CARBON AND IT'S COMPOUNDS

Bonding in carbon:- The covalent bond, Electron dot structure, Physical properties of organic compound, Allotropes of carbon.

Covalent Bond:- The atomic number of carbon is 6. Its electronic configuration is 2,4. It requires 4 electrons to achieve the inert gas electronic configuration. But carbon cannot form an ionic bond.

It could gain four electrons forming C^{4-} cation. But it would be difficult for the nucleus with six protons to hold on to ten electrons.

It could lose four electrons forming C^{4+} cationS. But it requires a large amount of energy to removes four electrons.

Thus, carbon overcomes this problem by sharing of its valence electrons with other carbon atoms or with atoms of other elements.

The bond formed by mutual sharing of electron pairs between two atoms in a molecule is known as ***COVALENT BOND***.

Types of Covalent Bond:-

- **Single Covalent Bond**: When a single pair of electrons are shared between two atoms in a molecule. For eg: F_2, Cl_2, H_2 etc.

- **Double Covalent Bond**: When two pairs of electrons are shared between two atoms in a molecule. For eg: O_2 ,CO_2 etc.

Triple Covalent Bond: When three pairs of electrons are shared between two atoms in a molecule. For eg: N_2, etc.

ELECTRON DOT STRUCTURE:- The electron dot structures provides a picture of bonding in molecules in terms of the shared pairs of electrons and octet rule.

FORMATION OF HYDROGEN MOLECULE:- Atomic number of Hydrogen= 1

Number of valence electrons=1

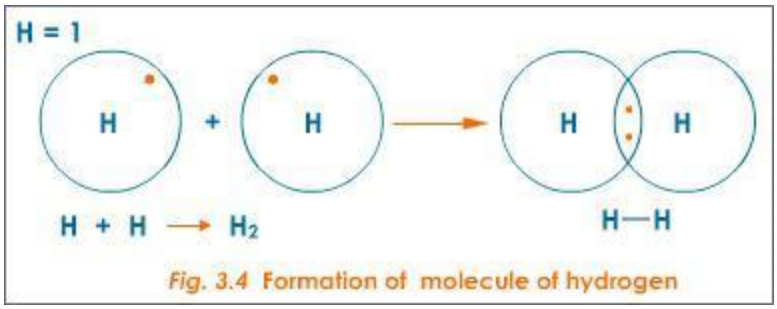


Fig. 3.4 Formation of molecule of hydrogen

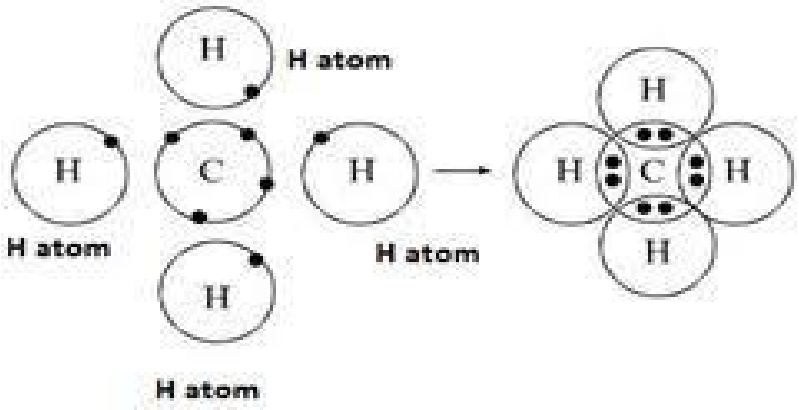
FORMATION OF CH_4 MOLECULE:-

Atomic no of Carbon=6(2,4)

