ORGANIC COMPOUNDS

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Organic compounds are the compounds of carbon and organic chemistry is the study of carbon compounds.

SOURCES OF ORGANIC COMPOUNDS

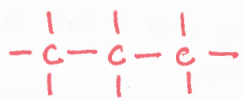
- Plants
- Animals
- Coal
- Petroleum
- Fermentation
- Wood
- Synthetic Methods

UNIQUE NATURE OF CARBON ATOMS

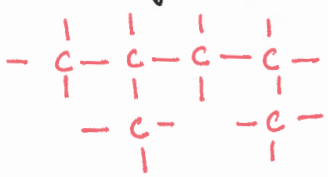
TETRAVALENCY OF THE CARBON ATOM : The characteristic of the carbon atom by virtue of which it forms covalent bonds is called the tetravalency of carbon.

CATENATION The property of self linking of atoms of an element through covalent bonds in order to form straight chains, branched chains and cyclic chains of different sizes is known as catenation.

- This is due to : Greater strength of carbon-carbon bond
  : Tetra-covalency of carbon



STRAIGHT CHAIN



BRANCHED CHAIN

CYCLIC CHAIN

ISOMERISM The phenomenon in which the compounds have the same molecular formula but differ in the structural formula is known as Isomerism. and the compounds are referred as Isomers.

$C_6H_{12}O_6$ — Glucose
$C_6H_{12}O_6$ — Fructose

TYPES OF ORGANIC COMPOUNDS

- Hydrocarbon
  - Alkane: -C-C-
  - Alkene: -C=C-
  - Alkyne: -C≡C-
- Alcohol: -OH
- Aldehyde: -CHO
- Ketone: $-\overset{\overset{O}{\|}}{C}-$
- Carboxylic acid: -COOH
- Ether: -COOR'
- Halide: -X (F, Cl, Br, I)

• HYDROCARBONS

Hydrocarbons are compounds that are made up only of carbon and hydrogen atoms.

CLASSIFICATION OF HYDROCARBONS

HYDROCARBONS
- Aliphatic or open chain compounds
  - Saturated → Alkanes (paraffins) C_nH_{2n+2}
  - Unsaturated
    - Alkenes (Olefins) C_nH_{2n}
    - Alkynes C_nH_{2n-2}
- Cyclic or closed chain compounds
  - Alicyclic
  - Aromatic

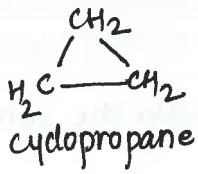
Aliphatic or Open Chain Compounds

- Saturated Organic Compounds
  - All four valencies of each carbon atom are satisfied by forming single covalent bonds with carbon and hydrogen atoms. Carbon atoms are joined by single covalent bond. They are less reactive due to the non-availability of electrons.
  - They undergo substitution reaction.
- Unsaturated Organic compounds
  - The valencies of atleast two carbon atoms are not fully satisfied by the hydrogen atoms.
  - Carbon atoms are joined by double or triple covalent bond.
  - They are more reactive due to the presence of electrons.
  - They undergo addition reactions

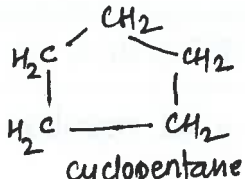
Cyclic or closed chain or ring-chain compounds

→ **Alicyclic compounds**

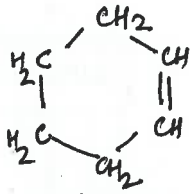
These are ringed carbon compounds containing three or more atoms of carbon arranged in a closed structure.



Cyclopropane



Cyclopentane

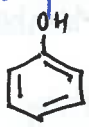


Cyclohexane

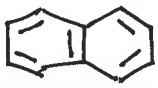
→ **Aromatic compounds**

Some hydrocarbons contain atleast one benzene ring in their molecules. These compounds have a pleasant smell. Hence, they are known as aromatic compounds.

