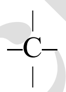
CARBON AND IT'S COMPOUNDS

Introduction: Carbon is an element. It is a non - metal. The symbol of carbon is C. The name carbon is derived from the latin word **"CARBO"** which means coal. The amount of carbon present in the earth's crust and atmosphere is very less. The Earth's crust contain only 0.02% carbon (in the form of carbonates, coal, petroleum & natural gas etc) and the atmosphere contains only 0.03% carbon in the form of CO_2. All the living things, plants and animals, are made up of carbon compounds (called organic compounds). A large number of things which we use in our daily life are made of carbon.

Testing of Carbon: To test a compound, containing carbon burn in the presence of oxygen of air and pass the gas formed through lime water. If the lime water turns milky ($CaCO_3$), then the given compound contains carbon.

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

Carbon Forms Covalent Bonds: The atomic number of carbon is 6. So, its electronic configuration is 2, 4. It is not possible to remove 4 electrons from a carbon atom to give the electronic configuration of inert gas. It is also not possible to add as many as 4 electrons to a carbon atom due to energy consideration. So carbon atoms have to acquire inert gas electronic configuration only by the sharing of electrons, therefore, carbon always forms covalent bonds. Since carbon atom has 4 valence electrons so, its valency is 4. The four valencies of carbon are usually represented by putting four short lines on the symbol of carbon which is represented as given:



Topic : Covalent Bond

<u>The chemical bond formed by the sharing of electrons between two atoms is known as covalent bond.</u>

Types of covalent bonds: There are three types of covalent bond. These are:

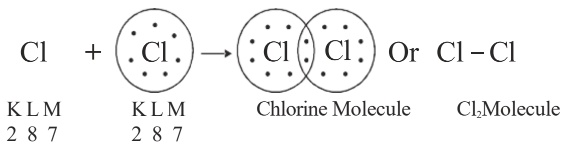
1. Single covalent bond (-)
2. Double covalent bond(=)
3. Triple covalent bond (≡)

1. Single covalent bond: <u>A single covalent bond is formed by the sharing of one pair of electrons between two atoms.</u> A single covalent bond is formed by the sharing of 2 electrons between the atoms, each atom contributing one electron for sharing.

Example of Single Covalent Bond:

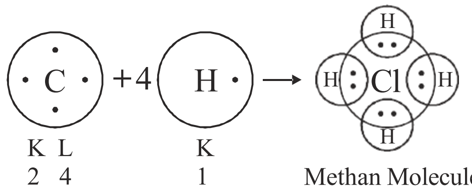
Ex1. Formation of a Chlorine Molecule (Cl_2)

The atomic number of chlorine is 17. So, its electronic configuration is 2, 8, 7. Hence, one atom of chlorine needs only one. Electron to achieve the electronic configuration of innert gas argon and become stable. So, two chlorine atoms share one electron each to form a chlorine molecule. The electron dot structure of chlorine molecules is shown below fig.

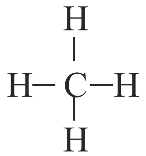


Ex2. Formation of a Methane Molecule, (CH_4):

The atomic number of carbon is 6. So its electronic configuration is 2, 4. Hence, one atom of carbon needs four electrons to achieve the electronic configuration of inert gas Neon and become stable and the atomic number of hydrogen is 1, so its electronic configuration is 1. So each atom of hydrogen needs only one electron to achieve the electronic configuration of inert gas Helium. Hence one atom of carbon shares its four valence electrons with one electron each of 4 hydrogen atoms to form a molecule of methane. The electron dot structure of methane molecule is shown in below figure.

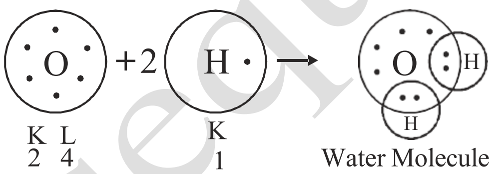


Methan Molecule

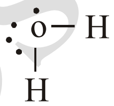
or  → CH_4 (Methane Molecule)

Ex3. Formation of a water molecule, (H_2O):

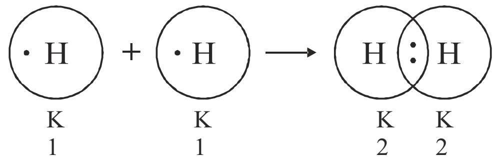
The atomic number of oxygen is 8, so its electronic configuration is 2, 6. Hence one atom of oxygen needs only two electrons to achieve the electronic configuration of inert gas Neon and become stable and the atomic number of Hydrogen is 1. So, its electronic configuration is 1. Hence each atom of hydrogen needs only one electron to achieve the electronic configuration of inert gas Helium and become stable. So, one atom of oxygen shares its two electrons with one electron each of two hydrogen atoms to form a water (H_2O) molecule. The electron dot structure of water molecule is shown in below figure.



Water Molecule

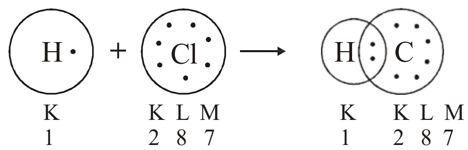
or  or H_2O (Water molecule)

Ex4. Formation of a Hydrogen Molecule: The atomic number of hydrogen is 1, so its electronic configuration is 1. So each atom of hydrogen needs only 1 electron to achieve the electronic configuration of inert gas Helium and become stable. So, two hydrogen atoms share one electron each to form single compound Bond and form a hydrogen molecule The electron dot structure of hydrogen molecules is shown in figure given below:



or H – H H_2 (Hydrogen Molecule)

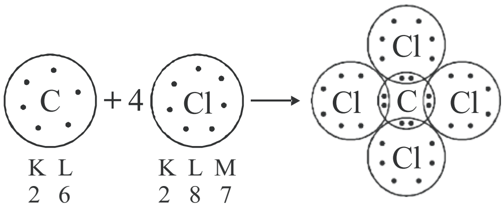
Ex5. Formation of a Hydrogen Chloride molecule (HCl): The atomic number of hydrogen is 1, so its electronic configuration is 1. So, each atom of hydrogen needs only 1 electron to achieve the electronic configuration of inert gas Helium and becomes stable and the atomic number of chlorine is 17, so its electronic configuration is 2, 8, 7. Hence, one atom of chlorine needs only 1 electron to achieve the electronic configuration of inert gas Argon and become stable. So, in the formation of hydrogen chloride molecule Hydrogen atom and chlorine atom share one electron each and form a hydrogen chloride molecule. The electron dot structure of HCl molecule is given below:

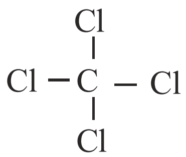


or H – Cl

HCl Molecule (Hydrogen Chloride Molecule)

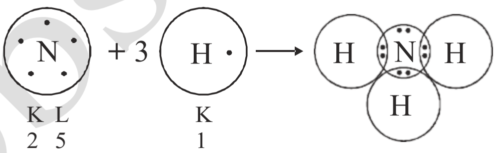
Ex6. Formation of a Carbon Tetrachloride molecule (CCl_4): The atomic number of carbon is 6. So its electronic configuration is 2, 4 so, one atom of carbon needs only 4 electrons to achieve the electronic configuration of inert gas Neon and become stable and the atomic number of chlorine is 17. So, its electronic configuration is 2, 8, 7 hence each atom of chlorine needs only one electron to achieve the electronic configuration of inert gas Argon and become stable. So one atom of carbon shares its four valence electrons with four chlorine atoms to form carbon tetrachloride molecule. The electron dot structure of CCl_4 is shown in below figure.

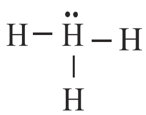


or  or CCl_4 (Carbon Tetrachloride molecule)

Cl_4Molecule

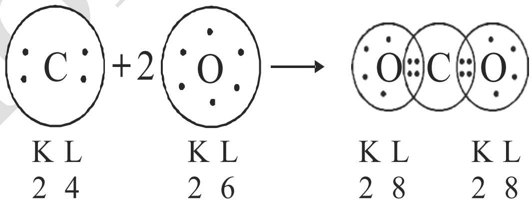
7. **Formation of Ammonia Molecule (NH_3):** The atomic number of nitrogen is 7. So, its electronic configuration is 2, 5 so, one atom of nitrogen needs only 3 electrons to achieve the electronic configuration of inert gas Neon and become stable and the atomic number of hydrogen is 1 so, its electronic configuration is 1. So each atom of hydrogen needs only one electron to achieve the electronic configuration of inert gas Helium and become stable. So, one atom of nitrogen shares its three valence electrons with three hydrogen atoms and form the ammonia molecule. The electronic dot structure of Ammonia molecule is shown is below figure.



or  or NH_1 (Ammonia Molecule)

2. **Double bond:** <u>A double bond is formed by the sharing of two pairs of electrons between two atoms.</u> Double covalent bond is formed by the sharing of four electrons between two atoms, each atom contributing two electrons for sharing. Examples of double covalent Bond.

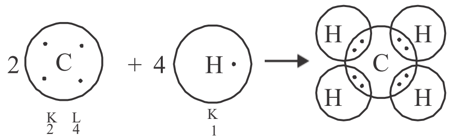
1. **Formation of Carbon dioxide Molecule (CO_2):** The atomic number of carbon is 6. So its electronic configuration is 2, 4 so one atom of carbon needs only 4 electrons to achieve the electronic configuration of inert gas Neon and become stable and the atomic number of oxygen is 8 so, its electronic configuration is 2, 6. So, each atom of oxygen needs two electrons to achieve the electronic configuration of inert gas Neon and become stable. So in the formation of CO_2 molecule one atom of carbon shares two electrons with each atom of oxygen and form double covalent bond with two atoms of oxygen.