Number of valence electrons=4

Atomic number of Hydrogen=1

Number of valence electrons=1



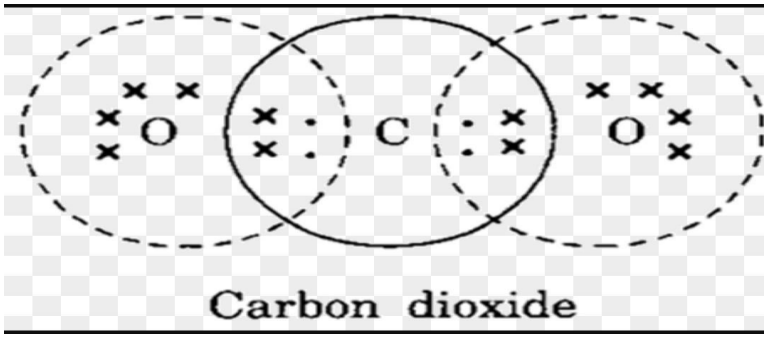
FORMATION OF CO_2 MOLECULE:-

Atomic number of Carbon= 6(2,4)

Number of valence electrons=4

Atomic number of Oxygen=8(2,6)

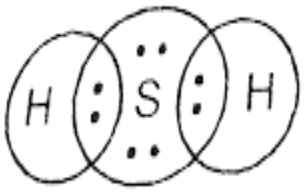
Number of valence electrons=6



FORMATION OF H_2S MOLECULE:-

Atomic number of Sulphur=16(2,8,6)

Number of valence electrons=6



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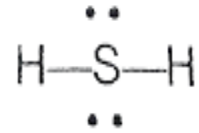


Hydrogen sulphide molecule

PHYSICAL PROPERTIES OF ORGANIC COMPOUNDS

Most of the organic compounds have low boiling and melting point, due to the weak force of attraction(i.e, the inter-molecular force of attraction) between these molecules.

- ❖ Most carbon compounds are poor conductors of electricity, due to the absence of free electrons and free ions.

Table 4.1 Melting points and boiling points of some compounds of carbon

Compound	Melting point (K)	Boiling point (K)
Acetic acid (CH_3COOH)	290	391
Chloroform ($CHCl_3$)	209	334
Ethanol (CH_3CH_2OH)	156	351
Methane (CH_4)	90	111

ALLOTROPES OF CARBON:-

Allotropy: The phenomenon in which the element exists in two or more different physical states with similar chemical properties are called ALLOTROPY.

CARBON HAS THREE MAIN ALLOTROPES

- ***Diamond:*** In this, carbon, an atom is bonded to four other atoms of carbon forming three-dimensional structures. It is the hardest substance and an insulator. It is used for drilling rocks and cutting. It is also used for making jewelery.
- ***Graphite:*** In this , each carbon atom is bonded to three other carbon atoms. It is a good conductor of electricity and used as a lubricant.
- ***Buckminster Fullerene:*** It is an allotrope of the carbon containing cluster of 60 carbon atoms joined together to

form spherical molecules. It is dark solid at room temperature.

Versatile Nature of Carbon: The existence of such a large number of organic compounds is due to the following nature of carbon,

- Catenation
- Tetravalent nature

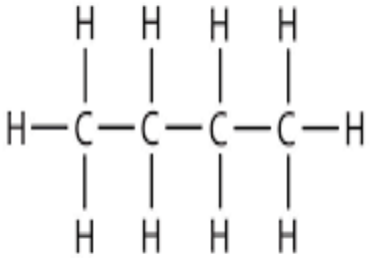
a) **Catenation:** The self linking property of an element mainly carbon atom through covalent bonds to form long straight, branched and rings of different sizes are called Catenation.

This property is due to

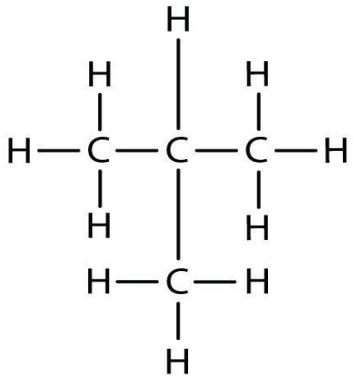
- The small size of the carbon atom.
- The great strength of the carbon- carbon bond.

Carbon can also form stable multiple bonds (double or triple) with itself and with atoms of other elements.

