10th Compounds of Carbon Chemistry

<u>Position of carbon in the periodic table: -</u>

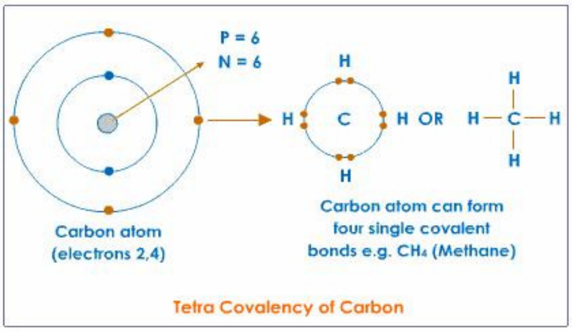
Carbon is a typical nonmetal. An atom of carbon has four electrons in its outermost shell. So, it lies in Group IV A (now Group 14) of the periodic table. It has two electronic shells (K and L). So, it lies in the second period of the periodic table. The elements of Group IV A (now Group 14) are; Carbon (C), Silicon (Si), Germanium (Ge), Tin (Sn), Lead (Pb).

<u>Occurrence of Carbon in Nature: -</u>

Carbon is one of the most widely distributed elements. It occurs free as well as in the combined state,

a) Free carbon occurs as diamond, graphite, and coal.
b) Carbon in the combined form occurs as carbonates, such as limestone ($CaCO_3$), magnesite ($MgCO_3$), calamine ($ZnCO_3$), dolomite ($CaCO_3$. $MgCO_3$) etc.
c) Carbon in the combined form also occurs as hydrocarbons in marsh gas, petroleum, coal tar etc., and as CO_2 in the atmosphere to an extent of about 0.03 percent. Carbon is a common constituent of all organic compounds.

<u>Tetravalency of Carbon: -</u> A carbon atom has four electrons in its outermost (valence) shell. So, it needs four more electrons to complete its octet. A carbon atom completes it octet by a result, carbon atom forms four covalent bonds by sharing valence electrons with other atoms. This is knows as tetravalency of carbon, (tetra means four). These four valencies of carbon are directed towards four corners of a tetrahedron, and directed towards four corners of a tetrahedron, and inclined to each other at an angle of $109^0 28'$. The carbon atom is assumed to be at the centre of tetrahedron. In common use, the four valencies of carbon are shown by four bonds around a carbon atom.



<u>Self linking property of carbon (Catenation): -</u>

The property of self-linking is also called the property of self-combination or catenation. Carbon has unique property by virtue of which it forms regular covalent bonds with other carbon atoms almost infinitely. This self-linking property of carbon leading to the formation of long chains and rings of carbon atoms is called self-combination or catenation.

It is due to this property of self-linking (catenation) that carbon forms very large number (about 5 million) of compounds.

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  |   |   |   |   |
- C – C – C – C – C –
  |   |   |   |   |
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Straight chain

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- C – C – C – C – C –
          |
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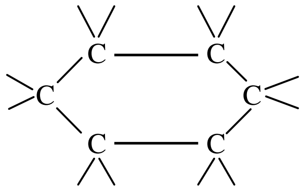
Branched Chain



Ring Chain

<u>Allotropy: -</u>

Many elements can exist in more than one form, which have different physical properties but similar chemical properties. The property by virtue of which an element can exist in more than one physical form is called allotropy.

The various physical forms of an element which have different physical properties but similar chemical properties are called its allotropic forms, or simply as allotropes.

For example, the main allotropic forms of phosphorus are white (yellow) phosphorus and red phosphorus.

<u>Allotropic forms of carbon: -</u>

The various allotropic forms of carbon broadly fall into the following two categories.

a) Crystalline form: - Diamond and Graphite are the two crystalline allotropic forms of carbon.
b) Amorphous form: - Coke, Coal, Lamp black, Carbon black, Gas carbon, Animal charcoal, wood charcoal are the amorphous allotropic forms of carbon.

Diamond and graphite are the purest forms of carbon.

Diamond: - Diamond is the purest crystalline form of carbon. Structurally, each carbon atom is surrounded by four other carbon atoms at an angle of $109^0 28'$, which are present at the vertices of a regular tetrahedron. Diamond is an aggregate of carbon atoms. The number of carbon atoms in any piece of diamond depends upon its size. Therefore, diamond may be described by the formula C_n, where n is a very large whole number. Commonly diamond is represented by its empirical formula C.

Occurrence of diamond: - Diamonds were first found in Golconda (India) around 800 BC. About 2400 years later (1600 AD), diamonds were also found in Brazil. In 1866, diamonds were found in Hope Town (South Africa). In India, diamonds have been found around Panna in Madhya Pradesh and Wajrakarur in Andhra Pradesh. At present, South Africa is the largest producer of natural diamonds in the world. The famous Kohinoor diamond (186 carat) was found at Wajrakarur (India). The Cullinan found in Pretoria in 1905 was the largest diamond (3032 carat) ever found. Later it was cut into nine pieces.

Diamonds are weighed in carats: 1 carat = 200 miligrams.

Diamonds in nature: -

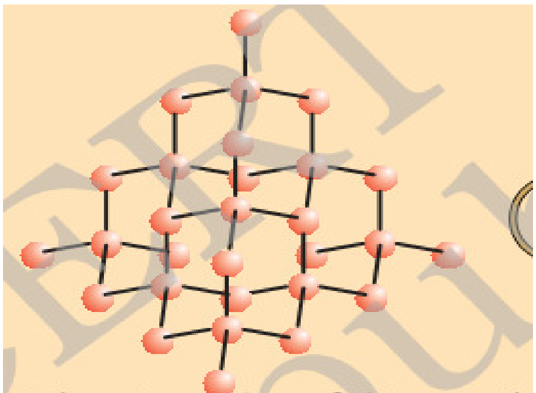
Diamond is formed from the carbon present in the upper mantle of the earth at depths of over 150 km under extremely high pressure (about 70,000 atmosphere) and temperature (about 15000 C). Diamonds thus formed are brought to the surface along with the kimberlite rock provided the kimberlite shoots up fast enough at a speed of about 15 km per hour. The kimberlite rock serves as the carrier rock (or source rock) for diamonds.

Properties of diamond: - Some important properties of diamond are given below: -

1. **Appearance:** - Diamond is a transparent substance having high refractive index, (refractive index value: 2.45). Properly cut and polished diamonds shine and shine and show extraordinary brilliance. It occurs as octahedral crystals.
2. **Hardness: -** Diamond is the hardest natural substance known.
3. **Density: -** Diamond has high density. At room temperature, its density is 3.5 g/ml, (or 3500 Kg/m^3)
4. **Electrical conductivity: -** Diamond is a nonconductor of electricity, i.e. electricity cannot pass through a diamond.
5. **Thermal conductivity:-**Diamond is a nonconductor of heat; i.e.diamond does not permit heat to pass through it.
6. **Solubility: -** Diamond is insoluble in all known solvents.
7. **Action of air: -** When heated in air at 900^0 C, it burns to give carbon dioxide (CO_2).
8. **It is not attacked** by acids and alkalies. It reacts with fluorine at high temperature forming carbon tetraflouride.

Structure of diamond: -

Diamond is an aggregate of carbon atoms. In diamond each carbon atom is surrounded by four other carbon atoms tetrahedrally. Thus, a diamond, each carbon atom lies at the centre of a tetrahedron and the four other carbon atoms surrounding it lie at the corners of the tetrahedron. Each carbon atom in diamond is bonded to its neighbours by single covalent bonds.



The structure of diamond

As a result of this continuous network of carbon-carbon covalent bonds,

a) Diamond is very hard. b) Diamond has high melting and boiling points.
b) Diamond is a nonconductor of heat of electricity.

Uses of diamond: -Some important uses of diamonds are,

a) Diamond is used as precious decorative stones in jewellery. This is because of its extraordinary brilliance due to high refractive index.

b) Diamonds are used to manufacture tools for cutting and grinding glass and rocks, and making dies for drawing very thin wires of harder metal. Thus, diamonds are used for making rock cutting and drilling equipments. Diamond dust (very fine powder) is used for polishing hard surfaces. These uses of diamond are due to its extraordinary hardness.

c) Diamonds are also used for making high precision cutting tools for use in medical field such as, removal of cataract.

d) Diamonds are used for making high precision thermometers. This is because of its high sensitivity to the heat rays.
e) Diamonds are used for making protective windows for spacecrafts. This is because diamonds do not allow harmful radiation to pass through them.

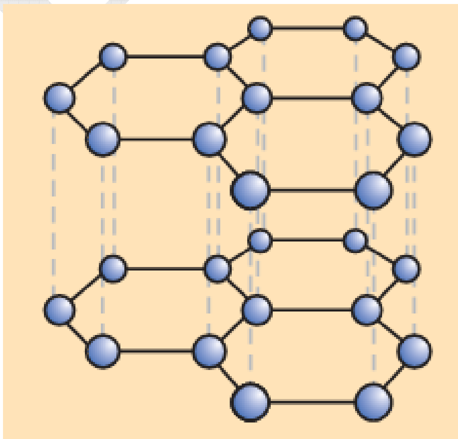
Graphite: - Graphite is also known as black lead because it marks paper black. Graphite is another crystalline allotropic form of carbon. A graphite crystal is an aggregate of carbon atoms and can be described by the formula C_n where n is a large integral number. The value of n depends upon size of the graphite crystal. In common use, graphite is described by the symbol C.

Occurrence of graphite: - Graphite occurs free in nature and is more widely distributed in nature than diamond. It is found extensively in Ceylon, Siberia, Canada, U.S.A, India, etc. In India, graphite is found in Orissa, Rajasthan, Bihar, Jammu and Kashmir, Andra Pradesh and Tamilnadu.

Graphite is also prepared artificially by heating anthracite coal with a little iron oxide or silica (catalyst) in an electric furnace.

