **ORGANIC CHEMISTRY.**

1. VITAL FORCE THEORY OR BERZELIUS HYPOTHESIS

According to Berzelius Hypothesis organic compounds were obtained straight from nature and there was no known method of preparing them in the laboratory. It was believed that they were the products of some "vital force" of nature. This theory in known as vital force theory.

2. WOHLER'S SYNTHESIS

The vital force theory of organic compounds was soon discarded when, in 1828, a German chemist named Friedrich Wohler showed that it was possible to obtain an organic compound urea, from the laboratory process.

He synthesized urea (a well known organic compound) in the laboratory by heating Ammonium sulphate and Potassium cyanate.

$$(NH_4)_2SO_4 + 2KCNO \xrightarrow{\text{Heat}} 2NH_4CNO + K_2SO_4$$

$$NH_4CNO \xrightarrow[\text{Rearrangement}]{\text{Heat}} \underset{\text{Urea}}{NH_2-\overset{\overset{O}{\|}}{C}-NH_2}$$



Focus Point

- Urea is the first organic compound synthesized in the laboratory.
- In 1845, Kolbe prepared acetic acid (CH_3COOH) from its constituent elements, carbon, hydrogen and oxygen.
- Berthelot, in 1856, synthesized methane gas (CH_4).

3. MODERN DEFINITION OF ORGANIC CHEMISTRY

Organic compounds may be defined as hydrocarbons and their derivatives and the branch of chemistry which deals with the study of hydrocarbons and their derivatives is called ORGANIC CHEMISTRY.

Organic chemistry is treated as a separate branch because of following reasons :

(i) Organic compounds are large in number.

(ii) Organic compounds generally contain covalent bond.

(iii) Organic compounds are soluble in non polar solvents.

(iv) Organic compounds have low melting and boiling points.
(v) Organic compounds show isomerism .
(vi) Organic compounds exhibit homology.

3.1 SOURCES OF ORGANIC COMPOUNDS

1. **Plants :** Compounds like sugar, starch and cellulose, as well as several drugs, are obtained from plants.
2. **Animals :** Urea, proteins, fats, etc., are obtained from animals.
3. **Coal :** Destructive distillation of coal produces benzene, toluene, naphthalene, dyes, drugs, perfumes, etc.
4. **Petroleum :** A large number of organic compounds, like gasoline, fuel gases, petrol, naphtha, etc., are obtained from petroleum.
5. **Fermentation :** compounds like ethyl alcohol and acetic acid are obtained by fermentation.
6. **Wood :** Methyl alcohol, acetone, etc., are obtained by destructivbe distillation of wood.
7. **Synthetic Methods :** Most organic compounds are synthesized in the laboratory.

4. BONDING IN CARBON- THE COVALENT BOND

Most carbon compounds are poor conductors of electricity. The boiling and melting points of the carbon compounds are low. Forces of attraction between these molecules of organic compounds are not very strong. As these compound are largely non conductors of electricity hence the bonding in these compound does not give rise to any ions. The reactivity of elements is explained as their tendency to attain a completely filled outer shell, that is, attain noble gas configuration. Element forming ionic compounds achieve this by either gaining or losing electrons from the outermost shell.
In the case of carbon, it has four electrons in its outermost shell and needs to gain or lose four electrons to attain noble gas configuration. If it were to gain or lose electrons -
(i) it could gain four electrons forming C^{4-} anion. But it would be difficult for the nucleus with six protons to hold onto ten electrons, that is, four extra electrons.
(ii) it could lose four electrons forming C^{4+} cation. But it would require a large amount of energy to remove four electrons leaving behind a carbon cation with six protons in its nucleus holding onto just two electrons.
Carbon overcomes this problem by sharing its valence electrons with other atoms of carbon or with atoms of other elements. The shared electrons belong to the outer shell of both the atoms and lead to both atoms attaining the noble gas configuration.
♦ **Covalent bond :** A chemical bond formed between two atoms by mutual sharing of valence electrons between two atoms so that each atom acquires the stable electronic configuration of the nearest noble gas is called a covalent bond.
The number of electrons shared by each atom is known as its covalency and the compound formed by sharing of electrons are called covalent compounds. Covalent bond is formed between non-metals.

4.1 SOME MOLECULES FORMED BY THE SHARING OF VALENCE ELECTRONS

(i) Hydrogen molecule : This is the simplest molecule formed by sharing of electrons. The atomic number of hydrogen is 1 and it has only one electron in its outermost K shell. It requires only one more electron to complete the K shell i.e., to achieve nearest noble gas He configuration. So, when two hydrogen atoms approach each other, the single electron of both the atoms form a shared pair.

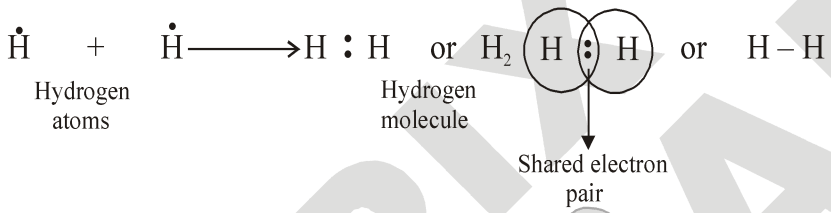
Hydrogen

Atomic number	1	Incomplete duplet (unstable)
Shell	K	
Electron	1	

Helium

Atomic number	2	Complete duplet (stable)
Shell	K	
Electron	2	

This may be represented as :



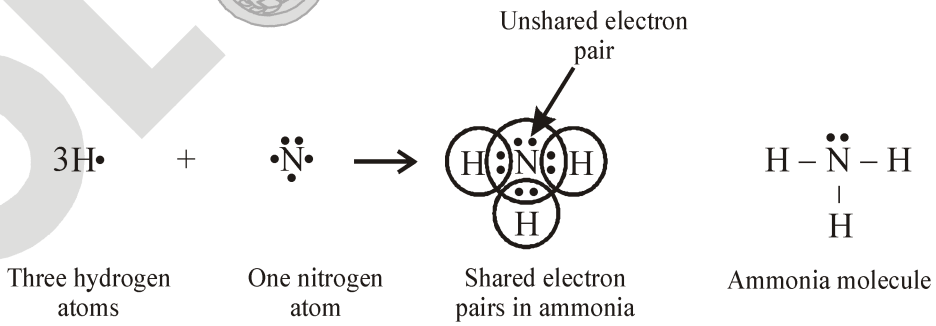
The shared pair of electron is said to constitute a single bond between the two hydrogen atoms and is represented by a line between the two atoms. Pictorially, the molecule can be represented by drawing two overlapping circles around the symbols of the atoms and showing the shared pair of electrons in the overlapping part.



Focus Point

According to Lewis notation, the electrons in the valence shell are represented by dots and crosses. This method was proposed by G.N. Lewis and is known as Lewis representation or Lewis structure.

(ii) Formation of ammonia molecule (NH_3) : The atomic number of N is 7. Its electronic configuration is 2, 5. There are 5 electrons in its valence shell. It needs 3 electrons more to complete its octet like noble gas, neon (2, 8).



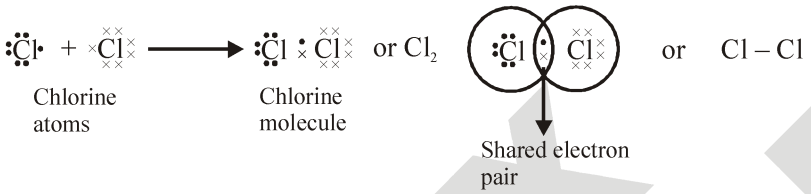
(iii) Formation of Chlorine molecule : Each chlorine atom has seven electrons in its outermost shell. When the two chlorine atoms come close together, an electron of both the atoms is shared between them to complete octet i.e., to achieve nearest noble gas configuration of argon.

Chlorine

Atomic number	17			Incomplete octet
Shell	K	L	M	
Electron	2	8	7	

Argon

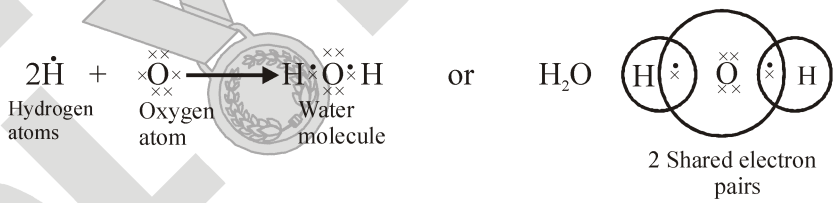
Atomic number	18			Complete octet
Shell	K	L	M	
Electron	2	8	8	



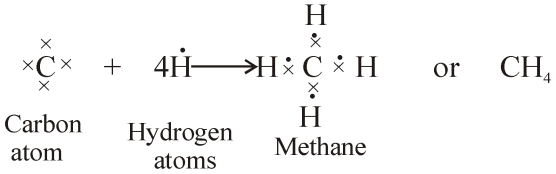
(iv) Formation of Hydrogen chloride molecule : It may be noted that a covalent bond is not only formed between two similar atoms, but it may be formed between dissimilar atoms also. For example, hydrogen and chlorine form a covalent bond between their atoms. In HCl, hydrogen atom (1) has only one electron in its valence shell and chlorine atom (2, 8, 7) has seven electrons in its valence shell. Therefore, by mutual sharing of electron pair between a hydrogen and a chlorine atom, both the atoms acquire nearest noble gas configuration.



(v) Formation of water molecule (H_2O) : Each hydrogen atom has only one electron in its outermost shell. Therefore, each hydrogen atom requires one more electron to achieve the stable configuration of helium (nearest noble gas). The oxygen atom has the electronic configuration 2, 6 and has six electrons in its outermost shell. It needs two electrons to complete its octet.
Therefore, one atom of oxygen shares one electron each with two hydrogen atoms.



(vi) Formation of methane molecule (CH_4) : Methane (CH_4) is a covalent compound containing covalent bonds. Carbon atom has atomic number 6. Its electronic configuration is 2, 4. It has four electrons in its valence shell and needs 4 more electrons to get the stable noble gas configuration. Each hydrogen atom has one electron and needs one more electron to get stable electronic configuration of nearest noble gas, helium. Therefore, one atom of carbon shares its four electrons with four atoms of hydrogen to form four covalent bonds.

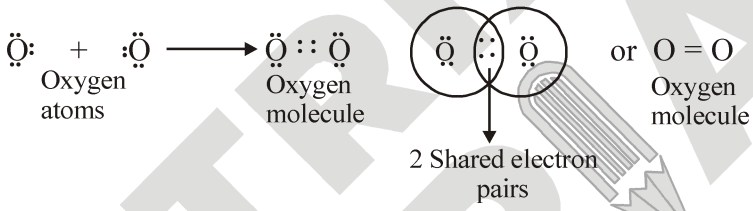


4.2 DIFFERENT KINDS OF COVALENT BONDS

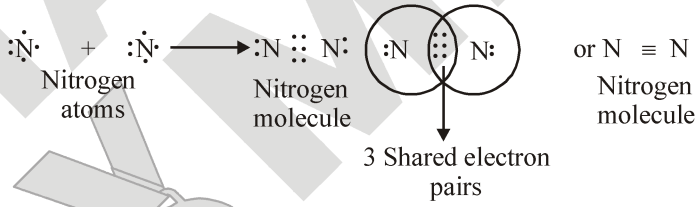
Electron pair shared between two atoms results in the formation of a covalent bond. This shared pair is also called bonding pair of electron.

- If two atoms share one electron pair, bond is known as single covalent bond and is represented by one dash (–).
- If two atoms share two electron pairs, bond is known as double covalent bond and is represented by two dashes (=).
- If two atoms share three electron pairs, bond is known as triple covalent bond and is represented by three dashes (≡).

(i) Formation of double bond (oxygen molecule) : Two oxygen atoms combine to form oxygen molecule by sharing two electron pairs. Each oxygen atom (2, 6) has six electrons in the valence shell. It requires two electrons to acquire nearest noble gas configuration. Therefore, both the atoms contribute two electrons each for sharing to form oxygen molecule. In the molecule, two electron pairs are shared and hence there is a double bond between the oxygen atoms.



(ii) Formation of triple bond (Nitrogen molecule) : Nitrogen atom has five electrons in its valence shell. In the formation of a nitrogen molecule each of the nitrogen atoms provide three electrons to form three electron pairs for sharing. Thus, a triple bond is formed between two nitrogen atoms.



4.3 CHARACTERISTIC PROPERTIES OF COVALENT COMPOUNDS

The important characteristic properties of covalent compounds are :

(i) Covalent compounds consists of molecules : The covalent compounds consists of molecules. They do not have ions. For example - water, hydrogen chloride, methane consists of H_2O, HCl, CH_4 molecules respectively.

(ii) Physical state : Weak Vanderwaal's forces are present between the molecules of covalent compounds. So, covalent compounds are in solid, gaseous or liquid state at normal temperature and pressure.

For example : Hydrogen chloride , methane are gases while carbon tetrachloride, ethyl alcohol, ether etc, are liquids. Glucose, sugar, urea etc, are some solid covalent compounds.

(iii) Crystal structure - Covalent compounds exhibit both crystalline and non crystalline structure.

(iv) Melting point and boiling point : Energy required to break the crystal is less due to the presence of weak Vanderwaal's force, so their melting and boiling points are less.

(v) Electrical conductivity - Covalent compounds are bad conductors of electricity due to the absence of free electrons or free ions.

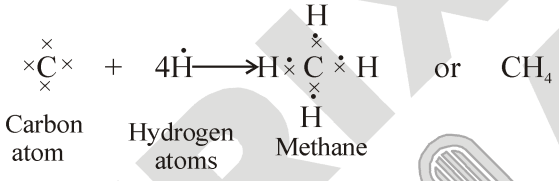
(vi) Solubility : Due to the non - polar nature of covalent compounds they are soluble in non - polar solvents like benzene, carbon tetrachloride etc, and insoluble in polar solvents like water etc.

5. VERSATILE NATURE OF CARBON

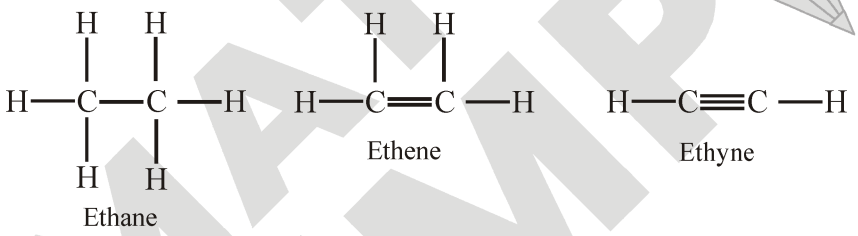
About 3 million organic compounds are known today. The main reasons for this huge number of organic compounds are -

(i) Catenation : The property of self linking of carbon atoms through covalent bonds to form long straight or branched chains and rings of different sizes is called catenation. Carbon shows maximum catenation in the periodic table due to its small size, electronic configuration and unique strength of carbon-carbon bonds.

(ii) Tetravalency of carbon : Carbon belongs to group 14 of the periodic table. Since the atomic number of carbon is 6, the electronic configuration of carbon atom is 2,4. It has four electrons in the outermost shell. Therefore, its valency is four. Thus, carbon forms four covalent bonds in its compounds. A methane molecule (CH_4) is formed when four electrons of carbon are shared with four hydrogen atoms as shown below.



(iii) Tendency to form multiple bonds : Due to small size of carbon it has a strong tendency to form multiple bonds (double & triple bonds) by sharing more than one electron pair.