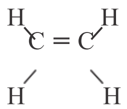


or O$=$C$=$O (CO_2 Molecule)

2. **Formation of Ethene Molecule, (C_2H_4)** The atomic number of carbon is 6. So, its electronic configuration is 2, 4 so, each atom of carbon needs 4 electrons to achieve the electronic configuration of inert gas Neon and become stable and the atomic number of hydrogen is 1 so, its electronic configuration is 1, so, each atom of hydrogen needs one more electron to achieve the electronic configuration of inert gas Helium and become stable. So, in the formation of ethene molecule, the two carbon atoms share two pair of electrons to form a double bond between two atoms of carbon. The remaining four electrons of the two carbon atoms are shared with four hydrogen atoms to form

four carbon-hydrogen single bonds. The electron dot structure of ethene is given below:

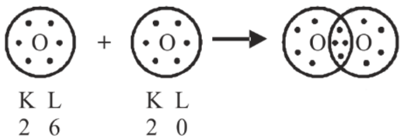




or C_2H_4 (Ethene Molecule)

E2. Formation of Oxygen Molecule, (O_2):

The atomic number of oxygen is 8, So, its electronic configuration is 2, 6. Hence each atom of oxygen needs only two electrons to achieve the electronic configuration of inert gas Neon and become stable. So, the atoms of oxygen share two pairs of electrons to form double covalent bond and form oxygen molecule. The electron dot structure of oxygen molecule is shown in the below figure.



O = O or O_2 (Oxygen Molecule)

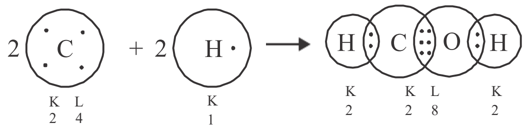
3. Triple Bond:

A triple bond is formed by the sharing of three pairs of electrons between two atoms. A triple bond is formed by the sharing of six electrons between two atoms, each atom contributing three electrons for sharing.

Examples of tripple covalent Bonds:

1. Formation of Ethyne Molecule, (C_2H_2)

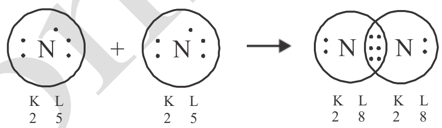
The atomic number of carbon is 6 so its electronic configuration is 2, 4 so, each atom of carbon needs 4 electrons to achieve the electronic configuration of inert gas Neon and become stable. The atomic number of hydrogen is 1.So its electronic configuration is 1. So each atom of hydrogen needs only 1 electron to achieve the electronic configuration of inert gas Helium and become stable. In the formation of ethyne molecule two carbon atom share three pair of electron and each carbon atom share one pair of electrons with two atoms of hydrogen. The electron dot structure of ethyne molecule is shown in below figure.



or H − C ≡ C − H or C_2H_4 (Ethyne molecule)

2 Formation of a Nitrogen Molecule (N_2):

The atomic number of nitrogen is 7, so its electronic configuration is 2, 5. So, one atom of nitrogen needs 3 more electrons to achieve the electronic configuration of inert gas Neon and become stable. So, the nitrogen atoms combine together by sharing 3 electrons each to form a molecule of nitrogen gas. The electron dot structure of nitrogen molecule is shown in below figure.



or N ≡ N or N_2 (Nitrogen molecule)

Difference b/w Covalent and Ionic Compounds

Ionic Compounds	Covalent Compounds
1. Ionic compounds are formed by transfer of electrons.	1. Covalent compounds are formed by sharing of electrons.
2. Ionic compounds are generally solid.	2. The covalent compounds may be liquid, gases or solid, .
3. The boiling points and melting points of ionic compounds are quite high.	3. Covalent compounds generally have low melting point and boiling point.
4. Ionic compounds are soluble in inorganic solvent like water.	4. Covalent compounds are soluble in organic solvent like, alcohol, benzene, chloroform etc.
5. Ionic compounds are good conductor of electricity.	5. Covalent compounds are bad conductors of electricity.
6. Ionic compounds react very rapidly.	6. Covalent compounds react very slowly.

Topic : Allotrophy

The phenomenon of existence of an element into two or more than two forms having similar chemical properties but different physical properties is called Allotrophy and the different forms of such element are called allotropes. There are three allotropes of carbon. These are

a. Diamond b. Graphite

c. Buckminsterfullerene

☞ If we burn diamond, graphite & buckminster-fullerene in the presence of oxygen of air, we get only carbon-di-oxide gas and no residue is left behind, this activity shows that allotropes of carbon are made up of only carbon atoms.

Occurance of Carbon: Carbon occurs in nature in 'free state' as well as in the 'combined state'

1. **In Free State:** In free state Carbon occurs in nature in the form of: diamond, graphite, buckminster-fullerene and some free carbon is also present in the earth crust.
2. **In the Combined State:** In the combined state Carbon occurs in nature in the form of compounds such as:
   (i) Carbon dioxide gas (CO_2) in air
   (ii) Carbonates or Bicarbonate (like limestone, marble and chalk) in the earth crest.
   (iii) Fossil fuels like coal, petroleum and natural gas in the earh crest.
   (iv) In organic compounds like carbohydrates, fats, proteins, wood, cotton and wool etc.

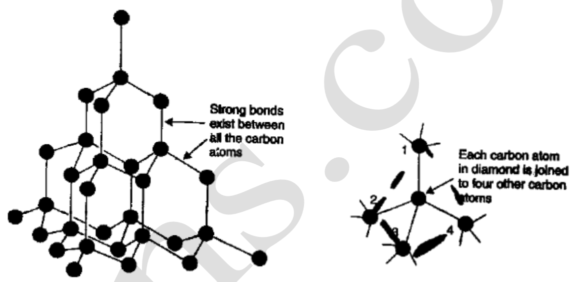
1. Diamond and their properties

Physical Properties:

1. Diamond is a colourless transparent substance.
2. Diamond has extraordinary brilliance.
3. Diamond is very hard substance. Infact it is the hardest natural substance.
4. Diamond does not conduct electricity due to absence of free electrons.
5. The density of diamond is very high (3.5 gram / cm^3).
6. Diamond has high melting point (3700^{o}C).
7. Diamond is a bad conductor of heat.

☞ Diamond burns in the presence oxygen of air on strong heating to form carbon dioxide gas and no residue is left behind. This result shows that diamond is made up of only carbon atoms. The symbol of diamond is C.

Structure of Diamond: A diamond crystal is a very big molecule of carbon atoms. Each carbon atom in the diamond crystal is linked to four other carbon atoms by strong covalent bonds in the form of tetrahedron shape.



Reason for hardness of diamond: In diamond crystal carbon atoms are strongly bonded to each other due to this, diamond crystal is very rigid. The rigid structure of diamond makes it very hard substance. Due to the rigid structure of diamond the density of diamond is very high and melting point and boiling point also very high.

☞ Diamond is a non - conductor of electricity this is because carbon atom has no free electron for conduction of electricity. In diamond crystal valence electron of each carbon atom are joined with other four carbon atoms and no electron is free with each carbon atoms due to this diamond does not conduct electricity.

Uses of Diamond:

1. Due to its hardness, diamonds are used in cutting instruments like glass cutters, saw for cutting marbles and in rock drilling equipment.
2. Diamonds are used for making jewellery, due to their extra ordinary brilliance.
3. Diamond are used in making special surgical equipment. Sharp edged diamonds are used by eye surgeons to remove cataract from eyes.

Note: Diamonds can be made artificially by subjecting pure carbon to very high pressure and temperature.

2. Graphite and their properties

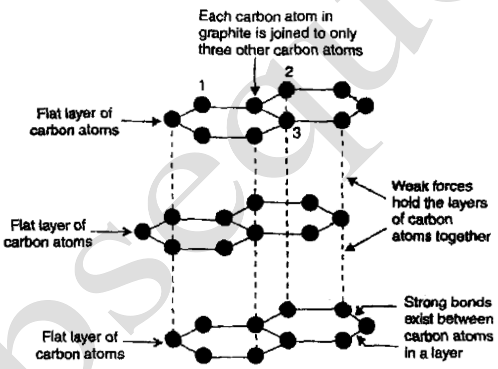
Physical Properties:

1. Graphite is a greyish - black opaque substance.
2. Graphite is soft and slippery to touch.
3. Graphite is a good conductor of electricity.
4. The density of graphite is 2.0 - 2.5 gram/cm^3.
5. The melting point of graphite is approx 1500^{o}C.

Note: Graphite burns on strong heating in the presence of oxygen of air to form carbon dioxide gas and no residue is left behind. This result shows that graphite is made up of only carbon atoms. The symbol of graphite is C.

☞ The allotropes of carbon, have different physical properties due to the different arrangement of carbon atoms in their crystals and they have same chemical properties because they are made up of same kinds of atoms.

Structure of Graphite: A graphite crystal consists of layers of carbon atoms.



Each carbon atom in a graphite layer is joined to three other carbon atoms by strong covalent bonds to form flat hexagonal rings. The various layers of carbon atoms in graphite are quite far apart so that no covalent bonds can exist between them. Due to the sheet like structure, graphite is a comparatively soft substance and Graphite is a good conductor of electricity. Due to the 'presence of free electrons' in a graphite crystal.

Uses of Graphite:

(1) Graphite is used for making carbon electrodes in dry cells and electric arcs. This is because it is a good conductor of electricity.

(2) Being soft, greasy, having high melting point and non volatile, powdered graphite is used as lubricant for the fast moving parts of heavy machines.

(3) Graphite is used as moderate in nuclear power plants.

(4) Graphite is used to make graphite crucibles because it has high melting point and good conductor of heat.

(5) Graphite is used for making the course of our pencils. This is because graphite is black in colour and quite soft.

Differences between Diamond & Graphite

Diamond	Graphite
1. Diamond has a three dimensional network structure.	1. Graphite has a two dimensional sheet like structure.
2. Diamond is a hard substance.	2. Graphite is a soft and greasy substance.
3. Diamond is a bad conductor of electricity.	3. Graphite is a good conductor of electricity.
4. Diamond is a bad conductor of head.	4. Graphite is a good conductor of heat.
5. Diamond is a transparent substance	5. Graphite is an opaque, and greyish black substance.

3. Buckminsterfullerene and their properties (C_{60}):

The chemical formula is Buckminsterfullerence is C_{60} buckminsterfullerene was named after the American Architect buckminsterfuller because its structure resembled with the frame work of dome shaped halls designed by fuller for the large International Exhibitions.

Physical Properties:

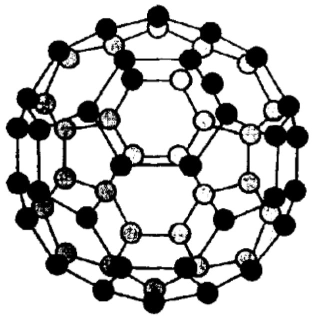
(i) These are dark solids at room temperature.

(ii) These are neither too hard nor too soft.

(iii) These are the purest allotrophic forms of carbon because of the absence of free valencies.