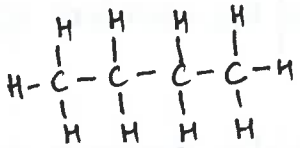

Benzene



Phenol


Naphthalene.

- **STRUCTURAL FORMULA**: The formula that shows how atoms of different elements are linked together in a molecule is known as structural formula.

C_4H_{10} :  or, $CH_3-CH_2-CH_2-CH_3$

Butane — n-butane — condensed or Abbreviated formula of butane

ALKYL GROUP An alkyl groups is formed by removing one atom of hydrogen atom from an alkane

$C_nH_{2n+2} \xrightarrow{-H} C_nH_{2n+1}$

Alkane → Alkyl

FUNCTIONAL GROUP

- An atom or group of atoms joined in a specific manner which is responsible for the characteristic chemical properties of the organic compounds.

CHARACTERISTICS OF FUNCTIONAL GROUP

→ Chemical properties of the compounds containing the same functional group are similar.

→ The physical and chemical properties of the compounds of diff. functional groups are different

→ There exists a homologous series of compounds containing a particular type of functional group.

HOMOLOGOUS SERIES: It is a group of organic compounds represented by the same general formula and having a similar structure and similar chemical properties in which the successive compounds differ by a $-CH_2$ group.

CHARACTERISTICS OF A HOMOLOGOUS SERIES

- All members share the same general formula. (G.f of alkane: C_nH_{2n+2})
- Each member of the series differs from the preceding one by the addition of $-CH_2$ group or 14 a.m.u.
- The physical properties of the members show gradation as the molecular mass increases
- Members of same homologous series have similar chemical properties
- They can be prepared by same general method of preparation

SIGNIFICANCE OF THE HOMOLOGOUS SERIES

- If the properties of the first few members are known, the nature of any member of that family can be ascertained
- It helps to predict the properties of the members of the series which are yet to be prepared.
- Systematic study of organic chemistry becomes easy.

NOMENCLATURE

Naming of organic compound following Trivial system and IUPAC system.

Name of the compound following IUPAC :

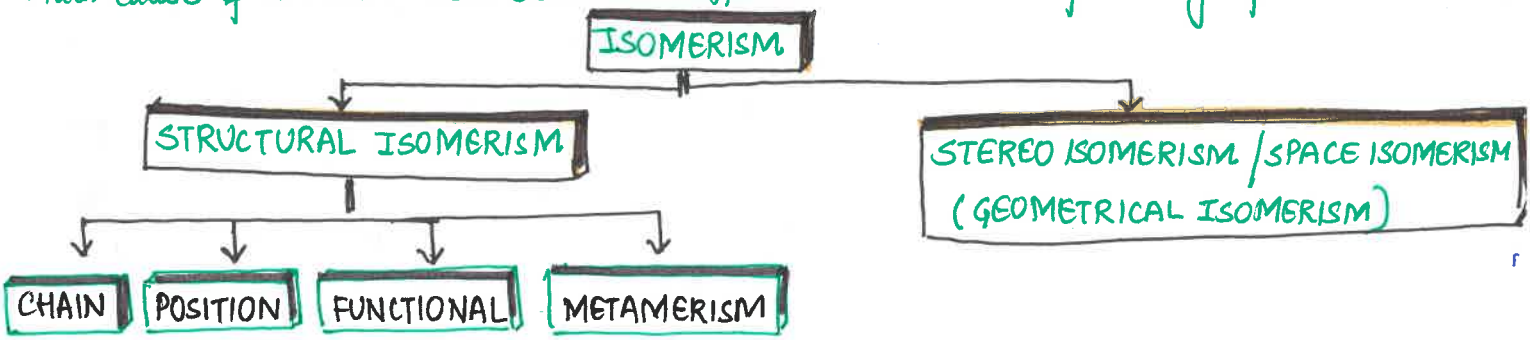
Prefix + Word root + Primary suffix + Secondary suffix

- **Prefix**: Additional substituent alkyl or functional group and its position in the carbon chain in alphabetical order
- **Word root**: depends on the number of carbon atoms
- **Primary suffix**: Nature of the bond in carbon-carbon atom i.e.
  - C-C : -ane
  - C=C : -ene
  - C≡C : -yne
- **Secondary suffix**: Particular functional group linked to the carbon chain.