Properties of graphite: - Some important properties of graphite are:

1. **Appearance:** Graphite is black, opaque material having metallic (shiny) lustre. Graphite occurs as hexagonal crystals.
2. **Hardness:** - Graphite is soft having a soapy (slippery) touch.
3. **Density: -** Graphite is lighter than diamond. The density of graphite is 2.3 g.ml (or 2300 kg/m3).
4. **Electrical conductivity:** - Graphite is good conductor electricity. That is why it is used for making electrodes in dry cells, electrolytic cells and in electric arc furnaces.
5. **Thermal conductivity:** - Graphite is a good conductor of heat. That is why graphite is used for making crucibles for melting metals.
6. **Melting Point: -** Graphite has a very high melting point (38000 C).
7. **Solubility: -** Graphite is insoluble in all common solvents.
8. **Action of air: -** Graphite is insoluble in all common solvents.
9. **It is not atta**cked by acids and alkalies.



Structure of Graphite: - In graphite, carbon atoms are arranged hexagonally in flat parallel layers. Each carbon atom in these layers is bonded to three others by covalent bonds.

Each layer is bonded to the adjacent layers by weak van der Wall's forces. As a result, each layer can slide over the other easily.

Graphite as a soft, slippery lubricant: -

Graphite has a layered (sheet-like) structure. Each layer is bonded to the neighboring layers by weak van der Walls' forces. Thus, each layer can slide over the other easily. It is because of this layered structure that graphite is soft, slippery and can act as a lubricant.

Graphite as a good electrical conductor: -In graphite, each carbon atom in a layer is bonded to three other carbon atoms. Thus, in graphite only three valence electrons of each carbon atom are used in bonding. As a result, the fourth valence electron of each carbon atom remains 'free'. These 'free' electrons can easily flow through the entire body of graphite. So, the presence of 'free' electrons in graphite makes it a good conductor of electricity. In other words, graphite is a good conductor of electricity due to the presence of 'free' electrons in its structure.

Uses of graphite: -Graphite is mainly used for the following purposes: -

a) **For making electrodes in dry cells and electric arc furnaces: -** Graphite being electrically conducting is used for making electrodes in dry cells, electric arc furnaces etc.
b) **As a high temperature lubricant: -** Graphite is nonvolatile, soft and slippery. So, graphite powder is used as a lubricant for fast moving machines at higher temperature.
c) **For making crucibles for melting metals: -** Graphite has very high melting point. It is a good conductor of heat. So, graphite is used for making crucibles for melting metals and alloys.
d) **For manufacturing lead pencils: -** Graphite marks paper black. So, graphite is used for making the core of lead pencils**.** **e) For the manufacture of gramophone records and in electrotyping**

e) **For the manufacture of artificial diamonds: -** Graphite when heated under very high pressure in the presence of a catalyst gives artificial diamond.

Distinguish between graphite and diamond: -

Diamond and graphite are two allotropes of carbon. Diamond and graphite both are covalent crystals. But, they differ considerably in their properties. Their properties are described below:

Property	Diamond	Graphite
1. Occurrence	Diamond occurs naturally in free state.	Graphite occurs naturally, as well as manufactured artificially.
2. Hardness	Diamond is the hardest natural substance known.	Graphite is soft and greasy to touch.
3. Density	Diamond has high density (3.5 g/mL)	Graphite has a density of 2.3 g/mL
4. Appearance	Diamond is transparent and has high refractive index (2.45)	Graphite is black in colour and opaque.
5. Electrical and thermal conductivities.	Diamond is a nonconductor of heat and electricity.	Graphite is a good conductor of heat and electricity.
6. Action of air	Diamond burns in air at 900^0 C to give CO_2	Graphite burns in air at 700 – 800^0C to give CO_2
7. Crystal shape	Diamond occurs as octahedral crystals.	Graphite occurs as hexagonal crystals.
8. Solubility	Diamond is insoluble in all solvents.	Graphite is insoluble in all solvents.

Fullerenes:- fullerenes reprent the recently prepared allotrophic form of carbon. These 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} allotrophe and traces of compounds containing even up to 370 carbon atoms.

Out of the different fullerenes that are known only the structure of C_{60} has been established on the basis of investigations carried by Buckminster. This is often called Buckminster Fullerene. Its shape resembles that of a soccer ball with six membered as well as five membered rings. There are in all twelve five membered and twenty six membered rings. All the carbon atoms in fullerenes have been found to be equivalent and are connected by both single bonds and double bonds. These are often called buckyballs.

Fullerenes reprent the purest allotropic form of carbon ,since they don't have any free valences or surface bonds to attract other atoms.

Uses of Fullerenes:-

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

ii) Bukyballs ability of fullerenes to trap different atoms or molecules makes them useful in the medical field. For example, radioactive $C_{60}O$ can be used in cancer as well as AIDS therapy.

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

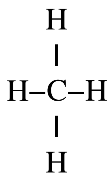
iv) Fullerenes in small amounts can catalyze the photochemical refining in industry.

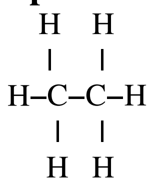
Organic Compounds:-

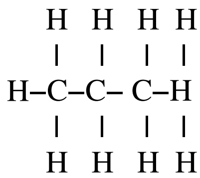
Organic compounds are the hydrocarbons and their derivatives. These are regarded as the derivatives of hydrocarbons since they can be formed by replacing the hydrogen atoms in the hydrocarbons by these atoms.

Classification of organic compounds:-

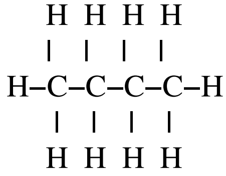
Open chain compounds:- these compounds contain an open chain of carbon atoms which may be either straight chain or branched chain in nature. Apart from that, they may be also saturated or unsaturated based upon the nature of bonding in the carbon atoms. For examples,


(Methane)

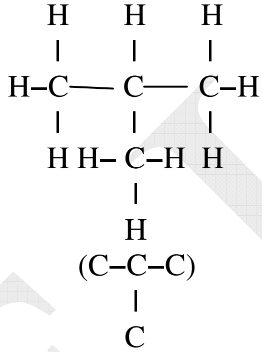

(Ethane)


(Propane)

(All are straight chain alkane molecules)


(C–C–C–C)

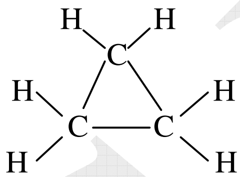
Butane


2-Methylpropane

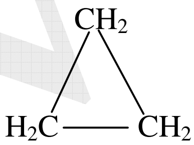
Open chain compounds are also known as aliphatic compounds because some of the originally known compounds were obtained from animal fats (In Greek; alei : animal and phato : fats.)

<u>Closed Chain or Cyclic Compounds</u>:- 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.

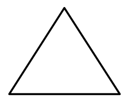
(a) **Alicyclic compounds**. These compounds contain ring of three or more carbon atoms and resemble aliphatic compounds in characteristics. For example, cyclopropane (C_3H_6) can have the following ring structures which are all basically same but differ in presentation.


(Structural formula)

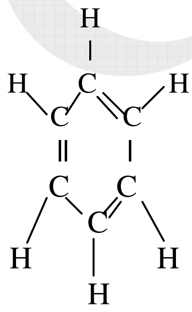
OR


(Condensed formula)

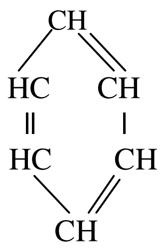
OR


(Bond line notation)

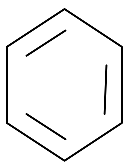
(b) **Aromatic compounds**. Aromatic compounds are the cyclic compounds which contain in them one or more hexagonal rings of carbon atoms with three double bonds in the alternate positions. This is known as benzene ring.


(Structure formula)

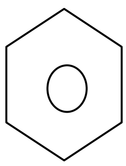
OR


(Condensed formula)

OR

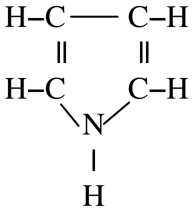


OR

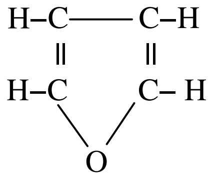

(Bond line notation)

These compounds are mostly represented by bond line notation.

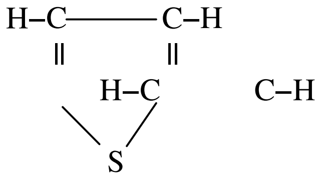
(c) **Heterocyclic compounds**. Both alicyclic and aromatic compounds have rings of carbon atoms only. These are therefore, homocyclic in nature. In heterocyclic compounds, the ring may contain one or more atoms of N, O or S as its constituent. These are called atoms. For example,



Pyrrole



Euran



Thiophene

Hydrocarbons: -The compounds consisting of only carbon and hydrogen are called hydrocarbons. The natural sources of hydrocarbons are petroleum (crude oil) and natural gas. Crude oil and natural gas occur deep inside the earth.

Kerosene is a mixture of hydrocarbons. The gas (LPG) we use for cooking our food is also a mixture of hydrocarbons. Some simple hydrocarbons are listed below:

Name:	Methane	Ethane	Ethene (or ethylene)	Ethyne (or acetylene)
Formula:	CH_4	C_2H_6	C_2H_4	C_2H_2

Formation of a large number of hydrocarbons is due to the self-linking property (called catenation) of carbon.

Types of hydrocarbons: -

There are two types of hydrocarbons. These are: a) Saturated hydrocarbons b) Unsaturated hydrocarbons.

Saturated Hydrocarbons: - A saturated hydrocarbons may be defined as follows:

The hydrocarbons in which all the four valencies of carbon are fully satisfied are called saturated hydrocarbons. In other words, the hydrocarbons in which all carbon atoms are bonded to each other by single covalent bonds are called saturated hydrocarbons. Saturated hydrocarbons were earlier called Paraffin. In IUPAC system, saturated hydrocarbons are known as alkanes.

Thus, alkanes are the hydrocarbons in which all carbon atoms are bonded to each other by single covalent bonds.

The general formula of saturated hydrocarbons (or alkanes) is C_nH_{2n+2} where n is an integral number i.e. n = 1, 2, 3 ------.

