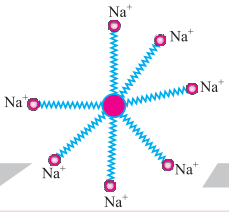


Chapter - 4

Carbon and its Compounds

Introduction :

- The element carbon is non-metal. Its symbol is C.
- Carbon is a versatile element the percentage of carbon present in earth crust in form of mineral is 0.02% and in atmosphere as CO_2 is 0.03%.
- All the living things, plants and animals are made up of carbon based compounds.

Carbon always form covalent bonds :

The atomic number of carbon is 6.

Electronic configuration :

	K	L
C (6)	2	4

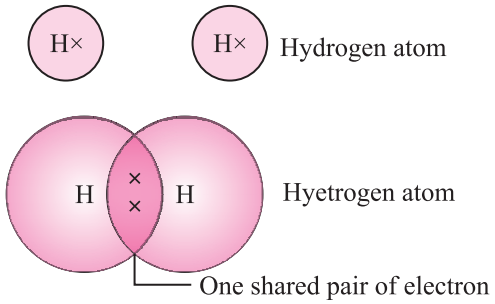
How carbon attain noble gas configuration ?

(i) 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.

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

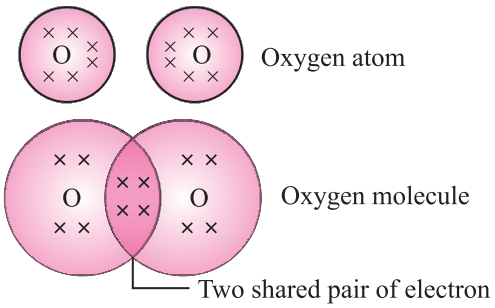
(iii) The bond formed by sharing of electrons between same or different atoms is covalent bond.

(i) H_2



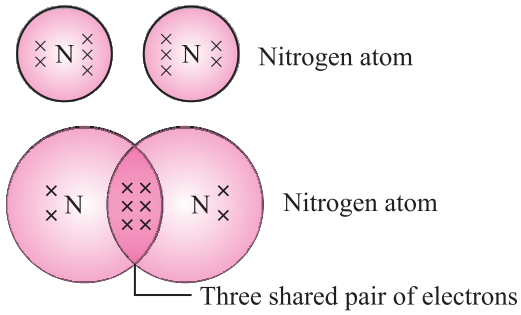
H – H single bond between hydrogen atoms

(ii) O_2



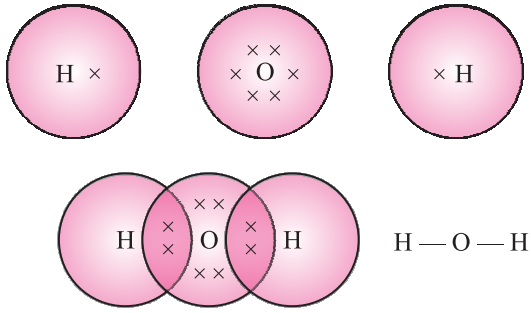
O = O double bond between oxygen atoms

(iii) N_2



N ≡ N triple bond between nitrogen atoms

Molecule of water has single covalent bond between one oxygen and two hydrogen atoms.



Physical Properties of Covalent Compounds

(a) Covalent compounds have low melting and boiling points as they have weak intermolecular force.

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

Versatile Nature of Carbon

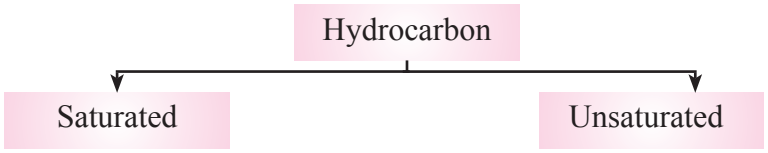
The two characteristic properties of carbon element which lead to the formation of large number of compounds :

(i) 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.

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

Saturated and Unsaturated Carbon Compounds

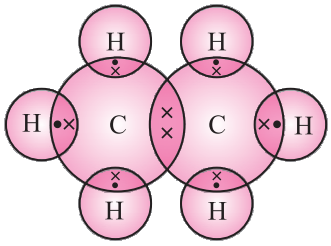
Compounds made up of hydrogen and carbon are called hydrocarbon.