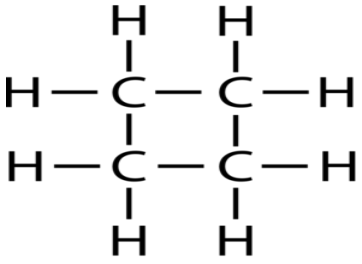
STRAIGHT CHAIN:



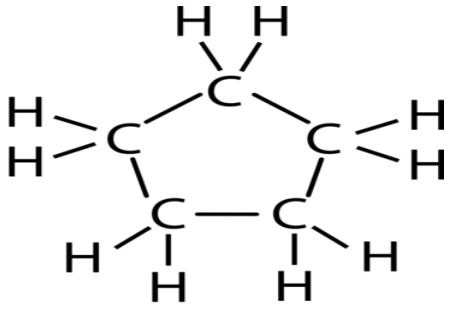
BRANCHED CHAIN:



RINGS:

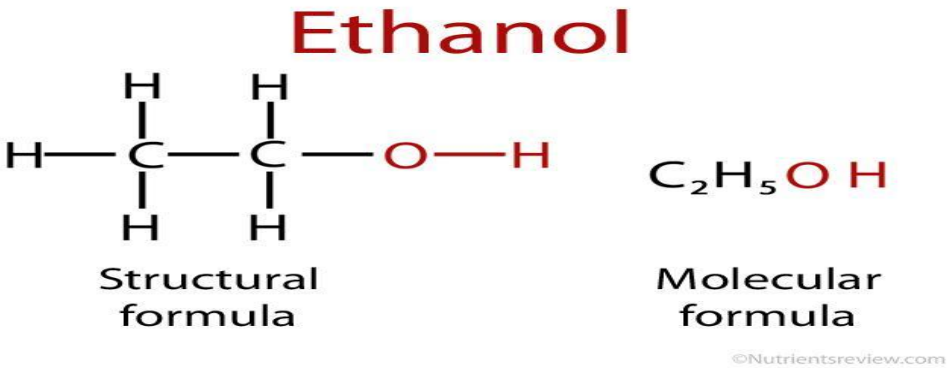


cyclobutane

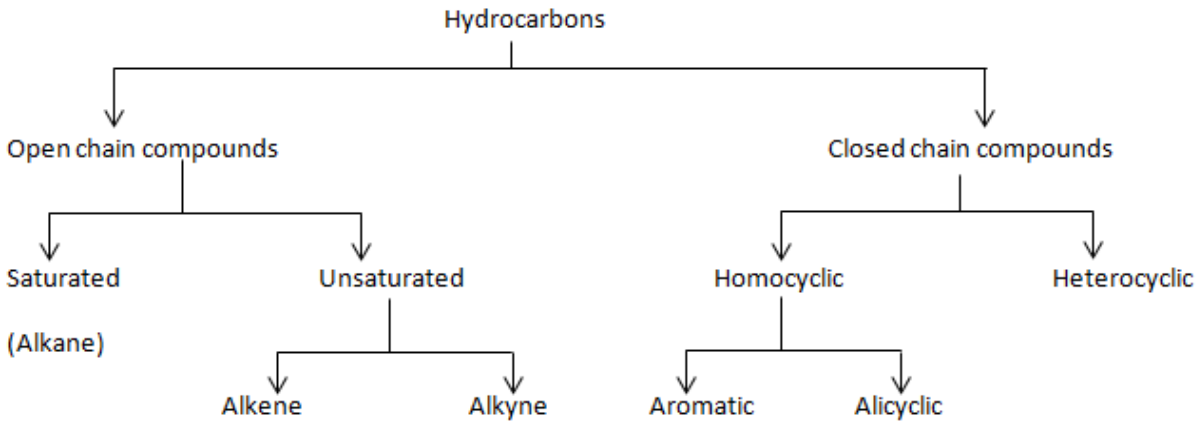


cyclopentane

b) **Tetravalent Nature**: Carbon has valency of four. It is capable of bonding with four other atoms of carbon or some other hetero atoms with single covalent bond as well as double or triple bond.



Hydrocarbons: Compounds of carbon and hydrogen are known as hydrocarbons. For eg: Methane, Ethane, Ethene, Ethyne etc.