(iv) On burning, these produce only carbon di oxide gas.

Structure: C_{60} is a football shaped spherical molecule in which 60 carbon atoms are arranged in inter locking hexagonal and pentagonal rings of carbon atoms. one C_{60} molecule contains 20 hexagones and 12 pentagones of carbon atoms.



Uses of Bulkminister fullerene:

(i) In pure form, these behaves as insulators however, these can be converted into semi conductors under suitable conditions.

(ii) $C_{60}O$, a molecule formed when C_{60} traps O atoms, is used in cancer as well as AIDS therapy.

(iii) In small amounts, these are used to catalyse the photo chemical refining in industry.

☞ If we burn Buckminsterfullerene in the presence of oxygen of air, we get only carbon di oxide and no residue is left behind. This result shows that Buckminsterfullerene is made up of only carbon atoms.

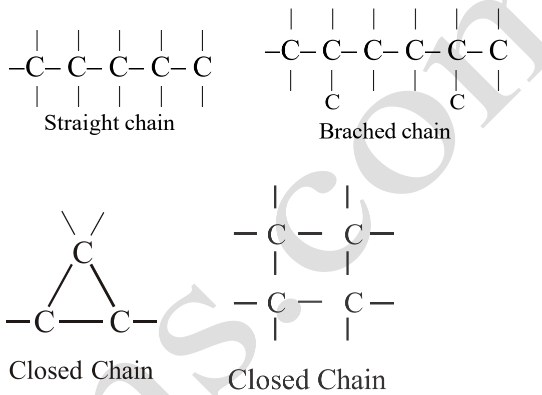
Versatile Nature of Carbon

Many things we use in our daily life are made of carbon atoms. The number of carbon compounds known today is approximately 4 millions but now the question is, which property or properties of carbon is/are responsible for the formation of such a large number of carbon compounds. There are two characteristics properties of carbon are responsible for this. These properties are:

(i) Catenation (self linking property)

(ii) Tetravalency of carbon element.

(i) **Catenation:** The ability of carbon atoms to combine with itself to form long chain of carbon atoms is called catenation, due to this property carbon gives large number of organic compounds. When carbon atoms combines with each other, there are three types of chains are formed these are: 1. Straight Chain. 2. Branched Chain 3. Closed Chain



(ii) **Tetravalency of carbon:** Carbon has a valency of four. Therefore, it is capable of bonding with four other atoms of carbon or other elements. Due to this property carbon gives large number of carbon compounds.

Topic: Organic Chemistry

The branch of chemistry in which we study the compounds of carbon is called organic chemistry.

Organic Compounds: The compounds of carbon (except oxides of carbon, Carbonates, Bi-Carbonates and carbides) are known as organic compounds. Organic compounds occure in all living things like plant and animals. Methane (CH_4), Ethane (C_2H_6), Ethene (C_2H_4), Ethyne (C_2H_2), Trichloromethane ($CHCl_3$), Ethanol (C_2H_5OH), Ethanal (CH_3CHO), Ethanoic acid (CH_3COOH), and Urea [$CO(NH_3)_2$]. These are the examples of organic compounds.

☞ Carbon compounds are covalent compounds having low melting points and boiling points.

Note: Urea [$CO(NH_2)_2$] was the first organic compound which has accidently prepared in the laboratory by German Chemist **Fridrich Woler** in 1828.

Reaction:

$$NH_4C\ell + KCNO \xrightarrow{\Delta} NH_4CNO + KC\ell$$

$$NH_4CNO \xrightarrow{\Delta} \underset{\text{Urea}}{H_2N - CO - NH_2}$$

Vital Force Theory: Until early nineteenth century, it was believed that organic compounds cannot be prepared in the laboratory but can only be isolated from animals and plants. On the basis of this belief, Berzelius, a leading Swedish Chemist in 1815, proposed Vital Force Theory. According to this theory, organic compounds are produced only under the influence of some mysterious force existing in the living organisms. This mysterious force was called the vital force. Since such a mysterious force cannot be created artificially, it is impossible to synthesize organic compounds in the laboratory.

Types of organic compounds: There are six types of organic compounds, these are:

1. Hydrocarbons
2. Haloalkanes
3. Alcohols
4. Aldehydes
5. Ketons
6. Organic Acids

1. Hydrocarbons

Those organic compounds which are made up of only hydrogen and carbon atoms are called hydrocarbons. Methane (CH_4), Ethane (C_2H_6), Ethyne (C_2H_2) etc are the examples of hydrocarbons.

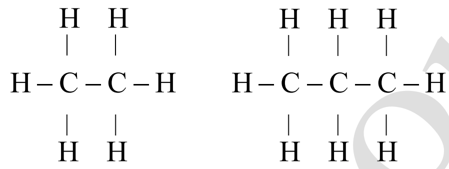
☞ The most important natural source of hydrocarbons are petroleum (or crude oil) and natural gas.

Types of Hydrocarbons: There are two types of hydrocarbons, these are

1. Saturated hydrocarbons and
2. Unsaturated hydrocarbons

1. Saturated Hydrocarbons (Alkanes)

A hydrocarbon in which the carbon atoms are connected by only single bonds (C–C) is called saturated hydrocarbon. Saturated hydrocarbons are also called alkanes. Methane (CH_4), ethane (C_2H_6), Propane (C_3H_8), butane (C_4H_{10}) etc, are the examples of saturated hydrocarbons



Ethane Propane

☞ The general formula of saturated hydrocarbons or alkanes is C_nH_{2n+2} where n is the number of carbon atoms in one molecule of the alkane. The first five members of homologous series of alkanes are given below:

Name of alkane	Number of C atoms (n)	Molecular formula
Methane	1	CH_4
Ethane	2	C_2H_6
Propane	3	C_3H_8
Butane	4	C_4H_{10}
Pentane	5	C_5H_{12}

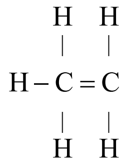
2. Unsaturated Hydrocarbons:

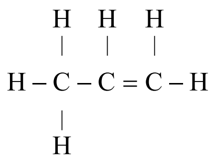
A hydrocarbon in which the two carbon atoms are connected by a 'double bond' or a 'triple bond' is called an unsaturated hydrocarbon. Unsaturated hydrocarbons are of two types these are:

a. Alkenes b. Alkynes

☞ The unsaturated hydrocarbons are obtained mostly from petroleum by a process called cracking.

a. Alkenes: An unsaturated hydrocarbons in which the two carbon atoms are connected by a double bond (C=C) are called alkenes. Ethene (C_2H_4) propene (C_3H_6) ... etc are the examples of alkenes.

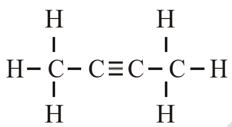

Ethene

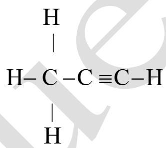

Propene

☞ The general formula of an alkene is $\mathbf{C_nH_{2n}}$ where n is he number of carbon atoms in its one molecule. The first five members of homologous series of alkenes is given below:

Name of alkene	Number of C atoms (n)	Molecular formula
Ethene	2	C_2H_4
Propene	3	C_3H_6
Butene	4	C_4H_8
Pentene	5	C_5H_{10}
Hexene	6	C_6H_{12}

b. Alkynes: An unsaturated hydrocarbon in which by two atoms of carbon are joined by a triple bond (C≡C) are called an alkynes. Ethyne (C_2H_2), propyne (C_3H_4), Butyne (C_4H_6) etc. are the examples of alkynes.


Butyne


Propyne

☞ The general formula of alkynes is C_nH_{2n-2} where 'n' is the number of carbon atoms in one molecule of the alkyne. The first five members of homologous series of alkynes are given below:

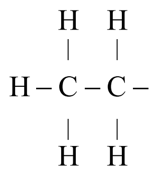
Name of alkyne	No. of carbon atoms (n)	Molecular formula
Ethyne	2	C_2H_2
Propyne	3	C_3H_4
Butyne	4	C_4H_6
Pentyne	5	C_5H_8
Hexyne	6	C_6H_{10}

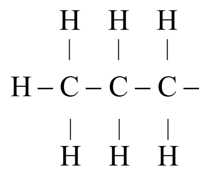
Note: The first member of alkynes and alkenes must be started with carbon 2 atoms because they have double bond and triple bond between two atoms of carbon. In one atom of carbon, double bond and triple bond are not possible.

Alkyl Group

The group formed by the removal of one hydrogen atom from an alkane is called an alkyl group. The general formula of an alkyl group is C_nH_{2n+1}. Methyl (CH_3-), ethyl (C_2H_5-) and propyl (C_6H_7) etc. are the examples of alkyl group. The first five members of homologous series of alkyl group is given below:

Name of alkyl	Number of C atoms (n)	Molecular formula
Methyl	1	CH_3
Ethyl	2	C_2H_5
Propyl	3	C_3H_7
Butyl	4	C_4H_9
Pentyl	5	C_5H_{11}


Ethyl


Propyl

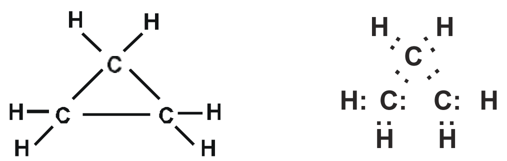
Topic: Cyclic Hydrocarbons

Those hydrocarbons in which the carbon atoms are joined in the form of ring are called Cyclic Hydrocarbons. There are two types of cyclic hydrocarbons: These are:

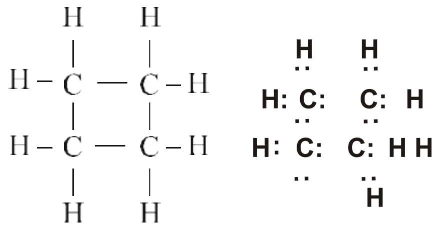
1. Saturated Cyclic Hydrocarons
2. Unsaturated Cyclic Hydrocarbons

1. Saturated Cyclic Hydrocarbons: Those hydrocarbons in which carbon atoms are joined with each other by single covalent bond in the form of ring are called saturated cyclic hydrocarbons. Cyclohexane (C_6H_{12}), cyclopentane (C_5H_{10}), cyclobutane (C_4H_8), cyclopropane (C_3H_6) etc. are the examples of satuarted cyclic hydrocarbons. The general formula of saturated cyclic hydrocarbon is C_nH_{2n}. Some examples of saturated cycic Hydrocarbons are given below:

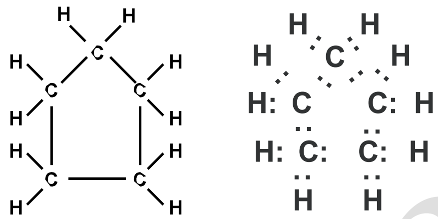
1. Structure of cyclo propane (C_3H_6)



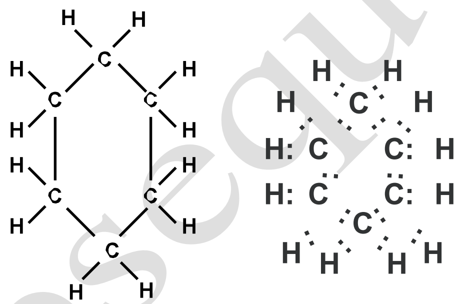
2. Structure of cyclo Butane (C_4H_8)



3. Sturcture of cyclo pentane (C_5H_{10})

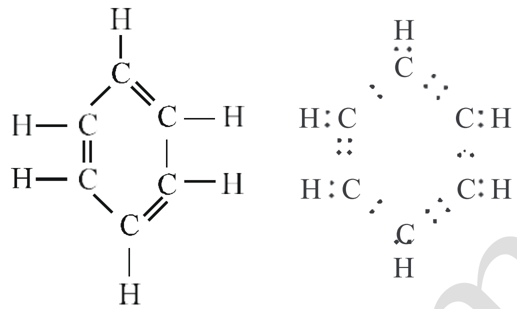


4. Sturcture of cyclo Hexane (C_6H_{12})



2. Unsatuared Cyclic Hydrocarbons: Those hydrocarbons in which carbon atoms are joined with each other alternatively by double bond in the form of ring are called unsatuared cyclic hydrocarbons.The gerenal formula of unstaurated cyclic hydrocarbon is C_nH_n. Benzene is an example of unsatuared cyclic hydrocarbon. The structural of benzene is given below.

1. Structure of cyclo benzene (C_6H_6)



Topic: Naming or nomenelature of Hydrocarbons or Organic Compounds:

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. There are three things required for the naming of Hydrocarbons (or organic comnpounds), these are:

(1) Word root (or stem) (2) Suffix (3) Prefix

(1) Word root: Word root tells us the number of carbon atoms present in an organic compound. For Example.

Number of carbon atoms present in Organic compounds	Name of 'word root'
One atom of carbon (1)	'Meth'
Two atoms of carbon (2)	'Eth'
Three atoms of carbon (3)	'Prop'
Four atoms of carbon (4)	'But'
Five atoms of carbon (5)	'Pent'
Six atoms of carbon (6)	'Hex'
Seven atoms of carbon (7)	'Hept'
Eight atoms of carbon (8)	'Oct'
Nine atoms of carbon (9)	'Non'
Ten atoms of carbon (10)	'Dec'

(2) Suffix: Suffix is a word which is added after the name of the compound. There are two types of suffix. These are:

(i) Primary Suffix (ii) Secondary Suffix

(i) Primary Suffix: Primary Suffix is issued to denote the nature of carbon to carbon bond in the organic compounds. The Table of Primary Suffix is given below:

Name of Group	Suffix	Nature of Carbon Bond
Alkane	'–ane'	C – C
Alkene	'–ene'	C = C
Alkyne	'–yne'	C ≡ C

(ii) **Secondary Suffix:** Secondary suffix is used to represent the functional group, if present in an organic compound. Secondary Suffix of some functional groups are given below:

Family of organic compounds	Functional group	Secondary Suffix
Alcohols	– OH –	– ol –
Aldehydes	– CHO	– al –
Ketones	– CO –	– One
Carboxylic Acid or organic acid	– COOH –	– Oic acid

(3) Prefix: Prefix is a Part of the IUPAC name which appear in the bigning it denotes the substituent group if present in the organic compound. (or Hydrocarbon)

Substituent Group	Prefix
– F	Fluoro
– Cl	Chloro
– Br	Bromo
– I	Iodo
– CH_3	Methyl
– C_2H_5	Ethyl
– C_3H_7	Propyl

(i) IUPAC nomenclature of Alkanes:

1. Select the longest chain of carbon atoms in hydrocarbons.
2. The alkyl groups present as side chains (branches) are considered as substituents and named separately as methyl (CH_3-) or ethyl (C_2H_5-) groups.
3. The carbon atoms of the longest carbon chain are numbered in such a way that the alkyl groups get the lowest possible number.
4. The position of alkyl group is indicated by writing the number of carbon atom to which it is attached.
5. The IUPAC name of the compound is obtained by writing the 'position and name of alkyl group' just before the name of 'parent hydrocarbon'.

Examples:

(i) CH_3 $CH_2 - CH_2 - CH_2 - CH_3$

IUPAC Name : Pentane

Common Name: *n* Pentane

(ii) $\overset{4}{C}H_3 \; \overset{3}{C}H_2 - \overset{2}{C}H(CH_3) - \overset{1}{C}H_3$

IUPAC Name : 2-Methyl Butane

Common Name: Iso Pentane

(iii) $\overset{4}{C}H_3 \; \overset{3}{C}H(CH_3) - \overset{2}{C}H(CH_3) - \overset{1}{C}H_3$

IUPAC Name : 2, 3-Diemethyl Butane

(iv) $\overset{4}{C}H_3 - \overset{3}{C}H_2 - \overset{2}{C}(CH_3)_2 - \overset{1}{C}H_3$

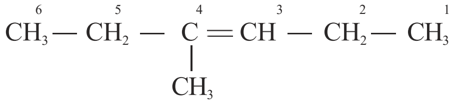
IUPAC Name: 2, 2-Diemethyl Butane

Common Name: Neo Hexane

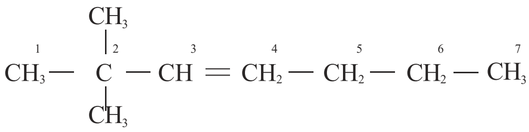
(ii) IUPAC nomenclature of Alkenes:

1. Select the longest continious chain of carbon atoms (called parent chain) including double bond.
2. The carbon atoms of the longest chain are numbered in such a way that double bond gets longest possible number.
3. The position of the Prefixes or Suffixes are indicated by numerical figures which are mentioned before their names are separated by hyphens (–).

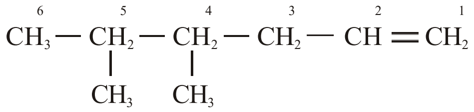
Examples:

(i) 

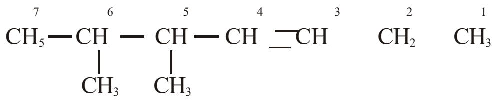
IUPAC Name: 4 – Methyl Hex - 3 - ene

(ii) 

IUPAC Name: 2, 2 - Dimethyl Hept - 3 - ene

(iii) 

IUPAC Name: 4, 5 - Dimethyl Hex - 1 - ene

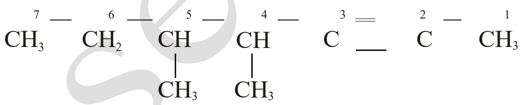
(iv) 

IUPAC Name: 5, 6 - Dimethyl Hept - 1- ene

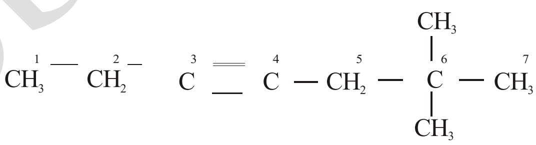
(iii) IUPAC nomenclature of Alkynes:

1. Select longest continious chain of carbon atoms called parent chain including tripple bond.
2. The carbon atoms of the longest carbon chain are numbered in such a way that tripple bond gets lowest possible number.
3. Prefixes or suffixes are indicated by numerical figures which are mentioned before their name are separated by hypenes (–).

Examples:

(i) 

IUPAC Name: 3,4-Dimethyl Helpt - 2- yne

(ii) 

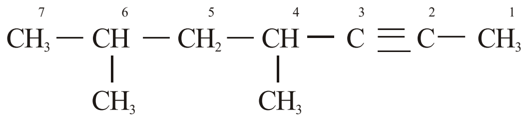
IUPAC Name: 7, 7 - Dimethyl Oct - 3 - yne

(iii) 

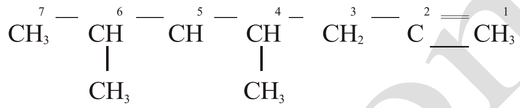
IUPAC Name: Hex - yne

(iv) 

IUPAC Name: Hept - 2 - yne

(v) 

IUPAC Name: 4, 5 - Dimethyl Hept - 2 - yne

(vi) 

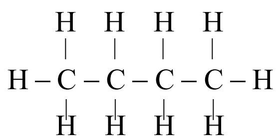
IUPAC Name: 4, 5, 6 - Tri methy Hept - 1 - yne

Topic : ISOMERS

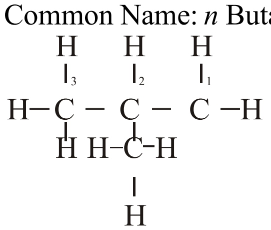
The organic compounds having the same molecular formula but different structures are known as isomers.

- **Isomerism:** The existence of two or more organic compounds having the same molecular formula but different structures is called isomerism. Isomerism is possible only with hydrocarbons having four or more carbon atoms. No isomerism is possible in hydrocarbons containing 1 or 2 or 3 carbon atoms per moleucles. The first member of isomers is butane.

(1) Isomers of Butane (C_4H_{10})

(i) 

IUPAC Name: butane
Common Name: *n* Butane

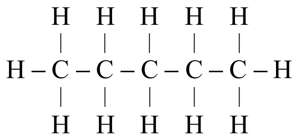
(ii) 

IUPAC Name: 2 methyl propane

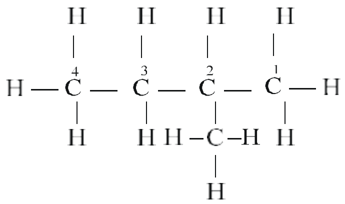
Common Name: Iso Butane

☞ There are only two isomers of butane.

