REVISION NOTES ON - CARBON & ITS COMPOUNDS

Introduction

→ Compounds are of two types:
(i) Organic Compounds
(ii) Inorganic Compounds

→ Organic Compounds are made up of Carbons and form the basis of all living organisms.

The Covalent Bond

→ Carbon always forms covalent bond.

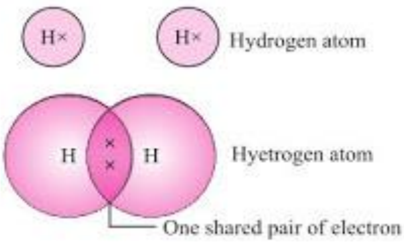
→ The bond formed by sharing of electron pair between two atoms are known as covalent atoms.

• Noble gas configuration of Carbon

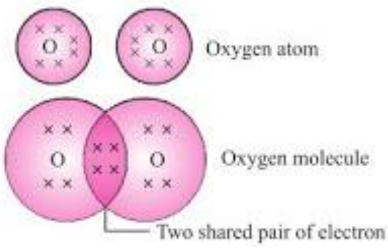
→ Carbon is tetravalent, it does not form ionic bond by either losing four electrons (C^{4+}) or by gaining four electrons (C^{4-}). It is difficult to hold four extra electron and would require large amount of energy to remove four electrons. So, carbon can form bond by sharing of its electrons with
the electrons of other carbon atom or with other element and attain noble gas configuration.

→ The atoms of other elements like hydrogen, oxygen and nitrogen, chlorine also form bonds by sharing of electrons.

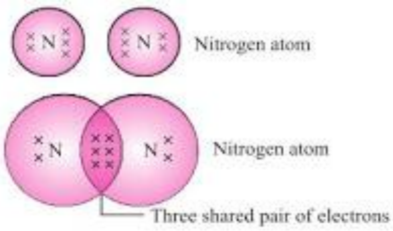
• H – H single bond between hydrogen atoms (H_2)



• O = O double bond between oxygen atoms (O_2)

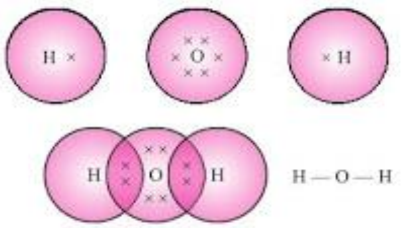


• N ≡ N triple bond between nitrogen atoms



 Prepared By – Aditya Mishra

• **Water molecule has single covalent bond between one oxygen and two hydrogen atoms.**



Physical Properties of Covalent Compounds

→ Covalent compounds have low melting and boiling points as they have weak intermolecular force.

→ They are generally poor conductor of electricity as electrons are shared between atoms and no charged particles are formed.

Versatile Nature of Carbon

The two characteristic properties of carbon element which lead to the formation of large number of compounds:

• **Catenation:** Carbon can link with carbon atoms by means of covalent bonds to form long chains, branched chains and closed ring. Compound
Carbon atoms may be linked by single, double or triple bonds.

• **Tetravalency:** Carbon has 4 valence electrons. Carbon can bond with four carbon atoms, monovalent atoms, oxygen, nitrogen and sulphur.

Hydrocarbon

→ Compounds made up of hydrogen and carbon are called hydrocarbon.
→ There are two types of Hydrocarbons.

(i) Saturated Hydrocarbons
(ii) Unsaturated Hydrocarbons

• **Saturated Hydrocarbons**

→ Single bond between carbon atoms.
→ —C—C—
→ **Alkanes** are saturated hydrocarbons.
General Formula: C_nH_{2n+2}

• **Unsaturated Hydrocarbons**

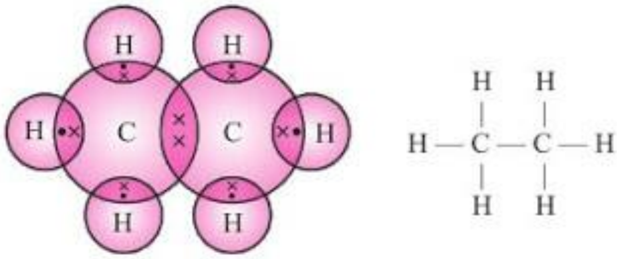
→ Double or triple bond between carbon atoms.
→ Alkenes and Alkynes are unsaturated hydrocarbons.