ISOMERISM

Compounds having the same molecular formula but different structural formula are known as 'Isomers' and the phenomenon is known as Isomerism

Main cause of structural isomerism is difference in the mode of linking of atoms



CHAIN ISOMERISM: Exhibited by compounds having similar molecular formula but differ in the arrangement of carbon atoms in straight or branched chains.

C_5H_{12}

$CH_3CH_2CH_2CH_2CH_3$ — n-pentane

$CH_3-\underset{CH_3}{\underset{|}{CH}}-CH_2-CH_3$ — Iso-pentane

$CH_3-\underset{CH_3}{\underset{|}{\overset{CH_3}{\overset{|}{C}}}}-CH_3$ — neo-pentane

POSITION ISOMERISM When two or more compounds with same molecular formula differ in the position of substituent atom or functional group on the carbon atom they are called position isomers.

C_4H_6 (Butyne)

- $CH_3CH_2C\equiv C-H$ but-1-yne
- $CH_3C\equiv C-CH_3$ but-2-yne

FUNCTIONAL ISOMERISM Two or more compounds with the same molecular formula but different functional groups are called functional isomers.

C_2H_6O

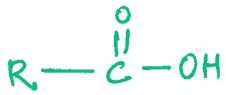
- CH_3CH_2OH (Ethanol)
- CH_3-O-CH_3 (Dimethyl ether)

METAMERISM It arises due to unequal distribution of alkyl groups on either side of the functional groups in the molecule

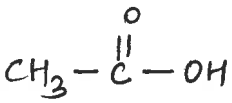
- $CH_3-O-C_3H_7$ methoxy propane
- $C_2H_5-O-C_2H_5$ Ethoxyethane

CARBOXYLIC ACIDS

- An organic compound containing the carboxyl group (–COOH).
- **General Formula:** $C_nH_{2n+1}COOH$ or $RCOOH$ Known as "Alkanoic acids"



ETHANOIC ACID / ACETIC ACID : CH_3COOH



- 4-5% solution of ethanoic acid is called Vinegar.

PHYSICAL PROPERTIES OF ETHANOIC ACID

- Pure Ethanoic acid is a colourless liquid
- characteristic pungent smell
- The anhydrous acid on cooling forms a crystalline mass resembling ice: m.pt is 17°C and for this reason it is called 'glacial acetic acid'.
- It boils at 118°C
- It is a hygroscopic liquid, sp.gravity at 0°C is 1.08
- It is miscible with water, alcohol and ether in all the proportions.

CHEMICAL PROPERTIES OF ETHANOIC ACID

ACIDITY: It is a weak acid, hence:

(i) turns moist blue litmus red.

(ii) reacts with active metals (i.e Zn and Mg) evolving hydrogen

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

$$2CH_3COOH + Mg \longrightarrow (CH_3COO)_2Mg + H_2\uparrow$$

(iii) reacts with alkalies to form salt and water:

$$\text{Acid} + \text{Base} \longrightarrow \text{Salt} + \text{water}$$

(iv) liberates brisk effervescence of CO_2 with carbonates and or

ALKYNES

ALKYNES : Aliphatic hydrocarbons that contain triple bond (-C≡C-) i.e acetylenic bond.