6. ALLOTROPIC FORMS OF CARBON

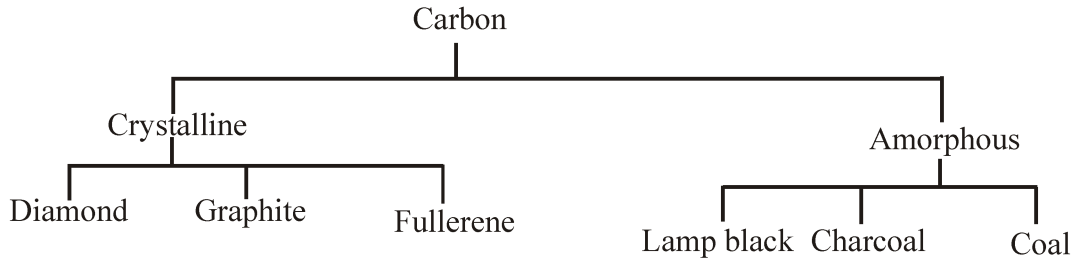
Allotropy is the property by virtue of which an element exists in more than one form and each form has different physical properties but identical chemical properties. These different forms are called allotropes.

Carbon exists in two different allotropic forms :

(i) Crystalline form.
Examples : diamond, graphite and fullerene.

(ii) Non - crystalline or Amorphous form.
Examples : coal, lampblack and charcoal.

Various allotropic forms of carbon



There are three crystalline allotropes of carbon. These are diamond, graphite and fullerene. Diamond and graphite are familiar allotropes of carbon but fullerene is a recently (1985) discovered allotrope of carbon. Each one of diamond, graphite and fullerene is composed of carbon atoms. But the C atoms are arranged in different ways in each allotrope of carbon. Therefore, the three allotropes of carbon have different crystal structures.

6.1 DIAMOND

Diamond is a beautiful crystalline allotrope of carbon. Its atomic symbol is C. The name 'diamond' has been taken from Greek words diaphanes (which means transparent) and adamas (which means indomitable or invincible) with reference to its extreme hardness.

(i) Structure of Diamond :

In a crystal of diamond, each carbon atom is bonded very strongly to four other carbon atoms in tetrahedron manner. The valency of each carbon atom is completely satisfied in diamond and there is no free electron. This arrangement of C-atoms makes diamond very hard, unreactive and bad conductor of electricity. The given figure depicts a portion of diamond.

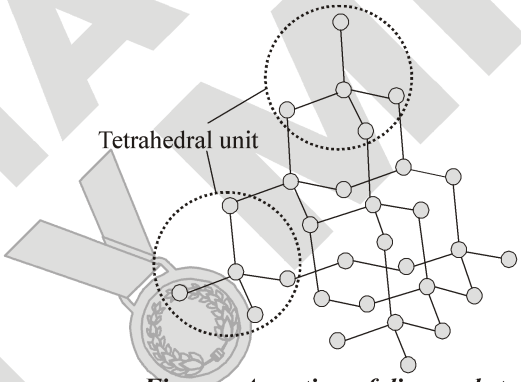


Figure : A portion of diamond structure

(ii) Properties of Diamond :

(A) Diamond is a transparent and colourless solid.

(B) Suitably cut and polished diamond sparkles brightly because it reflects most of the light (Refractive index of diamond is 2.45).

(C) The density of diamond is 3.51 g per cm^3 at 20°C.

(D) Diamond is the hardest natural substance known. Only a diamond can cut another diamond.

(E) It is a bad conductor of electricity.

(F) Diamonds are not attacked by acids, alkalis and solvents like water, ether, benzene or carbon tetrachloride. But diamond is attacked by fluorine when heated to 750°C. The reaction results in the formation of carbon tetrafluoride.

$$\underset{\text{Carbon}}{C(\text{diamond})} + \underset{\text{Fluorine}}{2F_2} \xrightarrow{750^{\circ}C} \underset{\substack{\text{Carbon}\\ \text{tetrafluoride}}}{CF_4}$$

(iii) Uses of Diamond :

(A) They are used in jewellery because of their ability to reflect and refract light.

(B) Diamonds are used in cutting glass and drilling rocks.

(C) Diamond has an extraordinary sensitivity to heat rays and due to this reason, it is used for making high precision thermometers.

(D) Diamond has the ability to cut out harmful radiations and due to this reason it is used for making protective windows for space probes.

(E) Diamond dies are used for drawing thin wires. Very thin tungsten wires of diameter less than one-sixth of the diameter of human hair have been drawn using diamond dies.

(F) Surgeons use diamond knives for performing delicate operations.

6.2 GRAPHITE

Graphite is an allotrope of carbon. Its atomic symbol is C. The name 'graphite' has been taken from the Greek word "graphein" (which means to write) in reference to its use as 'lead' in pencils.

(i) Structure of Graphite :

In a crystal of graphite, the carbon atoms are arranged in hexagonal patterns in parallel planes. In a layer of graphite, each carbon atom is strongly bonded to three carbon atoms by covalent bonds. Thus, one valence electron of each carbon atom is free in every layer of graphite crystal. The free electron makes graphite a good conductor of electricity. Any two adjacent layers in graphite are bonded by comparatively weak forces (shown by dotted lines) which makes graphite soft and slippery. The given figure represents a portion of graphite crystal.

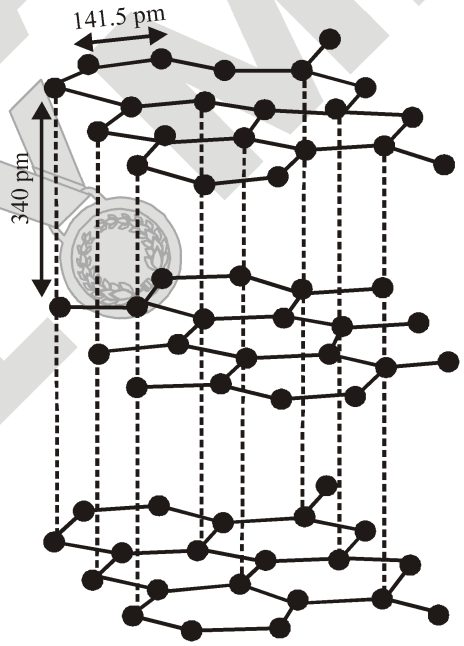


Figure : A portion of graphite crystal

(ii) Properties of Graphite

Graphite is an opaque and dark grey solid. It is soft and has a soapy touch. It leaves marks on paper. Graphite is not attacked by acid, alkali, water or alcohol. It has shine like metals (but graphite is a non-metal). Graphite melts at a very high temperature of 3730°C. The density of graphite is 2.26 g per cm^3 at 20°C. Graphite is a good conductor of electricity.

(iii) Uses of graphite :

(A) It is used for making pencil lead, printer's ink, black paint etc.
(B) It is used as dry lubricant for heavy machinery.
(C) It is used in making crucibles for melting substances.
(D) It is used as an electrode in batteries and electric furnaces.
(E) It is used in nuclear reactors as moderator to regulate nuclear reactions.
(F) It is also used in making artificial diamonds.

COMPARISON OF DIAMOND AND GRAPHITE

S.No.	Properties	Diamond	Graphite
1.	Appearance	Transparent and colourless when pure	Dark grey and opaque
2.	Crystal form	Tetrahedral giant structure	Hexagonal plates
3.	Hardness	Hardest natural substance known	Soft and slippery
4.	Impression	Does not mark paper	Leaves impression on paper
5.	Conductivity (a) Electrical (b) Thermal	 Bad conductor Good conductor	 Good conductor Good conductor
6.	Density	3.51 g per cm^3	2.26 g per cm^3
7.	Melting point	About 3550 °C	About 3730° C
8.	Combustion	Burns in air at above 900°C and gives CO_2	Burns in air about 700°C and gives CO_2

6.3 FULLERENE

Fullerenes represent the recently prepared allotropic form of carbon. These were formed for the first time by H.W. Kroto, Smalley and Robert Curt by the action of laser beam on a sample of graphite in the vapour state. They were awarded Noble prize for the same in 1996. Later on, these were prepared by heating graphite by striking an electric arc in the presence of inert gas such as helium or argon. Fullerenes have also been found to be present in the chimney where soot gets deposited and in candle flame.

Chemically, fullerenes are formed by the combination of a large number of carbon atoms (C_n). Most commonly known fullerene contains sixty carbon atoms (C_{60}) with smaller proportion of C_{70} allotrope and traces of compounds containing even upto 370 carbon atoms. C_{60} and C_{70} fullerenes have been isolated from the soot by extracting with toluene in which they dissolve to form purple and orange-red coloured compounds. From the extract, the individual fullerenes can be isolated with the help of adsorption chromatography carried on the surface of alumina (Al_2O_3).

Out of the different fullerenes that are known, only the structure of C_{60} has been established. This is often called Buckminster Fullerene after the architect Buckminster Fuller, the inventor of the Geodesic dome, which resembles the molecular structure of C_{60}. Its shape resembles that of a soccer ball with six membered as well as five membered rings as shown in the figure. There are twelve five membered and twenty six membered rings. These are often called Bucky Balls. Fullerenes represent the purest allotropic form of carbon since they do not have any free valencies or surface bonds to attract other atoms. However, such free valencies are present on the surface of diamond and graphite and these are therefore, not as pure as fullerenes.

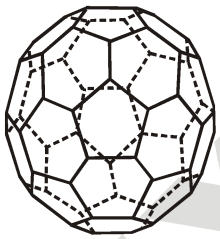


Figure : Shape of C_{60} Fullerence

(i) Formula of fullerene

The formula of popular form of fullerene is C_{60}. That is, a molecule of fullerene is composed of 60 carbon atoms.

(ii) Uses of Fullerene

(A) Fullerenes in pure state act as insulators but can be converted to semiconductors and super conductors under suitable conditions.

(B) Buckyball's ability of fullerenes to trap different atoms or molecules makes them useful in the medical field. For example, radioactive C_{60} can be used in cancer as well as AIDS therapy.

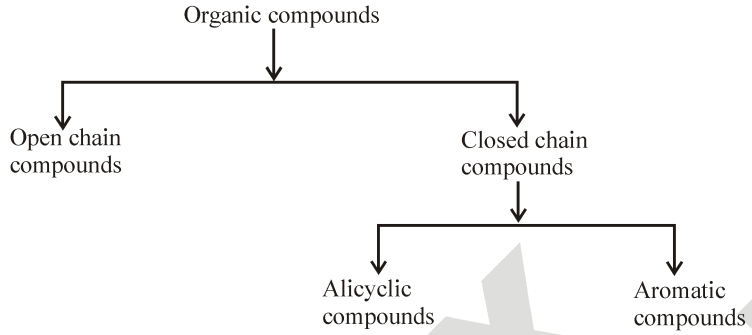
(C) Fullerenes help in improving antiwear and antifriction properties of lubricating oils.

COMPARISON OF GRAPHITE AND FULLERENE

	Graphite	Fullerene
1.	Graphite has extends crystal structure in which C- atoms are bonded in hexagonal layers. These layers are held by weak vander waal forces.	Fullerene is a spherical molecule like a cage in which the C atoms are arranged in mixed hexagons and pentagons. In solid state these molecules are attached to each other by weak vander waal forces.
2.	Graphite is good conductor of electricity.	Crystalline fullerene has semiconducting properties. Compounds of fullerene with alkali metals are called fullerides and they are superconductors.
3.	An impression can be created on paper by graphite.	Fullerene doesn't leave any impression on paper.

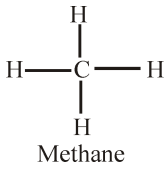
7. CLASSIFICATION OF ORGANIC COMPOUNDS

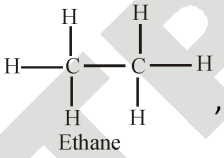
The organic compounds are very large in number on account of the self -linking property of carbon called catenation. These compounds have been further classified as open chain and cyclic compounds.

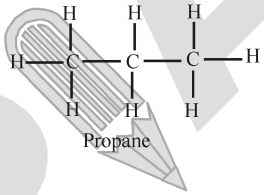


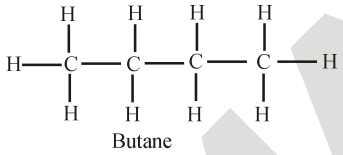
7.1 OPEN CHAIN COMPOUNDS

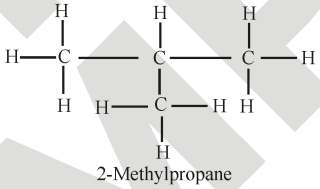
These compounds contain an open chain of carbon atoms which may be either straight chain or branched chain in nature. For example,


Methane


Ethane ,


Propane


Butane

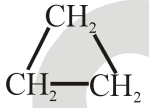

2-Methylpropane

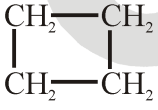
7.2 CLOSED CHAIN OR CYCLIC COMPOUNDS

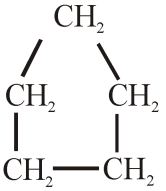
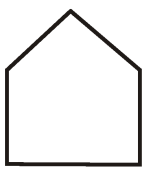
Apart from the open chains, the organic compounds can have cyclic or ring structures. A minimum of three atoms are needed to form a ring. These compounds have been further classified into following types.

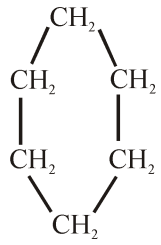
(i) Alicyclic compounds : Those carbocyclic compounds which resemble to aliphatic compounds in their properties are called alicyclic compounds.

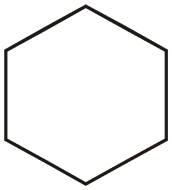
e.g.

(a)  or  Cyclopropane

(b)  or  Cyclobutane

(c)  or  Cyclopentane

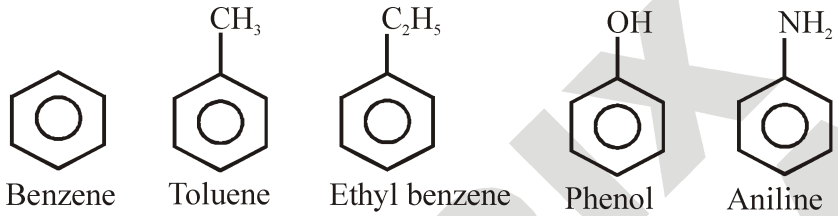
(d) 



Cyclohexane

(ii) Aromatic compounds : Organic compounds which contain one or more fused or isolated benzene rings are called aromatic compounds.

e.g



Note : Benzene is the parent compound of majority of aromatic organic compounds.

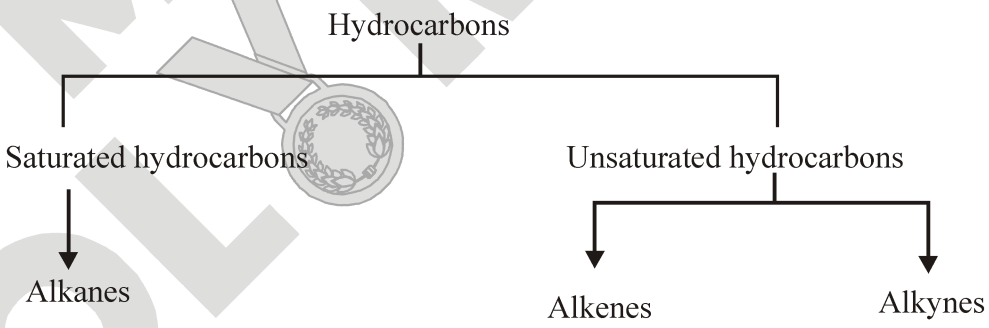
8. HYDROCARBON

The organic compounds containing only carbon and hydrogen are called hydrocarbons. These are the simplest organic compounds and are regarded as parent organic compounds. All other compounds are considered to be derived from them by the replacement of one or more hydrogen atoms by other atoms or groups of atoms.