→ **Alkenes**: —C=C—
General formula: C_nH_{2n}

→ **Alkynes**: —C≡C—
General Formula: C_nH_{2n-2}

Electron Dot Structure of Saturated Hydrocarbons

- **Ethane C_2H_6**

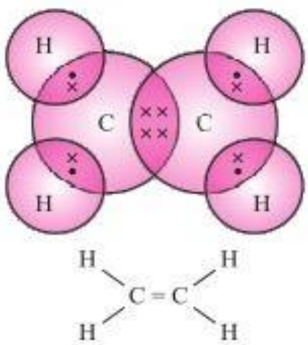


Names, molecular formulae and structure formulae of saturated hydrocarbons (Alkanes):

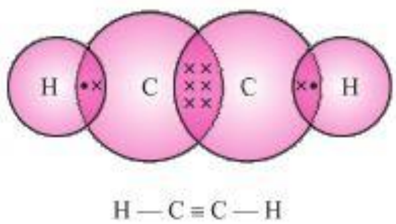
No. of C atoms	Name	Formula	Structure
1	Methane	CH_4	H H-C-H H
2	Ethane	C_2H_6	H H H-C-C-H H H
3	Propane	C_3H_8	H H H H-C-C-C-H H H H
4	Butane	C_4H_{10}	H H H H H-C-C-C-C-H H H H H
5	Pentane	C_5H_{12}	H H H H H H-C-C-C-C-C-H H H H H H
6	Hexane	C_6H_{14}	H H H H H H H-C-C-C-C-C-C-H H H H H H H

Electron Dot Structure of Unsaturated Hydrocarbons

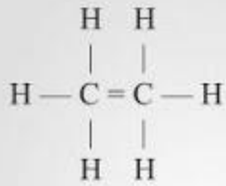
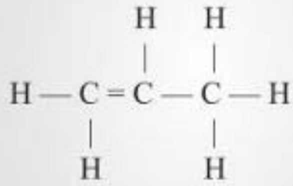
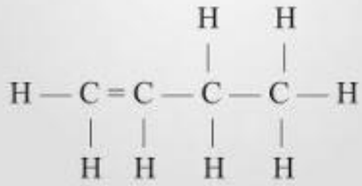
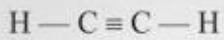
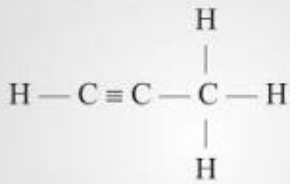
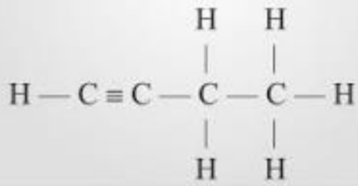
- **Ethene (C_2H_4)**



- **Ethyne (C_2H_2)**



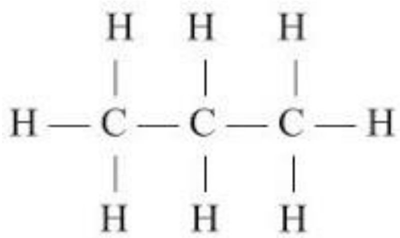
Names, molecular formulae and structure formulae of unsaturated hydrocarbons (Alkenes and Alkynes):

Name of Hydrocarbon	Molecular Formula	Structural Formula
Alkenes :		
1. Ethene	C_2H_4	
2. Propene	C_3H_6	
3. Butane	C_4H_8	
Alkynes :		
1. Ethyne	C_2H_2	
2. Propyne	C_3H_4	
3. Butyne	C_4H_6	

Carbon Compounds on the Basis of Structure

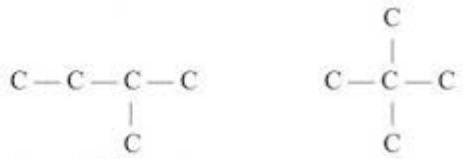
(i) Straight (unbranched) chain

Example: C_3H_8

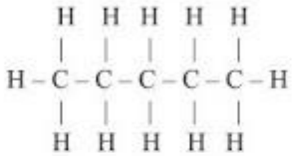


(ii) Branched

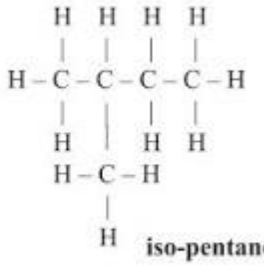
—C—C—C—C—C—



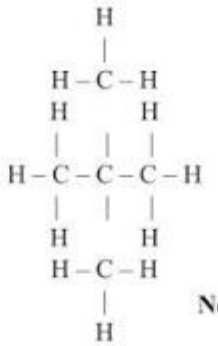
Isomerism of C_5H_{12} **(Pentane)**



n-pentane



iso-pentane

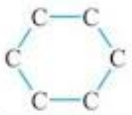


Neo-pentane

→ These three compounds have same molecular formula but different structures are called structural isomers and phenomenon is structural isomerism.