- They are unsaturated hydrocarbons **General formula:** C_nH_{2n-2}

SOURCES OF ALKYNE:

Natural gas and Petroleum

ISOMERISM: Position Isomerism

Chain Isomerism

i) Butyne: shows position isomerism

$CH_3-CH_2-C\equiv CH$: But-1-yne

$CH_3-C\equiv C-CH_3$: But-2-yne

ii) Pentyne: shows chain and position isomerism

$CH_3-CH_2-CH_2-C\equiv CH$: Pent-1-yne

$CH_3-CH_2-C\equiv C-CH_3$: Pent-2-yne

$CH_3-\underset{\underset{CH_3}{|}}{CH}-C\equiv CH$: 3-Methyl But-1-yne

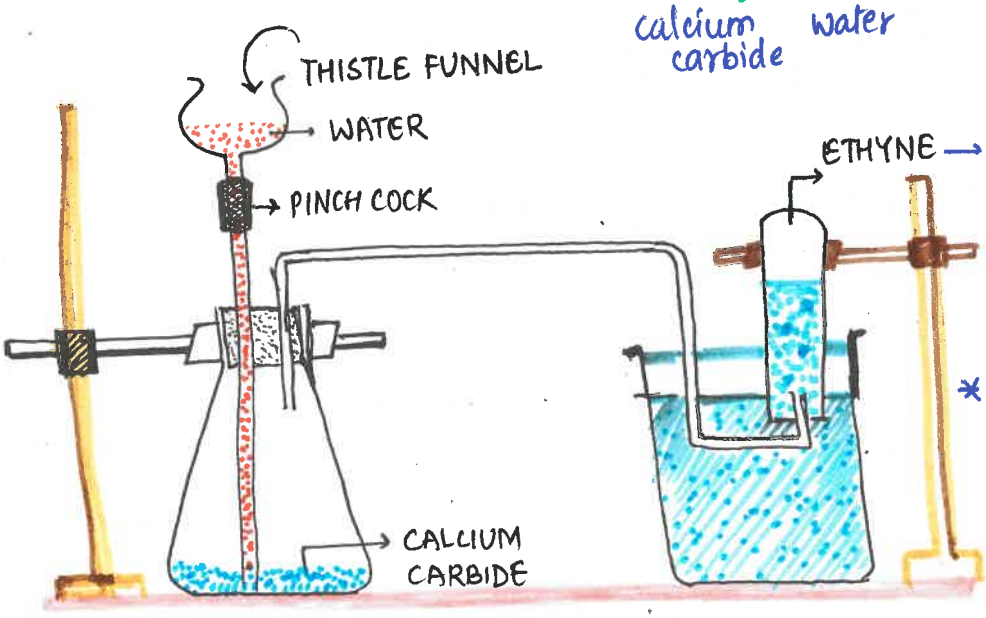
ETHYNE: C_2H_2

COMMON NAME: Acetylene : $H-C\equiv C-H$

Linear

LABORATORY PREPARATION OF ETHYNE:

$$\underset{\text{calcium carbide}}{CaC_2} + \underset{\text{water}}{2H_2O} \longrightarrow \underset{\text{calcium hydroxide}}{Ca(OH)_2} + \underset{\text{ethyne}}{C_2H_2}\uparrow$$



The gas is collected by the downward displacement of water, since it is insoluble in water.

* The flask should not contain air as ethyne forms an explosive mixture with air. Therefore, the air of the flask is displaced by oil or some inert gas.

PHYSICAL PROPERTIES OF ETHYNE

- Ethyne is a colourless gas with an ether like odour
- Negligibly soluble in water but highly soluble in organic solvents like acetone and alcohol.
- It is lighter than air
- Liquefies at $-84°C$
- Its boiling point is $-75°C$

CHEMICAL PROPERTIES OF ETHYNE

Ethyne is a highly reactive compound due to the presence of triple bond.

1. OXIDATION OF ETHYNE: COMBUSTION

- Ethyne burns in excess air with a brilliant white flame to produce CO_2, water vapour and large amt. of heat.

$$2CH{\equiv}CH + 5O_2 \longrightarrow 4CO_2 + 2H_2O + \text{Heat}$$

2. ADDITION REACTIONS

Alkynes are unsaturated compounds, so they are associated with addition reactions, since triple bonds breaks easily.