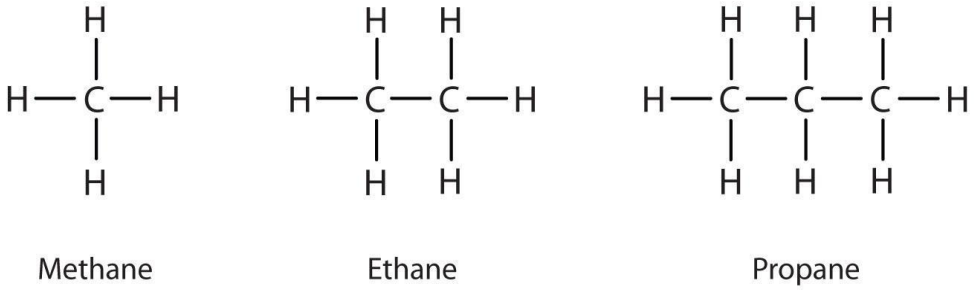


Saturated Hydrocarbon(Alkanes): General formula is $C_nH_{2n}+2$

n= number of carbon atom

In this, the carbon atoms are connected by only a single bond.

For eg, Methane, Ethane, Propane



Methane Ethane Propane

Unsaturated Hydrocarbons:

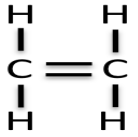
Alkenes: General formula is C_nH_{2n}

n= where of carbon atoms.

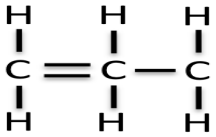
In this, the two carbon atoms are connected by double bond.

Alkenes C_nH_{2n}

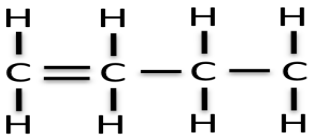
ethene C_2H_4



propene C_3H_6

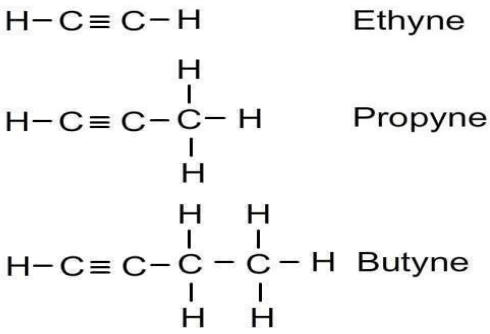


butene C_4H_8

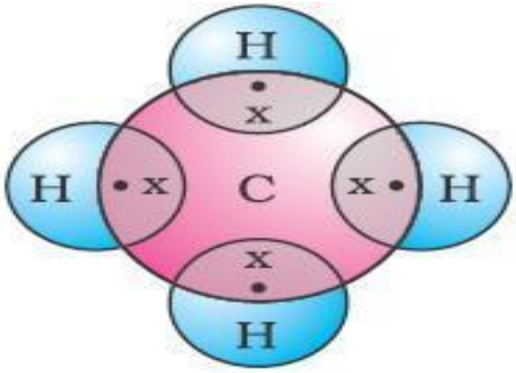


Alkynes: General formula is C_nH_{2n}-2

n= number of carbon atoms are connected by triple bond.



Electron Dot Structure Of Hydrocarbon

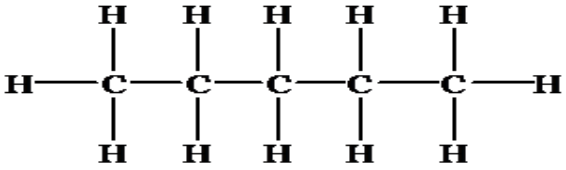
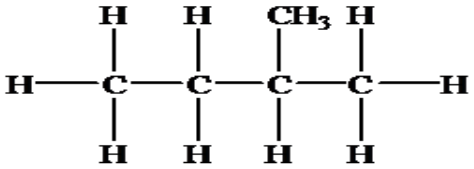
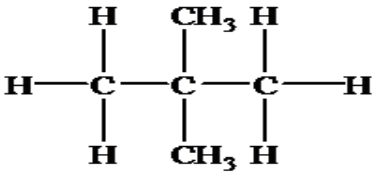


ISOMERISM: Compounds having the same

molecular formula but different structural formula and properties are known as isomers and this phenomenon is known as isomerism.