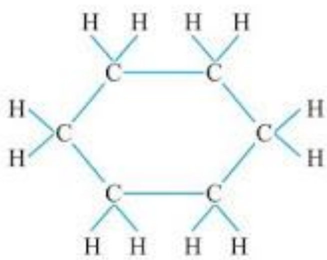
(iii) Cyclic

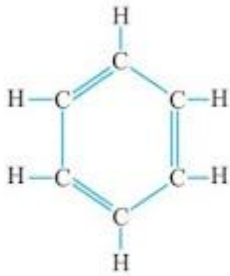
Example: C_6H_{12}



Cydic soluated

Cyclic unsaluraled
C_6H_6 (Benezene)





Functional Groups

→ In hydrocarbon chain, one or more hydrogen atom is replaced by other atoms in accordance with their valencies. These are heteroatom.

→ These heteroatom or group of atoms which make carbon compound reactive and decides its properties are called functional groups.

Hetero atom	*Functional group*	*Formula of functional group*
Cl/Br	Halo- (Chloro/bromo)	—Cl, —Br (substitutes for hydrogen atom)
Oxygen	1. Alcohol	—OH
	2. Aldehyde	$-C(=O)H$
	3. Ketone	$-C(=O)-$
	4. Carboxylic acid	$-C(=O)-OH$

Homologous Series

→ It is series of compounds in which some functional group substitutes for the hydrogen in a carbon chain.

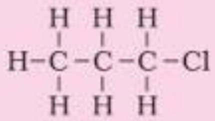
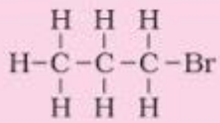
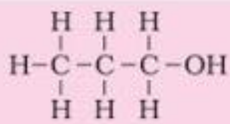
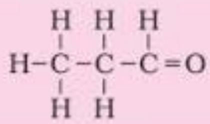
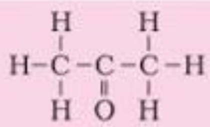
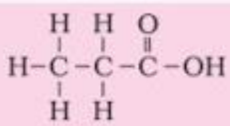
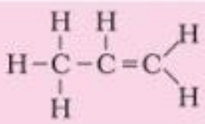
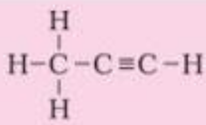
Example: Alcohols – CH_3OH, C_2H_5OH, C_3H_7OH, C_4H_9OH

- They have same general formula.

- Any two homologues differ by – CH_2 group and difference in molecular mass is 14μ.

- They have same chemical properties but show gradual change in physical properties.

Nomenclature of Carbon Compounds
(i) Identify the number of carbon atoms in compounds.
(ii) Functional group is indicated by suffix or prefix.

Functional group	Prefix/Suffix	Example
1. Halogen	Prefix-chloro, bromo, etc.	 Chloropropane
		 Bromopropane
2. Alcohol	Suffix - ol	 Propanol
3. Aldehyde	Suffix - al	 Propanal
4. Ketone	Suffix - one	 Propanone
5. Carboxylic acid	Suffix - oic acid	 Propanoic acid
6. Double bond (alkenes)	Suffix - ene	 Propene
7. Triple bond (alkynes)	Suffix - yne	 Propyne

Chemical Properties of Carbon Compounds

(i) Combustion

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

• Carbon and its compounds are used as fuels because they burn in air releasing lot of heat energy.

• Saturated hydrocarbon generally burns in air with blue and non-sooty flame.

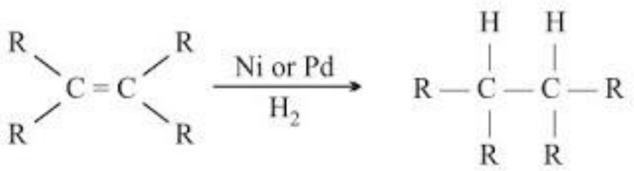
• Unsaturated hydrocarbon burns in air with yellow sooty flame because percentage of carbon is higher than saturated hydrocarbon which does not get completely oxidized in air.

(ii) Oxidation

Alcohols can be converted to carboxylic acid in presence of oxidizing agent alkaline $KMnO_4$ (potassium permanganate) or acidic potassium dichromate.

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[\text{Acidic } K_2Cr_2O_7]{\text{Alkaline } KMnO_4 \text{ Or}} \underset{\text{Ethanoic acid}}{CH_3COOH}$$

(iii) Addition Reaction



Unsaturated hydrocarbon add hydrogen in the presence of catalyst palladium or nickel. Vegetable oils are converted into vegetable ghee using this process.

