12. Carbon and its compounds

Carbon is very important element in the world. carbon can form more than 5000 compounds.

⇒ About carbons :-

* carbon is a non-metal.
* carbon is fourth IV A [fourteenth] group element and second period element.
* Electron configuration [z = 6] $1s^2 2s^2 2p^2$.
  It has two orbits and it's valency electron is 4.
* The valency is 4.
* The electro negativity is 2.5.

Q) carbon can participate in only covalent bond but not in ionic bond. Why ?

A:- carbon should not participate in ionic bond because it should not loose 4 electrons, carbon has 6 protons and 6 electrons if it gain 4 electrons total will be these it is difficulty to hold 10 electron by 6 protons so, no C^{-4} ions).

⇒ If it loose 4 electrons it should require more. Ionisation energy. so, it is not possible. so it should not form C^{+4}.

carbon participate in only covalent bond.

Hybridization

Defination :- The inter mixing of atomic orbitals of almost equal energy and form equal number of hybrid orbitals. But the shape and size are equal.

⇒ **Types of Hybridization :-**

1) sp - $BeCl_2$ hybridization → Ex :- C_2H_2 (or) $BeCl_2$
2) sp^2 - BF_3 hybridization → Ex :- C_2H_4 (or) BF_3
3) sp^3 - H_2O hybridization → Ex :- CH_4, NH_3, H_2O etc.

The intermixing of hybrid to CH_4, NH_3, H_2O.

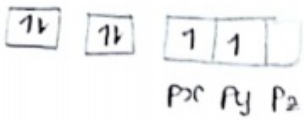
⇒ Explain the sp hybridization in C_2H_2.

one s orbital and one p orbitals are intermix and form 2sp hybrid orbital.

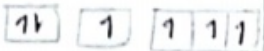
Explanation

* carbon ground state electron configuration is [z = 6]

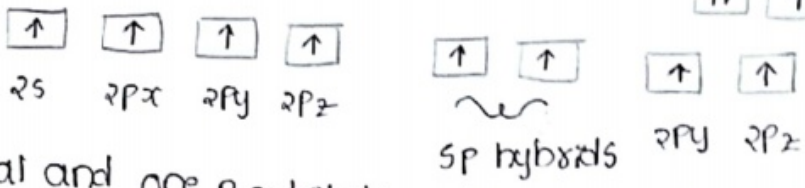
$1s^2\ 2s^2\ 2p^2$



* In excited state the electron configuration is $1s^2\ 2s^1\ 2p^3$



* Energy ↑



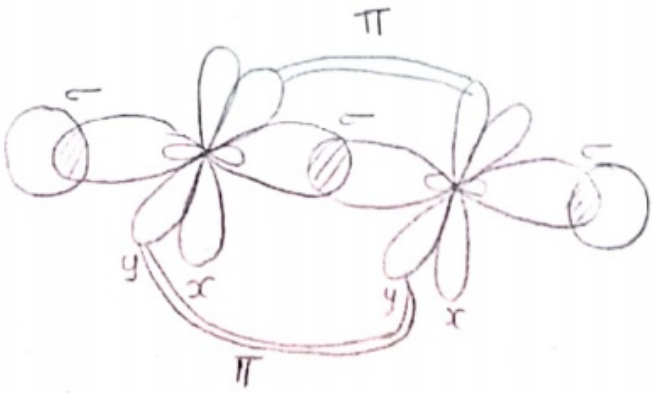
* one s orbital and one p orbitals intermix and form 2sp hybrid orbitals.

* These sp hybrid orbitals of 2 carbons overlap with 2 hydrogen and form 2 π bonds and 3 σ bonds.

* In this way C_2H_2 will form.

⇒ The shape is linear

⇒ The bond angle is 180°



⇒ Explain the sp^2 hybridization in C_2H_4

One s orbital two p orbital are intermix and form $3sp^2$ hybrid orbital.