The major source of hydrocarbons is petroleum.

♦Types of Hydrocarbons :

The hydrocarbons can be classified as :



8.1 SATURATED HYDROCARBONS

(A) Alkanes : Alkanes are saturated hydrocarbons containing only carbon - carbon and carbon - hydrogen single covalent bonds.

General formula- C_nH_{2n+2} (n is the number of carbon atoms)

e.g. CH_4 (Methane)

C_2H_6 (Ethane)

8.2 UNSATURATED HYDROCARBONS

(A) Alkenes : These are unsaturated hydrocarbons which contain carbon - carbon double bond. They contain two hydrogen less than the corresponding alkanes.

General formula - C_nH_{2n}

e.g. C_2H_4 (Ethene)

C_3H_6 (Propene)

(B) Alkynes : They are also unsaturated hydrocarbons which contain carbon-carbon triple bond. They contain four hydrogen atoms less than the corresponding alkanes.

General formula - C_nH_{2n-2}

e.g. C_2H_2 (Ethyne)

C_3H_4 (Propyne)



Focus Point

- Alkanes are relatively unreactive under ordinary conditions and so, they are also known as paraf fins (*paraum*-little, *affinis*-affinity).
- Alkenes are also called olefins (oil-forming) because the lower members of alkenes form oily products when they are treated with chlorine or bromine.

♦ **Basic rule to identify Alkane, Alkene and Alkyne :**

- If the number of hydrogen atoms is "2 more" than double the number of carbon atoms, then it will be an alkane.
- If the number of hydrogen atoms is "exactly equal" to double the number of carbon atoms, then it will be an alkene.
- If the number of hydrogen atoms is "2 less" than double the number of carbon atoms, then it will be an alkyne.

9. NOMENCLATURE OF ORGANIC COMPOUNDS

Nomenclature means the assignment of names to organic compounds. There are two main systems of nomenclature of organic compounds -

- Trivial system
- IUPAC system (International Union of Pure and Applied Chemistry)

♦ **Trivial and Derived naming of organic compounds**

- **Trivial naming**

In the early days. the name of a compound depended on the source from which it was obtained.

For example, CH_4 was named marsh gas since it was obtained from marshy places. Acetic acid (Latin : acetum = vinegar) was obained from vinegar, methyl alcohol (methus = spirit, hule = wood) was obtained from wood, and citric acid from the botanical source citrus, Such names are called common names or trivial names.

• **Derived naming**

(a) $H-\overset{\overset{O}{\|}}{C}-$ **Form group**

e.g : HCHO (formaldehyde), HCOOH (formic acid), HCOCl (Formyl chloride), $HCONH_2$ (formamide).

(b) $CH_3-\overset{\overset{O}{\|}}{C}-$**Acet group**

e.g : CH_3CHO (Acetaldehyde), CH_3COOH (Acetic acid), CH_3COCl (Acetyl chloride), CH_3CONH_2 (Acetamide).

♦ **IUPAC naming**

The official names or systematic names of organic compounds were given by International Union of Pure and Applied Chemistry in 1958, so they are called IUPAC names or IUPAC nomenclature. We will now discuss the IUPAC nomenclature for organic compounds

♦ **Basic rules of IUPAC nomenclature of organic compounds :**

For naming simple aliphatic compounds, the normal saturated hydrocarbons have been considered as the parent compounds and the other compounds as their derivatives obtained by the replacement of one or more hydrogen
atoms with various functional groups.

Each systematic name has the following parts :

(i) Prefix : Prefix is a part of the IUPAC name which appears in the beginning. It denotes the substituent group if present in the organic compound.

(ii) Word root : The basic unit is a series of word root which indicate the number of carbon atoms present in parent chain.

(iii) Primary suffix : Primary suffixes are added to the word root to show saturation or unsaturation in a carbon chain.

(iv) Secondary suffix : Suffixes added after the primary suffix to indicate the presence of a particular functional group in the carbon chain are known as secondary suffixes.

Prefix + word root + primary suffix + secondary suffix

(A) Names of straight chain hydrocarbons : The name of straight chain hydrocarbon may be divided into two parts-

(a) Word root

(b) Primary suffix

(a) Word roots for carbon chain lengths :

Chain length	Word root	Chain length	Word root
C_1	Meth-	C_6	Hex-
C_2	Eth-	C_7	Hept-
C_3	Prop-	C_8	Oct-
C_4	But-	C_9	Non-
C_5	Pent-	C_{10}	Dec-

(b) Primary suffix :

Class of compounds	Primary suffix	General name
$\rangle C - C \langle$ saturated	– ane	Alkane
$\rangle C = C \langle$ Unsaturated	– ene	Alkene
$-C \equiv C-$ Unsaturated	– y ne	Alkyne

Examples :

Molecular formula	Word root	Primary suffix	IUPAC Name
CH_4	Meth-	–ane	Methane
$CH_3–CH_3$	Eth -	– ane	Ethane
$CH_3CH_2CH_3$	Prop-	– ane	Propane
$CH_3CH_2CH_2CH_3$	But-	– ane	Butane
$CH_3 – CH = CH_2$	Prop-	– ene	Propene
$CH_3 – C \equiv CH$	Prop -	– yne	Propyne



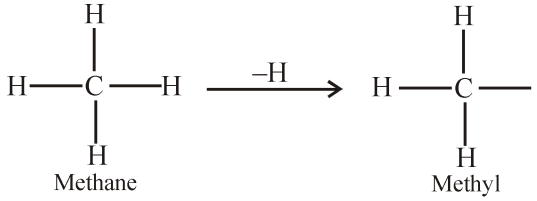
Focus Point

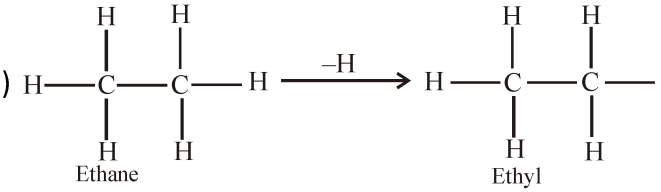
- Ethane, C_2H_6, is an alkane containing a single bond between two carbon atoms. So, it should be written as $H_3C–CH_3$. This formula shows that the single bond is between the two carbon atoms. For the sake of convenience in writing, however, we usually represent ethane as $CH_3–CH_3$ (and not as $H_3C–CH_3$). Both are just the same.
- Though the more correct formula of ethene is $H_2C = CH_2$, but for the sake of convenience in writing on paper, we usually put it as $CH_2 = CH_2$.
- Again, though we should write ethyne as $HC \equiv CH$, but for the sake of convenience we write it as $CH \equiv CH$.

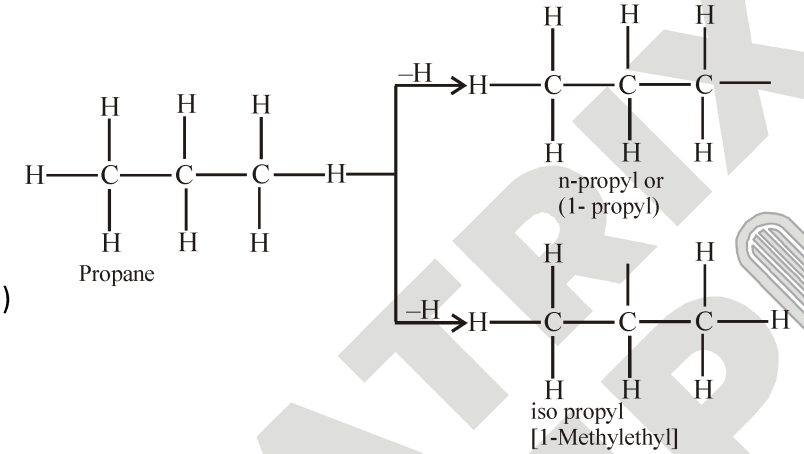
(B) Names of branched chain hydrocarbon : The carbon atoms in branched chain hydrocarbons are present as side chain . These side chain carbon atoms constitute the alkyl group or alkyl radicals. An alkyl group is obtained from an alkane by removal of a hydrogen.

General formula of alkyl group = $-C_nH_{2n+1}$

An alkyl group is represented by R.

(i) 

(ii) 

(iii) 

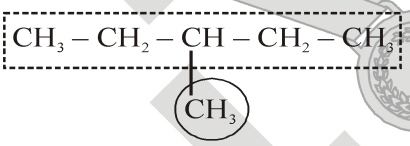
A branched chain hydrocarbon is named using the following general IUPAC rules :

Rule1: Longest chain rule : Select the longest possible continuous chain of carbon atoms. If some multiple bond is present, the chain selected must contain the multiple bond.

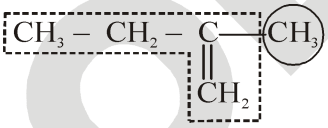
(i) The number of carbon atoms in the selected chain determines the word root .

(ii) Saturation or unsaturation determines the primary suffix.

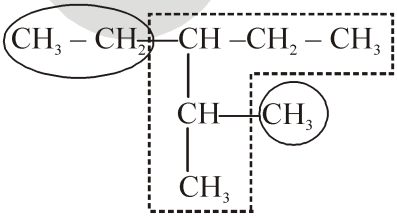
(iii) Alkyl substituents are indicated by prefixes.

e.g. 

Prefix : Methyl
Word root : pent-
P. Suffix: - ane

e.g. 

Prefix : Methyl
Word root : But-
P. Suffix : –ene

e.g. 

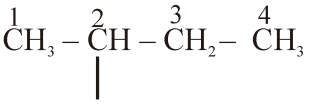
Prefixes : Ethyl, Methyl
Word root : Pent-
P. Suffix : -ane

Rule 2 : Lowest number rule: The chain selected is numbered in terms of arabic numerals and the position of the alkyl groups are indicated by the number of the carbon atom to which alkyl group is attached.

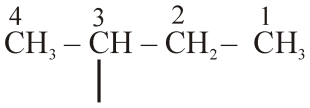
(i) The numbering is done in such a way that the substituent carbon atom has the lowest possible number.

(ii) If some multiple bond is present in the chain, the carbon atoms involved in the multiple bond should get lowest possible numbers

e.g.

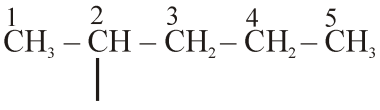


2-methylbutane
(Correct)

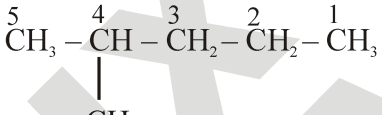


3-methylbutane
(Wrong)

e.g.

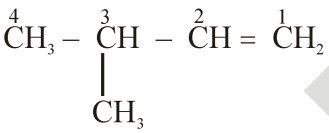


2-methylpentane
(Correct)

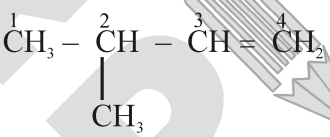


4-methylpentane
(Wrong)

e.g.

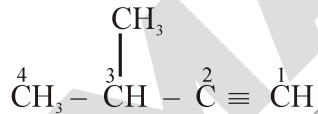


3-methylbut-1-ene
(Correct)

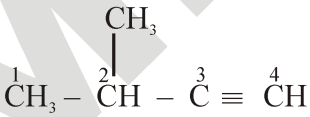


2-methylbut-3-ene
(Wrong)

e.g.



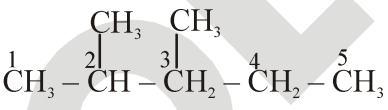
3-methylbut-1-yne
(Correct)



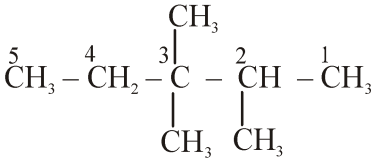
2-methylbut-2-yne
(Wrong)

Rule 3 : Use of prefixes di, tri etc. : If the compound contains more than one similar alkyl groups, their positions are indicated separately and an appropriate numerical prefix di, tri etc. , is attached to the name of the substituents. The positions of the substituents are separated by commas.

e.g.

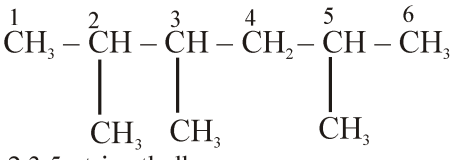


2,3- dimethylpentane

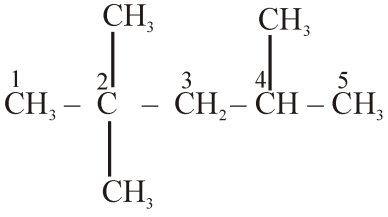


2,3 - trimethypentane

e.g.



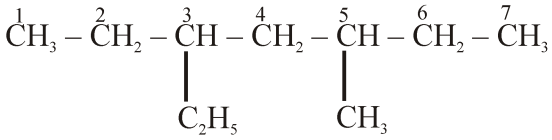
2,3,5 - trimethylhexane



2,2,4 - trimethylpentane

Rule 4 : Alphabetical arrangement of prefixes: If there are different alkyl substituents present in the compound
their names are written in the alphabetical order. However, the numerical prefixes such as di, tri etc., are not considered for the alphabetical order.

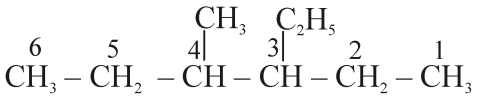
e.g.



3-ethyl -5- methylheptane

Rule 5 : Naming of different alkyl substituents at the equivalent positions :
Numbering of the chain is done in such a way that the alkyl group which comes first in alphabetical order gets the lower position.

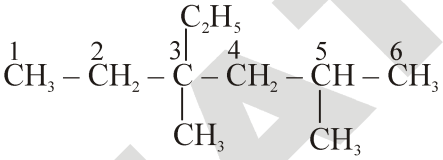
e.g.



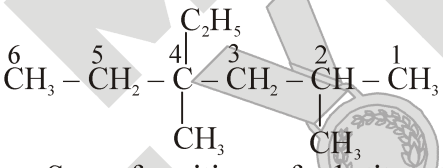
3-ethyl -4-methylhexane

Rule - 6 : Lowest sum rule
According to this rule numbering of chain is done in such a way that the sum of positions of different substituents gets lower value.

e.g.