STRUCTURAL ISOMERISM: Compounds having the same molecular formula but different structures are called Structural Isomers.

Eg: Isomers of butane (C_4H_{10})

Structure	Molecular formula
 Pentane	C_5H_{12}
 2-Methylbutane	C_5H_{12}
 2-Dimethylpropane	C_5H_{12}

HOMOLOGUS SERIES: Series of organic compounds having the same functional group and chemical properties and successive members differ by a CH_2 unit or 14 mass units are known as Homologous series.

Homologous series of Alkanes, Alkenes and Alkynes.

Alkanes: Methane(CH_4), Ethane(CH_3-CH_3)

Alkenes: Ethene(CH_2=CH_2), Propene(CH_3-CH=CH_2)

Alkynes: Ethyne, Propyne

Characteristics of Homologous Series

- The successive member in homologous series differ by CH_2 unit or 14 mass unit.
- Members of given homologous series have the same functional group.
- All the members of homologous series shows similar chemical properties.

***FUNCTIONAL GROUP*:**

The Common Functional Groups

Class	Functional Group	General Formula*	Example
halohydrocarbons†	—X(F, Cl, Br, I)	R—X	CH_3I
alcohols	—OH	R—OH	CH_3OH
ethers	—O—	R—O—R′	$CH_3—O—CH_3$
aldehydes			
ketones			
carboxylic acids			
esters			
amines	$—NH_2$	$R—NH_2$	CH_3NH_2

*R and R′ represent hydrocarbon fragments, which may be the same or different. †These substances are also called alkyl halides.

Chemical properties of carbon compounds:

- **Combustion:** The complete combustion of carbon compounds in the air gives CO_2, water, heat ,light

  $CH_3CH_2OH(l)+O_2(g)-\quad CO_2(g)+H_2O+Heat+Light$

Saturated hydrocarbons burns with a blue flame in flame in the presence of a sufficient supply of air or oxygen.

$CH_4+2O_2(g)\quad CO_2(g)+2H_2O(l)+Heat+Light$

Unsaturated hydrocarbons burns with a yellow smoky flame.

The gas and kerosene stove used at home has inlet for air so that, burnt to given clean blue flame.

Due to presence of small amount of nitrogen and sulphur , coal and petroleum produces CO_2 withoxides of nitrogen and sulphur which are major pollutant.

Oxidation: Oxidation of ethanol in presence of oxidizing agents gives ethanoic acid.

$$\underset{\text{Ethanol}}{CH_3 - CH_2 - OH} + \underset{\substack{\text{Oxygen (From the oxidizing agent)}}}{2[O]} \xrightarrow[\text{or Acidified } K_2Cr_2O_7 + \text{Heat}]{\text{Alkaline } KMnO_4 + \text{Heat}} \underset{\text{Ethanoic acid}}{CH_3 - \overset{\overset{O}{\|}}{C} - OH} + \underset{\text{Water}}{H_2O}$$

Oxidizing agent: some substances are capable of adding oxygen to others, are known as Oxidizing Agent.

Eg: Alkaline $KMnO_4$

Addition reaction: Addition of di hydrogen with unsaturated hydrocarbons in the presence of catalysts such as nickel or platinum or palladium are known as Hydrogenation reaction

$CH_2=CH_2+H_2$ CH_3-CH_3

Catalyst: Substances that cause a reaction to occur or proceeds to different rate without consuming in it are called a catalyst. For eg; Ni, Pt, Pd etc.

Process of converting vegetable oil into solid fat (vegetable ghee) is called Hydrogenation of oil.

Vegetable fats are saturated fats which are harmful for health.

Vegetable oil containing unsaturated fatty acids are good for health

- **Substitution reaction**: Replacement of one or more hydrogen atom of an organic molecule by another atom 0r group of the atom is known as substitution reaction. $CH_4+Cl_2 \quad CH_3Cl+HCl$

  Some important carbon compounds:

Ethanol (CH_3CH_2OH) commonly known as Ethyl Alcohol.