Ex:- Ethyline $[C_2H_4]$

Explanation

* carbon ground state electron configuration is $[z = 6]$

$1s^2\ 2s^2\ 2p^2$

[↑↓] [↑↓] [↑] [↑] [ ]

* In excited state the electron configuration is $1s^2 2s^1 2p^3$

[↑↓] [↑] [↑] [↑] [↑]

* Energy ↑

[↑] [↑] [↑] [↑]

s px py pz

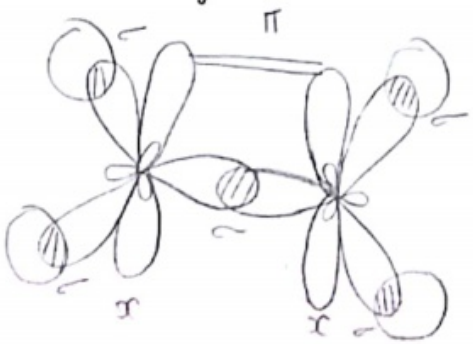
* One s orbital and 2p orbitals intermix and form $3sp^2$ hybrid orbitals.

* These three $(3sp^2)$ hybrid orbitals of 2 carbons overlap with 4 Hydrogen and form five σ sigma bond and 1 π bond.

* In this way C_2H_4 will form

* The bond angle is 120.

⇒ The shape is trigonal planar.



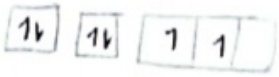
⇒ Explain the sp^3 hybridization in CH_4.

one s orbital 3p orbitals are intermix and form $4sp^3$ hybrid orbital.

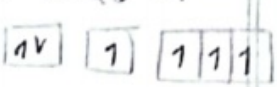
Explanation

* carbon ground state electron configuration is (Z = 6)

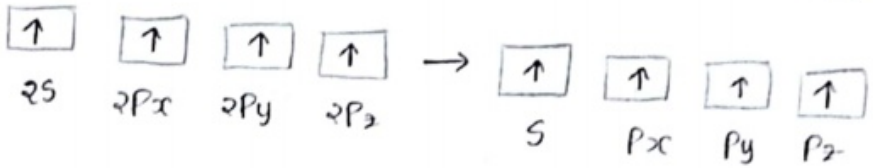
$1s^2 2s^2 2p^2$



* In excited state the electron configuration is $1s^2 2s^1 2p^3$



* Energy ↑



* one s orbital and 3p orbitals intermix and form $4sp^3$ hybrid orbitals. (sp^3 hybrids)

* These $4sp^3$ hybrid orbitals of carbons over lap with 4 Hydrogens and form 4 σ sigma bonds no π pie bonds.

* In this way CH_4 will form.

* shape is tetrahedron

* Bond angle is 109°28'

Allotrope :-

The occurance of an element in two or more form is called Allotrope.

⇒ carbon has two types of allotrope :-

i) crystalline

ii) NON - crystalline (Amorphous)

crystalline

Ex :- Diamond, Graphite, C_{60}, nanotubes.

NON - crystalline (Amorphous)

Ex :- coal, coke, wook charcoal, animal charcoal, lamp black, Gas carbon, petroleum coke, sugar charcoal etc.

Diamond :-

It is strongest stone material.

* The density is 3.5.
* The refractive index is 2.42
* The structure of diamond is tetrahedral
* The hybridization is sp^3.
* Bond angle is 109°28'.
* It is poor conductor of electricity and heat.

Uses :-

i) It is used to cut glasses.

ii) It is used in preparing of ornaments.

Graphite :-

Graphite is a smooth and black substance.

* The density is 2.25
* The distance between layer 3.35
* The structure is trigonal planar.
* It forms sp^2 hybridisation.
* Bond angle is 120°
* Uses :-

i) It is good conductor of electricity.

ii) It is used as lubricant.

C_{60} [Buck Minister fullerene] :-

* C_{60} is in spherical shape [soccer ball]
* C_{60} molecule contains 12 pentagonal and 20 hexagonal faces on its soccer ball.

Uses :-

i) It is used in medicine, Antibiotics and target certain cancer cells such as melanoma.