The names and formula of some typical saturated hydrocarbons (or alkanes) are given below:

General formula of saturated hydrocarbon (or alkane): C_nH_{2n+2}				
n	1	2	3	4
Molecular formula	CH_4	C_2H_6	C_3H_8	C_4H_{10}
Condensed formula	CH_4	$CH_3 – CH_3$	$CH_3 – CH_2 – CH_3$	$CH_3 – CH_2 – CH_2 – CH_3$
Structural formula	H | H – C – C | H	H H | | H – C – C – H | | H H	H H H | | | H – C – C – C – H | | | H H H	H H H H | | | | H – C – C – C – C –H | | | | H H H H
Name:	Methane	Ethane	Propane	Butane

Unsaturated hydrocarbon: -An unsaturated hydrocarbon may be defined as follows:

A hydrocarbon in which two carbon atoms are bonded to each other by a double (=) or a triple ( ) bond is called an unsaturated hydrocarbon.

Example: Typical unsaturated hydrocarbons are,

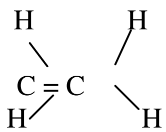
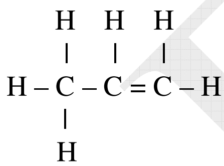
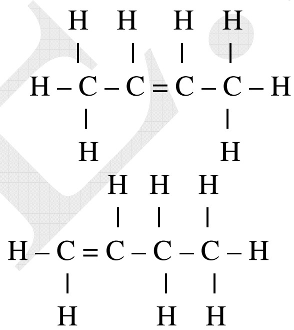
$H_2C = CH_2$	$HC \equiv CH$
Ethene (ethylene)	ethyne (acetylene)
(it contains a carbon-carbon double bond)	(it contains a carbon-carbon triple bond)

Alkenes: -Alkenes were earlier called olefins. Alkenes may be defined as follows: -
An unsaturated hydrocarbon in which two carbon atoms are bounded by a double bond is called an alkene.

In an alkene two carbon atoms are bonded to each other by a double bond. Thus, an alkene contains a > C = C < group

The general formula of alkenes is C_nH_{2n}, where n is the number of carbon atoms in a molecule of an alkene: n is an integral number viz., 2,3 -------.

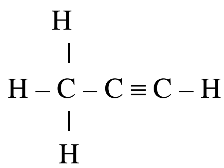
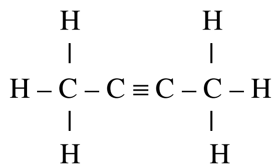
The names and formulae of some typical alkenes are given below:

General formula of alkenes*: C_nH_{2n}			
n	2	3	4
Molecular formula	C_2H_4	C_3H_6	C_4H_8
IUPAC Name	Ethene	Propene	Butene
Common Formula	Ethylene	Propylene	Butylene
Condensed formula	$H_2C = CH_2$	$CH_3 - CH = CH_2$	$CH_3 - CH = CH - CH_3$ Or $CH_2 = CH - CH_2 - CH_3$
Structural formula			

Alkynes: - Alkynes were earlier called acetylenes. Alkynes may be defined as follows:
An unsaturated hydrocarbon in which two carbon atoms are bonded to each other by a triple (≡) bond is called an alkyne. In an alkyne two carbon atoms are bonded to each other by a triple (≡) bond. Thus, an alkyne contains a – C ≡C – group.

The general formula for alkynes is CnH2n – 2, where n is the number of carbon atoms in a molecule of alkyne i.e. n is an integral number greater than one viz. n = 2,3 ……

The names and formulae of some alkynes are given below:

General formula of alkynes*: C_nH_{2n-2}			
n	2	3	4
Molecular formula:	C_2H_2	C_3H_4	C_4H_6
IUPAC Name:	Ethyne	Propyne	Butyne
Common Name:	Acetylene	Methylacetylene	Dimethylacetylene
Condensed formula	$H - C \equiv C - H$	$H_3C - C \equiv C - H$	$H_3C - C \equiv C - CH_3$
Structural formula:	$H - C \equiv C - H$		

Difference between Saturated and Unsaturated hydrocarbon

Saturated Hydrocarbons	Unsaturated Hydrocarbons
1. Saturated hydrocarbons are represented by a general formula C_nH_{2n+2}	1. Unsaturated hydrocarbons are represented either by the formula C_nH_{2n} or C_nH_{2n-2}.
2. Saturated hydrocarbons do not decolorize bromine water or potassium permanganate solution.	2. Unsaturated hydrocarbons decolorize bromine water and potassium permanganate solution.
3. Saturated hydrocarbons burn in air with a nonsmoky flame	3. Unsaturated hydrocarbons burn in air with a smoky flame.

Homologous series: -A homologous series may be defined as follows:
A group of organic compounds containing a particular functional group is termed a homologous series. A member of any homologous series is called homologue.
Characteristics of homologous series: - A homologous series shows the following characteristics:
a) All the members of a homologous series can be described by a common general formula. For example, all alkanes can be described by the general formula C_nH_{2n+2}.
b) Each member of a homologous series differs from its higher and lower neighboring members by a common differences of - CH_2 **c)** All the members of a homologous series show similar chemical properties.
d) Physical properties in a homologous series show a regular variation with an increase in molecular mass.

Some typical members of alkane, alkene and alkyne homologous series are listed below: -

Hydrocarbons: General formula	Alkane C_nH_{2n+2}	Alkene C_nH_{2n}	Alkyne C_nH_{2n-2}
	Homologous series name formula difference	Homologous series name formula difference	Homologous series name formula difference
	Methane CH_4	- - -	
	- CH_2		- - - -
	Ethane C_2H_6	Ethane C_2H_4	
	- CH_2	- CH_2	Ethyne C_2H_2
	Propane C_3H_8	Propane C_3H_6	- CH_2
	- CH_2	- CH_2	Propyne C_3H_4
	Butane C_4H_{10}	Butene C_4H_8	- CH_2
	- CH_2	- CH_2	Butyne C_4H_6
	Pentane C_5H_{12}	Pentene C_5H_{10}	- CH_2
	- CH_2	- CH_2	Pentyne C_5H_8
	Hexane C_6H_{14}	Hexene C_6H_{12}	- CH_2
			Hexyne C_6H_{10}

Change in the physical properties in a homologous series of hydrocarbons: -
The physical properties of the various members of a homologous series change regularly with an increase in the molecular mass. Variation of some physical properties in a homologous series of hydrocarbons are described below:

a) Variation in melting and boiling points: Melting and boiling points of hydrocarbons in a homologous series increase with an increase in molecular mass. Thus, a compound containing larger number of carbon atoms will have higher melting and boiling points.
b) Variation in physical state: - Hydrocarbons having lesser number of carbon atoms have lower melting and boiling points, whereas hydrocarbons having larger number of carbon atoms have higher melting and boiling points. As a result, under normal conditions,

i) Hydrocarbons containing lesser number of carbon atoms are gases.
ii) Hydrocarbons containing large number of carbon atoms are solids.

iii) Hydrocarbon containing intermediate number of carbon atoms are liquids.

For example, hydrocarbons containing 1 – 4 carbon atoms are gases, those containing 5 – 13 carbon atoms are liquids and those containing more than 14 carbon atoms are solids.

Alkyl group: - The residue left after the removal of one hydrogen atom from the molecule of an alkane is called an alkyl group. So, if an alkane is represented by the molecular formula RH, then R is the corresponding alkyl group i.e.,

$$\underset{\text{Alkane (saturated hydrocarbon)}}{RH} - H \longrightarrow \underset{\text{alkyl group}}{R}$$

For example, the alkyl groups derived from methane (CH_4) and ethane (C_2H_6) are,

$$\underset{\text{Methane}}{CH_4} - H \longrightarrow \underset{\text{Methyl group}}{CH_3 -}$$

$$\underset{\text{Ethane}}{C_2H_6} - H \longrightarrow \underset{\text{ethyl group}}{C_2H_5 -}$$

Naming of alkyl groups: -

Alkyl groups are named by replacing the –ane in the name of alkane by –yl.

Alkane – ane + yl ⟶ Alkyl

Thus, the alkyl groups of methane and ethane are named as follows:

Methane – ane + yl ⟶ Methyl

Ethane – ane + yl ⟶ Ethyl

The structural formulae of methyl and ethyl groups are,

```
       H                         H     H
       |                         |     |
  H    C                   H     C     C
       |                         |     |
       H                         H     H
  Methyl group                ethyl group
```

Naming Hydrocarbons: -

There are about 5 million organic compounds. It is very difficult to remember the name of each individual compound. Therefore, these compounds are named according to a system of nomenclature. Two commonly used systems of nomenclature are,

a) Common (or trivial) system b) IUPAC system

The names of any compound in these systems are known as Common name and IUPAC name respectively.

Hydrocarbons (infact all organic compounds) are called by two names:

i) Common name (also called trivial name).

ii) IUPAC name

Common name of a compound is generally derived from the source of its occurrence. For example, methane (CH_4) was earlier called marsh gas, because of its occurrence in the marshy lands.

IUPAC name of a compound is derived on the basis of number of carbon atoms in the longest carbon chain in its molecule.

IUPAC names of straight chain hydrocarbons: -

To write the IUPAC name of a straight chair hydrocarbon, we should know,

a) Number of carbon atoms present in its molecule.
b) Nature of hydrocarbon, i.e. whether it is saturated or unsaturated hydrocarbon.

This is done as follows: -

1. Indicating the number of atoms in the molecule: - The number of carbon atoms in the molecule of a hydrocarbon is indicated by a word root (or stem). For compounds containing up to four carbon atoms, the word roots are obtained from their common names. For compounds consisting of five or more carbon atoms, the word roots are derived from the Greek numerals describing the number of carbon atoms. The word roots (or stems) for organic compounds containing a chain of carbon atoms

No. of carbon atoms in the molecule	Word root (or stem)	No. of carbon atoms in the molecule	Word root (or stem)
One carbon atom	Meth	Six carbon atoms	Hex
Two carbon atom	Eth	Seven carbon atoms	Hept
Three carbon atoms	Prop	Eight carbon atoms	Oct
Four carbon atoms	But	Nine carbon atoms	Non
Five carbon atoms	Pent	Ten carbon atoms	Dec

From the word roots given in the above table, it is clear that the word roots for compounds consisting up to four carbon atoms are derived from their common names. For compounds consisting of five or more carbon atoms, the word roots are derived from the Greek prefix indicating the number of carbon atoms present in it. For example, the word root pent is derived from pent (means five), whereas the word root oct derived from octa (means eight).

