	INDIAN SCHOOL AL WADI AL KABIR	
Class: X	**Department: SCIENCE** **SUBJECT: CHEMISTRY**	**Date of completion: - 10.11.22**
HANDOUT-3	**CHAPTER:** **CARBON AND ITS COMPOUNDS**	**Note:** **A4 FILE FORMAT**
Name of the student:	**Class & Sec:**	**Roll No:**

CHAPTER-4-CARBON AND ITS COMPOUNDS

- Carbon is found in the atmosphere, inside the earth's crust and in all living organisms.
- Carbon is present in fuels like wood, coal, charcoal, petroleum, coke, natural gas, biogas etc.
- Carbon is present in compounds like carbonates and hydrogen carbonates.
- Carbon is found in free state as diamond, graphite and fullerenes.
- Earth's crust contains **0.02%** of carbon as minerals
- Atmosphere has **0.03%** of carbon dioxide gas.

CARBON (NON-METAL)
Atomic no.- 6
Electronic configuration– K L
2 4
4 electrons in the outer shell and needs to gain or lose 4 electrons to attain stability.

- Carbon cannot gain 4 electrons. The nucleus with 6 protons cannot hold 10 electrons.so it cannot form C4-
- Carbon cannot lose 4 electrons. large amount of energy is required to remove 4 electrons. So, it cannot form C4+
- Carbon can share its valence electrons with other carbon atoms or with atoms of other elements.

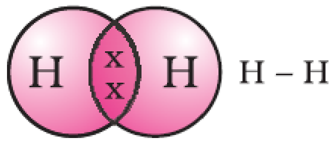
COVALENT BOND

- The bond which is formed by the sharing of electrons is known as covalent bond.
- The compounds which are formed by the sharing of electrons are called covalent compounds.

Examples for simple covalent molecules

1. H_2

   Atomic number-1, Electronic configuration- K
   1



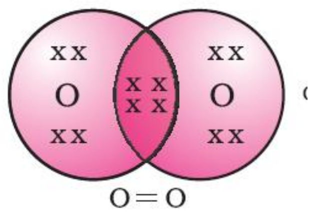
It requires one more electron to fill the K shell. So, sharing of one pair of electrons.

The covalent bond which is formed by the sharing of one pair of electrons is known as a **single bond(-)**

2. **Oxygen molecule**

   Atomic no- 8, K L
   2 6

Two more electrons are required (sharing of two pairs of electrons)

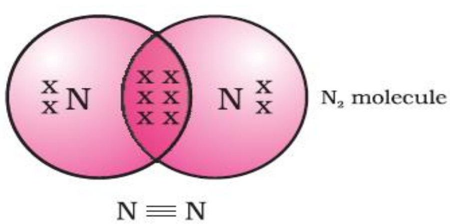


Double bond- The covalent bond which is formed by the sharing of two pairs of electrons.

3. **Nitrogen molecule**

Atomic no-7, K L
2 5

Three more electrons are required (sharing of 3 pairs of electrons)



Triple bond- The covalent bond which is formed by the sharing of 3 pairs of electrons.

Properties of covalent compounds

1. They have strong bonds within the molecule. But intermolecular forces are weak.

2. Low melting and boiling points.
3. Generally poor conductors of electricity.

Versatile nature of carbon (Reason for the formation of large number of carbon compounds)

The two properties of carbon element which leads to the formation of large number of carbon compounds are: -

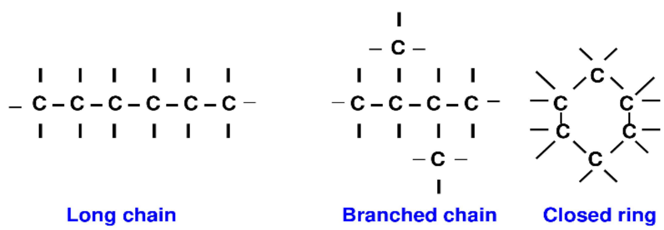
1. Catenation and
2. Tetravalency

1. **Catenation** (self-linking)

The property of carbon element due to which its atoms can join with one another to form long carbon chains is called catenation.

Three types of chains can be formed:

- Straight chains (long chains)
- Branched chains
- Rings



The carbon – carbon bond is very strong and stable. (This gives large number of compounds)

Silicon also exhibits catenation. Only up to 7/8 atoms join together to form compounds. These silicon compounds are unstable and very reactive.