Nanotubes :- [10^{-9} meters]

Uses :-

* It is used as electrical conductor.
* It is used as molecular wires.
* It is used instead of copper to connect the components in integrated circuits.

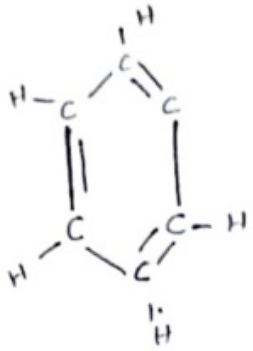
Versatile nature of carbon

i) **Catenation :-**

The ability of an element to form a long chain or ring structure (is) with its own atoms is called catenation.

Chain :- C - C - C - C - C

Ring :-



Benzne.

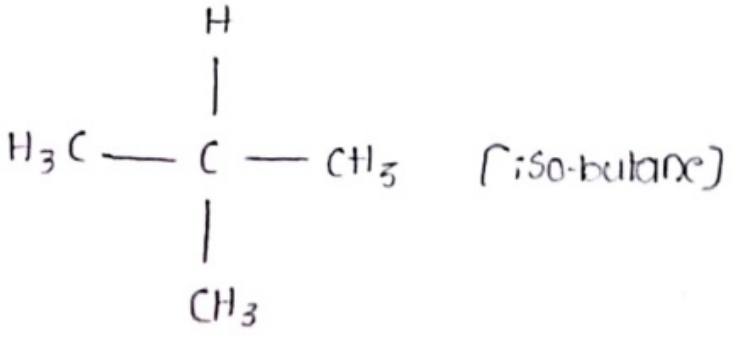
ii) **Isomerism :-**

Isomerism is the phenomenon in which have same chemical formula but different chemical structures is called Isomerism.

⇒ The compounds that exhibit isomerism are called isomers.

Eg :- C_4H_{10} (Butane)

$H_3C - H_2C - H_2C - CH_3$ (n-Butane)



(iso-butane)

Hydro carbons

- Saturated
  - Alkanes
  - General formula
  - C_nH_{2n+2}
  - Single bond (−)
  - Eg:- C_1H_4 (Methane)
    C_2H_6 (Ethane)
    C_3H_8 (Propane)
    C_4H_{10} (Butane)
    C_5H_{12} (pentane)
    C_6H_{14} (Hexane)
- Un-saturated
  - Alkenes
  - General formula
  - C_nH_{2n}
  - double bond (=)
  - Eg:- C_2H_4 (Ethene)
    C_3H_6 (Propene)
    C_4H_8 (Butene)
    C_5H_{10} (Pentene)
    C_6H_{12} (Hexene)
    C_7H_{14} (Heptene)
  - Alkynes
  - General formula
  - C_nH_{2n-2}
  - Triple bond (≡)
  - Eg:- C_2H_2 (Ethyne)
    C_3H_4 (Propyne)
    C_4H_6 (butyne)
    C_5H_8 (Pentyne)
    C_6H_{10} (Hexyne)
    C_7H_{12} (Heptyne)

⇒ If we remove a Hydrogen from alkane then it is called as alkyle.

Eg:- CH_3 (Methyle)
C_2H_5 (Ethyle)
C_3H_7 (Propyle)
C_4H_9 (Butyle)
C_5H_{11} (Pentyle)
C_6H_{13} (Hexyle)
C_7H_{15} (Heptyle)

Homologous series

The series of carbon compounds in which two successive compounds differ by CH_2 unit is called homologous series.

Properties :-

⇒ They have an general formula C_nH_{2n+2}, C_nH_{2n}, C_nH_{2n-2}, C_nH_{2n+1}.

⇒ They posses similar chemical properties.

⇒ They show a regular gradation in their physical properties.