2. Indicating the nature of hydrocarbon: - The nature of hydrocarbon is indicated as follows:

a) a saturated hydrocarbon or an alkane is indicated by adding ane to the word root (or stem)
b) an unsaturated hydrocarbon containing a double bond (or an alkene) is indicated by adding ene to the word root (or stem).
c) An unsaturated hydrocarbon containing a triple bond (or alkyne) is indicated by adding yne to the word root (or stem)

Illustrating the naming of saturated hydrocarbons (alkanes):

Here we illustrate the process of naming some simple saturated hydrocarbons (alkanes).

1. CH_4: The CH_4 molecule consists of one carbon atom. The number of hydrogen atoms in this molecule (=4) indicates that this is a saturated hydrocarbon (alkane). So, for this molecule

Word root (or stem) = Meth
Primary suffix = ane

So, CH_4 is named as, Meth + ane ⟶ Methane

Therefore, the IUPAC name of CH_4 is also methane.

2. C_2H_6: The C_2H_6 molecule consists of two carbon atoms. The number of hydrogen atoms in this molecule (=6) shows that this hydrocarbon can be described by the general formula C_nH_{2n+2} (= $C_2H_{2 \times 2 + 2}$ = C_2H_6). So this hydrocarbon is a saturated hydrocarbon (alkane). Thus, for this molecule,

Word root (or stem) = Eth
Primary suffix = ane

So, C_2H_6 is named as Eth + ane ⟶ Ethane

Therefore, the IUPAC name of C_2H_6 is ethane. The common name C_2H_6 is also ethane.

Illustrating the naming of unsaturated hydrocarbons: -

Here, we illustrate the process of naming some simple straight chain unsaturated hydrocarbons.

1. $CH_2 = CH_2$: The molecule $CH_2 = CH_2$ has a chain consisting of two carbon atoms. So, the word root for the name of this compound is eth. There is one double bond in this molecule, i.e., this compound is an alkene. So, the primary suffix is ene. Thus, the IUPAC name of $CH_2 = CH_2$ is ethane. The common name of $CH_2 = CH_2$ is ethylene.
2. **$CH_3 - CH = CH_2$**: The molecule $CH_3 - CH = CH_2$ has a chain of three carbon atoms. So, the word root for the name of this compound is prop. There is one double bond in this molecule, i.e., this compound is an alkene. So, the primary suffix is ene. Thus, the IUPAC name of $CG_3 - CH = CH_2$ is propene. The common name of $CH_3 - CH = CH_2$ is propylene.
3. **C_2H_2 or $CH \equiv CH$:** The molecule C_2H_2 (or CH=CH) has a chain of two carbon atoms. So, the word root for the name of this compound is eth. There is one triple bond in this molecule, i.e., this compound is an alkyne. So, the primary suffix is yne. Thus, the IUPAC name of $CH \equiv CH$ is ethyne. The common name of $CH \equiv CH$ is acetylene.

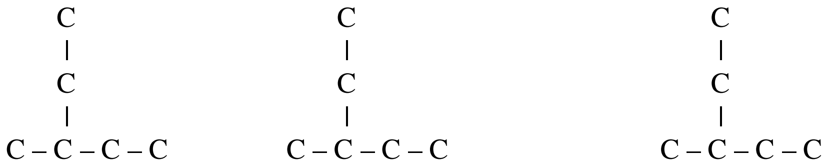
IUPAC names of the branched chain hydrocarbons: -

The branched chain hydrocarbons are named as derivatives of the parent hydrocarbon. The parent hydrocarbon is identified by the number of carbon atoms in the longest continuous chain of carbon atoms. The IUPAC names of the branched hydrocarbons are written as follows:

Step 1. Longest chain rule: Select the longest continuous chain of carbon atoms in the molecule of the given compound. This longest chain is called the parent chain. The number of carbon atoms in the parent chain gives the word root (or stem). The hydrocarbon which corresponds to the longest carbon chain is called parent hydrocarbon.

For unsaturated hydrocarbons, the parent chain must contain the double or triple bond.

The selection of the parent chain in the molecule of a compound is illustrated below. Given below are three different ways in which continuous chain of carbon atoms in a molecule can be selected.

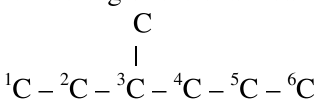


The chain described in (I) consists of five carbon atoms, whereas the chains described in (II) and (III) consist of four carbons each. So, the chain described in (I) is the longest chain. Therefore, the parent chain in this molecule consists of five carbon atoms. Then, the word root (or stem) for the name of this molecule is pent.

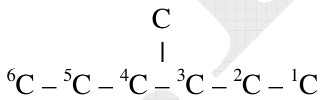
2. Lowest number rule: - The alkyl groups present in the side chain of the parent chain are considered as substituents. The carbon atoms of the longest carbon chain are numbered in such a way so that the carbon atom having the substituent gets the lowest possible number.

Let us consider the following chain atoms to illustrate the lowest number rule.

The numbering of the chain can be done in two ways as shown below:



(i) Right



(ii) Wrong

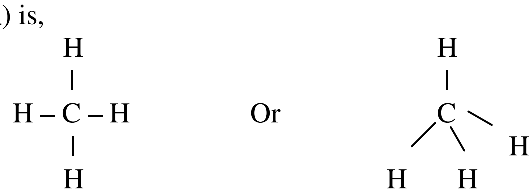
According to the lowest number rule, the numbering done in structure I is right because here, the side chain is at carbon number 3. The other choice (II) is wrong because in this the side chain is present at carbon atom number 4.

3. Writing the name of the side chain: - The side chain groups are named separately. For example – CH_3 group named methyl, C_2H_5 – group is named ethyl. The name of the side chain placed before the word root (or stem). The position of the side chain is indicated by writing the serial number of carbon atoms to which it is attached, before it. For example, if a methyl (- CH_3) group is present at carbon atom number 3, then the side chain is described as 3 – methyl.

4. Writing the IUPAC name of the compound: - The IUPAC name of the compound is then obtained by writing the position of the side chain followed by a hyphen, name of the side chain group, the word root and the primary suffix for the hydrocarbon as a simple word.

Structural formula of a compound: -

The formula showing the arrangement of various atoms present in a molecule of the compound is called its structural formula. In other words, the formula showing the way various atoms are linked to each other in a molecule of any compound is called its structural formula. In structural formula, single bonds are shown by single lines, double bonds are shown by double lines and triple bonds by three lines. For example structural formula of methane (CH_4) is,



Electronic formula of a compound: -

The formula showing the mode of electron – sharing between different atoms in the molecule of a compound is called its electronic formula. In other words, electronic formula is the structural formula in which a single bond is replaced by one pair of shared electrons (... or x.), a double bond by two pairs of shared electrons (.. or x.) and a triple bond by three pairs of shared electrons (or). For example, the electronic formula of methane can be obtained as follows.

H | H – C – H | H	Each single bond is replaced by one electron pair →	H H C H H
Structural formula of methane		Electronic formula of methane

Structural and electronic of some saturated hydrocarbons: -

Molecular, condensed and structural formula of some simple saturated hydrocarbons (alkanes) are given below:

Saturated hydrocarbons (alkane)		Condensed formula	Structural formula	Electronic formula
Name	Molecular formula			
1.Methane	CH_4	CH_4	H | H – C – H | H	H H C H H
2. Ethane	C_2H_6	$CH_3 – CH_3$	H H | | H – C – C – H | | H H	H H H C C H H H

Structural and electronic formula of some unsaturated hydrocarbons: -

Molecular, condensed and the structural formulae of some simple unsaturated hydrocarbons (alkanes and alkynes) are given below.

Unsaturated Hydrocarbon: IUPAC Name	Unsaturated Hydrocarbon: Molecular formula	Condensed formula	Structural formula	Electronic formula
1. Ethane	C_2H_4	$CH_2 = CH_2$	H H C = C H H	H H C C H H
2. Propane	C_3H_6	$CH_3 – CH = CH_2$	H H | | H – C – C = C – H | | H H	H H C C C H H H

Isomers: -

The compounds having the same molecular formula, but different structural formulae are called isomers. For examples, the molecular formula C_4H_{10} describes the following two structural formulae.

$CH_3 – CH_2 – CH_2 – CH_3$

$CH_3 – CH – CH_3$
|
CH_3

IUPAC name:	Butane	2-methylpropane
Common name:	n-butane	iso-butane

Therefore, the compounds described by these two structural formulae are the isomers of C_4H_{10} (butane). Thus, we can say that butane and 2 – methylpropane are isomers. In other words, n-butane and iso-butane are the two isomers of butane.

Isomerism: - Isomerism can be defined as follows:

Occurrence of two or more compounds having the same molecular formula, but different structural formulae is called isomerism.

Isomerism is possible only in hydrocarbons containing four or more carbon atoms. Thus, methane, ethane and propane do not show isomerism. Butane, pentane, hexane and heptane (and so on) show isomerism.

Characteristics of isomers: -

1. Isomers have the same molecular formula. 2. Isomers have different structural formula.
3. Isomers have different physical and chemical properties.

Isomers show different properties due to the different arrangement of carbon atoms in their molecules.

Isomers of Butane: -

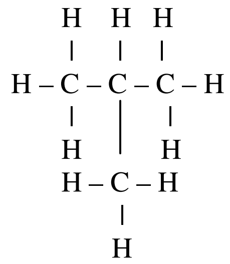
The molecular formula for butane is C_4H_{10}. The four carbon atoms of butane can be joined in two different ways to give two different structures. In one of them, the carbon atoms form a straight chain, while in the other a branched chain structures is formed. These two forms of butane ane called normal butane (n-butane) and iso-butane respectively. These arrangements are shown below:

$^1CH_3 – {}^2CH_2 – {}^3CG_2 – {}^4CH_3$

H H H H
| | | |
H – C – C – C – C – H
| | | |
H H H H

IUPAC name: - Butane
Common name : - n - Butane

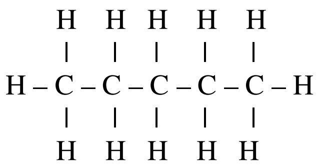
$^{1}CH_3 - {}^{2}CH - {}^{3}CH_3$
with CH_3 attached to C-2



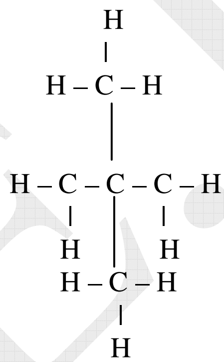
IUPAC name: 2 – methylpropane
Common name: - iso- butane

Isomers of pentane: -

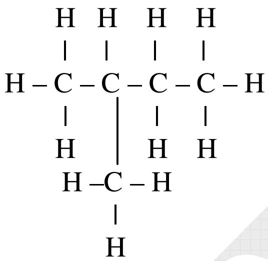
Pentane (C_5H_{12}) has three isomers. These are shown as under.



