Unit. No 11 **ORGANIC CHEMISTRY**

Organic Chemistry:

The branch of chemistry in which we study about carbon containing compounds and their properties is called organic chemistry.

Some compounds of carbon such as carbon dioxide, carbon monoxide, carbides and carbonates are considered as inorganic substances.

Organic Compounds:

Organic compounds are defined as the hydrocarbons and their derivatives.

Catenation:

Carbon has the ability to form long chain bond with itself. This self linking ability of carbon is called catenation. Carbon atom form long chains of bonds with itself and this chain may contain thousand of carbon atoms. No other atom can form such type of long chain bonds with itself.

Isomerism:

The compounds that have same molecular formula but different arrangement of atoms in their molecules are called isomers. This phenomenon is called isomerism.

Example: $\boldsymbol{Butane}$: $\boldsymbol{C_4H_8}$

n-butane: $CH_3 - CH_2 - CH_2 - CH_3$

Iso-Butane:

$$CH_3 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_3$$

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GENERAL CHARACTERISTICS OF ORGANIC COMPOUNDS

1. **Occurence:**

Most of the organic compounds are obtained from living things or from the things that were once living.

2. **Covalent Nature:**

Due to presence of covalent bond organic compounds are generally covalent in nature. Organic compounds contain both polar and non-polar covalent bond.

3. **Composition:**

Carbon is the main part of organic compounds. Hydrogen is also frequently present in organic compounds. Some other elements like oxygen, nitrogen, sulphur, phosphorous and halogens are also present in many organic compound.

4. **Melting & Boiling Point:**

Organic compounds are generally volatile; therefore they have low melting and boiling point.

5. **Solubility:**

Polar organic compounds are soluble in alcohols such as methyl alcohol and ethyl alcohol. Non-polar organic compounds are soluble in either, benzene and carbon disulphide.

6. **Similarity in Behaviors: (Homology)**

A very close relationship is present b/w different organic compounds. Due to this close relationship it is very easy for us to study millions of organic compounds. A series of related compounds in which any two adjacent molecules differ by – CH_2 – group is called homologous series or homology.

7. **Reaction Rates:**

Covalent bond is present in organic compounds. Due to presence of covalent bond the reaction rates of organic compound are very slow. Also organic compounds are generally less stable than inorganic compounds.

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SATURATED AND UN-SATURATED HYDROCARBONS

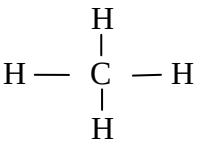
a) Saturated Hydrocarbon:

Those hydrocarbons which contain carbon – carbon single bonds are called saturated hydrocarbons. They are also called alkanes and there general formula C_nH_{2n+2} where 'n' is the number of carbon atoms. In alkanes each carbon atom is bonded to four other atoms.

Example:

Methane (CH_4), Ethane (C_2H_6), Propane (C_3H_8) are examples of alkanes.

Methane: CH_4



b) Un-Saturated Hydrocarbon:

Those hydrocarbons which contain carbon – carbon multiple bonds are called unsaturated hydrocarbons. There are two types of un-saturated hydrocarbons.

i) Alkenes ii) Alkynes

(i) Alkenes:

Those hydrocarbons which contain carbon-carbon double bond are called alkenes. Their general formula is "$C_n H_{2n}$" which 'n' is the number of carbon atoms.

Examples: Ethane ($CH_2 = CH_2$), Propene, Butane, Pentene are examples of alkenes.

(ii) Alkynes:

Those hydrocarbons which contain carbon-carbon triple bonds are called alkenes. Their general formula is "$C_n H_{2n-2}$" which 'n' is the number of carbon atoms.

Examples: Ethyne (CH ≡ CH) is an example of alkynes.