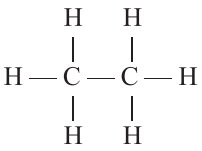


Saturated	Unsaturated	
• Single bond between carbon atoms.	• Double or triple bond between carbon atoms.	
• – C – C –	• – C = C –	– C ≡ C –
• Alkanes	• Alkenes	Alkynes
General formulae		
C_nH_{2n+2}	C_nH_{2n}	C_nH_{2n-2}

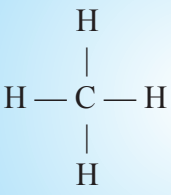
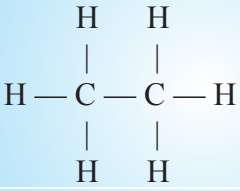
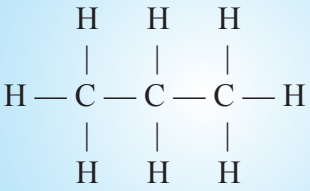
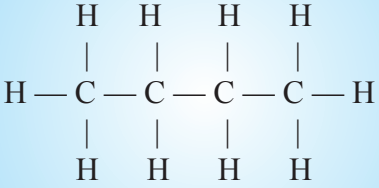
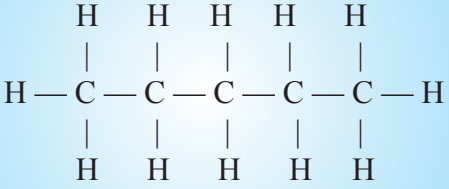
Electron Dot Structure of Saturated Hydrocarbons

Ethane C_2H_6



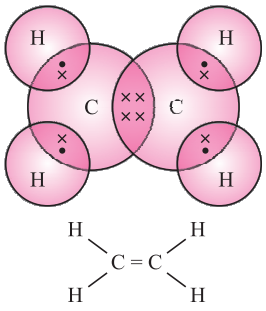


The names, molecular formulae and saturated formulae of saturated hydrocarbons (alkanes) are given below :

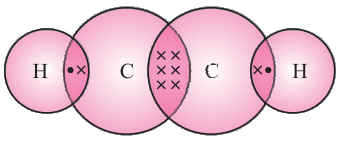
Name of Hydrocarbon	Mileculas formula	Structural Formula
1. Methane	CH_4	
2. Elhane	C_2H_6	
3. Propane	C_3H_8	
4. Butane	C_4H_{10}	
5. Pentane	C_5H_{12}	

Electron Dot Structure of Unsaturated Hydrocarbons

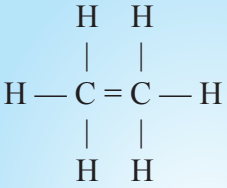
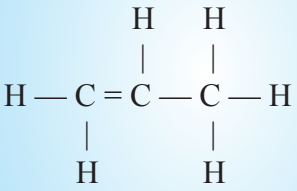
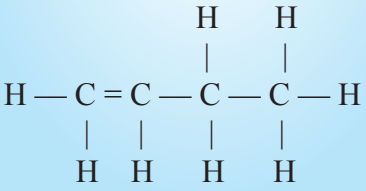
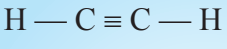
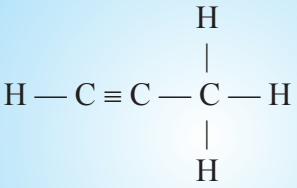
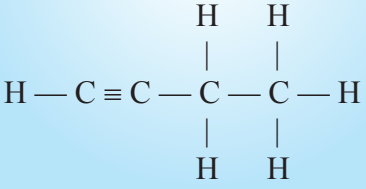
Ethene C_2H_4



Ethyne C_2H_2

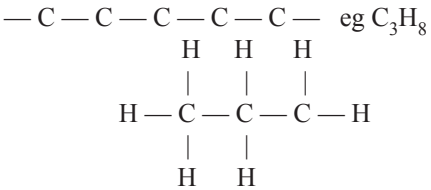


H — C ≡ C — H

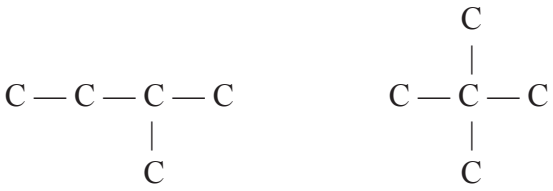
Name of Hydrocarbon	Mileculas formula	Structural Formula
Alkenes :		
1. Ethene	C_2H_4	
2. Propene	C_3H_6	
3. Butene	C_4H_8	
Alkynes :		
1. Ethyne	C_2H_2	
2. Propyne	C_3H_4	
3. Butyne	C_4H_6	