Tetravalency

Due to its large valency of 4, carbon can form covalent bonds with other four carbon atoms or atoms of other elements like Hydrogen, Oxygen, Nitrogen, Sulphur, Chlorine and many more atoms.

- Because of small size, carbon can form strong bonds with other atoms and these compounds are stable.

HYDROCARBONS

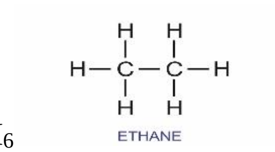
A compound made up of carbon and hydrogen only is called a hydrocarbon.
The most important natural source of hydrocarbons is petroleum or crude oil.

- Two types of hydrocarbons– saturated and unsaturated.

<u>Saturated hydrocarbons</u> (Alkanes)
A hydrocarbon in which the carbon atoms are connected by only single bonds is called a saturated hydrocarbon.

Eg:- methane CH_4,

Ethane C_2H_6



<u>Unsaturated hydrocarbons</u>

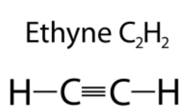
A hydrocarbon in which two carbon atoms are joined by a double bond or triple bond.
These are of two types--- **Alkenes and Alkynes**

<u>Alkenes-</u> An unsaturated hydrocarbon in which 2 carbon atoms are connected by a double bond.
<u>Eg:-</u> Ethene ($CH_2= CH_2$),
Propene (CH_3-CH=CH_2)

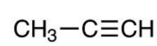
<u>Alkynes-</u>

An unsaturated hydrocarbon in which 2 carbon atoms are connected by a triple bond.

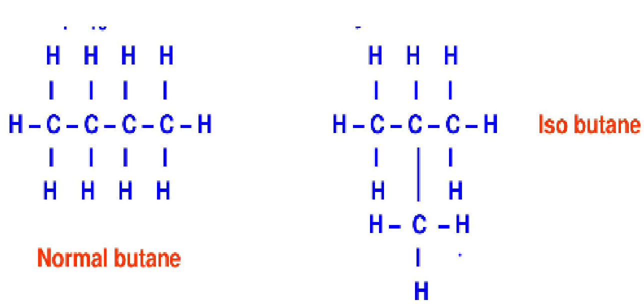
<u>Eg:-</u> Ethyne C_2H_2,



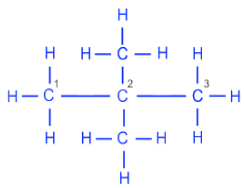
Propyne C_3H_4



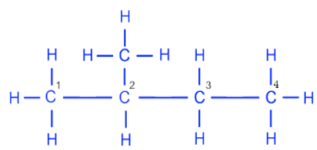
<u>ISOMERS</u>
Organic compounds having the same molecular formula and different structures are known as isomers. Isomerism is possible with hydrocarbons having 4 or more carbon atoms.
<u>Isomers of butane,</u> C_4H_{10}



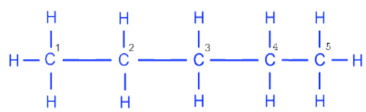
Isomers of pentane C_5H_{12}



Neo-pentane

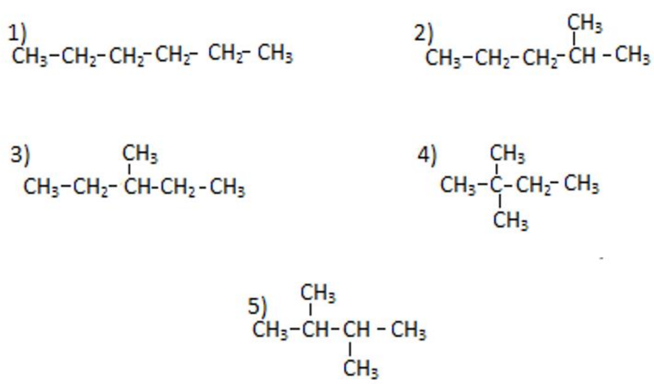


Iso-pentane



- n-pentane

Isomers of hexane, C_6H_{14}

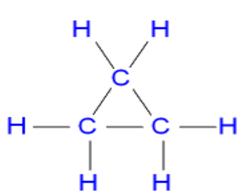


CYCLIC HYDROCARBONS

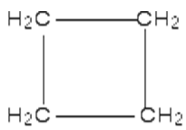
Hydrocarbons in which the carbon atoms are arranged in the form of a ring are called cyclic hydrocarbons.