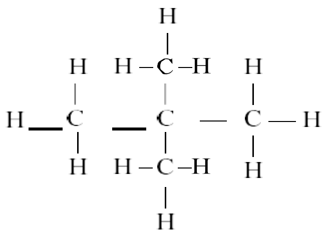
(2) Isomers of Pentane (C_5H_{12})

(i) 

IUPAC Name: Pentane
Commmon: *n* Pentane

(ii) 

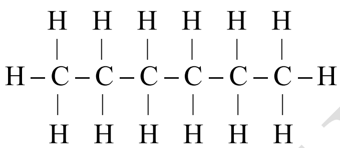
IUPAC Name: 2 - methyl Butane
Common Name: Iso Pentane

(iii) 

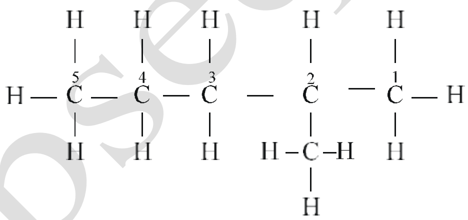
IUPAC Name: 2, 2, Die methyl Propane
Common Name:: Iso Pantane

☞ There are three isomers of pentane

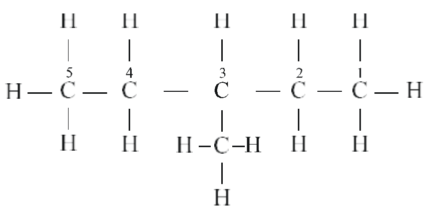
(3) Isomers of Hexane(C_6H_{14})

(i) 

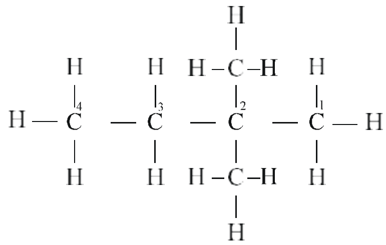
IUPAC Name: Hexane
Common Name: *n* Hexane

(ii) 

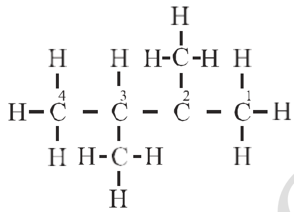
IUPAC Name: 2-methyl pentane
Common Name: Iso Hexane

(iii) 

IUPAC Name: 3-methyl pentane

(iv) 

IUPAC name: 2, 2 Die methyl Butane
Common Name: Neo Hexane

(v) 

IUPAC Name: 2, 3-Dimethyl Butane

Note:

Topic : Homologous Series

The series of organic compound having similar structure and similar chemical properties but different physical properties in which the successive compounds differ by CH_2 group. The Homologous Series of Hydrocarbons are given below:

(1) Homologous Series of Alkanes: The general formula of the homologus series of alkane is C_nH_{2n+2}. The first five members of the homologus series of alkanes are given below:

Number of C atoms (n)	IUPAC Name of alkane	Molecular formula
1	Methane	CH_4
2	Ethane	C_2H_6
3	Propane	C_3H_8
4	Butane	C_4H_{10}
5	Pentane	C_5H_{12}

(2) Homologous series of Alkenes: The general formula of homologous series of alkene is C_nH_{2n}. The first five members of the homologous series of alkenes are given below:

No. of C atoms	IUPAC Name of alkene	Molecular formula
2	Ethene	C_2H_4
	(Ethylene)	Common Name
3	Propene	C_3H_6
4	Butene	C_4H_8
5	Pentene	C_5H_{10}
6	Hexene	C_6H_{12}

(3) Homologous Series of Alkynes: The general formula of homologous series of alkyne is C_nH_{2n-2}. The first five members of the homologous series of alkynes are given below:

No. of C atoms	IUPAC Name of alkyne	Molecular formula
2	Ethyne	C_2H_2
	(Acetylene)	Common Name
3	Propyne	C_3H_4
4	Butyne	C_2H_6
5	Pentyne	C_4H_8
6	Hexyne	C_6H_{10}

Properties of Homologous series:

1. All the members of a homologous series can be represented by the same general formula.
2. Any two adjacent homologues differ by CH_2 group .
3. The difference in the molecular masses of any two adjacent homologues is 14 u.
4. All the compounds of a homologous series shows similar chemical properties & similar structure.
5. The members of a homologous series show a gradual change in their physical properties (like melting point, boiling point and density etc.) with increase in molecular mass.

Topic: Functional Groups

Saturated hydrocarbons are unreactive but if we introduce some other atom or group of atoms into it the resulting organic compounds (hydrocarbons) becomes reactive. The other atom or group of atoms is known as functional group.

Definition: An 'atom' or 'a group of atoms' which makes an organic compound reactive and decides its properties (or functions) is called a functional group.

For example, if we replace one hydrogen atom from ethane (C_2H_6) by group of atoms (–OH) called alcohol group, the new compound called ethyl alcohol or Ethanol is formed with new properties such as

(i) Ethane is a gas while ethanol is a liquid.

(ii) Ethyl alcohol react with sodium metal to form hydrogen gas, whereas ethane does not re act with sodium metal.

$$\underset{\text{ethane}}{C_2H_6} \xrightarrow[+(OH)]{-(H)} \underset{\text{ethanol}}{C_2H_5OH}$$

Types of Functional Group: There are six types of functional groups. These are:

1. Halo Group (–X)
2. Alcohol Group (–OH) or Alcoholic group
3. Aldehyde Group (–CHO) or Aldehydic group
4. Ketone Group (–CO–) or Ketonic group
5. Carboxylic Group (–COOH) or Organic acid

1. Halo group: -X (X can be Cl, Br or I)

: The halo group can be chloro (-Cl), bromo (-Br) ; or iodo (-I). The organic compounds containing halo group are called Haloalkanes. The general formula of halo alkanes is R – X (where R is an alkyl group). The homologous series of haloalkanes is given below:

S.No	IUPAC Name of Haloalkanes	Formula of Haloalkanes
1.	Chloromethane Methyl Chlorine	CH_3Cl (Common Name)
2.	Chloroethane	C_2H_5Cl
3.	Chloropropane	C_3H_7Cl
4.	Chlorobutane	C_4H_9Cl
5.	ChloroPentane	$C_5H_{11}Cl$

Naming of haloalkanes: The IUPAC naming of Haloalkane is given by the following concept.

CONCEPT: Write the name of Halo + Parent alkane

Example:

(i) $\overset{5}{C}H_3 - \overset{4}{C}H_2 - \overset{3}{C}H_2 - \overset{2}{C}H - \overset{1}{C}H_2 - Cl$

IUPAC Name: Chloro Pentane

(ii) $\overset{6}{C}H_3 - \overset{5}{C}H_2 - \overset{4}{C}H(Br) - \overset{3}{C}H(Br) - \overset{2}{C}H_2 - \overset{1}{C}H_3$

IUPAC Name: 3, 4–Dibromo Hexane

(iii) $\overset{6}{C}H_3 - \overset{5}{C}H_2 - \overset{4}{C}H_2 - \overset{3}{C}H_2 - \overset{2}{C}H_2 - \overset{1}{C}H_2 - I$

IUPAC Name: Iodo Hexane

(iv) $\overset{7}{C}H_3 - \overset{6}{C}H_2 - \overset{5}{C}H_2 - \overset{4}{C}H_2 - \overset{3}{C}H_2 - \overset{2}{C}H_2 - \overset{1}{C}H_2 - Br$

IUPAC Name: Bromo Heptane

2. Alcohol Group: -OH: The alcohol group is consist of one oxygen atom and one hydrogen atom. The alcohol group is also known as alcoholic group or hydroxyl group. The compounds containing alcohol group are known as alcohols. Methanol, (CH_3OH), ethanol (C_2H_5OH) etc are the examples of alcohol group. The molecular formula of alcohol is ($C_nH_{2n+2}O$) and the general formula of an alcohol is (R-OH) (where R is an alkyl group. The homologous series of alcohol is given below:

S.No	IUPAC Name of Alcohol	Formula of Alcohol
1.	Methanol Methyl Alcohol	CH_3OH Common Name
2.	Ethanol	C_2H_5OH
3.	Propanol	C_3H_7OH
4.	Butanol	C_4H_9OH
5.	Pentanol	$C_5H_{11}OH$

☞ The other common name of Methyl Alcohol is wood Alcohol.

Naming of alcohol: The IUPAC naming of Alcohols is given by the following concept.

CONCEPT: Write the anme of Parent Alkane – e + ol

Example:

(i) $\overset{6}{C}H_3 \; \overset{5}{C}H_2 - \overset{4}{C}H_2 - \overset{3}{C}H_2 - \overset{2}{C}H - \overset{1}{C}H_2 - OH$

IUPAC Name: Hexanol

(ii) $\overset{7}{C}H_3 - \overset{6}{C}H_2 - \overset{5}{C}H_2 - \overset{4}{C}H_2 - \overset{3}{C}H(OH) - \overset{2}{C}H_2 - \overset{1}{C}H_3$

IUPAC Name: Heptan - 3 – ol

(iii) $\overset{7}{C}H_3 - \overset{6}{C}H_2 - \overset{5}{C}H_2 - \overset{4}{C}H_2 - \overset{3}{C}H_2 - \overset{2}{C}H_2 - \overset{1}{C}H_2 - OH$

IUPAC Name: Heptanol

(iv) $\overset{7}{C}H_3 - \overset{6}{C}H_2 - \overset{5}{C}H_2(OH) - \overset{4}{C}H_2 - \overset{3}{C}H_2 - \overset{2}{C}H_2 - \overset{1}{C}H_3$

IUPAC Name: Heptan - 5 - ol

3. Aldehyde Group: –CHO

or $-\overset{O}{\overset{\|}{C}}-H$ or $-\overset{H}{\overset{|}{C}}=O$

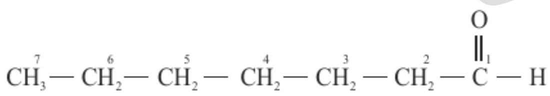
The aldehyde group consists of one carbon atom, one hydrogen atom and one oxygen atom. The organic compounds containing aldehyde group are called aldehydes. methanal, (HCHO), ethanal (CH_3CHO) etc. are the examples of aldehydes. The molecular formula of aldehydes is ($C_n H_{2n} O$) and the general formula of aldehyde group is (R-CHO) (where R is an alkyl group). The homologoes series of aldehydes is given below: .