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TABLES OF FIRST TEN ALKYNES

1	Methane	**CH_4**
2	Ethane	**C_2H_6**
3	Propane	**C_3H_8**
4	Butane	**C_4H_{10}**
5	Pentane	**C_5H_{12}**
6	Hexane	**C_6H_{14}**
7	Heptane	**C_7H_{16}**
8	Octane	**C_8H_{18}**
9	Nonane	**C_9H_{20}**

10	Decane	**$C_{10}H_{22}$**

Naming Alkanes:

An international body **"International Union of pure and applied chemistry". (IUPAC)** has devised a system of naming organic compounds. These names of organic compounds indicate the number of carbon atom present in the organic compounds. We can easily recognize an

organic compound by its IUPAC name. These IUPAC names are called systematic names. The IUPAC name has two parts.

1. Stem **2.** Suffix

1. Stem:

The stem tells the number of carbon atoms in the change. A table given below shows stems. **NUMBER STEMS FOR CARBON CHAINS:**

Stem	Number of C-atoms
Meth –	1
Eht –	2
Prop –	3
But –	4
Pent –	5
Hex –	6
Hept –	7
Oct –	8
Non –	9
Dec –	10

2. Suffix:

Suffix is the word which is placed after the stem. It tells about the class of organic compounds.

For Alkane the suffix "ane" is used.

For Alkene the suffix "ene" is used.

For Alkyne the suffix "yne" is used.

Example:

Suffix (It indicate alkane)

Butane

Stem (It indicate number of C-atoms)

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EXAMPLE # 11.2

Write names of Alkanes.

i) $CH_3 - CH_2 - CH_2 - CH_3$

Number of carbon atoms = 4 so stem = But

Suffix = alkane

Name = Butane

ii) $CH_3 - CH_2 - CH_2 - CH_2 - CH_3$

Number of carbon atoms = 5 so stem = Pent

Suffix = alkane

Name = Pentane

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SOURCES OF ORGANIC COMPOUNDS

There are four major sources of organic compounds.

1. Coal **2.** Natural gas

3. Petroleum **4.** Living Organisms

1. <u>COAL</u>:

Coal is a source of many organic compounds. When it is heated in the absences of air at high

temperature. Then it is converted into three components. Coal gas, Coal tar and coke.

Destructive Distillation:

The process in which coal is converted into its three components coal gas, coal tar and coke, is called destructive distillation.

Coal Gas:

Coal gas contains methane, hydrogen and carbon monoxide gases. It is mainly used as a fuel in Industry.

Coal Tar: Coal tar is a source of many organic compounds such as benzene and its derivatives. compounds are very useful in synthetic organic chemistry to produce plastics, dyes, drugs, paints and varnishes.

Pitch: The residue left behind in the preparation of synthetic organic compound such as plastic, fibers, and varnishes is called pitch. It is used to metal roads and roof.

2. Natural Gas:

Natural gas is a mixture of low boiling hydrocarbons. The major component of natural gas is methane. It also contain small amount of ethane, propane and butane.

3. Petroleum:

Petroleum consist of different types of alkanes''having vary long chains. By the process of fractional distillation petroleum is separated into various hydrocarbons. These hydrocarbons are called fractions. Each fraction is a mixture of different hydrocarbons.

4. Living Organisms.

Living organisms are very important sources of organic compounds. Many important organic compounds such as proteins, fats, carbohydrates, vitamins, drugs and medicines are obtained from plants and animals.

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SYNTHESIS IN LABORATORY OR SYNTHETIC ORGANIC COMPOUNDS

Those organic compounds that cannot be obtained directly from any natural source but they can be prepared in the laboratory are called synthetic organic compounds. More than 10 million organic compounds have been prepared in the laboratories. Synthetic organic compound are used in medicines,