It is also called hydrogenation of vegetable oils.

(iv) Substitution Reaction

$$CH_4 + Cl_2 \xrightarrow{\text{Sunlight}} CH_3Cl + HCl$$

Important Carbon Compounds: Ethanol and Ethanoic Acid

a. ETHANOL

Physical Properties

- Colourless, pleasant smell and burning taste.
- Soluble in water.
- Volatile liquid with low boiling point of 351 K.
- Neutral compound.

Chemical Properties

(i) Reaction with Sodium

$2Na + CH_3CH_2OH \rightarrow 2CH_3CH_2ONa^+ + H_2$
(Sodium ethoxide)

This reaction is used as a test for ethanol by evolution of H_2 gas (Burn with pop sound).

(ii) Dehydration

$$CH_3CH_2OH \xrightarrow[H_2SO_4]{\text{Hot conc.}} CH_2 = CH_2 + H_2O$$

b. ETHANOIC ACID

Physical Properties of Ethanoic acid

- Colourless liquid having sour taste and have smell of vinegar.
- Boiling point is 391 K.
- When pure CH_3COOH is frozen, it forms colourless ice like solid. So, it is called glacial acetic acid.

Chemical Properties

(i) Esterification

$$\underset{\text{(Ethanoic acid)}}{CH_3COOH} + \underset{\text{(Ethanol)}}{CH_3CH_2OH} \xrightarrow{\text{Acid}} \underset{\text{Ester}}{CH_3\,\underset{\underset{O}{\|}}{CO}\,CH_2\,CH_3}$$

Sweet smelling ester is formed.

$$CH_3\,\underset{\underset{O}{\|}}{CO}\,CH_2\,CH_3 + NaOH \rightarrow CH_3COONa + CH_3CH_2OH$$

This is saponification as soap is prepared by this.

(ii) Reaction with base

$NaOH + CH_3COOH \rightarrow CH_3COONa + H_2O$

(iii) Reaction with carbonates and hydrogen carbonates:

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

$CHH_2COOH + NaHCOH_2 \rightarrow CH_3COONa + H_2O + CO_2$

Soaps and Detergents

• Soap is sodium or potassium salt of long chain carboxylic acid. Example: $C_{17}H_{35}COONa^+$

• Soaps are effective only in soft water.

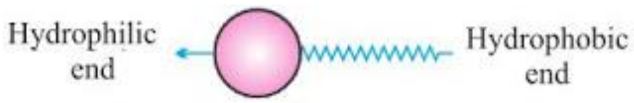
• Detergents are ammonium or sulphonate salt of long chain of carboxylic acid.

• Detergents are effective in both hard and soft water.

Soap molecule has:

(i) Ionic (hydrophilic) part

(ii) Long hydrocarbon chain (hydrophobic) part



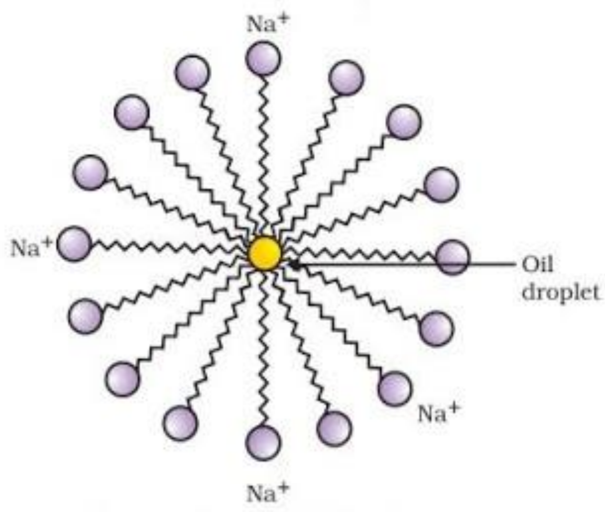
Structure of soap molecule

Cleansing Action of Soap

• Most dirt is oily in nature and hydrophobic end attaches itself with dirt and the ionic end is surrounded with molecule of water. This result in formation of a radial structure called micelles.

• Soap micelles helps to dissolve dirt and grease in water and cloth gets cleaned.

• Soap is a mixture of micelles.



Formation of micelles

• The magnesium and calcium salt present in hard water react with soap molecule to form insoluble product called scum. This scum creates difficulty in cleansing action.

• By use of detergent, insoluble scum is not formed with hard water and clothes get cleaned effectively.