Physical properties:

- It is colourless, inflammable liquid.
- It is miscible with water in all proportions.

It has no effect on the litmus paper.

Chemical properties:

Reaction with sodium $2CH_3CH_2OH+2Na \; 2CH_3\text{-}CH_2\text{-}ONa^{+}+H_2$

Reaction with conc.H_2SO_4

CH_3-CH_2-OH--- CH_2=CH_2+H_2O

Dehydrating agent

Substances which removes water from ethanol is known as Dehydrating agent

Uses: As solvent , as antiseptic, as anti freeze in automobiles.

Ethanoic acid (CH_3COOH): Commonly known as Acetic acid 5-8% of ethanoic acid in water is called Vinegar. The melting point of pure ethanoic acidis 290k and hence, it often freezes in cold climate so named as glacial acetic acid.

Physical properties:

It is a colourless, pungent smelling liquid.

- Miscible with water in all proportions.
- Turns blue litmus to red.

Chemical properties:

Esterification Reaction: Reaction of ethanoic acid with an alcohol in the presence of a few drops of conc. H_2SO_4 as catalyst gives a sweet smelling substance known as Ester, called Esterification reaction. $CH_3COOH+CH_3CH_2OH-\ CH_3COOC_2H_5+H_2O$

Esters are used in making perfumes and flavouring agents.

Saponification reaction: Reaction of ester with sodium hydroxide, gives alcohol and sodium salt of carboxylic acid (soap). This reaction is known as Saponification reaction.

$$CH_3COOC_2H_5 + NaOH \text{-} \; C_2H_5OH \; + \; CH_3COONa$$

Reaction with carbonates and hydrogen carbonates: Ethanoic acid reacts with sodium carbonates and sodium hydrogen carbonates to give rise to a salt , carbon di oxide and water.

$2CH_3COOH + Na_2CO_3 \; 2CH_3COONa + H_2O + CO_2$

$CH_3COOH + NaHCO_3 \; CH_3COONa + H2O + CO_2$

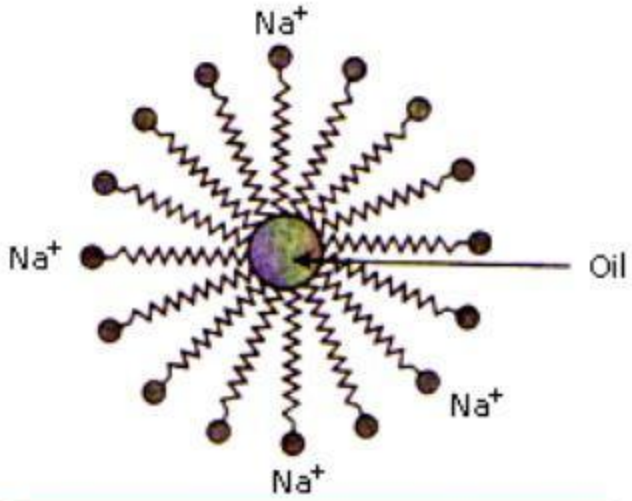
- Used as vinegar.
- Used as raw material for the preparation of chloride and esters

Difference between soaps and detergent

SOAPS	DETERGENTS
They contain sodium carboxylate (COONa) group.	They contain sodium sulphonate (SO_3Na) group.
They are not suitable for washing with hard water.	They are suitable for both hard and soft water.
They have relatively weak cleansing action.	They have strong cleansing action.
They are biodegradable.	Most of them are non-biodegradable.

Advantage of Detergent: The main advantage of detergent over soaps is that soaps cannot be used in hard water for washing because hard water reacts with soap to form curdy white precipitate called ***scum.***

Cleansing Action of Soaps and Detergents: Both soaps and detergent contains two parts. A long hydrocarbons part which is hydrophobic (water repelling) in nature and a short ionic part which is hydrophilic (water attracting) in nature.
They hydrocarbon part of the soap molecule links itself to the oily (dirt) drop and ionic end orients itself towards water and forms a spherical structure called micelles. The soap micelle helps in dissolving the dirt in water and wash our clothes.



Formation of Micelles

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