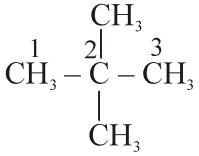
Sum of positions of substituents
= 3 + 3 + 5 = 11 (Wrong)



Sum of positions of substituents
= 2 + 4 + 4 = 10 (Correct)

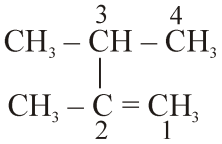
Word root : Hex -
Primary suffix : - ane
Substituent : two methyl & one ethyl groups
IUPAC name : 4-Ethyl - 2, 4 - dimethylhexane
Some other example :

(i)



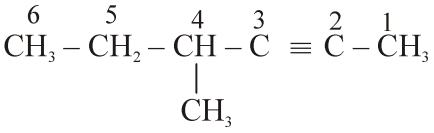
Word root : Prop -
P. Suffix : -ane
Substituent : two methyl groups
IUPAC name : 2, 2 - Dimethylpropane

(ii)



Word root : But -
P. Suffix : - ene
Substituent : two methyl groups
IUPAC name : 2, 3 - Dimethylbut - 1 - ene

(iii)



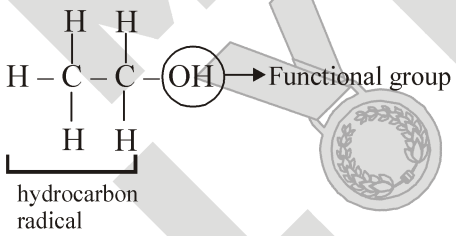
Word root : Hex -
P. Suffix : - yne
Substituent : one methyl group
IUPAC name : 4 - Methylhex - 2 - yne

♦FUNCTIONAL GROUP

An atom or group of atoms in an organic compound or molecule that is responsible for the compounds characteristic reactions and determines its properties is known as **functional group.** An organic compound generally consists of two parts -

(i) Hydrocarbon radical (ii) Functional group

e.g.



- Functional group is the most reactive part of the molecule.
- Functional group mainly determines the chemical properties of an organic compound.
- Hydrocarbon radical mainly determines the physical properties of the organic compound.



Focus Point

- In an organic compound the alkyl group determines mainly the physical properties. Whereas the functional group is responsible for the chemical properties or reactivity of the compounds.

- **Main Functional Groups :**

(i) Hydroxyl group (- OH) : All organic compounds containing – OH group are known as alcohols .
e.g. Methanol (CH_3OH) , Ethanol ($CH_3 – CH_2 – OH$) etc .
(ii) Aldehyde group (– CHO) : All organic compounds containing – CHO group are known as aldehydes.
e.g. Methanal (HCHO), Ethanal (CH_3CHO) etc.
(iii) Ketone group (– CO –) : All organic compounds containing -CO- group are known as ketones.
e.g. Propanone (CH_3COCH_3), Butanone ($CH_3COCH_2CH_3$) etc.
(iv) Carboxyl group (–COOH) : All organic compounds containing carboxyl group are called carboxylic acids.
e.g. CH_3COOH (Ethanoic acid)
CH_3CH_2COOH (Propanoic acid)
(v) Halogen group (X = F, Cl, Br, I) : All organic compounds containing -X (F, Cl, Br or I) group are known as halides.
e.g. Chloromethane (CH_3Cl), Bromomethane (CH_3Br) etc .

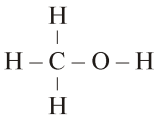
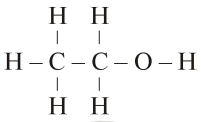
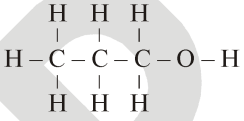
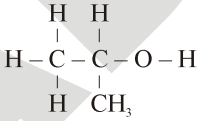
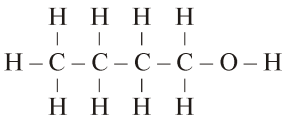
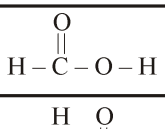
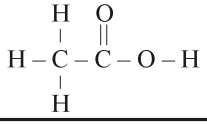
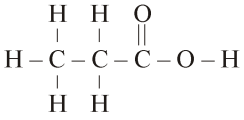
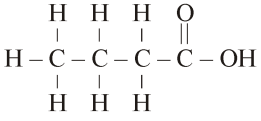
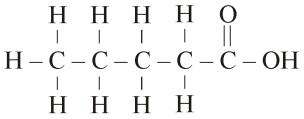
(C) Nomenclature of Compounds Containing only one Functional Group :

In case functional group (other than C = C and C ≡ C) is present, it is indicated by adding secondary suffix after the primary suffix. The terminal 'e' of the primary suffix is removed if it is followed by a suffix beginning with 'a', 'e', 'i', 'o', 'u'. Some groups like -F, – Cl, – Br and – I are considered as substituents and are indicated by the prefixes.

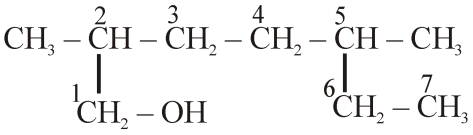
Some groups like $-CHO, -\overset{\overset{O}{\|}}{C}-, -COOH$, and – OH are considered as functional groups and are indicated by suffixes.

Class	Functional Group	General Formula	Preflx	Suffix	IUPAC Name
Carboxylic acid	$-\overset{\overset{O}{\|}}{C}-OH$	$R-\overset{\overset{O}{\|}}{C}-OH$ $(R = C_nH_{2n+1})$	Carboxy	– oic acid	Alkanoic acid
Ester	$-\overset{\overset{O}{\|}}{C}-OR$	$R-\overset{\overset{O}{\|}}{C}-O-R'$	Carbalkoxy	alkyl (R') – oate	Alkyl alkanoate
Aldehyde	– CHO	R – CHO	Formyl or oxo	–al	Alkanal
	$-\overset{\overset{O}{\|}}{C}-$	$R-\overset{\overset{O}{\|}}{C}-R$	oxo	– one	Alkanone
Alcohol	OH	R – OH	Hydroxy	– ol	Alkanol
Alkenes	C = C	C_nH_{2n}	–	– ene	Alkene
Alkynes	C ≡C	C_nH_{2n-2}	–	– yne	Alkyne
Halides	– x (X = F, Cl, Br,l)	R – X	Halo	–	Haloalkane

Steps of naming of an organic compound containing functional group :

S.No.	Compound	Common name	Derived name	IUPAC Name	Structure
1.	$CH_3 - OH$	Methyl alcohol or wood spirit	Carbinol	Methanol	
2.	$CH_3 - CH_2 - OH$	Ethyl alcohol	Methyl carbinol	Ethanol	
3.	$CH_3 - CH_2 - CH_2 - OH$	n–Propyl alcohol	Ethyl carbinol	1–Propanol	
4.	$CH_3 - CH(CH_3) - OH$	Isopropyl alcohol	Dimethyl carbinol	2–Propanol	
5.	$CH_3 - CH_2 - CH_2 - CH_2 - OH$	n–Butyl alcohol	n–Proply carbinol	1–Butanol	
6.	HCOOH	Formic acid	–	Methanoic acid	
7.	CH_3COOH	Acetic acid	–	Ethanoic acid	
8.	$CH_3 - CH_2 - COOH$	Propionic acid	Methyl acetic acid	Propanoic acid	
9.	$CH_3 - CH_2 - CH_2 - COOH$	Butyric acid	Ethyl acetic acid	Butanoic acid	
10.	$CH_3 - CH_2 - CH_2 - CH_2 - COOH$	Valeric acid	n–propyl acetic acid	Pentanoic acid	

Some more examples :

(i) 

Word root : Hept-
Primary suffix : - ane
Functional group : - OH
Secondary suffix : - ol
IUPAC Name : 2, 5-dimethylheptan-1- ol

(ii) $\overset{5}{CH_3} - \overset{4}{CH_2} - \overset{3}{CH} = \overset{2}{CH} - \overset{1}{\overset{\|}{C}}\overset{O}{} - OH$

Word root : Pent -
Primary suffix : - ene
Secondary suffix : - oic acid
Position of double bond : 2nd position
IUPAC name : Pent-2-en-1-oic acid/Pent-2-enoic acid

(iii) $CH_3 - CH_2 - CH_2 - NH_2$

Word root : Prop -
Primary suffix : - ane
Secondary suffix : - amine
IUPAC name : Propan - 1 - amine

10. HOMOLOGOUS SERIES

Homologous series may be defined as a series of similarly constituted compounds in which the members possess similar chemical characteristics and the two consecutive members differ in their molecular formula by $–CH_2$.

(A) Characteristics of Homologous Series :

(i) All the members of a series can be represented by the same general formula.
e.g. General formula for alkane series is C_nH_{2n+2}.
(ii) Any two consecutive members differ in their formula by a common difference of $– CH_2$ and differ in molecular mass by 14.
(iii) Different members in a series have a common functional group.
e.g. All the members of alcohol family have –OH group .
(iv) The members in any particular family have almost identical chemical properties. Their physical properties such as melting point, boiling point, density etc, show a regular gradation with the increase in the molecular mass.
(v) The members of a particular series can be prepared almost by the identical methods.

(B) Homologues :

The different members of a homologous series are known as homologues.
e.g.

(i) Homologous series of alkanes

General formula : C_nH_{2n+2}

Value of n	Molecular formula	IUPAC name
n = 1	CH_4	Methane
n = 2	C_2H_6	Ethane
n = 3	C_3H_8	Propane

(ii) Homologous series of alkenes

General formula : C_nH_{2n}

Value of n	Molecular formula	IUPAC name	Common name
n = 2	C_2H_4	Ethene	Ethylene
n = 3	C_3H_6	Propene	Propylene
n = 4	C_4H_8	But-1-ene	α- Butylene

(iii) Homologous series of alkynes

General formula : C_nH_{2n-2}

Value of n	Molecular formula	IUPAC name	Common name
n = 2	C_2H_2	Ethyne	Acetylene
n = 3	C_3H_4	Propyne	Methyl acetylene
n = 4	C_4H_6	But -1-yne	Ethyl acetylene

(iv) Homologous series of alcohol

General formula : $C_nH_{2n+2}O$

Value of n	Molecular formula	IUPAC name	Common name
n = 1	CH_3OH	Methanol	Methyl alcohol
n = 2	C_2H_5OH	Ethanol	Ethyl alcohol

(v) Homologous series of carboxylic acid

General formula : $C_nH_{2n}O_2$

Value of n	Molecular formula	IUPAC name	Common name
n = 1	HCOOH	Methanoic acid	Formic acid
n = 2	CH_3COOH	Ethanoic acid	Acetic acid

(vi) Homologous series of aldehyde

General formula : $C_nH_{2n}O$

Value of n	Molecular formula	IUPAC name	Common name
n = 1	HCHO	Methanal	Formaldehyde
n = 2	CH_3CHO	Ethanal	Acetaldehyde

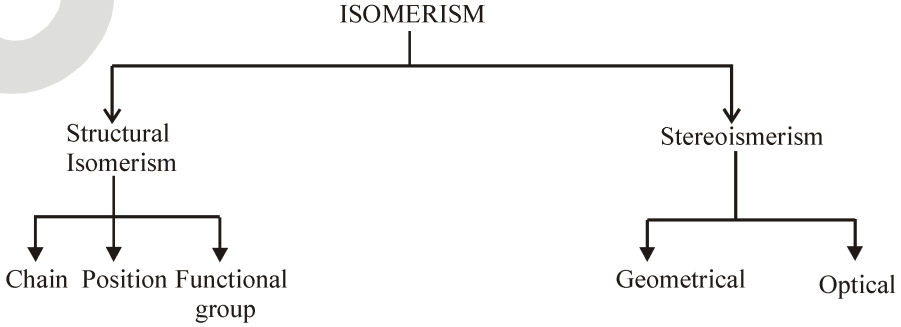
(vii) Homologous series of ketone

General formula : $C_nH_{2n}O$

Value of n	Molecular formula	IUPAC name	Common name
n = 3	C_3H_6O	Propanone	Acetone
n = 4	C_4H_8O	Butanone	Methyl ethyl ketone

11. ISOMERISM

Such compounds which have same molecular formula but different physical and chemical properties are known as isomers and the phenomenon is known as isomerism.



(A) Chain Isomerism :

The isomerism in which the isomers differ from each other due to the presence of different carbon chain skeletons is known as chain isomerism.

e.g.

(i) C_4H_{10}

$CH_3 - CH_2 - CH_2 - CH_3$.
n - Butane

$CH_3 - CH(CH_3) - CH_3$
2 -methypropane
(Isobutane)

(ii) C_5H_{12}

$CH_3 - CH_2 - CH_2 - CH_2 - CH_3$
n - Pentane

$CH_3 - CH(CH_3) - CH_2 - CH_3$
2 - methylbutane (Isopentane)

$CH_3 - C(CH_3)_2 - CH_3$
2, 2- dimethylpropane
(neo pentane)

(iii) C_4H_8

$CH_3 - CH_2 - CH = CH_2$.
But-1- ene

$CH_3 - C(CH_3) = CH_2$
2- methylpropene

(B) Position Isomerism :

In this type of isomerism, isomers differ in the structure due to difference in the position of the multiple bond or functional group.

e.g.

(i) C_4H_8

$CH_3 - CH_2 - CH = CH_2$,
But-1-ene

$CH_3 - CH = CH - CH_3$
But-2-ene

(ii) C_3H_8O

$CH_3 - CH_2 - CH_2 - OH$,
Propan -1-ol

$CH_3 - CH(OH) - CH_3$
Propan -2-ol

(C) Functional Group Isomerism :

In this type of isomerism, isomers differ in the structure due to the presence of different functional groups.

e.g.

(i) C_3H_8O

$CH_3 - CH_2 - CH_2 - OH$
Propan-1-ol

$CH_3 - CH_2 - O - CH_3$
Methoxyethane

(ii) C_3H_6O

$CH_3 - CH_2 - CHO$ $\qquad$ $CH_3 - \underset{\underset{O}{\|}}{C} - CH_3$

Propanal $\qquad$ Propanone

12. CHEMICAL PROPERTIES OF CARBON COMPOUNDS

The important chemical properties of organic compounds are discussed below :

12.1 COMBUSTION REACTIONS

Carbon in all its allotropic forms burns in air or oxygen to give carbon dioxide and releases energy in the form of heat and light.

Most carbon compound also release a large amount of heat and light on burning.

$$\underset{\text{Carbon}}{C} + \underset{\text{Oxygen}}{O_2} \longrightarrow \underset{\text{Carbon dioxide}}{CO_2} + \text{Heat and light}$$

$$\underset{\text{Methane}}{CH_4} + 2O_2 \longrightarrow \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{2H_2O} + \text{Heat and light}$$

$$\underset{\text{Ethene}}{C_2H_4} + \underset{\text{Oxygen}}{3O_2} \longrightarrow \underset{\text{Carbon dioxide}}{2CO_2} + \underset{\text{Water}}{2H_2O} + \text{Heat and light}$$

$$\underset{\text{Ethanol}}{CH_3CH_2OH} + \underset{\text{Oxygen}}{3O_2} \longrightarrow \underset{\text{Carbon dioxide}}{2CO_2} + \underset{\text{Water}}{3H_2O} + \text{Heat and light}$$

Saturated hydrocarbons will generally give a clean flame while unsaturated carbon compounds will give a yellow flame with lots of black smoke. This results in a sooty deposit on the surface. However, limiting the supply of air results in incomplete combustion of even saturated hydrocarbons giving a sooty flame.