IUPAC Name: - Pentane
Common name: - n – Pentane



IUPAC Name: - 2,2 – dimethylpropane
Common name: - neo-propane



IUPAC Name: - 2 – methylbutane Common name: iso-propane

Chemical properties of carbon compounds:-

The important chemical properties of carbon compounds can be discussed as below:-

(a) **Combustion Reactions:-** carbon and hydrogen present in organic compounds got used during combustion to form carbon compounds also release a large amount of heat and light on burning.

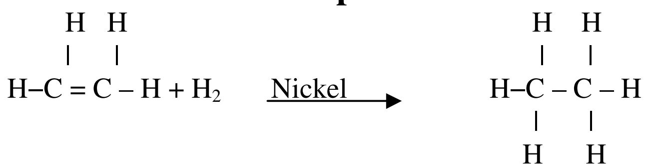
$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Heat} + \text{Light}$$

$$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O + \text{Heat} + \text{Light}$$

(b) **Oxidation Reaction:-** carbon compounds are oxidation on combustion.

$$C_2H_5OH + \text{Heat} \longrightarrow CH_3COOH + H_2O$$

(c) **Addition Reactions:-** organic compounds become saturated if their molecules contain at least one carbon to carbon double bond (C = C) or triple bond ($C \equiv C$). In order to change into saturated hydrocarbons which contain all C – C bonds, they take part in chemical reactions known as addition reactions. In these reactions, the attacking species adds to the molecule of unsaturated hydrocarbon which gets converted to saturated hydrocarbon.



(d) Substitution Reaction:- in the presence of sunlight, chlorine is added to hydrocarbon in a very fast reaction. It replaces the hydrogen atoms one by one to give the higher homolgnes of alkenes.

$$CH_4 + Cl_2 \longrightarrow CH_3\,Cl + HCl$$

Alkanes: -

Saturated hydrocarbons are called alkanes. Alkanes were earlier called paraffins. The term paraffins comes from the Latin words 'para' (means little) and 'affins' (means affinity).In alkanes carbon atoms are bonded to each other by single covalent bonds. Alkanes can be represented by general formula C_nH_{2n+2} where n= 1,2,3,…….

First four members of alkane series are,

Methane (CH_4), Ethane (C_2H_6), Propane(C_3H_8), Butane (C_4H_{10}).

The main source of saturated hydrocarbons is petroleum and natural gas.

Physical properties of Alkanes: -

The general physical properties of alkanes are described below:

i) Physical state: - Alkanes having up to four carbon atoms are gases at room temperature. Those having 5 to 17 carbon atoms are solids at room temperature. For example, methane, ethane, propane and butane are gases and pentane, hexane are liquids at room temperature. Thus, we can say that the physical states of alkanes depend upon their molecular masses.

ii) Solubility: - Alkanes are non-polar. Therefore, alkanes are insoluble in water. Alkanes are however soluble in the non – polar solvents such as benzene, either, carbon tetrachloride.

iii) Melting and boiling points: - The melting and boiling points of alkanes increase with an increase in their molecular masses. Thus, hydrocarbon having more carbon atoms have higher melting and boiling points.

General chemical properties of alkanes: -

Some typical chemical reactions given alkanes are described below.

i) **Combustion: -** All alkanes burn in excess of air (or oxygen) with almost blue flame to give CO_2 and H2O and a large amount of heat is liberated. Thus, alkanes are good fuels. Combustion of alkanes can be represented by the chemical equation,

$$\underset{\text{Alkane}}{C_nH_{2n+2}} + \underset{\text{(excess)}}{\frac{3_{n+1}}{2}}\ O_2 \longrightarrow n\,CO_2 + (n+1)\,H_2O + \text{Heat}$$

For example, methane and butane burn to give heat and light.

$$CH_4 + 2O_2\ (\text{excess}) \longrightarrow CO_2\,(g) + 2H_2O\,(l) + 890\ \text{KJ mol} -1$$

$$2C_4H_{10} + 13O_2\ (\text{excess}) \longrightarrow 8CO_2\,(g) + 10H_2O\,(l) + 2880\ \text{KJ mol-1}$$

LPG contains mainly butane, while the natural gas mostly contains methane (CH_4).

However, if the supply of air or oxygen is not sufficient for complete combustion, carbon monoxide is formed. Carbon monoxide (CO) is highly poisonous.

$$2CH_4 + 3O_2 \longrightarrow 2CO + 4H_2O$$

$$2C_4H_{10} + 9O_2 \longrightarrow 8CO + 10H_2O$$

ii) Substitution reactions: - All alkanes give substitution reactions. In a substitution reaction, an atom or a group present in a compound is replaced by another without affecting the structure of the molecule. For example, in the reaction of methane with chlorine, Cl atoms replace H atoms of methane.

$$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$$

$$CH_3Cl + Cl_2 \longrightarrow CH_2Cl_2 + HCl$$

Member	No. of carbon atoms	Formula		Name	
		Molecular	Condensed	IUPAC	Common
First	2	C_2H_4	$CH_2 = CH_2$	Ethene	Ethylene
Second	3	C_3H_6	$CH_3 - CH = CH_2$	Propene	Propylene
Third	4	C_4H_{10}	$CH_3 - CH_2 - CH = CH_2$ Or $CH_3 - CH = CH - CH_3$	1-Butune	1-Butylene

$$CH_2Cl_2 + Cl_2 \longrightarrow CHCl_3 + HCl$$

$$CHCl_3 + Cl_2 \longrightarrow CCl_4 + HCl$$

iii) <u>Cracking (or pyrolysis).</u> Higher alkanes undergo thermal decomposition to give lower alkanes. This process is called pyrolysis or cracking. In this process, vapour of higher alkanes is passed through a hot metal tube (500 – 700^{0}C). Propane on cracking gives,

$$C_3H_8 \xrightarrow{\Delta} C_3H_6 + H_2$$

$$C_3H_8 \xrightarrow{\Delta} CH_4 + C_2H_4$$

Cracking of hexane gives butane and ethane.

$$C_6H_{14} \longrightarrow C_4H_{10} + C_2H_4$$

Large quantities of high-boiling fractions of petroleum are converted into low boiling gasoline by cracking. Cracking is very important commercial process.

General uses of alkanes:

i) Lower alkanes are generally used as domestic fuels. For example, methane (in natural gas), butane (in LPG)_ are excellent fuels. Diesel, petrol are fuels for cars, buses, trucks, etc. Kerosene used as a domestic fuel is also mixture of alkanes.

ii) Higher alkanes are used for producing more useful lower hydrocarbons by cracking.

iii) Alkanes are also used for the preparation of many useful organic compounds.

ALKENES: -

Alkenes are unsaturated hydrocarbons. An unsaturated hydrocarbon containing one double bond in its molecule is called an alkene. In an alkene, two carbon atoms are bounded to each other through a double bond. Thus, an alkene contains a > C = C < group.

The general formula of alkenes is CnH2n, where n is the number of carbon atoms in the molecule of alkene. Since an alkene must have at least two carbon atoms, for alkenes n = 2, 3, 4 …………..

First three members of alkene series are given below:

Physical properties of alkenes: - General physical properties of alkenes are described below:

i) **Physical state:** First three members of the alkenes series i.e. alkenes containing 2 to 4 carbon atoms are colourless gases. Ethane, propane, and butane are colourless gases at room temperature. Alkenes having 5 to 15 carbon atoms are liquids, while the higher alkenes containing more than 15 carbon atoms are solids.

ii) **Solubility:-**Alkanes are insoluble in water, but dissolve in organic solvents such as, benzene, either, ethanol etc.

iii) **Melting and boiling points: -** The physical characteristics such as melting points and boiling points show a gradual change with an increase in the number of carbon atoms in the chain.

ALKYNES: -

Alkynes are unsaturated hydrocarbons. An unsaturated hydrocarbon in which two carbon atoms are linked to each other by a triple bond is called an alkyne. An alkyne contains a – C C – group. The general formula for alkynes is C_nH_{2n-2}. Since an alkyne must contain at least two carbon atoms hence for alkynes, n = 2, 3, 4 …..

Substitution of different values of n gives molecular formulae of alkynes. Thus, first two members of the alkyne series are,

Members	No. of C – atoms	Formula of alkyne		Name of the alkyne	
		Molecular	Condensed	Common	IUPAC
First	2	C_2H_2	$HC \equiv CH$	Acetylene	Ethyne
Second	3	C_3H_4	$H_3C–C \equiv CH$	Allylene	Propyne

Physical properties of alkynes: -Some common physical properties of alkynes are,
i) **Physical state: -** First three members of the alkyne series i.e. ethyne, propyne and butyne are gases under normal conditions. Alkynes containing 5 to 13 carbon atoms are liquids, whereas higher alkynes are solids.

Lower alkynes cause unconsciousness when inhaled in large amounts.
ii) **Solubility: -** Alkynes are insoluble in water. However, alkynes are soluble in organic solvents like benzene, alcohol, acetone etc.
iii) **Melting and boiling points: -** The melting and boiling points of alkynes increase with the increase in number of carbon atoms in their molecules. Thus, higher alkynes have higher melting and boiling points than lower alkynes.