S.No	IUPAC Name of Aldehyde	Formula of Aldehyde
1.	Methanal (Formal dehyde)	HCHO Common name
2.	Ethanal (Acetal dehyde)	CH_3CHO Common name
3.	Propanal	C_2H_5CHO
4.	Butanal	C_3H_7CHO
5.	Pentanal	C_4H_9CHO

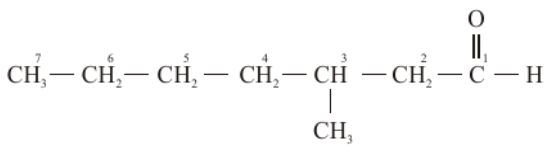
Naming of aldehydes: The IUPAC naming of Aldehydes is given by the following concept.

CONCEPT: Write the name of Parent Alkane – e + al

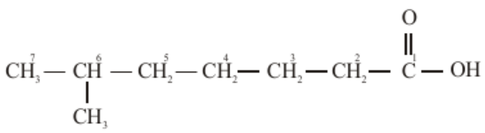
Example:

(i) 

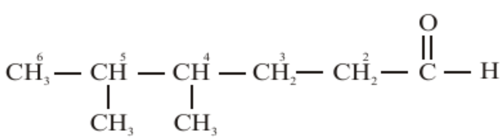
IUPAC Name : Heptanal

(ii) 

IUPAC Name : 3 - Methyl - 1 Heptnal

(iii) 

IUPAC Name : 6 - Methyl - 1 Heptanal

(iv) 

IUPAC Name: 4, 6 - Dimethyl - 1 - Hexnal

☞ The first member of aldehydic group is HCHO. The bonding of Aldehyde groups (–CHO) is completed by joining hydrogen atom not by alkyl group. If we add alkyle group before functional group then it become the second member of aldehydic group because one carbon atom is already present with functional group.

4. Ketone Group: $>C=O$ or – CO –

or $-\overset{\overset{O}{\|}}{C}-$ or — CO —

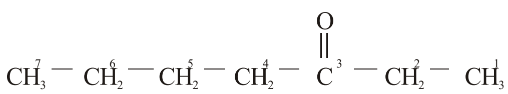
The ketone group consists of one carbon atom and one oxygen atom. The ketone group is also called a ketonic group. The organic compounds containing ketonic group are called ketones. The molecular formula of ketones is ($C_n H_{2n} O$) and the general formula of ketone is ($R-CO-R'$) (where R and R' are same or different alkyl group. Propanone, (CH_3 $COCH_3$), and butanone, ($CH_3COCH_2CH_3$) etc. are the examples of ketones. The Homologous series of ketones is given below:

S.No	IUPAC Name of Ketone	Formula of Ketone
1.	Propanone (Acetone)	CH_3COCH_3 Common Name
2.	Butanone	$CH_3COC_2H_5$
3.	Pentanone	$CH_3COC_3H_7$
4.	Hexanone	$CH_3COC_4H_9$
5.	Heptanone	$CH_3COC_5H_{11}$

Naming of Ketones: The IUPAC naming of Ketones is given by the following concept.

CONCEPT: Parent Alkane– e + one (read 'own')

Example:

(i) 

IUPAC Name: Heptan - 3 – one

(ii) $\overset{7}{CH_3}-\overset{6}{CH}(CH_3)-\overset{5}{CH_2}-\overset{4}{CH_2}-\overset{3}{C}(=O)-\overset{2}{CH_2}-\overset{1}{CH_3}$

IUPAC Name: 6–Methyl Heptane – 3 – one

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

IUPAC Name: 2 - Methyl Penten - 3 - one

(iv) $\overset{6}{CH_3}-\overset{5}{CH_2}-\overset{4}{CH_2}-\overset{3}{C}(=O)-\overset{2}{CH}(CH_3)-\overset{1}{CH_3}$

IUPAC Name: 2 - Methyl Hexan - 3 - one

NOTE: Ketonic group always occur in the middel of the organic compound. This is because if we join two atoms of hydrogen both the sides of ketonic group then it becomes a aldehyde. If we add one side hydrogen atom and other side is alkyle group than it also become aldehyde. So the first member of ketonic group must be starting from carbon three atoms. The first member of ketonic group is CH_3COCH_3 (Propone).

5. Carboxylic Acid Group (or Carboxy Group):

$-COOH$ or $-C(=O)-OH$ or $-C(OH)=O$

Carboxylic acid group consists of one atom of carbon, two atoms of oxygen and one atom of hydrogen. The carboxylic acid group is also called carboxyl group or organic acid group. The organic compounds containing carboxylic acid group (– COOH) are called carboxylic acids or organic acids.The molecular formula of carboxylic acids is ($C_n H_{2n}O_2$) and the general formula of organic acid is (R – COOH) where R is an alkyle group. The homologous series of organic acids is given below.

S.No	IUPAC Name of Acids	Formula of Acids
1.	Methanoic Acid Formic Acid	HCOOH Common Name
2.	Ethanoic Acid Acetic Acid	CH_3COOH Common Name
3.	Propanoic Acid	C_2H_5COOH
4.	Butanoic Acid	C_3H_7COOH
5.	Pentanoic Acid	C_4H_9COOH

Naming of Carboxylic acids: The IUPAC naming of carboxylic acids is given by the following concept.

CONCEPT: Write the name of Parent Alkane – e + oic acid

Example:

(i) $CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-COOH$

IUPACname Hexanoic acid

(ii) $CH_3\ \ CH_2-CH_2-CH_2-CH_2-C(=O)-OH$

IUPAC Name: Hexanoic acid

(iii) $CH_3\ \ CH_2-CH_2-CH_2-CH_2-CH_2-C(=O)-OH$

IUPAC Name: Heptanoic acid

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

IUPAC Name: Pentanoic acid

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

IUPAC Name: 3 - Methyl Pentan - 1 - oic acid

(v) $CH_3-CH_2-CH(CH_3)-CH_2-CH_2-C(=O)-OH$

IUPAC Name: 4 Methyl Hexane–1–oic acid

Topic : Chemical Properties of Hydro Carbon

1. Combustion (or Burning): Alkanes burns in the presence of oxygen of air to give carbon di oxide gas, water vapours and large amount of heat energy. For example when methane burns in the presence of oxygen if air to give carbon di oxide gas, water vapours and large amount of heat energy.

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Oxygen}}{2O_2} \xrightarrow{\text{Combustion}} \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{2H_2O} + \text{Heat}$$

☞ Alkanes burns in air with blue flame and produce a lot of heat due to this alkanes are considered excellent fuels.

☞ Organic compounds considered good fuels becomes they produces large amount of heat energy on burning.

Important Points

1. The saturated hydrocarbons (or alkanes) generally burns in air with a blue (non - sooty) flame. This is because, the percentage of carbon in the saturated hydrocarbons is comparatively low, which gets oxidised completely by the oxygen of air. If alkanes burns in insufficient supply of air then they also burns with sooty flame.
2. The unsaturated hydrocarbons (alkenes or alkynes) burns in air with a yellow, sooty flame (black smoke). This is because the percentage of carbon in the unsaturated hydrocarbons is very high which does not get oxidised completely by the oxygen present in air. If unsaturated hydrocarbons burns in pure oxygen, then they also burns with blue flame.

2. Substitution Reactions: Those reactions in which one (or more) hydrogen atoms of a hydrocarbon are replaced by some other atoms (like chlorine, bromine and iodine etc) are called substitution reactions. Substitution reactions is a characteristic property of saturated hydrocarbons (or alkanes).

(a) Substitution Reaction of Methane with Chlorine: Methane reacts with chlorine in the presence of sunlight to form chloromethane and hydrogen chloride.

$$\underset{\text{Methane}}{CH_4} + \underset{\text{Chlorine}}{Cl_2} \xrightarrow{\text{sunlight}} \underset{\substack{\text{Chloromethane} \\ \text{(or Methyl chlorine)}}}{CH_3Cl} + \underset{\substack{\text{Hydrogen} \\ \text{chloride}}}{HCl}$$

Note: By supplying more chlorine, it is possible to replace all the hydrogen atoms of methane by chlorine, one by one. In this way we obtain three more compounds these are:

1. Dichloromethane or Methylene dichloride, CH_2Cl_2 ; $CH_3Cl + Cl_2 \longrightarrow CH_2Cl_2 + HCl$.
2. Trichloromethane or Chloroform, $CHCl_3$; $CH_2Cl_2 + Cl_2 \longrightarrow CHCl_3 + HCl$.
3. Tetrachloromethane or carbon tetracloride, CCl_4. $CHCl_3 + Cl_2 \longrightarrow CCl_4 + HCl$.

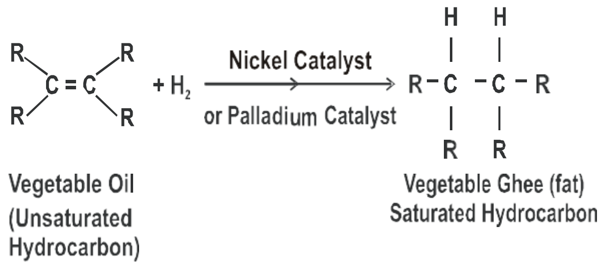
3. Addition Reactions: Those reactions in which unsaturated hydrocarbons combines with other substances (like, Hydrogen, Chlorine, Bromine etc.) to give a single product are called addition reactions. Addition reactions is a characteristic property of unsaturated hydroarbons.

Addition Reaction of Ethene with Hydrogen: Ethene react with hydrogen when heated in the presence of nickle or palladium catalyst to form ethane gas.

$$\underset{\substack{\text{Ethene} \\ \text{(unsaturated)}}}{CH_2 = CH_2} + \underset{\text{Hydrogen}}{H_2} \xrightarrow[\text{Heat}]{\substack{\text{Ni catalyst} \\ \text{or Palladium}}} \underset{\substack{\text{Ethane (saturated)} \\ \text{Single Product}}}{CH_3 - CH_3}$$

Hydrogenation: The addition of hydrogen with an unsaturated hydrocarbon to obtain a saturated hydrocarbon is called hydrogenation. Commercially Hydrogenation is used to prepare vegetable ghee (or vanaspati ghee) from vegetable oils.

Hydrogenation of Oil: When a vegetable oil is heated with hydrogen in the presence of finely divided nickel or palladium as catalyst, then a satuared fat called vegetable ghee is formed.



Note: Vegetable oils containing unsaturated fatty acids are good for our health. The saturated fats like vegetable ghee are not good for health, this is because they are unreactive so they accumulate in different parts of our body.