12.2 OXIDATION REACTIONS

Oxidation is a process in which oxygen is added to a substance. The substances which add oxygen to other substances are called oxidising agents. There are many oxidising agents such as alkaline potassium permanganate (alk. $KMnO_4$), acidified potassium dichromate ($K_2Cr_2O_7$), nitric acid (HNO_3) etc. which are commonly used in organic chemistry. Some common reactions of oxidation are-

(i) $CH_2 = CH_2 + H_2O + (O) \xrightarrow{\text{Alkaline } KMnO_4} \underset{\underset{\text{Ethylene glycol}}{\underset{OH\quad OH}{|\quad\quad|}}}{CH_2 - CH_2}$

(ii) $\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[\text{Acidified } K_2Cr_2O_7]{\text{Alkaline } KMnO_4 \text{ Or}} \underset{\text{Ethanoic acid}}{CH_3COOH}$

(iii) $\underset{\text{Ethanal}}{CH_3CHO} \xrightarrow[\text{Acidified } K_2Cr_2O_7]{\text{Alkaline } KMnO_4 \text{ Or}} \underset{\text{Ethanoic acid}}{CH_3COOH}$

12.3 SUBSTITUTION REACTIONS

The reaction in which an atom or group of atoms in a molecule is replaced or substituted by different atoms or group of atoms are called substitution reactions. Saturated hydrocarbons are fairly unreactive. For example, chlorine does not react with methane at room temperature. However, in the presence of sunlight the reaction of chlorine and hydrocarbons is fairly fast. It gives a variety of products.
In this reaction H- atom of methane has replaced by a –Cl atom converting CH_4 to CH_3Cl.

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Chlorine}}{Cl_2} \xrightarrow[\text{Sunlight}]{\text{Diffused}} \underset{\text{Chloromethane}}{CH_3Cl} + \underset{\text{Hydrogen chloride}}{HCl}$$

However, if Cl_2 is used in excess, all the hydrogen atoms are replaced by chlorine atom one by one.

$$\underset{\text{Chloromethane}}{CH_3Cl} + \underset{\text{Chlorine}}{Cl_2} \xrightarrow[\text{Sunlight}]{\text{Diffused}} \underset{\text{Dichloromethane}}{CH_2Cl_2} + \underset{\text{Hydrogen chloride}}{HCl}$$

$$\underset{\text{Dichloromethane}}{CH_2Cl_2} + \underset{\text{Chlorine}}{Cl_2} \xrightarrow[\text{Sunlight}]{\text{Diffused}} \underset{\text{Trichloromethane (Chloroform)}}{CHCl_3} + \underset{\text{Hydrogen chloride}}{HCl}$$

$$\underset{\text{Trichloromethane}}{CHCl_3} + \underset{\text{Chlorine}}{Cl_2} \xrightarrow[\text{Sunlight}]{\text{Diffused}} \underset{\text{Tetrachloromethane (Carbon tetrachloide)}}{CCl_4} + \underset{\text{Hydrogen chloride}}{HCl}$$



Focus Point

- All alkanes react with chlorine bromine and iodine in a similar manner, producing the corresponding substitued products.

12.4 ADDITION REACTIONS

The reactions in which a reactant molecule is added to another reactant molecule to form a product are known as addition reactions. Unsaturated hydrocarbons, such as alkenes and alkynes undergo addition reactions. For example, unsaturated hydrocarbons add hydrogen, in the presence of catalysts, such as nickel or palladium, to give saturated hydrocarbCons as given below :
This process of addition of hydrogen across double or triple bond is known as hydrogenation and is very useful in daily life. This process is especially useful for the preparation of vanaspati ghee from vegetable oils, in presence of nickel as discussed below :

♦Hydrogenation of oils :

Certain vegetable oils such as groundnut oil, cotton seed oil and mustard oil, contain double bonds (C = C) and are liquids at room temperature. Because of the presence of double bonds, the vegetable oils undergo hydrogenation, like alkenes, to form saturated products called vanaspati ghee, which is a solid or a semi-solid at the room temperature.

Vegetable oils (Unsaturated and in liquid state) + Hydrogen $\xrightarrow[473K]{\text{Nickel catalyst}}$ Vanaspati ghee (Saturated and in solid state)

You must have seen advertisements stating that some of the vegetable oils are 'healthy'. But it is worth mentioning that animal fats, such as 'Ghee' and butter contain saturated fatty acids which are not considered good for healthy
and even doctors discourage their use. On the other hand, oils containing unsaturated fatty acids are generally used for cooking purposes.



Focus Point

- **Test for unsaturation :** The addition of bromine water to alkenes or alkynes is also used to test the unsaturation in the given organic compound. If the reddish - brown colour of bromine water gets discharged on adding it to the organic compound, the compound must be unsaturated, i.e., it must be containing a double or triple bond.

Bromine reacts with ethyne to give, 1, 1, 2, 2-Tetrabromoethane which is a saturated compound

$$\underset{\text{Ethyne (Unsaturated)}}{H-C\equiv C-H} + \underset{\text{Bromine (Reddish Brown)}}{2Br_2} \xrightarrow{CCl_4} \underset{\text{1, 1, 2, 2- Tetrabromoethane (Saturated and colourless)}}{H-\overset{Br}{\overset{|}{C}}-\overset{Br}{\overset{|}{C}}-H \quad (Br\ Br\ /\ Br\ Br)}$$

13. BURNING OF SUBSTANCES WITH OR WITHOUT SMOKY FLAME

When coal or charcoal burns in an 'angithi', sometimes it just glows red and gives out heat without a flame. This is because a flame is only produced when gaseous substances burn. When wood or charcoal is ignited, the volatile substances present vapourise and burn with a flame in the beginning.

A luminous flame is also observed when the atoms of the gaseous substances are heated and start to glow. The colour of the flame is characteristic of that element. For example, when a copper wire is heated in the flame of the a gas stove, a bluish green colour is obtained.

The incomplete combustion gives soot or smoke which is due to carbon. Saturated hydrocarbons burn with blue non-sooty flame. This is because the percentage of carbon in these compounds is low which gets oxidized completely by the oxygen present in the air.

On the other hand, unsaturated hydrocarbons burn with yellow sooty flame. This is because the percentage of carbon in these compounds is comparatively higher (than saturated compounds). Therefore , all the carbon does not get oxidised completely in the oxygen of the air. Due to incomplete combustion, the flame is sooty due to the
presence of unburnt carbon particles.

The fuels such as coal, petroleum have some amount of nitrogen and sulphur in them. On heating, they are burnt to oxides of nitrogen and sulphur, which are released in the atmosphere. These are the major pollutants in the environment.



Focus Point

- The gas stove (and kerosene stove) used in our homes have tiny holes (or inlets) for air so that sufficient oxygen of air is available for the complete burning of fuel to produce a smokeless blue flame.
- The unsaturated hydrocarbons (alkenes and alkynes) burn in air with a yellow, sooty flame (producing black smoke). But if unsaturated hydrocarbons are burned in pure oxygen, then they will burn completely producing a blue flame (without any smoke at all).

For example,
Acetylene (ethyne) is an unsaturated hydrocarbon. When acetylene is burned in air, it burns with a very sooty flame due to incomplete combustion. The temperature of flame produced is also not high. Now, if a mixture of acetylene (ethyne) and pure oxygen is burned, then acetylene burns completely producing a blue flame. The oxygen – acetylene flame (called oxy – acetylene flame) is extremely hot and produces a very high temperature which is used for welding metals.

14. CATALYSTS AND THEIR USE IN REACTIONS

(i) Catalysts : Substance which alters the rate of a chemical reaction without undergoing any change in its mass and chemical composition at end of reaction

(ii) Positive catalysts : Positive catalysts increase the rate of chemical reaction e.g.

$$SO_2 \xrightarrow{O_2/V_2O_5} SO_3$$

(iii) Negative Catalysts : Negative catalysts decrease the rate of a chemical reaction e.g. $H_2O_2 \xrightarrow{Phosphoric\ acid} H_2O + O_2$

(iv) Catalytic poison : Certain substance like As, Co if present along with catalyst decrease the activity of catalyst are called catalytic poison.

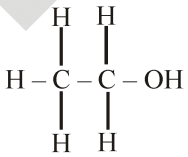
(v) Catalytic promotor : Substance if present along with catalyst increase the activity of catalyst e.g. Mo act as a promotor for iron catalyst during manufacturing of ammonia.

15. SOME IMPORTANT CARBON COMPOUNDS

15.1 ETHANOL

(A) Molecular formula: C_2H_6O or CH_3CH_2OH

(B) Structural formula :



(C) Physical properties of ethanol

(i) Ethanol is a colourless liquid having a pleasant smell.
(ii) Ethanol boils at 351 K.
(iii) It is miscible with water in all proportions.
(iv) It is a non-conductor of electricity (it does not contain ions).
(v) It is neutral to litmus.

(D) Chemical properties of ethanol

(i) Combustion : Ethanol burns in air with a blue flame to form CO_2 & H_2O.

$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$ + heat & light

(ii) Oxidation :

(a) By mild oxidizing agent CrO_3 (Chromic anhydride).

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow{CrO_3} \underset{\text{Ethanal}}{CH_3CHO} + H_2O$$

(b) By strong oxidizing agent ($K_2Cr_2O_7 + H_2SO_4$ or alkaline $KMnO_4$).

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[\text{Acidified } K_2Cr_2O_7]{\text{Alkaline } KMnO_4 \text{Or}} \underset{\text{Ethanoic acid}}{CH_3COOH}$$

(iii) Reaction with sodium : Ethanol reacts with sodium to produce hydrogen gas and sodium ethoxide.

$$\underset{\text{Ethanol}}{2\,C_2H_5OH} + 2Na \longrightarrow \underset{\text{Sodium ethoxide}}{2C_2H_5ONa} + H_2(\uparrow)$$

(iv) Reaction with carboxylic acids [Esterification] : The process of formation of an ester by the combination of an alcohol with carboxylic acid is known as esterification.

$$\underset{\text{Carboxylic acid}}{R-\overset{\overset{O}{\|}}{C}-OH} + \underset{\text{Alcohol}}{H-O-R'} \xrightarrow{\text{Conc.}H_2SO_4} \underset{\substack{\text{Alkyl alkanoate}\\(\text{Ester})}}{R-\overset{\overset{O}{\|}}{C}-OR'} + H_2O$$

For example,

When ethanol reacts with ethanoic acid in presence of concentrated sulphuric acid, ethyl ethanoate and water are formed .

$$\underset{\substack{\text{Ethanoic}\\\text{acid}}}{CH_3COOH} + \underset{\text{Ethanol}}{C_2H_5OH} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Ethyl ethanoate}}{CH_3COOC_2H_5} + H_2O$$

Esters are sweet smelling substances and thus are used in making perfumes.

(v) Action with concentrated sulphuric acid : Ethanol reacts with concentrated sulphuric acid at 443 K to produce ethylene. This reaction is known as acidic dehydration of ethanol because in this reaction, water molecule is removed from ethanol.

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[443K]{\text{Conc. } H_2SO_4} \underset{\text{Ethene}}{CH_2=CH_2} + H_2O$$

The concentrated sulphuric acid may be regarded as a dehydrating agent because it removes water from ethanol.

(E) Some Important Terms :

- **Denatured alcohol :** To prevent the misuse for drinking purpose, the alcohol supplied for industrial purpose is rendered unfit by mixing it with some poisonous substances like methanol, pyridine, copper sulphate etc. It is known as denatured alcohol.
- **Rectified spirit :** Ethanol containing 5 percent water is known as rectified spirit.
- **Absolute alcohol :** Rectified spirit is heated under reflux over quicklime for about 5 to 6 hours and then allowed to stand for 12 hours. On distillation, pure alcohol (C_2H_5OH = 100%) is obtained. This is called absolute alcohol.

• **Power alcohol :** Alcohol, which is used for generating power is called power alcohol. It consists of a mixture of absolute alcohol and petrol roughly in the ratio 20 : 80. Since alcohol itself, does not mix with petrol , therefore, a third solvent such as benzene, ether etc. is added as a co-solvent.

(F) Uses of Ethanol :

• Ethanol is a constituent of beverages like beer, wine, whisky and other liquors.

Beer	=	3-6% Ethanol
Whisky	=	50% Ethanol
Wine	=	10-20% Ethanol

• Ethanol is used to sterilize wounds and syringes.

• **Antifreeze :** It is a mixture of ethanol and water which has a much lower freezing point than that of water. It is used in radiators of vehicles in cold countries.

• It is used in manufacture of paints, dyes, medicines, soaps and synthetic rubber. Solution of ethanol prepared in pharmaceutical industry are known as tinctures.

• **Alcohol as a fuel**

Sugarcane plants are one of the most efficient convertors of sunlight into chemical energy. Sugarcane juice can be used to prepare molasses which is fermented to give alcohol (ethanol). Some countries now use alcohol as an additive in petrol since it is a cleaner fuel which gives rise to only carbon dioxide and water on burning in sufficient air (oxygen).

(G) Harmful effects of drinking alcohol :

• If ethanol is mixed with CH_3OH and consumed, it may cause serious poisoning and loss of eyesight.

• It causes addiction (habit forming) and mixes with blood. It damages liver if taken regularly.

• Higher amount of consumption of ethanol leads to loss of body control & consciousness. It may even cause death.



Focus Point

• When taken internally, methanol is a poison. So, unlike ethanol, drinking methanol even in very small quantity can cause severe poisoning leading to blindness and even death. This happens as follows.
Methanol damages the optic nerve causing permanent blindness in a person. Methanol is oxidised to methanal in the liver of a person. This methanal reacts rapidly with the components of the cells causing coagulation of their protoplasm. Due to this the cells stop functioning normally. This leads to the death of the person who drinks methanol.

(H) Test of alcohol :

The presence of ethanol or alcoholic group in an organic compound can be tested by the following tests:

• **Sodium metal test** :

Add a small piece of sodium metal to the organic compound (to be tested) in a dry test tube. If the bubbles of hydrogen gas are produced, it indicates the presence of alcohol.

• **Ester formation test :**

Warm the organic compound with acetic acid and a few drops of conc. H_2SO_4. A sweet smell (due to the formation of ester) indicates the presence of alcohol.



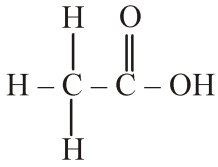
Focus Point

• If wine or beer is left open in the air, ethanol is oxidised to ethanoic acid. This is why wine tastes like vinegar after it's been left open for a couple days.

15.2 ETHANOIC ACID

(A) Molecular formula : $C_2H_4O_2$ or CH_3COOH

(B) Structural formula :



(C) Occurrence :

Ethanoic acid is known as vinegar, from ancient times. Vinegar is essentially a dilute solution of ethanoic acid in water. The acid is also present in some fruit juice . In the combined form, it is also present in many perfumed oils. Ethanoic acid was first prepared in the pure state by Stahl in 1720 .

(D) Physical properties :

(i) Ethanoic acid is a colourless, viscous liquid but has a pungent and irritating smell of vinegar.

(ii) Its boiling point is 391 K.

(iii) It dissolves in water, alcohol and ether. Its dissolution in water takes place with the evolution of heat and decrease in volume of the solution.

(iv) The melting point of ethanoic acid is 290 K and hence it often freezes during winter in cold climates. Therefore, it is named as glacial acetic acid.

(F) Chemical properties :

(i) Acidic character : Ethanoic acid is a monobasic acid. It has a replaceable hydrogen atom in its - COOH group. Therefore, it neutralizes alkalies.