COAL:-
Coal is a fossil fuel. It is a naturally occurring black mineral. It is a complex mixture of many compounds which contain high percentage of carbon and hydrogen. Besides carbon and hydrogen, the compounds contain oxygen, nitrogen and sulphur. Coal also contains inorganic matter.
Formation of Coal:- coal is believed to be formed from the remains of plants and animals (fossils) which died about 300 million years ago. These remains gradually got buried deep in the earth during earthquakes, volcanoes etc. these remains were covered with sand, clay and water. Due to high temperature and high pressure and the absence of air inside the earth, the fossils got converted into coal. ***This process of conversion of plants and animals buried inside the earth under high temperature and pressure to coal is*** called **carbonization**. It is a very slow process may have taken thousands of years. Since coal is obtained from fossils, it is known as **fossil fuel.**

PETROLEUM:-

Petroleum is a dark coloured viscous oily liquid known as rock oil (in Grek, petra____rock, oleum___oil). It consists of mixture of hydrocarbons (compounds of carbon and hydrogen) whose composition varies from lace to place.
Formation of petroleum:- petroleum is formed from the bacterial decomposition of the remains of animal and plants which got buried under the sea millions of years ago. When these organisms died, they sank to the bottom and got covered by sand and clay. Over a period of millions of years, these remains got converted into hydrocarbons by heat, pressure and catalytic action. The hydrocarbons formed rose through porous rocks and got trapped between two layers of impervious rocks forming an oil trap.

FUNCTIONAL GROUP: -
A functional group is defined as follows:

An atom or group of atoms which gives some characteristic properties to a compound is called a functional group.
Characteristics of functional group: -
Some characteristics of a functional group are listed below:
a) Hydroxyl group (- OH)

The functional group –OH is called hydroxyl or alcoholic group. The compounds in which hydroxyl (-OH) group is attached to an alkyl group are called alcohols. Thus, all alcohols contain – OH group as the functional group. The functional group present in methyl alcohol (CH_3 – OH) and ethyl alcohol (CH_3CH_2 – OH) is hydroxyl (or alcoholic) group.

b) Carboxylic group (- COOH or $-\overset{\overset{\large O}{\|}}{C}-OH$)

The functional group –COOH is called carboxyl group. The –COOH group sometimes is also called carboxylic acid group. The compounds in which –COOH is present are called carboxylic acids. For example, CH_3COOH is a carboxylic acid named acetic acid.

c) Ester group (- COOR or $-\overset{\overset{O}{||}}{C}-OR$)

The functional group – COOR is called ester group. In the ester group. In the ester group (-COOR), R is an alkyl group. For example, R may be methyl (- CH_3) or ethyl (-C_2H_5) group.

The compounds containing an ester group (-COOR) are called esters. For example, CH_3COOCH_3 is called methyl acetate, and $CH_3COOC_2H_5$ is called ethyl acetate.

Alcohols: -Alcohols are the simplest compounds, which contain carbon, hydrogen and oxygen. An alcohol may be defined as follows:

An organic compound in which a hydroxyl (- OH) group is attached to an alkyl group (R) is called an alcohol. If R is an alkyl group, then the corresponding alcohol is described by the formula ROH.

The functional group in alcohols is hydroxyl group (- OH). The –OH group in alcohols is also called alcoholic group.

Examples: - Methyl alcohol (CH_3OH) and ethyl alcohol (C_2H_5OH) are the simplest alcohols. An alcohol may also be considered as a hydroxy derivative of an alkane. So, an alcohol can be obtained by replacing a hydrogen atom of an alkane by a hydroxyl (-OH) group. Thus,

Alkane – H + OH ⟶ Alcohol

Or RH – H + OH ⟶ ROH

Or, $C_nH_{2n+2} - H + OH \longrightarrow C_nH_{2n+1}OH$

Therefore, simple alcohols can be described by the general formula $C_nH_{2n+1}OH$. For example, when a hydrogen atom of methane is replaced by –OH group, methyl alcohol is obtained.

$CH_4 - H + OH \longrightarrow CH_3OH$

Methane Methyl alcohol

Similarly, from ethane one gets ethyl alcohol.

$C_2H_6 - H + OH \longrightarrow C_2H_5OH$

Ethane Ethyl alcohol

Naming alcohols: -

Like hydrocarbons, alcohols are also known by their common and IUPAC names. The naming of alcohols is described below:

1. Common names of alcohols: - The common name of an alcohol is obtained by adding the term alcohol to the name of the alkyl group.

Common name of an alcohol = name of the alkyl group + alcohol

Name of the alkyl group is derived from the number of carbon atoms in the carbon chain attached to the – OH group. For example, C_2H_5OH is made of two parts as C_2H_5 and OH. C_2H_5 contains two carbon atoms. So, C_2H_5 is ethyl group (from ethane). So,

Common name of C_2H_5OH = Ethyl + alcohol = Ethyl alcohol

2. IUPAC names of alcohols: - In IUPAC system, an alcohol is named as alkanol. The IUPAC name of an alcohol is obtained as follows:

a) Count the number of carbon atoms in the continuous longest chain containing the –OH group.
b) From the number of carbon atoms in the longest chain, identify the parent alkane as done for hydrocarbons.
c) Name of the alcohol is then written by replacing 'e' of the parent alkane by –ol, i.e.

IUPAC name of an alcohol = IUPAC name of the parent alkane – e + ol

The method of naming alcohols is illustrated below:

a) CH_3OH: - The molecule CH_3OH contains a carbon chain containing only one carbon atom. Therefore, the parent alkane is methane. So, IUPAC name of CH_3OH = Methane – e + ol = Methanol

CH_3OH contains methyl (CH_3) group. So,

Common name of CH_3OH = Methyl + alcohol = Methyl alcohol

Naming the alcohol $^3CH_3 - {}^2CH_2 - {}^1CH_2 - OH$

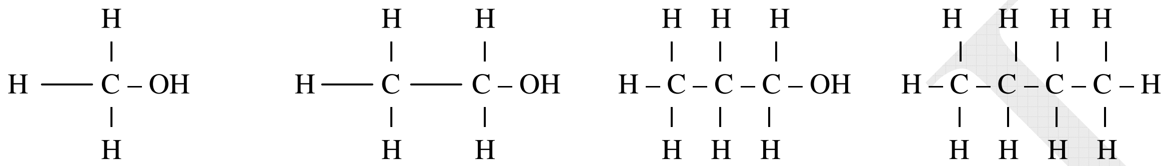
In this molecule, the – OH group is present on carbon atom number 1. So,

IUPAC name of $^3CH_3 - {}^2CH_2 - {}^1CH_2OH$ = 1 – Propane – e + ol = 1 – propanol

The compound $CH_3 - CH_2 - CH_2OH$ contains n – propyl group ($CH_3 - CH_2 - CH_2$ –). So,

Common name of $CH_3 - CH_2 - CH_2OH$ = n-propyl alcohol

Structural formula of some simple alcohols are given below:



Electronic formulae of methanol (methyl alcohol) and ethanol (ethyl alcohol) are given below:

Methanol Ethanol

Physical properties of alcohols: Some common general physical properties of alcohols are given below:

a) **Physical state and adour: -** Most common alcohols are colourless liquid. Alcohols containing more than 10 carbon atoms in their molecules are solids. Lower alcohols have a characteristic odour and burning taste.
b) **Solubility: -** Lower alcohols such as methyl alcohol, ethyl alcohol are soluble in water in all proportions. Solubility of alcohols in water decreases with an increase in the number of carbon atoms in the molecule.
c) **Conductivity: -** Alcohols do not conduct electricity. This is because alcohols are covalent compounds.
d) **Action of litmus: -** Alcohols have no effect on litmus, i.e., alcohols do not change the colour of litmus. This is because alcohols are neutral compounds.
e) **Boiling points: -** The boiling points of alcohols increase with an increase in their molecular masses, thus, an alcohol containing larger number of carbon atoms in its molecule has higher boiling point than alcohol containing lesser number of carbon atoms.

Alcohol	Methanol	Ethanol	1 – Propanol	1 – Butanol
Molecular mass:	32	46	60	74
Boiling point	64^0C	78.1^0C	97.4^0C	117.4^0C

METHANOL:

Methanol (CH_3OH) is the simplest alcohol, i.e. it is the first member of the homologous series of alcohols. Methanol (CH_3OH) is also called methyl alcohol (common name), wood alcohol or wood spirit, and carbinol. Methanol is called wood spirit because methanol can be obtained by the destructive distillation of wood.

Preparation of methanol:

Methanol may be obtained by the destructive distillation of wood. This method is an old method and is not commonly used nowadays. In this method, wood is heated strongly in the absence of air. (This is called destructive distillation of wood). The volatile matter obtained during heating is passed through water and the solution is allowed to stand. The upper aqueous layer (called pyroligneous acid) contains 2 – 4% methanol along with other organic compound. Methanol is separated from pyroligneous acid by chemical methods. The methanol so obtained is distilled further to obtain pure methanol.

Manufacture of methanol on commercial scale:

Methanol can be obtained on commercial scale by any one of the following methods:

1. **From methane: -** Methane when oxidized in the presence of a catalyst gives methanol (methyl alcohol).

$$\underset{\text{Methane}}{2CH_4 + O_2} \xrightarrow[\text{Copper tube}]{\text{100 atm, 525 K}} \underset{\text{Methanol}}{2CH_3OH}$$

Methane required is obtained in the form of natural gas.

2. **From water gas: -** Nowadays methanol is obtained from water gas. Water gas is a mixture of carbon monoxide and hydrogen (ratio 1:1). The whole process involves two steps.

Step **1: Production of water gas:** Water gas is produced by passing steam over red hot coke.

$$\underset{\text{Red hot coke}}{C} + \underset{\text{steam}}{H_2O} \longrightarrow \underset{\text{Carbon Monoxide}}{CO} + \underset{\text{Hydrogen}}{H_2}$$

Step **2: Production of methanol:** Water gas produced in step (1) is mixed with hydrogen in the volume ratio 2: 1. The mixture of water gas and hydrogen is compressed to 300 atmosphere and passed over a catalyst ($ZnO + CrO_3$) at 3000C to obtain methanol.

$$CO + H_2 + H_2 \xrightarrow[300^0C,\ 300\ atm]{ZnO + CrO_3} CH_3OH$$

Physical properties of methanol: -Some important physical properties of methanol are given below:

1. Physical state: Methanol is a colourless, inflammable liquid.
2. Character: Methanol is poisonous, and if taken, it causes blindness and even death.
3. Solubility: Methanol is miscible with water in all proportions, due to the formation of hydrogen bonds with water.
4. Flame on burning: Methanol burns with a faintly luminous flame.
5. Boiling point: Methanol boils at 64.50C under normal pressure.
6. Action on litmus: Methanol has no effect on the colour of litmus. This is because methanol is a neutral compound.