Eg :- Alkanes (C_nH_{2n+2})

$CH_4 \Rightarrow 4\sigma$

$C_2H_6 \Rightarrow 7\sigma$

$C_3H_8 \Rightarrow 10\sigma$

$C_4H_{10} \Rightarrow 13\sigma$

Alkanes (C_2H_2)

$C_2H_4 \Rightarrow 5\sigma + 1\pi$

$C_3H_6 \Rightarrow 8\sigma + 1\pi$

$C_4H_8 \Rightarrow 11\sigma + 1\pi$

$C_5H_{10} \Rightarrow 14\sigma + 1\pi$

Alkynes [C_nH_{2n-2}]

$C_2H_2 \Rightarrow 3\sigma + 2\pi$

$C_3H_4 \Rightarrow 6\sigma + 2\pi$

$C_4H_6 \Rightarrow 9\sigma + 2\pi$

$C_5H_8 \Rightarrow 12\sigma + 2\pi$

Eg :- C_4H_{10}

$CH_3-CH_2-CH_2-CH_3 \Rightarrow 13\ \sigma$ bonds

C_4H_8

$CH_3-CH=CH-CH_3 \Rightarrow 1\ \sigma$ bonds $+\ \pi$ bond

C_4H_6

$H_3C-C\equiv C-CH_2$

$9\ \sigma$ bonds and 2π bonds

C_2H_2

$HC\equiv CH \Rightarrow$ $3\ \sigma$ bonds and $2\ \pi$ bonds

C_3H

$H_3C-CH_2-CH_3 \Rightarrow$ only $10\ \sigma$ bonds

C_3H_6

$H_2C=CH-CH_3 \Rightarrow 8\ \sigma$ bonds and $1\ \pi$ bond

C_5H_{12}

$H_3C-CH_2-CH_2-CH_2-CH_3 \Rightarrow$ only $16\ \sigma$ bonds

C_3H_4

$HC\equiv C-CH_3 \Rightarrow 6\sigma$ bonds 2π bonds.

Word Root :-

C_1 - meth

C_2 - eth

C_3 - prop

C_4 - (per) but

C_5 - pent

C_6 - hex

C_7 - hept

C_8 - oct

C_9 - non

C_{10} - dec

IUPAC :- International Union of Pure and Applied Chemistry

	FUNCTIONAL GROUP NAME	GROUPS FORMULA	FUNCTIONAL UNIT	PREFIX	SUFFIX
1)	Carboxylic acid	R-COOH (or) R-C(=O)-OH	-COOH -C(=O)-OH	-	oic acid
2)	Aldehydes	R-CHO	-CHO	formyl	al
3)	Ketones	R-C(=O)-R	-C=O	oxo	one
4)	Esters	R-COOR	-COOR	-	oate
5)	Ethers	R-OR	-OR	-	oxy
6)	Nitriles	R-CN	-CN	cyano	Nitrile
7)	Amines	R-C(-NH2)-R	$-NH_2$	amino	amine
8)	Amides	R-C(=O)-NH2	-C(=O)-NH2	-	amide
9)	Alcohol	R-OH	-OH	Hydroxy	ol

Primary Prefix :- It is useful only for cyclic compounds [Cyclo]. If the compounds are not cyclic, this part of the name is absent

Secondary prefix

This tells about the second grade functional groups known as substituents.

Primary suffix

This tells about the saturation of the compound.

Secondary suffix

This tells about the functional groups with the particular term.

IUPAC names of some compounds

1) $CH_3-CH_2-CH_2-CH_3$

Butane

2) $CH_3-\underset{Cl}{CH}-CH_2-CH_3$

2-chloro butane

3) $CH_3-CH_2-CH_2-CH_2-OH$

Butan-1-ol

4) $CH_3-\underset{CH_3}{C}-CH_2-CH_2-CH_2-OH$

4,4-di-methyl-pent 1 ol

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

OH

hydroxy heptane-2-one

6) $CH-CH_2-Br$ (ring: CH, CH, CH_2)

1 Bromo-2-chloro pentane

7) $H_3C-\underset{Cl}{C}-\underset{NO_2}{CH}$

2 methyle-1-amino propane

8) $CH_3-CH_2-\underset{Br}{C}-CH-CH_2-OH$ (Br at C3)

3,3 di bromo 2 methoxy pentanol

9) $CH_3-\underset{NO_2}{\underset{CH_3}{C}}-C-\underset{CH_3}{\underset{OH}{CH}}-CH_2-CH_2-COOH$