- **ADDITION OF HYDROGEN: CATALYTIC HYDROGENATION**

$$\underset{\text{Ethyne}}{HC{\equiv}CH} \xrightarrow[Ni]{+H_2} \underset{\text{Ethene}}{CH_2=CH_2} \xrightarrow[Ni]{+H_2} \underset{\text{Ethane}}{CH_3-CH_3}$$

- **ADDITION OF HALOGEN:**

REACTION WITH CHLORINE:

$$\underset{\text{Ethyne}}{CH{\equiv}CH} \xrightarrow[\text{from } CCl_4]{Cl_2} \underset{\substack{\text{1,2-dichloroethene}}}{\begin{matrix}CHCl\\ \|\\ CHCl\end{matrix}} \xrightarrow{Cl_2} \underset{\text{1,1,2,2,-tetrachloroethane}}{\begin{matrix}CHCl_2\\ |\\ CHCl_2\end{matrix}}$$

REACTION WITH BROMINE:

$$\underset{\text{Ethyne}}{CH{\equiv}CH} \xrightarrow[\text{from } CBr_4]{Br_2} \underset{\substack{\text{1,2-dibromo}\\ \text{ethene}}}{C_2H_2Br_2} \xrightarrow{Br_2} \underset{\text{1,1,2,2-tetrabromoethane}}{C_2H_2Br_4}$$

* Reddish brown colour disappears due to the formation of an addition product.

REACTION WITH IODINE

$CH \equiv CH + I_2 \xrightarrow{\text{alcohol}} ICH=CHI$

1,2-di-iodoethene

REACTION WITH HCl

$HC \equiv CH + HCl \longrightarrow \underset{\underset{CH_2}{||}}{CHCl} \xrightarrow{HCl} \underset{\underset{CH_3}{|}}{CHCl_2}$

Chloroethene — 1,1-dichloroethane

CHEMICAL TESTS TO DISTINGUISH BETWEEN ALKANES, ALKENES, ALKYNES.

SERIAL NO.	TEST	ALKANES (SATURATED HC)	ALKENES (UNSATURATED HYDROCARBON)	ALKYNES (UNSATURATED HYDROCARBON)
1.	Hydrocarbon + Br_2/CCl_4 (Reddish brown)	No change	Reddish brown colour gets decolourised	Reddish brown colour gets decolourised
2.	Hydrocarbon + Alk. $KMnO_4$ (purple colour)	No change	Purple colour fades	Purple colour fades "BAYER'S TEST" $CH \equiv CH + 4[O] \xrightarrow{\text{Alk. } KMnO_4}$ COOH / COOH (oxalic acid)
3.	Hydrocarbon + Ammonical cuprous chloride	No change	No change	Red ppt of copper acetylide is formed
4.	Hydrocarbon + Ammonical $AgNO_3$	No change	No change	White ppt of silver acetylide is formed.

ALCOHOLS

- Hydroxy derivatives of alkanes

General Formula: $C_nH_{2n+1}OH$

ALCOHOL

MONOHYDRIC
- with one -OH group attached to the carbon atom.
- CH_3OH (methylalcohol)
- C_2H_5OH (Ethylalcohol)

DIHYDRIC
- with two -OH group attached to the carbon atom.
- $CH_2(OH)-CH_2(OH)$ (Ethane 1,2-diol)

TRIHYDRIC
- with three -OH group attached to the carbon atom

$CH_2(OH)-CH(OH)-CH_2(OH)$

Propane 1,2,3-triol

ETHANOL : C_2H_5OH

ISOMERS IN ALCOHOLS: Alcohol with 3 or more shows isomerism.