Uses of methanol: Some main uses of methanol are listed below:

a) Methanol is used as a solvent for fats, oils, gums, paints and varnishes.
b) Methanol is used as a fuel.
c) Methanol is used for producing denatured alcohol. A small quantity of methanol is added to ethanol to make it fit for drinking.
d) Methanol is used as a starting material for the manufacture of chloromethane, methyl esters and mathanal (farmaldehyde). Methanal is used for making a plastic known as bakelite.

Ethanol: Ethanol is the second member of the homologous series of alcohols. The common name of ethanol (C_2H_5OH) is ethyl alcohol. Ethanol is commonly called simply as alcohol. So, when the term alcohol is used, it means ethyl alcohol.

Preparation of ethanol: - Ethanol may be prepared by the following methods:

1. By the hydration of ethene: - The addition of a molecule of water to an unsaturated organic compound is called hydration. Hydration of ethane ($CH_2 = CH_2$) gives ethanol (ethyl alcohol). Ethanol can be manufacture by passing a mixture of ethene and steam over a catalyst, phosphoric acid on silica at 3000C and a pressure of 70 atomsphere.

$$\underset{\text{Ethene}}{H_2C = CH_2} + \underset{\text{Steam}}{H_2O} \xrightarrow[300^0C]{\text{Phosphoric acid on silica}} \underset{\text{Ethanol}}{CH_3 - CH_2OH}$$

2. By the fermentation of sugar: - Ethanol is prepared on the commercial scale by the fermentation of sugar. Molasses is a cheap source of sugar. Molasses is a dark- coloured viscous liquid left after the crystallization of sugar from the concentrated sugarcane juice. Molasses contains about 30% of left – over (which does no crystallize out) sugar.

Molasses is diluted to three times its volume by adding water. Then yeast extract is added to the dilute solution of molasses. The yeast extract contains the enzymes called invertase and zymase. Fermentation is allowed to take place at 298 – 303 K in the absence of air. This is because ethanol (ethyl alcohol) gets oxidized to ethanoic acid (acetic acid) in the presence of air. The reaction, taking place during fermentation are,

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Invertase}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

$$C_6H_{12}O_6 \xrightarrow{\text{Zymase}} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2\,(g)$$

The fermented liquor so obtained contains upto 10% of ethanol. From this dilute solution, ethanol is recovered by fractional distillation. This gives about 93 – 95% pure ethanol.

3. From starch: - Starch is also a good raw material for the manufacture of ethanol. Starch is hydrolysed to maltose by an enzyme called diastase.

$$\underset{\text{Starch}}{2(C_6H_{10}O_5)n} + nH_2O \xrightarrow{\text{Diastase}} \underset{\text{Maltose}}{nC_{12}H_{22}O_{11}}$$

The alcoholic fermentation of maltose is carried out with yeast in the absence of air. The enzyme maltase present in the yeast converts maltose into glucose. The enzyme zymase then converts glucose into ethanol.

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Maltase}} \underset{\text{Glucose}}{2C_6H_{12}O_6}$$

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow{\text{Zymase}} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2$$

Ethanol is recovered from the solution by fractional distillation.

Reactions of Ethanol:-

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

$$2Na + 2CH_3\,CH_2\,OH \longrightarrow 2CH_3\,CH_2\,ONa + H_2$$

(ii) **Reaction with oxygen**:- Ethanol burns in air with a blue flame to form carbon dioxide and water.

$$C_2H_5\,OH + 3O_2 \longrightarrow 2\,CO_2 + 3H_2O$$

(iii) **Reaction to give unsaturated hydrocarbon**:- Heating Ethanol at 443K with excess conc. Sulphate acid results in the dehydration of ethanol to give ethane.

$$CH_3 - CH_2\,OH \xrightarrow[H_2SO_4]{\text{Conc.}} 4CH_2 = CH + H_2O$$

Physical properties of ethanol:

Ethanol is a typical and the most widely used alcohol. Some important physical properties of ethanol are given below:

1. Physical state, colour and odour: Ethanol is a colourless, inflammable liquid with a spirituous odour and burning taste.
2. Solubility: Ethanol is miscible with water in all proportions. Ethanol dissolves in water due to the formation of hydrogen bonds with water molecules.
3. Boiling and melting points: Ethanol boils at 78.10C and freezes at –1180C.
4. Conductivity: - Ethanol does not conduct electricity. This is because ethanol is a covalent compound and it does not contain ions.
5. Action on litmus: Ethanol is a neutral compound. So, it has no effect on the colour of litmus.

Uses of Ethanol: Some of the important uses of ethanol:

a) Ethanol is used as a fuel for lamps and stoves.
b) Ethanol is used as a substitute of petrol in internal combustion engines of scooters and cars.
c) Ethanol is used as a solvent for drugs, tinctures, oils, perfumes, inks, dyes, varnishes etc.

d) Ethanol is used as a beverage. Ethanol is a constituent of beer, wine, whisky etc.
e) Ethanol is used as a preservative for biological specimens.
f) Ethanol is used as antifreeze for automobile radiators.
g) Ethanol is used for the manufacture of terylene and polythene.
h) Ethanol is used as raw material for large number of organic compounds, such as esters, chloroform,
i) Ethanol is used as an antiseptic to sterilize wounds and syringes in hospitals.

ORGANIC ACIDS: Carboxylic acid: - An organic compound containing a carboxylic (- COOH) group in its molecule is called a carboxylic acid. Carboxylic acids are also called organic acids. So, organic acids contain carboxylic (-COOH) group in their molecules. Thus, the functional group in organic acids is –COOH group.

An acid which contains only one carboxylic group in its molecule is called monocarboxylic acid. Methanoic acid (formic acid, HCOOH) and ethanoic acid (acetic acid, CH_3COOH) are typical carboxylic acids.

Organic acids are weak acids.

A carboxylic acid can be represented by the formula RCOOH, where R is an alkyl group, or a hydrogen atom.

For methanoic acid (formic acid, HCOOH) R is a H atom, whereas in ethanoic acid (acetic acid, CH_3COOH) R is a methyl group (CH_3-)

Saturated carboxylic acids (except formic acid) can also be represented by the formula C_nH_{2n+1} COOH.

Higher saturated carboxylic acids are called fatty acids. For example, palamitic acid (C_{15} H_{31}COOH) and stearic acid (C_{17} H_{35} COOH) are typical fatty acids.

2. IUPAC names of carboxylic acids. The IUPAC names of carboxylic acids are obtained as follows: -

i. Select the longest chain of carbon atoms containing – COOH group.
ii. On the basis of the number of carbon atoms in the longest chain, identify name of the parent alkane.
iii. The name of the carboxylic acid can be obtained by replacing 'e' of the alkane by ioc acid. Thus,

IUPAC name of carboxylic acid = Name of the parent alkane-e + oic acid

The two methods of naming the carboxylic acids are illustrated below.

1. **HCOOH.** The molecule HCOOH contains only one carbon atom. So, the parent alkane is methane. Therefore,

IUPAC name of HCOOH = Methane – e + oic acid = Methanoic acid.

Common name of HCOOH = Formic acid.

2. **CH_3COOH**: The molecule CH_3COOH consists of two carbon atoms. So, the parent alkane is ethane. Therefore,

IUPAC name of CH_3COOH = Ethane – e + oic acid = Ethanoic acid

Common name of CH_3COOH = Acetic acid

ETHANOIC ACID (ACETIC ACID):-

Ethanoic acid is commonly called acetic acid and belongs to the group of carboxylic acids. The delute solution of acetic acid in water is called Vinegar and is used for preserving food, pickles etc.

Manufacture of Ethanoic Acid: - Ethanoic acid in form of vinegar is manufactured by oxidation of ethanol with our in presence of the enzyme acetobactor.

$$CH_3CH_2OH + O_2 \longrightarrow CH_3COOH + H_2O$$

Physical Properties of Ethanoic Acid:-

- Ethanoic acid is a coloulerless liquid with sour taste and physical vinegar smell.
- It is miscible with water in all proportions.
- The acid boils at 391 K (118 ^{0}C).
- On cooling, pure ethanoic acid freezes to form ice like flakes. They look like a glacier. Due to this property, pure ethanoic acid is often called glacial ethanoic acid or glacial acetic acid.

Reactions of Ethanoic Acid:-

(i) **Esterfication Reaction**: - Ethanoic acid reacts with absolute ethanol in the presence of an acid catalyst to given an ester.

$$CH_3–COOH + CH_3–CH_2\,OH \xrightarrow{\text{Acid}} CH_3–\underset{\underset{O}{||}}{C}–O–CH_2CH_3$$

(ii) **Reaction with a base:-** Ethane acid reacts with a base such as sodium hydroxide to give a salt and water.

$$Na\,OH + CH_3\,COOH \longrightarrow CH_3\,COONa + H_2O$$

(iii) **Reaction with carbonates and hydrogen carbonates**:- Ethanoic acid reacts with carbonates and hydrogen carbonates to give rise to a salt, Co_2 and water.

$$2CH_3\,COOH + Na_2\,CO_3 \longrightarrow 2CH_3\,COONa + H_2O + CO_2$$

ESTERS: The organic compounds containing the functional group – COOR in their molecules are called esters. Esters are described by a general formula

$$R–\overset{\overset{O}{||}}{C}–OR'$$

Where R and R may be same or different alkyl groups.

Physical properties of esters: -Some general properties of esters are given below:

a) Physical state, colour and odour: - Lower esters are colourless volatile liquids, having pleasant odour i.e. they have fruity smell. Higher esters are colourless, wax-like solids.
b) Solubility: - Lower esters are soluble in water. The solubility, however, decreases sharply with an increase in the molecular mass of the esters. All esters are soluble in organic solvents such as alcohol, benzene etc.
c) Boiling points: - Boiling points of esters are lower than those of the corresponding acids. This is because esters do not show hydrogen bonding whereas acids do.

Uses of esters: -Some common uses of esters are given below:

a) Esters are used as solvents for oils, gums, resins etc.
b) Esters are used as plasticisers for resins and plastics.
c) Esters are used as flavoring agent in cold drinks, ice creams, sweets etc.