cosmetics, paints, plastics, fertilizers, detergents, etc

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USES OF ORGANIC COMPOUNDS

1. Natural gas and petroleum are used as fuel. These two materials are also used for the production of many organic compounds.
2. Propane and butane are gases obtained from natural gas are used as liquids in fuel cylinders (LPG).
3. Ethylene is an important organic material and it is used in different organic chemicals and products such as polyethylene (plastic), ethyl alcohol, acidic acid and ethylene glycol which is also called antifreeze.
4. Acetylene is used in the oxy-acetylene welding and cutting metals. Acetylene is also used in the preparation of polymers like (PVC), polyvinyl acetate, synthetic rubber, nylon etc.
5. Acetylene is used for artificial ripening of fruits.
6. Compounds of phenol produce antiseptic conditions in hospital operating rooms.
7. Methanol is used as a solvent for fats, oils, paints and varnishes.
8. Many organic compounds are used in manufacture of drugs, dyes, cosmetics, detergents, soaps,
   nylon, emulsions and paints.

CLASSIFICATION OF ORGANIC COMPOUNDS

There are two main classes of organic compounds.

1. Open Chain Compounds OR Acyclic Compounds
2. Closed Chain Compounds OR Cyclic Compounds

1. <u>Open Chain Compounds OR A Cyclic Compound</u>:

Those organic compounds which contain an open chain of carbon atoms are called open chain compounds. They are also called acyclic compounds.

Examples:

i) **Propane:** $CH_3 - CH_2 - CH_3$

ii) **Butane:** $CH_3 - CH_2 - CH_2 - CH_3$

iii) **Iso-Butane:**

$$CH_3 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_3$$

Open chain compounds are further divided into two groups.

1. Straight Chain Compounds
2. Branched Chain Compounds

1. <u>Straight Chain Compounds</u>:

Those organic compounds which contain any number of carbon atoms joined one after the other in a chain are called straight chain compounds.

Examples:

i) **Propane:** $CH_3 - CH_2 - CH_3$

ii) **Butane:** $CH_3 - CH_2 - CH_2 - CH_3$

iii) **Pentane:** $CH_3 - CH_2 - CH_2 - CH_2 - CH_3$

2. <u>Branched Chain Compounds</u>:

Those organic compounds which contain carbon atoms on the side of chain are called branched chain compounds.

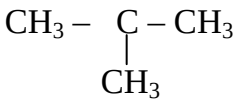
Examples:

i) **Iso-Butane:**

$$CH_3 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_3$$

ii) **Neo-Pentane**

$$\overset{\displaystyle CH_3}{\overset{|}{}}$$

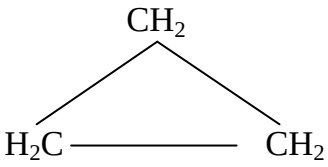


2. Closed Chain Compounds OR Cyclic Compounds:

Those organic compounds which contain rings of atoms are called closed chain compounds. They are also called cyclic compounds.

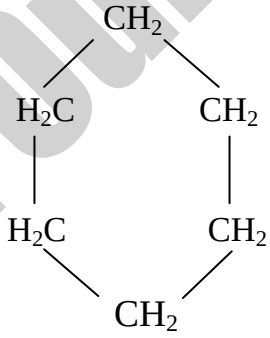
Examples:

i) Cyclo propane:



ii) Cyclo butane:

iii) Cyclo Hexane:



Closed chain compounds are further divided into two groups.

i) Homocyclic OR Carbocyclic Compounds

ii) Hetercyclic Compounds

i) Homocyclic OR Carbocyclic Compounds:

Those cyclic compounds which contain rings of carbon atoms are called homocyclic compounds. They are also called carbocyclic compounds.

ii) Heterocyclic Compounds:

Those cyclic compounds which contain one or more atoms other than carbon atoms in the rings are called heterocyclic compounds.

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ALKYL RADICAL

An alkyl radical is a group of atoms obtained by removing one hydrogen atom from an alkane. It is represented by "R".