3,5 di methyle 5 nitro 3 hydroxy hexanoic acid

10) $CH\equiv C-\underset{CH_3}{C}-CH_2-CH=CH_2$

4,4 methyle hexa 5 ene

4,4 di methyle hexyne 5ene

CHEMICAL PROPERTIES OF CARBON COMPOUNDS

1) **Combustion:**

The process of burning of a carbon compounds in presence of oxygen or air to give CO_2, heat and light. is called the combustion reaction. Ex: 1) $C + O_2 \rightarrow CO_2 + Energy$

2) $C_2H_5OH + 3O_2 \rightarrow CO_2 + 3H_2O + Energy$.

Question:-

a) Why do sometimes cooking vessels get blackened on a gas or kerosene stove?

Ans Because of the holes getting closed the fuel gases do not completely undergo combustion. Hence it forms a soot carbon form which gets coated over the vessels.

=> Saturated hydrocarbon burns with a clear blue flame, un-saturated hydrocarbons burn with yellow flame with a soot carbons.

=> Sometimes even saturated (all) hydrocarbons give sooty flame if air is not sufficiently available during combustion.

2) **Oxidation:-**

Adding of oxygen to a given compound (or) removal of hydrogen from the given compound is known as oxidation.

Ex:- Ethyl alcohol undegoes oxidation from the product and finally Acetic acid

$$CH_3CH_2OH \xrightarrow[K_2Cr_2O_7 + Heat]{KMnO_4 + Heat} CH_3CHO \longrightarrow CH_3COOH$$

Ethy alcohol — Acetaldehyde — Acetic acid.

3) Addition reaction :-

Unsaturated organic compounds that contains multiple bonds (=, ≡) like alkenes and alkynes undergo addition reaction to become saturated organic compounds that contains single bond.

$$CH_3C\equiv C-CH_3 \xrightarrow[H_2]{Ni\ catalyst} CH_3CH=CHCH_3 \xrightarrow[H_2]{Ni\ catalyst} CH_3-CH_2-CH_2-CH_3$$

Catalyst:

Its a substance which increases (or) decreases the rate of a given reaction without itself.

Fats and oils are both of fatty acids. Fats are saturated, oils are unsaturated. Oils are generally liquids at room temperature due to unsaturated fatty acids but fats are solids due to saturated fatty acids.

4) Substitution Reaction :-

Alkanes, the saturated hydrocarbons are chemically least reactive.

They are also called paraffins.

Methane (CH_4) reacts with chlorine in the presence of sunlight

$$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$$

$$CH_3Cl + Cl_2 \longrightarrow CH_2Cl_2 + HCl$$

$$CH_2Cl_2 + Cl_2 \longrightarrow CHCl_3 + HCl$$

$$CHCl_3 + Cl_2 \longrightarrow CCl_4 + HCl$$

ETHANOL (Ethyl Alcohol)

PREPARATION:-

Ethanol is prepared on large scale from ethene by the addition of water vapour to it in the presence of catalysts like P_2O_5, Tungsten oxide at high pressure and temperature

$$CH_2=CH_2 + H_2O \xrightarrow[\substack{100-300 \\ atm \\ At\ 300^\circ C}]{Catalyst} CH_3CH_2OH$$

PROPERTIES:

=> Ethanol boiling point is 78.3°C. pure Pure ethanol is called absolute (100%) alcohol. Ethanol is a colourless liquid with characteristic sweet odour.

=> Denatured alcohol is ethanol that contains impurities that make it undrinkable. The impurities are methanol, methyl isobutyl Ketone, aviation gasoline etc.

=> It is toxic, 200ml of it's a fatal dose to an adult.

=> Solution of about 10% ethanol in gasoline is a good motor fuel.

=> It is also used in medicines such as tincture iodine, cough syrups and many tonics.

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

Ethanol — Sodium ethoxide

Q) Why we are advised not to use animal fats for cooking?

Ans) Animal fats have recently been implicated as the cause of heart disease and obesity so, we are advised not to use animal fat for cooking.