Soaps: -

Sodium or potassium salt of a long chain fatty acid (those containing 15 – 18 carbon atoms) is called soap. A fatty acid is described by the general formula RCOOH. So, soaps can be described by the formula $RCOO^- \, Na^+$ or RCOO-K+. Thus, a soap molecule consists of an anion RCOO- and cation Na+ or K+.

Preparation of soap: -

Soaps are prepared by alkaline hydrolysis of oils or fats (triglycerides). Alkaline hydrolysis of oils or fats is called saponification.

Raw materials for making soap: - The following materials are needed for making washing soap

a) Cotton seed oil or coconut oil animal fat	200ml
b) Sodium hydroxide (20% solution)	400 ml
c) Common salt	50 g
d) Talc (as filler)	As required (100 – 150 g)

Reaction: - When oil is heated with an alkali, sodium salt of the long chain fatty acid and glycerol are formed. Sodium salt of long chain fatty acid is called soap.

$$\text{Oil / Fat + NaOH (aq)} \xrightarrow{\text{heat}} \text{Soap + Glycerol}$$

The alkaline hydrolysis (saponification) of tripalmitin can be descried by the reaction:

$CH_2O.COC_{15}H_{31}$			CH_2OH

$CH_2O.COC_{15}H_{31}$			CH_2OH		
|			|		
$CHO.COC_{15}H_{31}$ +	$3NaOH$	⟶	$CHOH$	+	$3C_{15}H_{31}COONa$
|			|		
$CH_2.COC_{15}H_{31}$			CH_2OH		
Tripalmitin	Caustic Soda		Glycerol		Soap

Procedure: - Take 200 ml of cotton seed oil or any animal fat in a beaker and add 400 ml of 20% sodium hydroxide solution into it. Heat the mixture slowly to boil and keep it boiling for about 5 – 10 minutes. Add 50 g of common salt and allow the mixture to cool. Soap floats over the surface as a frothy mass. Remove it with a wooden spatula. Mix it thoroughly with about 100 – 150 g of talc. Homogenise it and cast it into cakes. Your washing soap is ready for use.

Removing of dirt from cloth: -A molecule of soap is made up of the following two parts:

a) A pair part consisting of COO-Na+. This is called polar end.
b) A non polar part consisting of a long chain of twelve to eighteen carbon atoms. This is called hydrocarbon end.

The polar end of soap –COO-Na+ is water – soluble, whereas the hydrocarbon part is water-repellant and oil-soluble.

When an oily (dirty) piece of a cloth is put into soap solution, the hydrocarbon part of the soap molecule attaches itself to the oily drop, and the –COO- end orients itself towards water. The Na+ ions in solution arrange themselves around the – COO – ions. The negatively charged micelle so formed entraps the oily dirt.

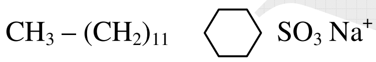
The negatively charged micelles repel each other due to the electrostatic repulsion. As a result, the tiny oily dirt particles do not come together and get washed away in water

Synthetic detergents: -

Sodium salts of sulphonic esters are called synthetic detergents. Some typical synthetic detergent is,

a) Linear alkylbenzene sulphonate R - SO3- Na+. Where R is a long chain alkyl group.

The most common detergent in this class is sodium n – dodecylbenzene sulphonate.

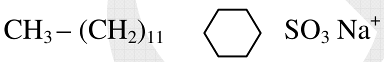


Sodium n – dodecylbenzene sulphonate

ii) Sodium lauryl sulphate, $C_{12}H_{22}O.\ SO_3^-\ Na^+$

Structure of detergent molecule: - The molecule of a synthetic detergent has two ends viz., hydrophobic (water – repellent) end of the hydrocarbon chain, and hydrophilic (water – attracting) end, usually an acidic or a basic group.

For sodium n-dodecylbenzene sulphonate, the two ends are shown below:



Hydrophobic end Hydrophilic end

Distinguish between soaps and detergents:

Property	Soap	Synthetic detergent
1. Chemical nature	Soap is the sodium or potassium salt of higher fatty acid. The ionic group in soaps is –COO-Na+.	Synthetic detergents are the sodium salts of a long chain alkyl benzene sulphonic acid or long chain alkyl hydrogen sulphates. The ionic group in synthetic detergents is

2. Preparation	Soaps are prepared from animal fat or vegetable oils.	Synthetic detergents are prepared from hydrocarbon obtained from petroleum.
3. Biodegradability	Soaps are biodegradable	Common synthetic detergents are not biodegradable,
4. Suitability in hard water.	Soaps are not suitable for washing in hard water.	Synthetic detergents can be used for washing even in hard water.
5. Cleansing action	Soaps have weak (mild) cleansing action	Synthetic detergents have strong cleansing action.

Advantages of synthetic detergents over soaps: -

Both synthetic detergents and soaps are used for cleansing. But synthetic detergents have some advantages over soaps. As a result, synthetic detergents are better than soaps. Some advantages synthetic detergents have over soaps are listed below:

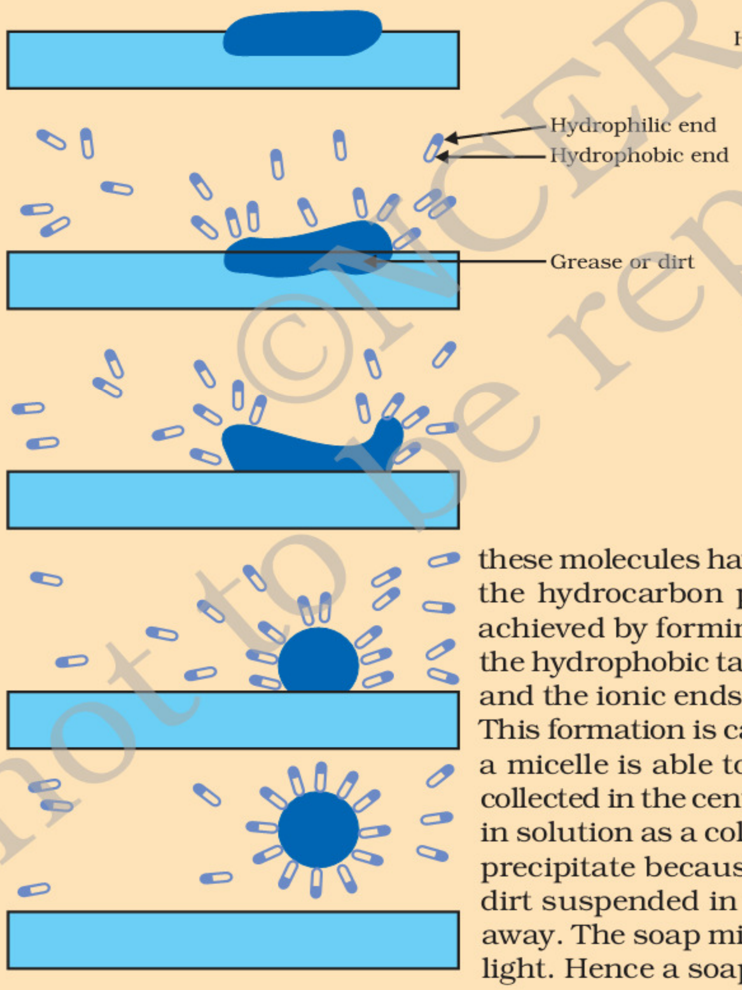
a) Synthetic detergents are prepared from hydrocarbon obtained from petroleum, whereas soaps are prepared from oils, which are becoming scarce. Thus, synthetic detergents help us to save oils.
b) Synthetic detergents can be used for washing even in hard water. Soaps cannot be used for washing in hard water. In hard water, soaps form curdy precipitate, which stick to the fabric.
c) Synthetic detergents have stronger cleansing power than soaps.
d) Synthetic detergents can be used even in the acidic solution, whereas soaps cannot be used in acidic solutions. This is because soaps decompose under acidic conditions to give free fatty acids.

Micelles:-

When soap is at the surface of water, the hydrophobic trail of soap will not be soluble in water and the soap will aligin along the surface of water with the ionic and in water and the hydrogen trail producing out of water. Onside water, these molecules have a unique orientation that keeps the hydrogen portion out of the water. This is achieved by forming clusters of molecules in which the hydrophobic trails are in the interior of the cluster. This formation is called micelle. Soap in the form of micelle is able to clean. The micelles stay in solution as a colloid and will not come together to precipitate because of ion-ion repulsion.

Micelles

Soaps are molecules in which the two ends have differing properties, one is hydrophilic, that is, it dissolves in water, while the other end is hydrophobic, that is, it dissolves in hydrocarbons. When soap is at the surface of water, the hydrophobic 'tail' of soap will not be soluble in water and the soap will align along the surface of water with the ionic end in water and the hydrocarbon 'tail' protruding out of water. Inside water, these molecules have a unique orientation that keeps the hydrocarbon portion out of the water. This is achieved by forming clusters of molecules in which the hydrophobic tails are in the interior of the cluster and the ionic ends are on the surface of the cluster. This formation is called a micelle. Soap in the form of a micelle is able to clean, since the oily dirt will be collected in the centre of the micelle. The micelles stay in solution as a colloid and will not come together to precipitate because of ion-ion repulsion. Thus, the dirt suspended in the micelles is also easily rinsed away. The soap micelles are large enough to scatter light. Hence a soap solution appears cloudy.



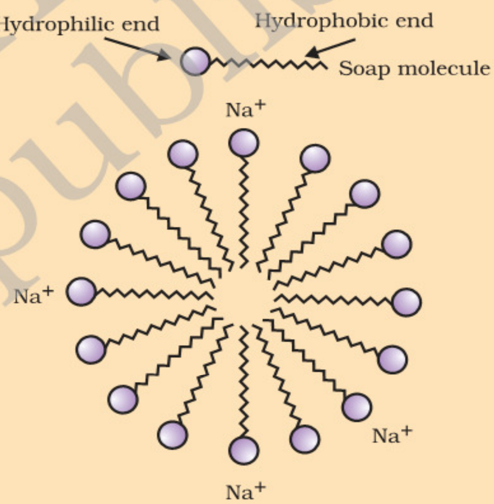


***Figure 4.13** Effect of soap in cleaning*