TABLE OF 1ST TEN ALKYL GROUPS

1	*Methane* CH_4	Methyl CH_3-
2	*Ethane* C_2H_6	*Ethyl* $C_2H_5^-$
3	*Propane* C_3H_8	*Propyl* $C_3H_7^-$
4	*Butane* C_4H_{10}	*Butyl* $C_4H_9^-$
5	*Pentane* C_5H_{12}	*Pentyl* $C_5H_{11}^-$
6	*Hexane* C_6H_{14}	*Hexyl* $C_6H_{13}^-$
7	*Heptane* C_7H_{16}	*Heptyl* $C_7H_{15}^-$
8	*Octane* C_8H_{18}	*Octyl* $C_8H_{17}^-$
9	*Nonane* C_9H_{20}	*Nonyl* $C_9H_{19}^-$
10	*Decane* $C_{10}H_{22}$	*Decyl* $C_{10}H_{21}^-$

Functional Groups:

An atom or groups of atoms that give a family of organic compounds its characteristics chemical and physical properties is called functional group. Each functional group defines a family of organic compounds. With the help of functional group we can easily study millions of organic compounds.

FUNCTIONAL GROUPS CONTAINING CARBON, HYDROGEN AND HALOGENS

1. **HaloAlkane:**

Those organic compounds in which one hydrogen atom of alkanes is replaced by one halogen atom are called haloalkanes.

Example: **i) Methane CH_4**

Chloromethane $CH_3 – Cl$

ii) Ethane C_2H_6

Bromoethane $CH_3 – CH_2 – Br$

2. **Alcohols**:

Those organic compounds in which one hydrogen of alkanes is replaced by hydroxyl group (OH) are called alcohols. Their general formula is "R – OH"

Example: **i) Methane CH_4**

Methanol (Methyl alcohol) $CH_3 – OH$

ii) Ethane $CH_3 – CH_3$

Ethanol (Ethyl alcohol) $CH_3 – CH_2 – OH$

3. **Phenols**:

Those organic compounds in which one hydrogen atom of benzene ring (C_6H_6) is replaced by hydroxyl group (OH) are called phenols. Phenol was the first antiseptic used in an operation theatre.

Example: **Benzene: C_6H_6**

Phenol $C_6H_5 - OH$

4. Ethers:

Those organic compounds in which two alkyl groups are attached with the same oxygen atom are called ethers.

Their general formula is "R – O –R" where R and R are two alkyl groups which may be same or different.

Example:

i) $CH_3 - O - CH_3$ (Dimethyl ether)

ii) $CH_3 - O - CH_2 - CH_3$ (Ethyl methyl ether)

iii) $CH_3 - CH_2 - O - CH_2 - CH_3$ (Diethyl ether)

5. Aldehydes:

Aldehydes are those organic compounds in which at least one hydrogen atom or two

hydrogens atoms are attached with carbonyl carbon atom.

If one hydrogen atom is attached with carbonyl carbon atom then an alkyl group is attached with the other side of the carbonyl carbon atom.

Their general formula is $R - \overset{\overset{O}{\|}}{C} - H$ or $H - \overset{\overset{O}{\|}}{C} - H$

Example:

i) $H - \overset{\overset{O}{\|}}{C} - H$ (Formualdehyde)

ii) $CH_3 - \overset{\overset{O}{\|}}{C} - H$ (Acetaldehyde)

6. Ketone:

Those organic compounds in which two alkyl groups are attached with the carbonyl carbon atom are called ketones.

Their general formula is $R-\overset{\overset{O}{\|}}{C}-R$ Where **R** and **R** are two alkyl groups which may be same or different.

Example:

i) $CH_3-\overset{\overset{O}{\|}}{C}-CH_3$ Propanone (Acetone)

ii) $CH_3-\overset{\overset{O}{\|}}{C}-CH_2-CH_3$ Butanone

7. Carboxylic Acid:

Those organic compounds in which hydroxyl group (OH) is bounded to carbonyl carbon atom are called carboxylic acids.