Eg: $CH_3CH_2CH_2OH$ Propan-1-ol

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

LABORATORY PREPARATION:

Alkyl halide + aq. KOH $\xrightarrow{\text{boil}}$ Alcohol + KX

Alkyl halide + aq. NaOH $\xrightarrow{\text{boil}}$ Alcohol + NaX

'Hydrolysis of alkyl halide'

Eg: $C_2H_5Cl + aq.\ KOH \xrightarrow{\text{boil}} C_2H_5OH + KCl$

Ethyl chloride → Ethanol

INDUSTRIAL METHOD : (Large Scale Method)

(i) $C_2H_4 + H_2SO_4 \xrightarrow[30\ atm]{80^\circ C} C_2H_5HSO_4 \xrightarrow[(Boiling)]{H_2O} C_2H_5OH + H_2SO_4$

Ethene → Ethanol

(ii) $C_2H_4 + H_2O \xrightarrow[300^\circ C,\ 60atm]{H_3PO_4} C_2H_5OH$

Ethanol

PHYSICAL PROPERTIES

- They are inflammable volatile liquids
- Bpt increases with an increase in molecular wt.
- They are soluble in water as well as in organic solvents
- Ethanol is lighter than water
- They are colourless, have a faint odour and a burning taste.
- Some are toxic.

CHEMICAL PROPERTIES

COMBUSTION (BURNING)

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

Ethanol burns with a blue flame.

OXIDATION WITH ACIDIFIED $K_2Cr_2O_7$:

Alcohol $\xrightarrow{[O]}$ Aldehyde $\xrightarrow{[O]}$ Acid $\xrightarrow{[O]}$ $CO_2 + H_2O$

- $CH_3OH \xrightarrow{[O]} HCHO + H_2O \xrightarrow{[O]} HCOOH$

Methanol — Formaldehyde — Formic acid

- $C_2H_5OH \xrightarrow{[O]} CH_3CHO + H_2O \xrightarrow{[O]} CH_3COOH$

Ethanol — Ethanal — Ethanoic acid

REACTION WITH SODIUM

$$2CH_3OH + 2Na \longrightarrow 2CH_3ONa + H_2\uparrow$$

Methanol — sodium methoxide

Effervescence of hydrogen serves as a test for alcohols.

$$2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2\uparrow$$

Ethanol — sodium ethoxide

REACTION WITH ACETIC ACID: ESTERIFICATION

- $CH_3OH + CH_3COOH \xrightarrow{\text{conc. } H_2SO_4/\Delta} CH_3COOCH_3 + H_2O$

methyl acetate

- $C_2H_5OH + CH_3COOH \xrightarrow{\text{conc. } H_2SO_4/\Delta} CH_3COOC_2H_5 + H_2O$

Ethyl acetate

DEHYDRATION WITH CONC. SULPHURIC ACID:

- $C_2H_5OH \xrightarrow[170^\circ C]{\text{Conc } H_2SO_4} CH_2 = CH_2 + H_2O$
  Ethyl alcohol — Ethene
- $C_2H_5OH \xrightarrow[350^\circ C]{Al_2O_3} C_2H_4 + H_2O$
  Ethanol — Ethene
- $2CH_3OH \xrightarrow[140^\circ C]{\text{conc. } H_2SO_4} CH_3-O-CH_3 + H_2O$
  Methanol — Dimethylether
- $2C_2H_5OH \xrightarrow[140^\circ C]{\text{conc. } H_2SO_4} C_2H_5-O-C_2H_5 + H_2O$
  Ethanol — Diethylether

COMMERCIAL FORMS OF ETHANOL

1. DENATURED ALCOHOL OR METHYLATED SPIRIT: Methylated spirit or denatured alcohol is ethyl alcohol with 5% methyl alcohol, a coloured dye and some pyridine.

2. SPURIOUS ALCOHOL: Illicit liquor made by improper distillation. It contains large proportions of methanol in a mixture of alcohols.