Carbon Compounds on the Basis of Structure

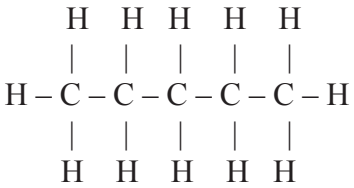
(i) Straight (unbranched) chain



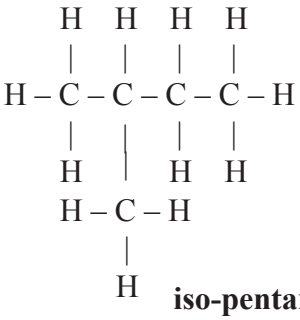
(ii) Branched



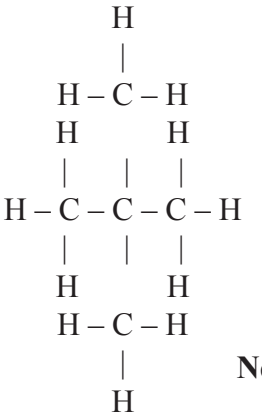
Isomerism of C_5H_{12} **(Pentane)**



n-pentane



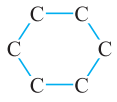
iso-pentane



Neo-pentane

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

(iii) Cyclic

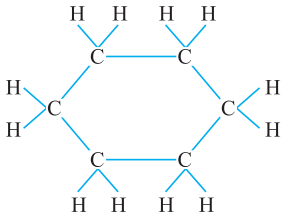


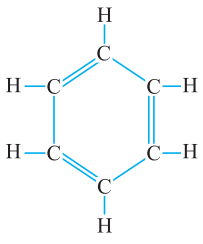
Cyclic Saturated

eg. C_6H_{12} (Hexane)

Cyclic unsaturated

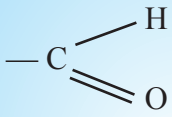
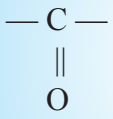
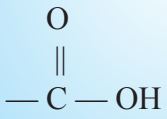
C_6H_6 (Benezene)





Functional Groups

- In hydrocarbon chain, one or more hydrogen atom is replaced by other atoms in accordance with their valancies. 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, — I
Oxygen	1. Alcohol	— OH
	2. Aldehyde	
	3. Ketone	
	4. Carboxylic acid	
Double bond	1. Alkene group	> C = C <
Triple bond	2. Alkyne group	— C ≡ C —

Homologous Series

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

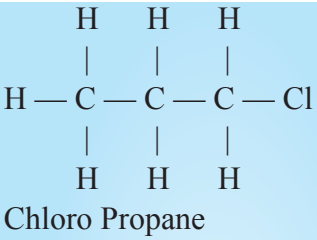
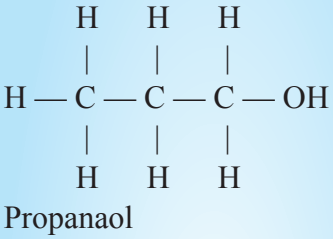
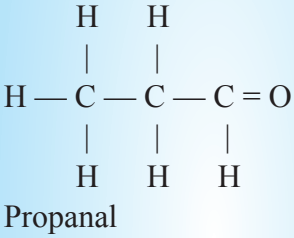
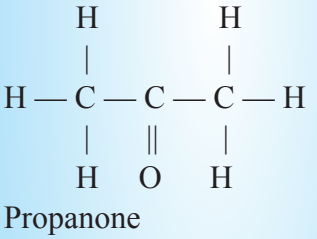
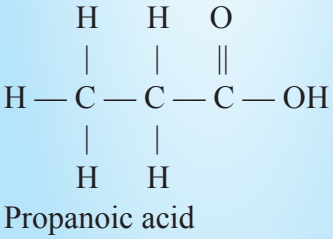
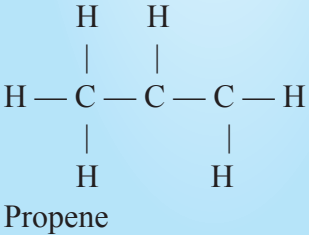
E.g., Alcohols – CH_3OH, C_2H_5OH, C_3H_7OH, C_4H_9OH