Their general formula is $R-\overset{\overset{O}{\|}}{C}-OH$

Example:

i) $H-\overset{\overset{O}{\|}}{C}-OH$ or HCOOH **Formic acid** (Methanoic acid)

ii) $CH_3-\overset{\overset{O}{\|}}{C}-OH$ or CH_3COOH **Acetic acid** (Ethanoic acid)

8. Ester's:

Those organic compounds which has general formula $R-\overset{\overset{O}{\|}}{C}-OR$ where **R** and **R** are two alkyl groups which may be same or different.

Example:

$\overset{\overset{O}{\|}}{}$

i) $CH_3 - C - OCH_3$ Methyl acetate

ii) $CH_3 - \overset{\overset{O}{\|}}{C} - O - CH_3 - CH_3$ Ethyl acetate

9. Amines:

Those organic compounds in which one hydrogen atom of an alkane is replaced by **NH_2** group is called amines. Their general formula is $R - NH_2$.

Example:

i) $CH_3 - NH_2$ Methyl Amine

ii) $CH_3 - CH_2 - NH_2$ Ethyl Amine

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EXERCISE QUESTIONS

Page - No- 86 Q-No-2(i) What is catenation?

Ans:- Catenation:-

The self linking ability of carbon atoms to form bond with itself is called catenation.

Carbon has this unique ability to form bond with itself and make long chains and rings. Due to this

self-linking ability carbon forms a large range of compounds which play a very important role in our daily life.

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Q-No-2(ii) Define isomerism.

Ans:- Isomersims:-

The compounds that have same molecular formula but different arrangement of atoms in their molecules are called isomers and this phenomenon is called isomerism.

Example:-

Two compounds have molecular formula C_4H_{10} but their structures are different.

$CH_3 – CH_2 – CH_2 – CH_3$ n-Butane

$CH_3 – CH_2 – CH_3$ Iso-Butane
|
CH_3

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Q-No-2(iii) Give three examples of alkyl groups.

Ans:- Alkyl group is an organic compound which is obtained by removing one hydrogen atom from an alkane.

i) Methane = CH_4 removing one hydrogen atom we get CH_3 – Methyl.

ii) Ethane = C_2H_6 removing one hydrogen atom we get C_2H_5 – Ethyl.

iii) Propane = C_3H_8 removing one hydrogen atom we get C_3H_7 – Propyl.

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Q-No-2(iv) Define Functional group.

Ans:- Functional group:-

An atom or groups of atoms that give a family of organic compounds its characteristics chemical and physical properties is called a functional group.

Example:- **i)** – OH is called hydroxyl group

ii) – COOH is called carboxyl group

iii) – CO – is called carboxyl group

Q-No-2(v) What is the difference b/w an alkane and alkyl radical?

Ans:- Alkane:-

Alkane is a type of hydrocarbons which contains carbon- carbon single bond. Their general formula is $\mathbf{C_n H_{2n+2}}$

Alkyl Radical:-

An alkyl radical is a group of atoms obtained by removing one hydrogen atom from an alkane. Alkyl radical are represented by the symbol '**R**' and their general formula is $\mathbf{C_nH_{2n+1}}$.

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Q-No-3: What do you mean by the term destructive distillation?

Ans:- When coal is heated in the absence of air at high temperature then it is converted into three components.

i. Coal gas ii. Coal tar iii. Coke.

This process of converting coal into these three components is called destructive distillation.

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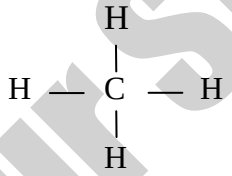
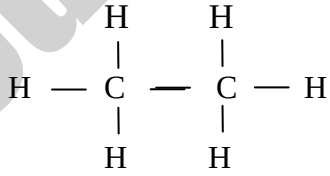
Q-No-9 Give the structural formula of two simple alkanes and one alkyne.

Ans:- **Alkanes:-**

i. Methane $=CH_4$





Alkynes:

Ethyne: CH ≡ CH H – C ≡ C – H