(1) It reacts with a solution of sodium hydroxide to form sodium ethanoate and water.

$$CH_3COOH + NaOH \rightleftharpoons \underset{\text{Sodium ethanoate}}{CH_3COONa} + H_2O$$

Sodium ethanoate is an ionic compound which dissolves in polar solvents such as water, but does not dissolves in non polar solvents such as alcohol, propanone etc. The aqueous solution of sodium ethanoate is alkaline due to hydrolysis.

$$CH_3COONa \overset{H_2O}{\rightleftharpoons} \underset{\text{Weak acid}}{CH_3COOH} + \underset{\text{Strong base}}{NaOH}$$

(2) It reacts with sodium carbonate and sodium bicarbonate with the evolution of CO_2 gas.

$$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2 \uparrow$$

$$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2 \uparrow$$

(3) It reacts with metals like sodium, zinc and magnesium to liberate hydrogen gas.

$$2CH_3COOH + 2Na \rightarrow 2CH_3COONa + H_2\uparrow$$

$$2CH_3COOH + Zn \rightarrow (CH_3COO)_2Zn + H_2\uparrow$$

(ii) Ester formation : When ethanoic acid is heated with ethanol in presence of small quantity of conc.H_2SO_4 ethyl ethanoate, a sweet smelling ester, is formed.

$$CH_3COOH + C_2H_5OH \overset{H^+}{\rightleftharpoons} \underset{\text{Ethyl ethanoate}}{CH_3COOC_2H_5} + H_2O$$

This process of ester formation is called esterification.

(iii) Decarboxylation :

When sodium ethanoate is heated with soda lime, methane is formed.

$$CH_3COONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

(G) Uses :

(i) Dilute aqueous solution (5-8%) of ethanoic acid is called vinegar, which is used to preserve food (sausage, pickles, etc).

(ii) Pure ethanoic acid is used as a solvent and chemical reagent.

(iii) As cellulose ethanoate, it is used in making photographic films and rayon.

(iv) Ethanoic acid also finds application in the preparation of propanone, chloroethanoic acid, ethanoates of metals etc.

(v) It is widely used in the manufacture of textiles.

(H) Tests for Carboxylic Acid :

(i) Litmus test : Add small amount of blue litmus solution to the given compound. If the blue litmus solution turns red, it indicates that the organic compound is acidic in nature.

(ii) Sodium bicarbonate test : Take a small portion of the organic compound in a test tube and add a pinch of solid sodium bicarbonate. Evolution of carbon dioxide with brisk effervescence shows that the organic compound is acidic in nature.

(iii) Ester formation: When a mixture of given compound and ethanol is heated in the presence of concentrated sulphuric acid, a fruity smelling ester, ethyl ethanoate, is produced which shows that the organic compound is acidic in nature.

16. SOAPS AND DETERGENTS

16.1 SOAP

A soap is a sodium or potassium salt of some long chain carboxylic acids (fatty acid). Sodium salts of fatty acids are known as hard soaps and potassium salts of fatty acid are known as soft soaps. A soap has a large non-ionic hydrocarbon group and an ionic $COO^- Na^+$ group. The structure of soap can be represented as :



where represents the hydrocarbon group and  represents negatively charged carboxyl group. Some examples of soaps are sodium stearate, $C_{17}H_{35}COO^- Na^+$, sodium palmitate, $C_{15}H_{31}COO^-Na^+$ and sodium oleate, $C_{17}H_{33}COO^- Na^+$.

(A) Preparation of soap : Soap is prepared by heating oil or fat of vegetable or animal origin with concentrated sodium hydroxide solution (caustic soda solution). Hydrolysis of fat takes place and a mixture of sodium salt of fatty acids and glycerol is formed. Since the salt of fatty acids thus formed are used as soap so alkaline hydrolysis of oils and fats is commonly known as saponification.

$$\begin{array}{l} CH_2OCOC_{15}H_{31} \\ | \\ CHOCOC_{15}H_{31} \\ | \\ CH_2OCOC_{15}H_{31} \end{array} + 3NaOH \longrightarrow \begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array} + \underset{\text{(Sodium palmitate)}}{3C_{15}H_{31}COONa}$$

Fat or oil (Tripalmitin)

Glycerol

(B) Limitation of soaps : Soap is not suitable for washing clothes with hard water because of the following reasons.

(i) Hard water contains salts of calcium and magnesium. When soap is added to hard water, calcium and magnesium ions of hard water react with soap forming insoluble calcium and magnesium salts of fatty acids.

$$\underset{\text{Soap}}{2C_{17}H_{35}COONa} + MgCl_2 \longrightarrow \underset{\text{(White ppt)}}{(C_{17}H_{35}COO)_2Mg\downarrow} + 2NaCl$$

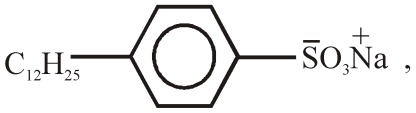
$$2C_{17}H_{35}COONa + CaCl_2 \longrightarrow \underset{\text{(White ppt)}}{(C_{17}H_{35}COO)_2Ca\downarrow} + 2NaCl$$

16.2 DETERGENTS

These are also called synthetic detergents or soapless soaps. A synthetic detergent is the sodium salt of a long chain benzene sulphonic acid or the sodium salt of a long chain alkyl hydrogen sulphate.

(A) Preparation of Synthetic Detergents : Synthetic detergents are prepared by reacting hydrocarbons from petroleum with conc. sulphuric acid and converting the product into its sodium salt.

Examples :



Sodium p-dodecyl benzensulphonate



Sodium lauryl sulphate

(B) Comparison Between Properties of Soaps and Detergents :

S. No.	Soaps	Synthetic detergents
1	Soaps are sodium slats of higher fatty acids	Synthetic detergents are sodium alkyl sulphates or sodium alkyl benzene sulphonates with alkyl group having more than ten carbon atoms.
2.	Soaps are prepared from natural oils and fats.	Synthetic detergents are prepared from the hydrocarbons of petroleum.
3.	Soaps form insoluble salts (curdy white ppt.) with calcium and magnesium which are present in hard water and hence, cannot be used in hard water.	Calcium and magnesium salts of detergents are soluble in water and, therefore, no curdy white precipitates are obtained in hard water and hence, can be used even in hard water.
4.	Soaps cannot be used in acidic medium as they are decomposed into carboxylic acids in acidic medium	They can be used in acidic medium as they are the salt of strong acids and are decomposed in acidic medium.
5.	Soaps are biodegradable.	Some of the synthetic detergents are not biodegradable.

(C) Advantages of Synthetic Detergents Over Soaps :

Synthetic detergents are widely used as cleaning agents these days. Some of their advantages over soaps are :

(i) Synthetic detergents can be used for washing even in hard water. On the other hand, soaps are not suitable for use with hard water.

(ii) Synthetic detergents can be used even in acidic solutions because they are not readily decomposed in acidic medium. On the other hand, soaps cannot be used in acidic medium because they are decomposed into carboxylic acids in acidic medium.

(iii) Synthetic detergents are more soluble in water than soaps.

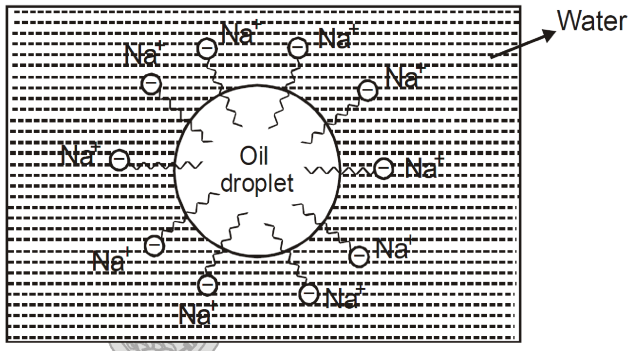
(iv) Synthetic detergents have a stronger cleaning action than soaps.

(D) Cleansing Action of Soaps and Detergents :

A molecule of soap is made up of two parts : a non polar part consisting of a long chain of 12 - 18 carbon atoms and a polar part, $-COO^-Na^+$. The polar end is water soluble and is thus hydrophilic whereas hydrocarbon part is insoluble in water and is thus hydrophobic.

In a soap solution, the hydrocarbon portions of several soap molecules huddle together to form aggregates of molecules (or ions) called micelles. The soap micelles are negatively charged due to the presence of carboxylate ions at the surface. Repulsion between similarly charged micelles keeps them dispersed in the solution.

Mostly the dirt is held to any surface such as cloth by the oil or grease which is present there. Now since the oil and grease are not soluble in water, the dirt particles cannot be removed by simply washing the cloth with water. However, when soap is applied, the non polar hydrocarbon part of the soap molecules dissolves in oil droplets while the polar $-COO^-\ Na^+$ groups remain attached to water molecules. In this way, each oil droplet gets surrounded by negative charge.



These negatively charged oil droplets cannot coalesce and continue breaking into small droplets .These oil droplets (containing dirt particles) can be washed away with water along with dirt particles. So, the action of soap or detergents is to emulsify oil or grease, this loosens the solid particles of dirt and they are removed. Soap or detergent helps in cleansing in another way. Not only it emulsifies oil or grease but it also lowers the surface tension of water. As a result of this water wets things more effectively.

When water is added on to the surface of the cloth then water molecules tend to stay as close to each other as possible because of the strong forces of attraction (hydrogen bonding) for each other and do not wet the cloth properly. If some soap solution is added to this water then polar end of soap dissolves in water and non polar hydrocarbon end remains away from the water. Thus, soap molecules arrange themselves between the water molecules on the surface of water and decrease the forces of attraction between the water molecules. Water can now spread on the surface of cloth and can make it wet effectively.

(E) Synthetic Detergents : A Serious Problem :

It may be noted that in the past, the widespread use of detergents caused pollution of rivers and other water bodies. Earlier the synthetic detergents were made from long chain of hydrocarbons having a lot of branched chains in them. These branched chain detergent molecules were degraded very slowly by the micro organisms present in
water bodies like lakes or rivers.

Therefore, they tend to remain in water bodies for a long time and make water unfit for aquatic life. For example, detergents containing phosphates can cause rapid growth of algae and therefore, deplete the dissolved oxygen present in the water of lakes and rivers. As a result of lack of oxygen, fish and other aquatic animals may die. To solve these problems, now-a-days, the detergents are prepared from hydrocarbons which have minimum branching. These are degraded more easily than branched chain detergents. Therefore, these are biodegradable and create less problems.

MATRIX OLYMPIAD

SOLVED EXAMPLES

SE. 1

Draw the electron dot structure of ethyne and also draw its structrual formula.

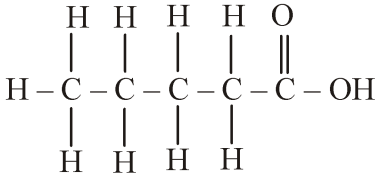
Ans. Molecular formula = C_2H_2

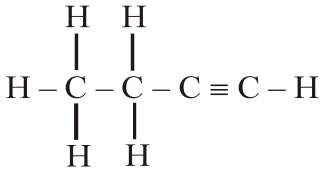
Electronic formula = $H\cdot\cdot C\vdots\vdots C\cdot\cdot H$

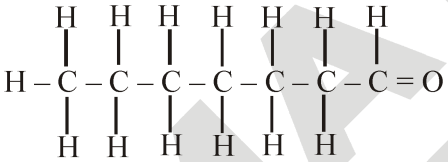
Structural formula = H-C≡C-H

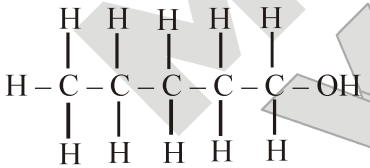
SE. 2

Write the names of the following compounds.

(a) 

(b) 

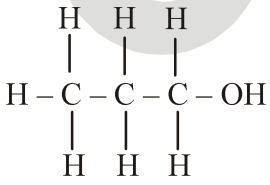
(c) 

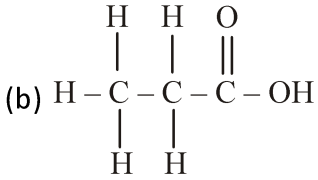
(d) 

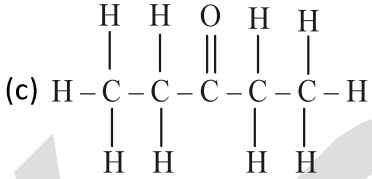
Ans. (a) Pentanoic acid (b) Butyne
(c) Heptanal (d) Pentanol

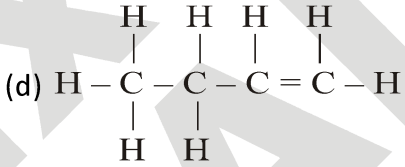
SE. 3

Identify and name the functional groups present in the following compounds.

(a) 

(b) 

(c) 

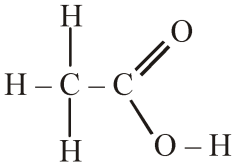
(d) 

Ans. (a) Alcohol (b) Carboxylic acid
(c) Ketone (d) Alkene

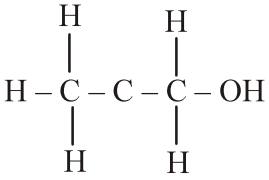
SE. 4

A compound X is formed by the reaction of a carboxylic acid $C_2H_4O_2$ and an alcohol in presence of a few drops of H_2SO_4. The alcohol on oxidation with alkine $KMnO_4$ followed by acidification gives the same carboxylic acid as used in this reaction. Give the names and structures of (a) carboxylic acid. (b) alcohol and (c) the compound X. Also write the reaction.

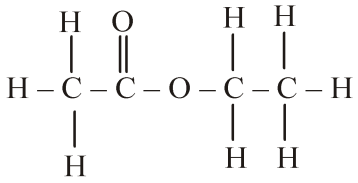
Ans. (a) Carboxylic acid = CH_3COOH (ethanoic acid)



(b) Alcohol = CH_3CH_2OH (ethanol)



(c) X = $CH_3COOCH_2CH_3$ (ethyl ethanoate)



SE. 5

Why detergents are better cleansing agents than soaps? Explain.

Ans. Detergents are better than soaps because detergents are ammonium or sulphonate salts of long chain carboxylic acids. Charged ends of these will not form precipitate with calcium and magnesium ions present in hard water. On the other hand soaps will form precipitate with calcium and magnesium ions present in the hard water.

SE. 6

Name the functional groups present in the following compounds

(a) $CH_3\,CO\,CH_2\,CH_2\,CH_2\,CH_3$

(b) $CH_3\,CH_2\,CH_2\,COOH$

(c) $CH_3\,CH_2\,CH_2\,CH_2\,CHO$

(d) $CH_3\,CH_2\,OH$

Ans. (a) Ketone

(b) Carboxylic acid

(c) Aldehyde

(d) Alcohol

SE. 7

How is ethene prepared from ethanol? Give the reaction involved in it.

Ans. Ethanol is heated at 443K along with excess sulphuric acid to obtain Ethene.

$$CH_3\text{-}CH_2OH \xrightarrow[H_2SO_4]{} CH_2 = CH_2 + H_2O$$

(ethanol) (ehene)

SE. 8

Intake of small quantity of methanol can be lethal. Comment.

Ans. Methanol gets converted to Methanal and liver and kills all the cells. Methanol also affect the optic nerves and causes blindness. Hence intake of small quantity of methanol can be lethal.

SE. 9

A gas is evolved when ethanol reacts with sodium. Name the gas evolved and also write the balanced chemical equation of the reaction involved.

Ans. When ethanol reacts with sodlium, it gives Sodium ethoxide with the liberation of Hydrogen gas.

$$2CH_3 - CH_2 - OH + 2Na \longrightarrow 2CH_3 - CH_2 - ONa + H_2$$

SE. 10

Ethene is formed when ethanol at 443 K is heated with excess of concentrated sulphuric acid. What is the role of sulphuric acid in this reaction? Write the balanced chemical equation of this reaction.

Ans. Sulphuric acid acts as a catalyst and a dehydrating agent in the formation of ethene.

$$\underset{\text{Ethyl alcohol}}{CH_3CH_2OH} \xrightarrow[443K]{\text{Conc.}H_2SO_4} \underset{\text{Ethene}}{CH_2 = CH_2} + \underset{\text{Water}}{H_2O}$$

SE. 11

Carbon, Group (14) element in the Periodic Table, is known to form compounds with many elements.