Excess animal fat is stored in fimpocycles which expand in size untill the fat is used for fuel.

Ethanoic Acid [ACETIC ACID]

⇒ Ethanoic acid is a colourless liquid with characteristic unpleasant odour. It is soluble in water and more acidic than H_2O or ethanol, but less acidic than mineral acids

⇒ Ethanoic acid is commonly called as acetic acid. 5-8% solution of acetic acid in water is called vinegar and is used widely as a preservative in pickles.

$$C_2H_5OH \longrightarrow CH_3CHO \longrightarrow CH_3COOH$$

Q) Which oil is recommended for cooking? Why?

Ans Canola oil, which is made from the crushed seeds of the canola plant is said to be amongst the healthiest of cooking oils. It has the lowest saturated fat content of any oil.

ESTERIFICATION :-

1) $2CH_3COOH + 2Na \longrightarrow 2CH_3COONa + H_2$

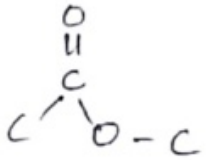
2) $CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$

3) $CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2$

* 5-8% of acetic acid is called as vinegar

ESTERIFICATION REACTION

The reaction between carboxylic acid and an alcohol in the presence of conc H_2SO_4 to form a sweet odoured substance,

Functional Group 

General formula :- $R-COOH + R-OH \longrightarrow R-COOR + H_2O$

$CH_3COOH + C_2H_5OH \longrightarrow CH_3COOC_2H_5 + H_2O$

⇒ It is used to make artificial perfumes

⇒ Used as a flavouring agents

⇒ Used for making ice creams, sweets and cooldrinks etc.

SAPONIFICATION

The process of making soap by the hydrolysis of fats and oil with alkalines is called Saponification

=> Soaps are good cleaning agents.

=> Soap is an electrolyte

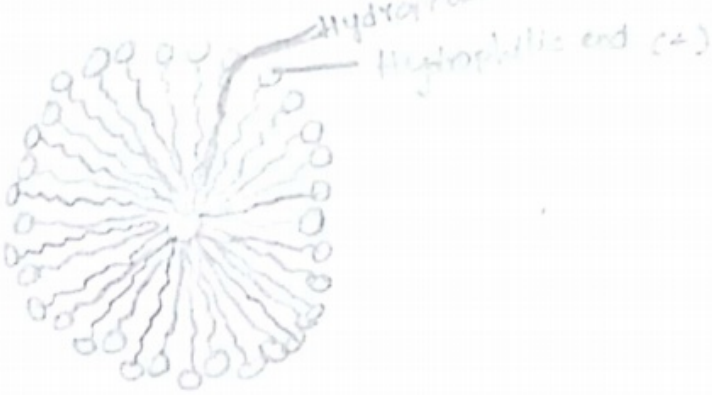
=> When soap is pure in water in very small amount it gives low concentrated solutions.

=> It gives true solution but, above a particular concentration known as critical micelle concentration (cmc).

MICELLE

=> A spherical aggregate of soap molecules in water (or) in the solution is called micelle.

=> When soap is dissolved in water it forms a colloidal suspension in which the soap molecules cluster together to form spherical micelle.



CLEANSING ACTION OF SOAP

When a dirty cloth is put in water containing dissolved soap, the hydrocarbons of the soap molecules in the micelle attach to the oil [or] greeze particles present on the surface of dirty clothes.

⇒ In this way the soap micelle entraps the oily [or] greasy particles by using its hydrocarbons ends.

⇒ The ionic ends of the soap molecules in the micelles however remain attached to water.

⇒ When the dirty cloth is agitated in soap solutions, the oily and greasy particles present on its surfaces and entrapped by soap micelles get dispersed in water due to which the soap water becomes dirty but the cloth gets cleaned.

⇒ The cloth is cleaned thoroughly by rising in clean water.

⇒ The whole purpose of using soap for washing is to make the oily and greasy dirt particles soluble in water and they can be washed away during rinsing.

⇒ The fact the soap acts by making oily and greasy particles mix with water