Test for Unsaturated Hydrocarbons: Add a few drops of bromine water to a test tube containing tested hydrocarbons. If the brown colour of bromine water disappears, than tested hydrocarbon is unsaturated.

Topic : Important Carbon Compounds

(i) Ethanol or Ethyl Alcohol (C_2H_5OH)

Ethanol (or Ethyl Alcohol) is the second member of homologus series of alcohol. The molcular formula of ethanol is C_2H_6O and the formula of ethanol is C_2H_5OH or $CH_3 - CH_2OH$ or $CH_3 - CH_2 - OH$. The common name of ethanol is ethyl alcohol.

Physical Properties of Ethyl Alcohol:

1. It is a neutral compound, ethanol has no effect on any type type of litmus paper on common indicator.
2. Ethanol is a colourless liquid having a pleasent smell and burning taste.
3. Ethanol is a volatile liquid having low boiling point of 78°C or (351 K).
4. It is lighter than water and mixed with water in any proportion.

☞ The solubality of ethanol in water is due to the persence of hydroxyl group (OH) in it.

Rectified Spirit (or commercial alcohol): 5% aqueous solution of Ethyl Alcohol is called rectified spirit. Rectified spirit is also called commercial alcohol.

Absolute Alcohol: 100% pure alcohol is called absolute alochol.

Additive Petral: A mixture of Petrol and Ethyl Alcohol is called additive petrol.

Chemical Properties of Ethyl Alcohol

1. Combustion: Ethanol burns in the presence of Oxygen of air with a blue flame to form carbon dioxide, water vapour, and releasing a lot of heat and light energy.

$$\underset{\substack{\text{Ethanol}\\\text{(Ethyl alcohol)}}}{C_2H_5OH} + \underset{\substack{\text{Oxygen}\\\text{(From air)}}}{3O_2} \xrightarrow[\text{(Burning}]{\text{Combustion}} \underset{\text{Carbon dioxide}}{2CO_2} + \underset{\text{Water vapour}}{3H_2O} + \text{Heat}$$

Note: All alcohols burns in the presence of Oxygen of air to form carbon dioxide gas, water vapours , and produce heat and light energy.

Ehthanol as a fuel: In some countries the mixture of Ethyl Alcohol and Petrol is used as fuel in cars. Such petrol is called additive petrol.

2. Oxidation: 'Oxidation' means 'controlled combustion'. When ethanol is heated with alkaline potassium permanganete solution $(KMnO_4 + NaOH)$ or acidified potassium dichromate solution $(K_2Cr_2O_7 + H_2SO_4)$ it gets oxidised to ethanoic acid:

$$\underset{\substack{\text{Ethanol}\\\text{(Ethyl alcohol)}}}{CH_3CH_2OH} + \underset{\substack{\text{Nascent Oxygen}\\\text{(Fromoxidisin g agent)}}}{2[O]} \xrightarrow[\text{(or Acidified } K_2Cr_2O_7)]{\text{Alkaline } KMnO_4\text{; Heat}} \underset{\substack{\text{Ethanoic acid}\\\text{(Acetic acid)}}}{CH_3COOH} + \underset{\text{Water}}{H_2O}$$

Note: The chemical formula of alkaline potassium permagnet is $(KMnO_4 + NaOH)$ and acidified potassium dichromate is ($K_2Cr_7O_7 + H_2SO_4$).

3. **Reaction with Sodium Metal:** Ethanol reacts with sodium metal to form sodium ethoxide and hydrogen gas:

$$\underset{\text{Ethanol (Ethyl alcohol)}}{2C_2H_5OH} + \underset{\text{Sodium}}{2Na} \longrightarrow \underset{\text{(Sodium ethoxide)}}{2C_2H_5ONa} + \underset{\text{Hydrogen}}{H_2}$$

Note: Above reaction is also used for testing of a alcohol.

4. **Dehydration of Ethanol:** When ethanol is heated with excess amount of concentrated sulphuric acid at a temperature of 170° C (or 443 K), it gets dehydrated to form ethene gas.

$$\underset{\text{Ethanol (Ethyl alcohol)}}{CH_3-CH_2OH} \xrightarrow[\text{(Dehydration)}]{\text{Conc.} H_2SO_4 : 170^\circ C} \underset{\text{(Ethene gas)}}{CH_2=CH_2} + \underset{\text{Water}}{H_2O}$$

Dehydration of an alcohol means removal of water molecule from it.

Note: In the above reaction concentrated sulphuric acid (H_2SO_4) act as dehydrating agent because, it removes water molecule from ethanol (or Ethyl Alcohol).

5. **Reaction with Ethanoic Acid:** Ethanol reacts with ethanoic acid on heating in the presence of a few drops of concentrated sulphuric acid to form a sweet smelling ester called ethyl ethanoate:

$$\underset{\text{Eh tan oic acid (Acetic acid)}}{CH_3COOH} + \underset{\text{Ethanol (Ethyl alcohol)}}{C_2H_5OH} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Ethyl ethanoate (Ethyl acetate)}}{CH_3COOC_2H_5} + \underset{\text{Water}}{H_2O}$$

Estrification: The reaction in which a carboxylic acid reacts with an alcohol in the presence of concentrated sulphuric acid to form an ester is called esterification.

ACTIVITY – 1

Aim: To demonstrate esterification process using ethanol (Ethyl Alcohol)and Ethanoic acid or acitic acid.

Materials Required: Beaker, Water, Test Tube, Ethanol, Acetic Acid, Conc Sulphuric acid (H_2SO_4) Tripod stand, Burner and Wire guaze, etc.

Procedure:

Step 1: Take 2 ml of ethanol in a test tube.

Step 2: Add 2 ml of ethanoic acid (acetic acid) in it.

Step 3: Add few drops of conc. H_2SO_4 in Test tube.

Step 4: Heated test tube in a beaker containing water.

Step 5: Observe the smell of the products formed.

Observations: Pleasent fruity smelling compound is formed.

Chemical Reaction:

$$\underset{\text{Eh tan oic acid (Acetic acid)}}{CH_3COOH} + \underset{\text{Ethanol (Ethyl alcohol)}}{C_2H_5OH} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Ethyl ethanoate (Ethyl acetate)}}{CH_3COOC_2H_5} + \underset{\text{Water}}{H_2O}$$

Conclusion: Carboxylic acid reacts with alcohol in the presence of conc. Sulphuric Acid (H_2SO_4) to form esters.

Tests for an Alcohol: An alcohol can be tested by the following two methods:

1. **Sodium metal Test:** The organic compound to be tested taken in a dry test tube and add a piece of sodium metals to it. If bubbles (or effervescence) of hydrogen gas are produced, it indicates that the given organic liquid is an alcohol.
2. **Ester Test for Alcohols:** The organic compound to be tested is heated with some pure etahnoic acid and a few drops of concentrated sulphuric acid. A sweet smell indicates that the organic compound is an alcohol.

Denatured Alcohol: Denatured alcohol is ethyl alcohol which has been made unfit for drinking purpose by adding small amounts of poisonous substance like methanol, pyridine and copper sulphate, etc.

Uses of Ethyl Alcohols: (Ethanol)

1. Ethyl alcohol (ethanol) is used in the manufacturing of paints, varnishes, lacquers, medicines, perfumes, dyes, soaps and synthetic rubber.
2. Ethyl alcohol (ethanol) is used as a solvent.
3. Ethyl alcohol (ethanol) is used as a fuel in cars alongwith petrol (called additive petrol).
4. Ethyl Alcohol is used as a fuel in spirit lamps.
5. Ethyl alcohol is used in alcoholic drinks like whisky, wine and beer etc.
5. Ethyl alcohol is used as an antiseptic in Hospital.

Harmful Effects of Ethyl Alcohol:

1. Alcohol slows down the activity of the nervous system and the brain.
2. Alcohol drinking lowers mental restrain due to which Person becomes quarrelsome.
3. Heavy drinking of alcohol over a long period of time can damage the stomach, liver heart and brain. The liver disease due to allcohol known as **'cirrhosis'**.
4. The drinking of adulterated alocohol causes severe poisoining leading to blindness and even death.

(ii) Ethanoic Acid (CH_3COOH)

Ethanoic acid is the member of Homologous same of carboxy acid. The formula of ethanoic acid is CH_3COOH. The molecules formula of Ethanin acid is C_2H_4O. The common name of ethanoic acid is acetic acid. A dilute solution of ethanoic acid in water is called vinegar. Vinegar contains about 5 to 8 per cent ethanoic acid.

Physical Properties of Ethanoic Acid:

1. Ethanoic acid is a colourless liquid having a sour taste and a smell of vinegar.
2. The boilding point of ethanoc acid is 118° C (391 K).
3. When pure ethanoic acid is cooled, it freezes to form a colourless, ice - like solid (which looks like a glacier). Due to this, it is called glacial ethanoic acid.
4. Ethanoic acid is miscible with water in all proportions.

Chemical Properties of Ethanoic Acid:

1. **Action on Litmus:** Dilute ethanoic acid turns blue litmus paper to red. Dilute ethanoic acid turns universal indicator paper to orange, showing that its pH is about 4. It means it is a weak acid.
2. **Reaction with sodium carbonate:** Ethanoic acid reacts with sodium carbonate to form sodium ethanoate, carbon dioxide gas and water.

$$\underset{\text{Ethanoic acid (Acetic acid)}}{2CH_3COOH} + \underset{\text{Sodium carbonate}}{Na_2CO_3} \longrightarrow \underset{\text{Sodium ethanoate (Sodiumacetate)}}{2CH_3COONa} + \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{H_2O}$$

3. **Reaction with Sodium Bi-carbonate:** Ethanoic acid reacts with Sodium Bi-carbonate to form Sodium Ethanoate, Carbondioxide gas and water.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Sodium hydrogencarbonate}}{NaHCO_3} \longrightarrow \underset{\text{Sodium ethanoate}}{CH_3COONa} + \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{H_2O}$$

ACTIVITY - 2

Aim: To demonstrate the reaction of carboxylic acid with sodium carbonate and sodium Bi-Carbonate.

Materials Required: Ethanoic acid, sodium carbonate, sodium Bi-Carbonate, Two Tes Tube

Procedure:

Step-1: Take 1 g of Sodium Carbonate (Na_2CO_3) in a test tube and add 2 ml of ethanoic acid into it.

Step-2: Pass the gas formed through lime water and note down the observations.