Write an example of a compound formed with

(a) chlorine (Group 17 of Periodic Table)

(b) oxygen (Group 16 of Periodic Table)

Ans. (a) CCl_4 – Carbon Tetra chloride

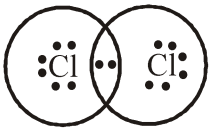
(b) CO_2 – Carbon-di-oxide

SE. 12

In electron dot structure, the valence shell electrons are represented by crosses or dots.
(a) The atomic number of chlorine is 17. Write its electronic configuration.

(b) Draw the electron dot structure of chlorine molecule.

Ans. (a) K L M – 2,8,7

(b) 

SE. 13

Catenation is the ability of an atom of form bonds with other atoms of the same element. It is exhibited by both carbon and silicon. Compare the ability of catenation of the two elements. Give reasons.

Ans. Catenation is shown by both Silicon and Carbon. Silicon bonds are less stable and reactive whereas bond formed by Carbon bonds are very strong hence carbon better catenation than Silicon.

SE. 14

Unsaturated hydrocarbons contain multiple bonds between the two C-atoms and show addition reaction. Give the test to distinguish ethane from ethene.

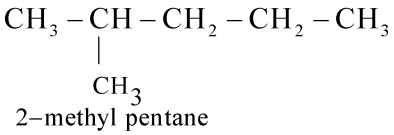
Ans. Saturated Hydrocarbons burns with clean flame and produce no soot where as un-saturated hydrocarbons burns with yellow flame and produces lot of soot. Ethane is saturated hydrocarbon and its burns with clean flame with no soot. Ethene is unsaturated hence it burns with yellow flame producing lot of soot.

SE. 15

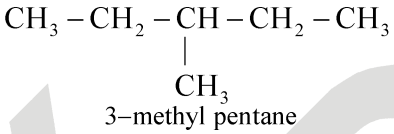
Write the structural formulae of all isomers of hexane.

Ans. $CH_3 - CH_2 - CH_2 - CH_2 - CH_3$

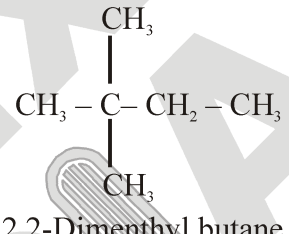
Hexane



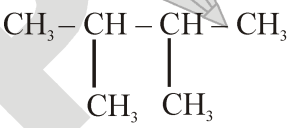
2–methyl pentane



3–methyl pentane



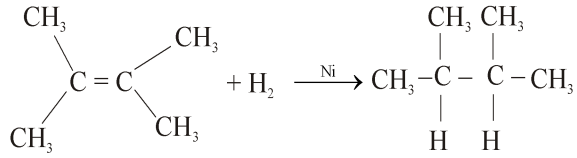
2,2-Dimenthyl butane



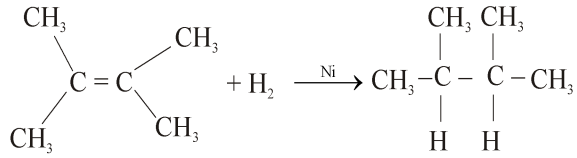
2, 3- Dimenthy butane

SE. 16

What is the role of metal or reagents written on arrows in the given chemical reactions?

(a) 

(b) $CH_3\ CH_2\ OH \xrightarrow[\text{Heat}]{\text{Alk.}KMnO_4} CH_3\ COOH$

Ans. (a) 

In this reaction, Ni acts as catalyst.

(b) $CH_3\ CH_2\ OH \xrightarrow[\text{Heat}]{\text{Alk.}KMnO_4} CH_3\ COOH$

In this reaction, Alk. $KMnO_4$ acts as oxidising agent.

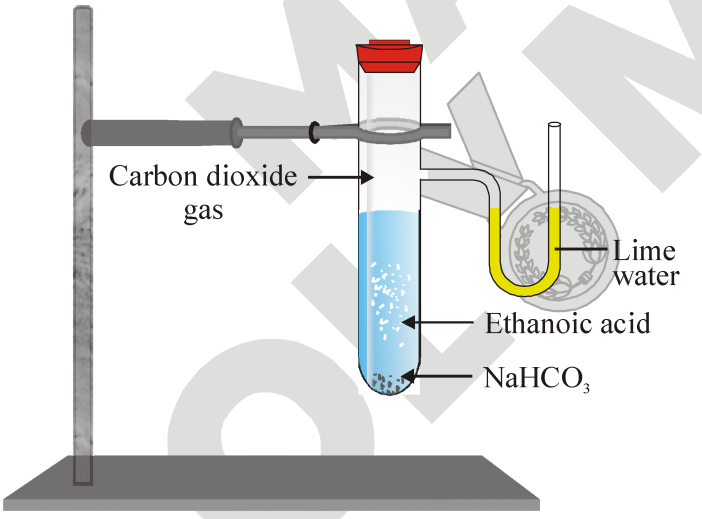
SE. 17

A salt X is formed and a gas is evolved when ethanoic acid reacts sodium hydrogencarbonate. Name the salt X and the gas evolved. Describe an activity and draw the diagram of the apparatus to prove that the evolved gas is the one which you have named. Also, write chemical equation of the reaction involved.

Ans. When ethanoic acid reacts with Sodium hydrogen carbonate with production of Sodium Ethanoate and producing Carbon-di-oxide gas.

$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2$

Here salt X is Sodium Ethanoate and gas evolved is Carbon-di-oxide.



Activity :

- Set up the experiment as shown in figure.
- Take a spoon full of Sodium hydrogen carbonate in a test-tube and add 2ml of dilute ethanoic acid.
- Brisk effervescence occur in test tube.
- Pass the produced gas into lime water.
- Lime water turn milky confirming the evolution of CO_2

SE. 18

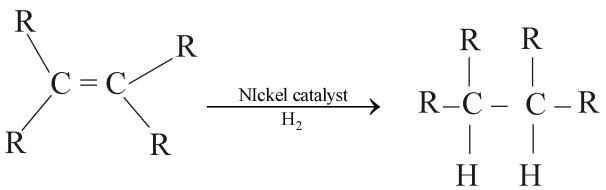
a) What are hydrocarbons? Give examples.
(b) Give the structural differences between saturated and unsaturated hydrocarbons with two examples each.
(c) What is a functional group? Give examples of four different functional groups.

Ans. (a) Compounds of carbon and hydrogen are called as Hydrocarbons.
Ex : Methane, Ethane.
(b) All the bond in saturated hydrocarbons are single bonds whereas bond in the unsaturated hydrocarbons are either double or triple bonds.
Saturated Hydrocarbon.
Ex : Methane, Ethane.
Unsaturated Hydrocarbons-Ethene, Ethyne
(c) Functional groups are set of atoms joined in a specific manner which are responsible for characteristic chemical property of the compound. Ex: CHO – Aldehyde, OH – Hydroxyl, COOH –Carboxylic acid.

SE. 19

Name the reaction which is commonly used in the conversion of vegetable oils to fats. Explain the reaction involved in detail.

Ans. Addition reaction is involved in the conversion of oils into fats. This process is known as Hydrogenation. Here unsaturated vegetable are converted to saturated fats which have saturated carbons.
Nickel is used as a catalyst in the hydrogenation process and the reaction is given below.

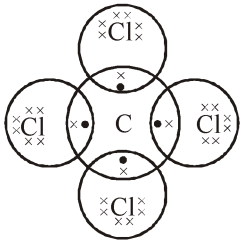


SE. 20

(a) Write the formula and draw electron dot structure of cabon tetrachloride.

(b) What is saponification? Write the reaction involved in this process.

Ans. (a) Carbon tetra chloride – CCl_4



(b) The reaction of an ester in the presence of base to give sodium ofcarboxylic acid and alcohol is known as saponification and it is used in the preparation of soap.

$CH_3COOC_2H_5 + NaOH \rightarrow CH_3COONa + C_2H_5OH$

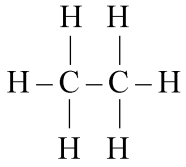
Space for Notes :

MATRIX OLYMPIAD

NS. 1

Ethane, with the molecular formula C_2H_6, has:
(A) 6 covalent bonds.
(B) 7 covalent bonds.
(C) 8 covalent bonds.
(D) 9 covalent bonds.

Ans. **(B)**

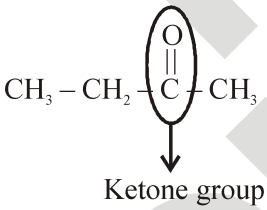


As is visible in the above structure, there are 6 covalent bonds between carbon and hydrogen and 1 covalent bond between carbon and carbon. Hence, there are a total of 7 covalent bonds.

NS. 2

Butanone is a four-carbon compound with the functional group:
(A) Carboxylic acid.
(B) Aldehyde.
(C) Ketone.
(D) Alcohol.

Ans. **(C)**



The functional group present in butanone is of ketone.

NS. 3

While cooking, if the bottom of the vessel is getting blackened on the outside, it means that:
(A) The food is not cooked completely.
(B) The fuel is not burning completely.
(C) The fuel is wet.
(D) The fuel is burning completely.

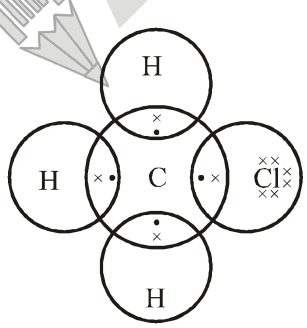
Ans. **(B)**

While cooking, if the bottom of the vessel is getting blackened on the outside, it indicates that the fuel is not burning completely. The blackening part happens due to the settling of soot which are unburnt carbon particles. Formation of soot is observed when incomplete combustion of fuels take place.

NS. 4

Explain the nature of the covalent bond using the bond formation in CH_3Cl.

Ans. Carbon has four electrons in its valence shell. To completes its octet, it shares its four electrons with other atoms to create four bonds, thus becoming stable. The bonds that are formed by sharing electrons are known as covalent bonds.

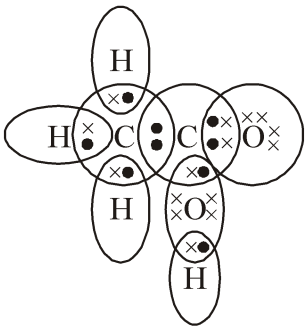


In CH_3Cl, carbon requires 4 electrons to complete its octet, while each hydrogen atom requires one electron to complete its duplet. Also, chlorine requires an electron to complete the octet.
Therefore, all of these share the electrons and as a result, carbon forms 3 bonds with hydrogen and one with chlorine.

NS. 5

Draw the electron dot structures for
(i) Ethanoic acid
(ii) H_2S
(iii) Propanone
(iv) F_2

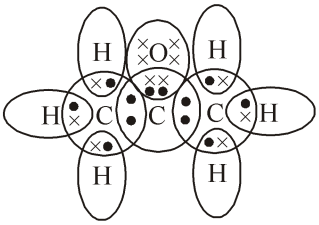
Ans. (i) Ethanoic acid



(ii) H_2S



(iii) Propanone



(iv) F_2



NS. 6

What is a homologous series? Explain with an example.

Ans. A homologous series is a series of carbon compounds in which the consecutive compounds differ by a formula of $–CH_2$ or an atomic mass 14 amu. The compounds of a particular group have the same functional group which leads to identical chemical properties. But, as the compounds have different masses, a slight gradation in physical properties is observed.

For example, methane, ethane, propane, butane, etc., are all part of the alkane homologous series.

The general formula of this series is C_nH_{2n+2}

Methane : CH_4

Ethane : CH_3CH_3

Propane : $CH_3CH_2CH_3$

As is evident, the difference between methane and ethane or between ethane and propane is of a $–CH_2$ group which has a mass of 14 amu.

NS. 7

How can ethanol and ethanoic acid be differentiated on the basis of their physical and chemical properties?

Ans. Ethanol is a liquid at room temperature with a pleasant odour while ethanoic acid has vinegar-like smell. The melting point of ethanoic acid is 17°C and that for ethanol is –114.1°C. This is below room temperature and hence, ethanol freezes during winters.

Ethanoic acid reacts with metal carbonates and metal hydrogen carbonates to form salt, water and carbon dioxide gas while ethanol does not react with them.

Metal carbonate / metal hydrogen carbonate + ethanoic acid → Salt + Water + Carbon dioxide

$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2$.

Metal Carbonate / Metal Hydrogen carbonate + Alcohols → No reaction

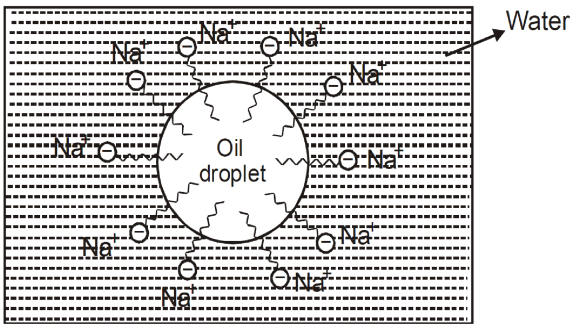
For example, $CH_3CH_2OH + Na_2CO_3 \rightarrow$ No reaction.

NS. 8

Why does micelle formation take place when soap is added to water? Will a micelle be formed in other solvents such as ethanol also?

Ans. Micelle formation takes place when soap is added to water. A soap molecule is a long chain molecule with one end having an alkyl group, which is hydrophobic, and the other end has COO^-Na^+ , which is hydrophilic. The COO^-Na^+ can be considered as the head of soap molecules and due to its ionic nature, it gets dissolved in water whereas the carbon chain dissolves in oil.

No, micelle formation does not take place in ethanol because the alkyl chain of soap becomes soluble in alcohol. Micelle can be formed only around suspended molecules of oil in water solution. Ethanol acts as a very good solvent and is able to dissolve even oil, thus forming a clear solution.



NS. 9

Why are carbon and its compounds used as fuels for most applications?

Ans. Most of the carbon compounds give out a large amount of heat and light when burnt in air (combustion reaction). Saturated hydrocarbons burn with a clean flame and no smoke is produced. The carbon compounds which are used as a fuel, have high calorific values. Due to this high calorific value, carbon and its compounds are used as fuels for most applications.

NS. 10

Explain the formation of scum when hard water is treated with soap.

Ans. Soap does not work properly when the water is hard. Soap molecules are long carbon chains with sodium or potassium at the other end. When soap is added to hard water, calcium and magnesium ions present in hard water displace sodium or
potassium ions from the soap molecules forming an insoluble substance called scum. A lot of soap gets wasted in the process of scum formation.

NS. 11

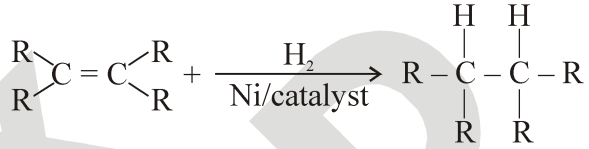
What change will you observe if you test soap with litmus paper (red and blue)?

Ans. Since soap is basic in nature, it will turn red litmus blue. However, the colour of blue litmus will remain blue because only an acidic substance can turn blue litmus into red.

NS. 12

What is hydrogenation? What is its industrial application?