- Cyclic hydrocarbons may be saturated or unsaturated.
- Examples for saturated cyclic hydrocarbons: -

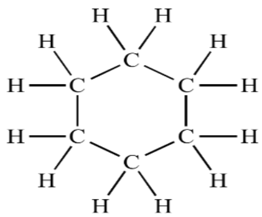
1. Cyclopropane



2. Cyclobutane



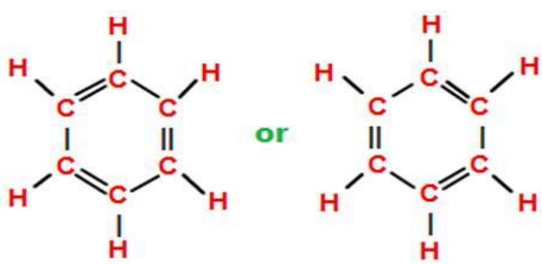
3. Cyclohexane



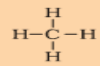
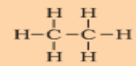
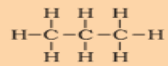
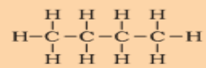
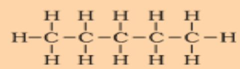
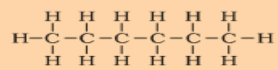
Example for unsaturated cyclic hydrocarbon: -

Benzene- C_6H_6

- Benzene contains alternate single and double bonds.



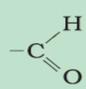
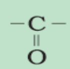
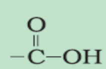
4.2 Formulae and structures of saturated compounds of carbon and hydrogen

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

FUNCTIONAL GROUPS

An atom or group of atoms which makes a carbon compound reactive and decides its properties is known as functional group.

(The elements which can replace hydrogen atoms are known as heteroatoms. Eg:- halogens, oxygen, nitrogen, sulphur)

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

HOMOLOGOUS SERIES

Homologous series is a group of organic compounds having similar structures and similar chemical properties in which the successive compounds differ by CH_2 unit.

Characteristics of homologous series

- All members can be represented by the same general formula.
- Adjacent members differ by CH_2 unit.

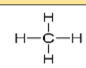
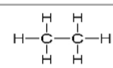
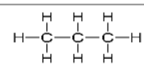
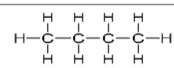
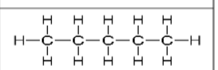
- Adjacent members differ by a molecular mass of 14 u
- Show a gradual change in physical properties (chemical properties are same)

Examples of homologous series

1. Alkanes

(General formula- C_nH_{2n+2})

Eg:- CH_4, C_2H_6, C_3H_8

ALKANE	CARBON NUMBER	FORMULA	STRUCTURE
METHANE	1	CH_4	
ETHANE	2	C_2H_6	
PROPANE	3	C_3H_8	
BUTANE	4	C_4H_{10}	
PENTANE	5	C_5H_{12}	

2. Alkenes

General formula-(C_nH_{2n})

Eg:- C_2H_4, C_3H_6, C_4H_8

ALKENE	No. of Carbons	Structure	Formula
Ethene	2	$CH_2=CH_2$	C_2H_4
Propene	3	CH3-CH=CH_2	C_3H_6
Butene	4	CH_3-CH_2-CH=CH_2	C_4H_8
Pentene	5	CH_3-CH_2-CH_2-CH=CH_2	C_5H_{10}

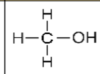
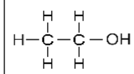
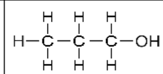
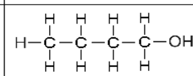
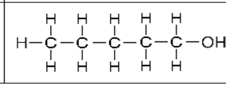
2. Alkynes

General formula- (C_nH_{2n-2})

C_2H_2, C_3H_4, C_4H_6

ALKYNE	No. of Carbons	Structure	Formula
Ethyne	2	HC ≡ CH	C_2H_2
Propyne	3	CH_3- C ≡ CH	C_3H_4
Butyne	4	CH_3-H_2C-C ≡CH	C_4H_6
Pentyne	5	CH_3-CH_2-CH_2-C ≡CH	C_5H_8

4. Alcohols

ALCOHOL	CARBON NUMBER	FORMULA	STRUCTURE
METHANOL	1	CH_3OH	
ETHANOL	2	CH_3CH_2OH	
PROPANOL	3	$CH_3CH_2CH_2OH$	
BUTANOL	4	$CH_3CH_2CH_2CH_2OH$	
PENTANOL	5	$CH_3CH_2CH_2CH_2CH_2OH$	