Step-3: Repeat the same procedure with sodium hydrogen carbonate and record your observations.

Observation: Brisk effervescence due to carbon dioxide formed which turns lime water milky.

Conclusion: Carboxylic acid reacts with Sodium carbonate and sodium Bi-Carbonate to liberate CO_2 gas which turns lime water milky.

3. **Reaction with Sodium Hydroxide:** Ethanoic acid react with sodium hydroxide solution to form a salt called sodium ethanoate and water.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Sodiumhydroxide}}{NaOH} \longrightarrow \underset{\text{Sodiumethanoate}}{CH_3COONa} + \underset{\text{Water}}{H_2O}$$

Note: In this reaction ethanoic acid behaves just like mineral acids (HCl, etc). In fact, all the carboxylic acids react with bases (or alkalis) like sodium hydroxide to form the corresponding salts and water.

4. **Reaction with Alcohols:** Ethanoic acid reacts with alcohols in the presence of a little of concentrated sulphuric acid to form esters.

Example: when ethanoic acid is heated with ethanol in the presene of a few drops of concentrated sulphuric acid, a sweet smelling ester called ethyl ethanoate is formed alongwith water.

$$\underset{\substack{\text{Ethanoic acid}\\(\text{Acetic acid})}}{CH_3COOH} + \underset{\substack{\text{Ethanol}\\(\text{Ethyl alcohol})}}{C_2H_5OH} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\substack{\text{Ethyl ethanoate}\\(\text{Ethyl acetate})}}{CH_3COOC_2H_5} + \underset{\text{Water}}{H_2O}$$

Hydrolysis of Esters: When an ester is heated with sodium hydroxide solution then its break down to form the parent alcohol and sodium salt of the carboxylic acid.

Example: when ethyl ethanoate is heated with sodium hydroxide solution, then its Break down to form sodium ethanoate and ethyl alcohol.

$$\underset{\substack{\text{Ethyl ethanoate}\\(\text{Ethyl acetate})}}{CH_3COOC_2H_5} + \underset{\text{Sodium hydroxide}}{NaOH} \xrightarrow{\text{Hat}} \underset{\substack{\text{Sodium ethanoate}\\(\text{Sodium acetate})}}{CH_3COONa} + \underset{\substack{\text{Ethanol}\\(\text{Ethyl alcohol})}}{C_2H_5OH}$$

Saponification: The break down of an ester by reacting with alkali to form sodium salt of acid (Soap) and alcohol is called saponification.

Tests for Carboxylic Acids:

1. **Sodim Bi-Carbonate Test:** The organic compound (to be tested) is taken in a test - tube and a pinch of sodium Bi-Carbonate added to it. Evolution of carbon dioxide gas with brisk effervescence shows that the given organic compound is a carboxylic acid.
2. **Ester Test:** The organic compound to be tested is warmed with some ethanol and 2 or 3 drops of concentrated sulphuric acid. A sweet smell (due to the formation of ester) shows that the organic compound is a carboxylic acid.
3. **Litmus Test:** Some blue litmus solution is added to the organic compound to be tested. If the blue litmus solution turns red, it shows that the organic compound is it is a carboxylic acid.

Uses of Ethanoic Acid:

1. Dilute ethanoic acid (in the form of vinegar) is used as a food preservative in the preparation of pickles and sauces (like tomato sauce).
2. Ethanoic acid is used for making cellulose acetate (artifical fibre).
3. Ethanoic acid is used in the manufacture of acetone (propanone) and esters used in perfumes.
4. Ethanoic acid is used in the preparation of dyes, plastic and pharmaceuticals.
5. Ethanoic acid is used to coagulate rubber from latex.

TOPIC : SOAPS & DETERGENTS

Detergent: Any substance which has cleansing action in water is called a detergent. There are two types of detergents

(i) Soapy detergents (Soaps)

(ii) Non - Soapy detergents (synthetic detergents)

Soaps: Soaps are the sodium salt (or potassium salt) of a long chain carboxylic acid (or fatty acid) which has cleaning properties in water. Sodium stearate $(C_{17}H_{35}COONa)$ and sodium palmitate $(C_{15}H_{31}COONa)$ etc are the examples of soap.

Note: A soap is the salt of strong base (NaOH) and weak carboxylic acid. So aqueous solution of soap is basic in nature. Being basic, a soap solution turns red litmus paper to blue.

Laboratory Preparation of Soap: Soap is made by heating animal fat or vegetable oil with concentrated sodium hydroxide solution (caustic soda solution). The fats or oils react with sodium hydroxide solution to form soap and glycerol:

$$\underset{\text{(An ester)}}{\text{Fat or oil}} + \underset{\text{(Alkali)}}{\text{Sodium hydroxide}} \xrightarrow{\text{Heat}} \underset{\left(\substack{\text{Sodium salt}\\ \text{of fatty acid}}\right)}{\text{Soap}} + \underset{\text{(An alcohol)}}{\text{Glycerol}}$$

Note: Fats and vegetable oils are naturally occurring Esters of long chain of carboxylic acids. The process of making soap by the hydrolysis of fats or oils with alkalies is called saponification.

ACTIVITY-3

Aim: Preparation of Soap in the Laboratory.

Raw Material: Vegetable oil, sodium chloride, sodium hydroxide, beaker and spirit lamp etc.

Procedure:

Step-1: Take about 20 mL of castor oil in a beaker.

Step-2: Add 30 mL of 20% sodium hydroxide solution to it.

Step-3: Heat the mixture with constant stirring till a paste of soap is formed.

Step-4: Then add 5 to 10 grams of common salt to it.

Step-5: Stirr the mixture well and allow it to cool. On cooling the solution, solid soap seperates out.

Step-6: When the soap sets, then it cut into pieces called 'soap bars'.

Function of Sodium Chloride: Though most of the soap seperates out on its own but some of it remains in solution. Common salt decreases the solubility of soap, due to which all the soap seperates out from the solution in the form of a solid.

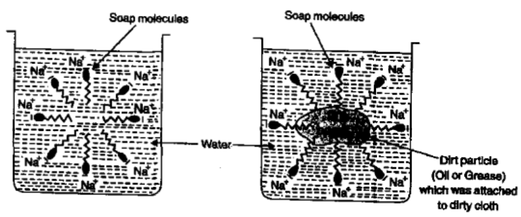
Structure of Soap Molecule: A soap molecule is consists of two parts.

(i) A long chain of hydrocarbon part (∼∼) and a short ionic part $(-COO^-Na^+)$ group.

(ii) The soap molecule is also called a tadpole structure (∼∼∼∼●). The long chain of hydrocarbon part of soap molecule is called hydrophobic (water repelling). Which is insoluble in water, but soluble in oil or grease. The short ionic part of soap molecule is called hydrophillic (water attracting) which is soluble in water, but insoluble in oil or grease.

Micelle: A spherical aggregation of soap molecules in the soap solution is called a 'micelle'.

Cleaning Action of Soap: When soap is dissolved in water it form a collidal solution in water. In which soap molecules form spherical micelles. When dirty clothe is put in water containing dissolved soap, the hydrocarbon parts of the soap molecules in the micelles attach to the oil or grease particles present on the surface of the dirty clothes. The ionic parts of the soap molecules in the micelles, however, remains attached to water, when dirty cloth is agitated in soap solution the oily and greasy particles present on the surface of dirty cloths are removed due to which the soap water becomes dirty and the clothes get cleaned.



(a) Soap micelle (b) Soap micelle entraps the dirt particle

Limitation of Soaps:

1. Soaps do not work properly with hard water. **Reason:** The hard water contains calcium ions (Ca^{2+}) and Magnesium ions (Mg^{2+}). Soap react with calcium ions and magnesium ions to form white precipitate which is called scum.
2. Soap is not suitable for washing woolen garments because it is basic in nature and wollen garments have acetic dyes.
3. Soaps are less effective in saline water and acidic water.

2. Synthetic Detergents: Detergents are also called 'soap-less soaps' because, they act like a soap but they do not contain the usual 'soaps' like sodium stearate, sodium Palmitate.

Definition: Detergents are the sodium salt of a long chain benzene sulphonic acid which has cleansing properties in water.

$$CH_3 - (CH_2)_{11} - C_6H_4 - SO_3^- \ Na^+$$

Sodium n–dodecyl benzene sulphonate
(A common detergent)

Structure of Detergents molecules: Detergent molecule consists of two part (i) A long chain Hydrocarbon part (~~~~) and (ii) a short ionic part ($SO_3^- Na^+$). The detergent molecule is said to have tadepole structure. The long chain of Hydrocarbon. Part of detergent molecule is called hydrophobic (water replling) which is Insoluble in water, but soluble in oil or grease. The short ionic part of detergent molecule is called hydrophilic (water attracting) which is soluble in water. But, Insoluble in oil or grease.

Cleaning action of detergent: When detergent is dissolved, in water, it form colloidal solution in water. In which detergent molecules form spherical micelles. When dirty cloths is put in water containing deter- gent, then the Hydrocarbon parts of the detergent molecules in the micelles attach to the oil or grease particles present on the surface of the dirty cloths. The ionic part of the soap molecules in the micells, however, remains attached to water, when dirty cloth is agitated in detergent solution, the oily and greacy particles present on the surface of the cloths are intrapped by detergent molecules get dispresed in water, due to which the detergent water becoes dirty and the cloths get cleaned detergent.

Advantages of Detergents over Soaps:

(i) Detergents work well even with hard water but soaps do not.

(ii) Detergents may be used in saline or acidic water.

(iii) Detergents are more easily soluble in water then soaps.

(iv) Detergents can be used for washing woollen garments whereas soaps cannot be used.

Disadvantages of Detergents over Soaps:

(i) Synthetic detergents having branched hydrocarbon chain are not fully biodegradable i.e., they are not decomposed by microrganisms in sewage and create water pollution.

Difference between Detergent and soap

Soap

1. Soaps are the sodium salts of long chain carboxylic acid.
2. Soaps do not work with hard water.
3. Soaps are biodegradable.
4. Soaps have relatively weak cleansing action.
5. Soaps do not work properly with saline water and acidic water.

Detergent

1. Detergents are the sodium salts of long chain benzene sulphonic acid.
2. Detergents work properly with hard water.
3. Detergents are non biodegradable.
4. Detergents have a strong cleansing action.
5. Detergents are obtained from coaltar and petrolium.
6. Detergents can be used even in acidic solution.