Ans. Hydrogenation is the process of addition of hydrogen. Unsaturated hydrocarbons (alkene or alkyne) are reacted with hydrogen in the presence of palladium and nickel catalyst to form saturated hydrocarbons.



NS. 13

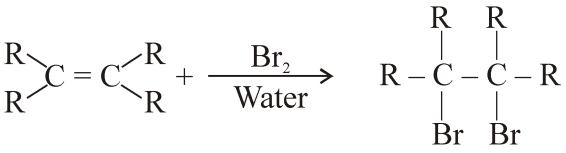
Which of the following hydrocarbons undergo addition reactions: C_2H_6,C_3H_8,C_3H_6,C_2H_2 and CH_4.

Ans. Saturated hydrocarbons (alkane general formula C_nH_{2n+2}) undergo substitution reactions.
Being saturated hydrocarbons C_2H_6,C_3H_8,and CH_4, the molecule already has maximum number of hydrogen atoms it can accommodate and thus, they do not undergo addition reactions.
Unsaturated hydrocarbons (alkenes C_nH_{2n} and alkynes C_nH_{2n-2}) undergo addition reactions. Being unsaturated hydrocarbons, C_3H_6 and C_2H_2, the double and triple bonds can be converted to single bonds and thus such compounds undergo addition reactions.

NS. 14

Give a test that can be used to differentiate between saturated and unsaturated hydrocarbons.

Ans. Unsaturated carbon compounds undergo addition reactions where as saturated compounds do not undergo such reactions. When unsaturated carbon compounds react with bromine water, bromine gets added to unsaturated compounds. This turns the colour of the solution from brown to colorless.



Saturated carbon compounds like alkane do not undergo such reactions and hence, are not able to decolorize the bromine water solution.

NS. 15

Explain the mechanism of the cleaning action of soaps.

Ans. Cleansing action of soaps: The dirt present on clothes is organic (nonpolar) in nature and thus, insoluble in water. Therefore, it cannot be removed by only washing with water. A soap molecule is a long chain molecule with one end having an alkyl group, which is hydrophobic, and the other end has COO^-Na^+, which is hydrophilic.

When soap is dissolved in water, its hydrophobic end attaches themselves to the dirt and remove it from the cloth. Then, the molecules of soap arrange themselves in a structure called micelle, where the dirt gets trapped at the center of the cluster. These micelles remain suspended in the water and get washed away, leaving behind clean clothes.



Space for Notes :

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EXERCISE – I

ONLY ONE CORRECT TYPE

SECTION (A) : INTRODUCTION, COVALENT BONDING :

1. The scientist who gave vital force theory was -
(A) Berzelius (B) Avogadro
(C) Wohler (D) Lavoisier

2. Which one of the following is not an organic compound?
(A) Hexane (B) Urea
(C) Ammonia (D) Ethyl alcohol

3. In a double covalent bond number of electron pairs shared are -
(A) 2 (B) 3
(C) 4 (D) 6

4. Which of the following compound contain single covalent bond ?
(A) Oxygen (B) Nitrogen
(C) Methane (D) Carbon dioxide

5. Carbon dioxide molecule contains -
(A) Single covalent bond
(B) Double covalent bond
(C) Triple covalent bond
(D) Ionic bond

6. Covalent compounds are generally-
(A) Good conductors of electricity.
(B) Bad conductors of electricity.
(C) Semiconductors of electricity.
(D) None of these

SECTION (B) : ALLOTROPIC FORMS OF CARBON :

7. In diamond, the bonding between carbon atoms is
(A) Co - ordinate (B) Ionic
(C) Electrostatic (D) Covalent

8. Diamond is _____ in nature :
(A) Transparent
(B) Hard
(C) Both A and B
(D) Conductor of electricity

9. Bond length between carbon-carbon atoms in diamond is :
(A) 1.34 A^o (B) 1.40 A^o
(C) 1.54 A^o (D) 1.7 A^o

10. Graphite is used in making electrodes because :
(A) It has high melting point
(B) It is soft and slippery
(C) It is a good conductor of electricity
(D) None of these

SECTION (C) : HYDROCARBONS AND HOMOLOGOUS SERIES:

11. Which of the following forms a homologus series -
(A) Ethane, ethylene, acetylene
(B) Ethane, propane, butanol
(C) Methanal, ethanol, propanoic acid
(D) Butane, 2-Methylbutane, 2,3-Dimethyl butane

12. Which of the following is an unsaturated compound
(A) C_6H_{14} (B) CH_3OH
(C) C_3H_7OH (D) C_4H_8

13. The functional group, present in $CH_3COOC_2H_5$ is
(A) Ketonic (B) Aldehydic
(C) Ester (D) Carboxylic

14. The general formula for saturated hydrocarbons is
(A) C_nH_{2n+2} (B) C_nH_{2n}
(C) C_nH_{2n-2} (D) C_nH_{2n-n}

15. Select the alkyne from the following -
(A) C_4H_8
(B) C_5H_8
(C) C_7H_{19}
(D) None of these

SECTION (D) : NOMENCLATURE OF ORGANIC COMPOUNDS AND ISOMERISM:

16. The IUPAC name of $(CH_3)_2$ $CHCH_2$ CH_2 Br is
(A) 1-Bromopentane
(B) 2-Methyl-4-bromo pentane
(C) 1-Bromo -3- methyl butane
(D) 2-Methyl-3-bromo pentane

17. The IUPAC name of the compound having the formula $(CH_3)_3$ CCH = CH_2 is -
(A) 3,3,3-Trimethyl-1-propene
(B) 1,1,1-Trimethyl-1-propene
(C) 3,3-Dimethyl-1-butene
(D) 1,1-Dimethyl-2-butene

MATRIX OLYMPIAD

18. The IUPAC name of the following compound is - $CH_2 = CH - CH(CH_3)_2$
(A) 1,1-Dimethyl-2-propene
(B) 3-Methyl-1-butene
(C) 2-Vinyl propane
(D) 1-Isopropyl ethylene

19. The IUPAC name of $CH_3 - C(CH_3)(OH) CH_2 - CH(CH_3) CH_3$ is -
(A) 2,4-Dimethylpentan-2-ol
(B) 2,4- Dimethylpentan-4-ol
(C) 2,2-Dimethylbutane
(D) Butanol-2-one

20. The IUPAC name of neopentane is
(A) 2, 2-dimethylpropane
(B) 2-methylpropane
(C) 2, 2-dimethylbutane
(D) 2-methylbutane

21. IUPAC name of second member of homologous series of carboxylic acids is -
(A) Methanoic acid
(B) Ethanoic acid
(C) Propanoic acid
(D) Butanoic acid

22. Which of the following hydrocarbon does not exhibit position isomerism ?
(A) C_2H_4 (B) C_3H_6
(C) C_3H_4 (D) All of these

23. The compound which can show chain iosmerism is
(A) CH_4 (B) CH_3CH_3
(C) $CH_3CH_2CH_3$ (D) $CH_3CH_2CH_2CH_3$

SECTION (E) : CHEMICAL PROPERTIES OF CARBON COMPOUNDS, ETHYL ALCOHOL AND ETHANOIC ACID:

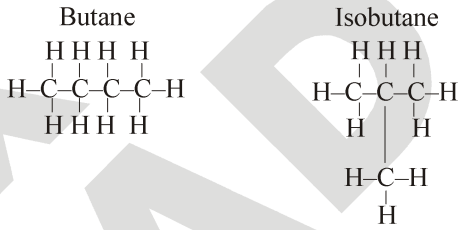
24. Rectified spirit is -
(A) 50% ethanol
(B) 80% ethanol
(C) 95% ethanol
(D) 100% ethanol

25. Glacial acetic acid is -
(A) 100% acetic acid free of water.
(B) Solidified acetic acid.
(C) Gaseous acetic acid.
(D) Frozen acetic acid.

PARAGRAPH TYPE QUESTION

PARAGRAPH # 1

The physical and chemical properties of hydrocarbons are directly related to their molecular geometries. Molecules that have the same molecular formula but different molecular geometries are called isomers. There are two major classes of isomers: structural isomers and stereoisomers.



Example of structural isomers: butane and isobutane

In structural isomers, the atoms in each isomer are connected, or bonded, in different ways. As a result, structural isomers often contain different functional groups or patterns of bonding. Consider butane and isobutane shown above, both molecules have four carbons and ten hydrogens, but butane is linear and isobutane is branched. As a result, the two molecules have different chemical properties (such as lower melting and boiling points for isobutane). Because of these differences, butane is typically used as a fuel for cigarette lighters and torches, whereas isobutane is often employed as a refrigerant or as a propellant in spray cans.

26. Why does carbon form large number of compounds ?
(A) due to catenation
(B) due to existences of Allotropic forms of carbon
(C) both (A) and (B)
(D) None of these

27. The self-linking property of the element to form chain, branch or ring is called
(A) Allotropy
(B) Catenation
(C) Homologous series
(D) None of these

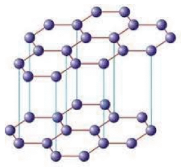
28. How many covalent bonds are present in C_5H_{12} ?
(A) 12
(B) 16
(C) 18
(D) 20

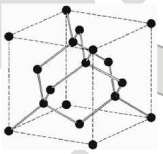
PARAGRAPH # 2

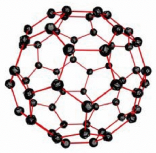
Allotropes of an element is its various physical forms in which it can exist. Allotropes have some differences in their physical and chemical properties. Diamond, graphite and fullerenes are the three allotropes of the element carbon with varying physical properties. Graphite is a soft, black, slippery substance; by contrast, diamond is one of the hardest substances known.

These differences in properties arise from their chemical structures. In diamond, each carbon atom is bonded to four other carbon atoms forming a rigid three-dimensional structure. In graphite, each carbon atom is bonded to three other carbon atoms (one bond being double bond) forming a hexagonal array.

In the fullerenes, the carbon atoms are arranged in the form of a hollow sphere, ellipsoid, or tube. The first one to be identified was Buckminsterfullerene where sixty carbon atoms are joined in the form of a football.


Graphite


Diamond


Fullerene

29. Name the phenomenon by which an element can link with another to form compounds of various physical forms.
(A) Allotropy
(B) Catenation
(C) Homologous series
(D) None of these

30. How many atoms of carbon Buckminsterfullerene has ?
(A) 60 (B) 62
(C) 70 (D) 72

31. Why graphite acts as a conductor ?
(A) due to presence of one unpaired electron in its structure
(B) due to presence of ions
(C) both (A) and (B)
(D) none of these

MATCH THE COLUMN TYPE

32

Column – I	Column – II
(P) Combustion reaction	(1) $C_3H_8 + Cl_2 \xrightarrow{UV\ light} C_3H_7Cl + HCl$
(Q) Oxidation reaction	(2) $CH_2 = CH_2 + H_2 \xrightarrow{Ni/Pd} CH_3 - CH_3$
(R) Addition reaction	(3) $C_2H_5OH \xrightarrow[K_2Cr_2O_7]{Acidified} CH_3COOH$
(S) Substitution reaction	(4) $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

(A) P – 4, Q – 3, R – 2, S – 1
(B) P – 1, Q – 2, R – 3, S – 4
(C) P – 4, Q – 1, R – 2, S – 3
(D) P – 1, Q – 3, R – 4, S – 2

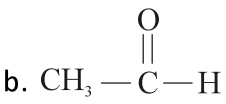
33.

Column – I	Column – II
(P) – CHO	(1) Carboxylic acid
(Q) – COOH	(2) Alcohol
(R) – OH	(3) Ketone
(S) $-\overset{\overset{O}{\|}}{C}-$	(4) Aldehyde

(A) P – 4, Q – 3, R – 2, S – 1
(B) P – 4, Q – 1, R – 2, S – 3
(C) P – 4, Q – 2, R – 3, S – 1
(D) P – 1, Q – 3, R – 4, S – 2

EXERCISE – II

VERY SHORT ANSWER TYPE

1. Write the molecular formula of 2nd and the 3rd member of homologous series whose first member is methane.
2. Name the following compounds:
   a. CH_3CH_2OH
   b. 
3. Select the saturated hydrocarbons from the following: C_3H_6, C_5H_{10}, C_6H_{14}, C_5H_{12}, C_4H_8
4. A molecule of ammonia has the formula NH_3. Predict the total number of bonds present around nitrogen atom.
5. Write the number of covalent bonds in the molecule of ethane.
6. Write molecular formula of alcohol which can be derived from butane.
7. Carbon has four electrons in its valence shell. How does carbon attain stable electronic configuration?
8. Name the process by which unsaturated fats are changed into saturated fats.
9. What happens when a small piece of sodium is dropped into ethanol?
10. How is scum formed?

SHORT ANSWER TYPE

1. Why are detergents preferred over soaps for washing clothes in hard water? Explain.
2. Why is hydrogenation? What is its industrial application?
3. What are soaps? Why do they form scum with hard water?
4. Write a chemical test to distinguish between ethanol and ethanoic acid.
5. Write the name and molecular formula of an organic compound having its name suffixed with '-ol' and having two carbon atoms in the molecule. With the help of a balanced chemical equation indicate what happens when it is heated with excess of cone. H_2SO_4.

LONG ANSWER TYPE

1. A compound X on heating with excess of cone. H_2SO_4 at 443 K gives an unsaturated compound Y. X also reacts with sodium metal to evolve a colourless gas Z. Identify X, Y and Z. Write the equations of the chemical reaction of formation of Y and also write the role of conc. sulphuric acid in the reaction.
2. Distinguish between esterification and saponification reaction with the help of equations for each. State one use of each (i) esters and (ii) saponification process.
3. Name two oxidising agents that are used to convert alcohols to acids. Distinguish between ethanol and ethanoic acid on the basis of (a) litmus test (b) reaction with $NaHCO_3$.
4. What are hydrocarbons? Write the general formula of (a) saturated hydrocarbons (b) unsaturated hydrocarbons and draw the structure of one hydrocarbon of each type.
5. An organic compound 'P' is a constituent of wine. 'P' on reacting with acidified $K_2Cr_2O_7$ forms another compound 'Q'. When a piece of sodium is added to 'Q' a gas 'R' evolves which burns with a pop sound. Identify P, Q and R and write the chemical equations of the reactions involved.

TRUE / FALSE TYPE

1. Unsaturated hydrocarbons nornally undergo addition reactions.
2. The functional group of chloro alkane is – Cl.
3. The first member of alkyne homologous series is ethyne.
4. When hydrocarbons burn in air, carbon dioxide and hydrogen are produced with heat energy.
5. Heating ethanol at 443K with excess of conc. H_2SO_4 results in the dehydration of ethanol to give ethene.

MATRIX OLYMPIAD

FILL IN THE BLANKS TYPE

1. C_nH_{2n} is the general formula of _____ hydrocarbons.
2. Hydrocarbons having the general formula C_nH_{2n-2} are called _____ .
3. The next higher homologue of ethanol is _____.
4. Organic compounds having $-\overset{\overset{O}{\|}}{C}-OH$ functional group are known as _____ .
5. _____ is better than soap for washing clothes when the water is hard.

Space for Notes :

MATRIX OLYMPIAD

Answer Key

EXERCISE–I

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

EXERCISE – II

TRUE / FALSE

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

FILL IN THE BLANKS

1. Alkene **2.** Alkyne **3.** Propanol

4. Carboxylic acid **5.** Detergent

MATRIX OLYMPIAD

SELF PROGRESS ASSESSMENT FRAMEWORK

(CHAPTER : CARBON & ITS COMPOUNDS)

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			

MATRIX OLYMPIAD

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 :