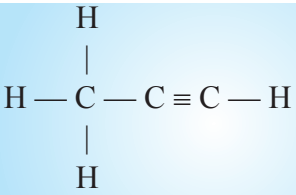
- Have same general formula.
- Any two homologues differ by – CH_2 group and difference in molecular mass is 14μ.
- Have same chemical properties but show gradual change in physical properties.

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, Iodo etc.	 Chloro Propane
2. Alcohol	Suffix – ol	 Propanaol
3. Aldehyde	Suffix – al	 Propanal
4. Ketone	Suffix – one	 Propanone
5. Carboxylic acid	Suffix – oic acid	 Propanoic acid
6. Alkene (– C = C –)	Suffix – ene	 Propene

7. Alkyne (– C ≡ C –)	Suffix – yne	 Propyne

Chemical Properties of Carbon Compounds

(a) Combustion

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

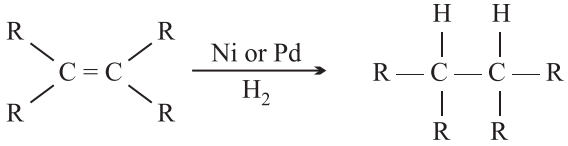
- Carbon and its compounds are used as fuels because they burn in air releasing lot of heat energy.
- Saturated hydrocarbon generally burn in air with blue and non-sooty flame.
- Unsaturated hydrocarbon burns in air with yellow sooty flame because percentage of carbon is higher than saturated hydrocarbon which does not get completely oxidized in air.

(b) Oxidation

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

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

(c) 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.

(d) Substitution Reaction :

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

Important Carbon Compounds : Ethanol and Ethanoic acid

Physical Properties of Ethanol

- 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 :

$$2Na + CH_3CH_2OH \rightarrow 2CH_3CH_2O^{-}Na^{+} + H_2$$

(Sodium ethoxide)

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

(ii) Dehydration :

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

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 freezed, it forms colourless ice like solid. So it is called glacial acetic acid.

Chemical Properties

(i) Esterification :

$$CH_3COOH + CH_3CH_2OH \xrightarrow{\text{Acid}} CH_3\ CO\ CH_2\ CH_3 + H_2O$$

(Ethanoic acid) (Ethanol)

Ester

Sweet smelling ester is formed.

$$CH_3\ CO\ CH_2\ CH_3 + NaOH \rightarrow CH_3COONa + CH_3CH_2OH$$

This is saponification as soap is prepared by this.

(ii) Reaction with base :

$$NaOH + CH_3COOH \rightarrow CH_3COONa + H_2O$$

(Sod. acetate)

(iii) Reaction with carbonates and hydrogen carbonates :

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

$$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2$$

(Sodium acetate)

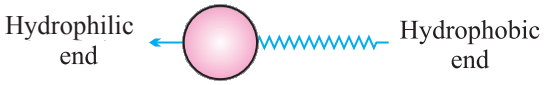
Soaps and Detergents

- Soap is sodium or potassium salt of long chain carboxylic acid. *E.g.,* $C_{17}H_{35}COO^-Na^+$
- 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

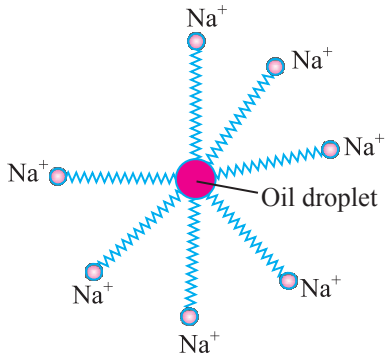
(ii) Long hydrocarbon chain (hydrophobic) part



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.



- The magnesium and calcium salt present in hard water react with soap molecule to form insoluble product called scum. This scum create difficulty in cleansing action.
- By use of detergent, insoluble scum is not formed with hard water and cloths get cleaned effectively.