5. Aldehydes

Aldehydes	No. of carbon atoms	Formula
Methanal	1	H-CHO
Ethanal	2	CH_3-CHO
Propanal	3	CH_3-CH_2- CHO

6. Ketones

Ketones	No. of carbon atoms	Formula
Propanone	3	CH_3-CO-CH_3
Butanone	4	CH_3-CH_2-CO-CH_3
Pentanone	5	CH_3-CH_2-CH_2-CO-CH_3

7. Carboxylic acids

Carboxylic acids	No. of carbon atoms	Formula
Methanoic acid	1	HCOOH
Ethanoic acid	2	CH_3-COOH
Propanoic acid	3	CH_3-CH_2-COOH

CHEMICAL PROPERTIES OF CARBON COMPOUNDS

COMBUSTION

Carbon burns in oxygen to give CO_2 and large amount of heat and light energy.

$$C + O_2 \rightarrow CO_2 + \text{heat} + \text{light}$$

On burning, carbon compounds release large amount of heat and light with CO_2 and H_2O

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + \text{heat and light}$$

$$CH_3CH_2OH + 3O_2 \rightarrow 2CO_2 + 3H_2O + \text{heat and light}$$

- Saturated hydrocarbons on burning gives clean blue flame.
- Unsaturated hydrocarbons give yellow smoky flame.
- In limited supply of air, even saturated hydrocarbons give yellow smoky flame.

OXIDATION

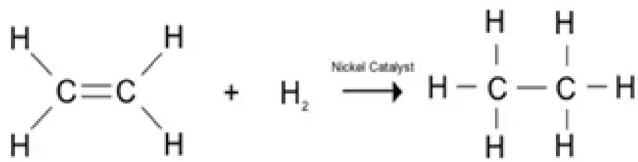
Alcohols can be oxidised to carboxylic acid by heating in presence of alkaline potassium permanganate (alk.$KMnO_4$) or acidified potassium dichromate (acidified $K_2Cr_2O_7$)

$$CH_3-CH_2OH \xrightarrow[\text{Or acidified } K_2Cr_2O_7 + \text{Heat}]{\text{Alkaline } KMnO_4 + \text{Heat}} CH_3COOH$$

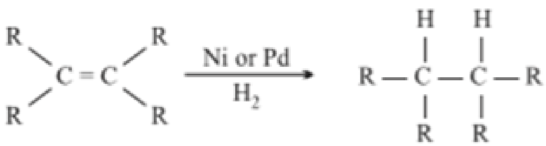
Alkaline potassium permanganate or acidified potassium dichromate can add oxygen to the starting material. Hence they are known as oxidising agents.

ADDITION REACTION

- Unsaturated hydrocarbons undergo addition reaction.(ie, alkenes and alkynes)
- In addition reaction, unsaturated hydrocarbons are converted to saturated hydrocarbons.
- Addition reaction takes place only in presence of catalysts such as Nickel or Palladium.
- Addition reactions are reactions in which unsaturated hydrocarbons add hydrogen in presence of catalysts such as Ni/Pd to give saturated hydrocarbons.



- The addition of hydrogen to an unsaturated hydrocarbon to obtain a saturated hydrocarbon is called hydrogenation.
- Addition reaction is commonly used in the hydrogenation of vegetable oil.



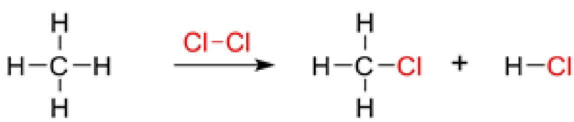
Veg.oil(liquid) veg.ghee(saturated-solid)

- Vegetable oils containing unsaturated fatty acids are good for our health.
- Animal fats (contain saturated fatty acids) are harmful for our health.

SUBSTITUTION REACTION

- Saturated hydrocarbons undergo substitution reaction.
- Substitution reactions are reactions in which one type of atom or group of atoms take the place of another.
- In presence of sunlight chlorine can replace hydrogen atoms one by one.

Eg:- substitution reaction of methane with chlorine.



ETHANOL AND ETHANOIC ACID

Ethanol (ethyl alcohol-CH_3-CH_2-OH)

Ethanol is a liquid at room temperature. It is used in medicines such as tincture iodine, cough syrups and many tonics.
Pure ethanol is called absolute alcohol. Ethanol which contains 5% water is called rectified spirit.

Reactions of Ethanol

1. Reaction with sodium

Alcohols react with sodium to release hydrogen gas.

$$2CH_3CH_2OH + 2Na \rightarrow \underset{\text{sodium ethoxide}}{2CH_3\text{-}CH_2\text{-}O^-Na^+} + H_2$$

2. Reaction with concentrated H_2SO_4

Ethanol reacts with conc. H_2SO_4 to give unsaturated hydrocarbon(ethene)

$$CH_3-CH_2OH \xrightarrow[H_2SO_4]{\text{Hot conc.}} CH_2 = CH_2 + H_2O$$

Conc. H_2SO_4 is a dehydrating agent which removes water from ethanol.

Ethanoic acid- CH_3COOH

Ethanoic acid is also called acetic acid.5-8% solution of acetic acid in water is called vinegar.
It is a colourless liquid.
When pure ethanoic acid is cooled, it freezes to form a colourless ice-like solid(looks like a glacier).Due to this pure ethanoic acid is called glacial acetic acid.

REACTIONS OF ETHANOIC ACID

1. Esterification Reaction

An ester is formed by the reaction of an acid and an alcohol.
Ethanoic acid reacts with ethanol in the presence of an acid to give an ester. Esters are sweet smelling substances.

$$\underset{\text{(Ethanoic acid)}}{CH_3-COOH} + \underset{\text{(Ethanol)}}{CH_3-CH_2OH} \xrightleftharpoons{\text{Acid}} \underset{\text{(Ester)}}{CH_3-C-\underset{\underset{O}{\|}}{C}-CH_2-CH_3} + H_2O$$

Ethyl ethanoate

(Esters are most commonly formed by the reaction of an acid and an alcohol. Esters are used in making perfumes and as flavouring agents.)

Saponification: -

On treatment with NaOH (alkali) ester is converted back to alcohol and sodium salt of carboxylic acid. This reaction is known as saponification. It is used in the preparation of soap.

$$CH_3COOC_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COONa$$

2. Reaction with a base (acid + base →salt + H_2O)

Ethanoic acid reacts with a base such as NaOH to give a salt (sodium ethanoate/sodium acetate) and water.

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

3. Reaction with carbonates and hydrogen carbonates

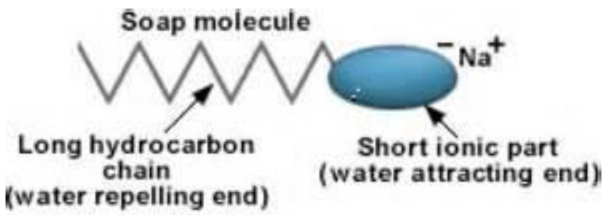
Ethanoic acid reacts with carbonates and hydrogencarbonates to give rise to a salt, carbon dioxide and water. The salt produced is commonly called sodium acetate.

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

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

SOAPS AND DETERGENTS

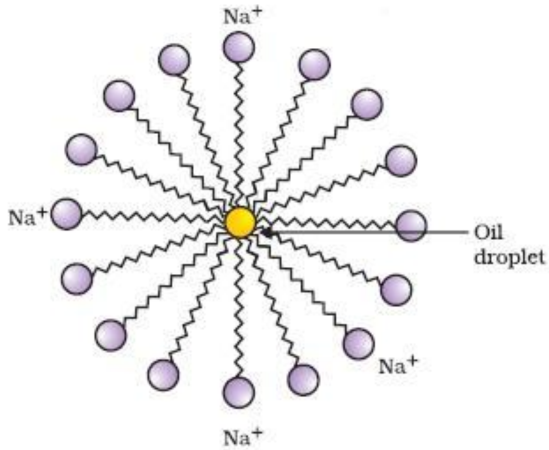
A soap is the sodium salt (or potassium salt) of long chain Carboxylic acid. A soap molecule has two parts: -a long hydrocarbon part and a short ionic part containing $–COO^-Na^+$.



The long hydrocarbon chain is hydrophobic (water repelling). So, the hydrocarbon part is insoluble in water but soluble in oil and grease. The ionic part of soap molecule is hydrophilic (water attracting). So, the ionic part is soluble in water, but insoluble in oil and grease.

Cleansing action of soap

Most dirt is oily in nature and oil does not dissolve in water. The ionic end of soap dissolves in water while the carbon chain dissolves in oil. Inside water these molecules have a unique orientation that keeps the hydrocarbon portion out of the water. This is achieved by forming clusters of molecules in which the hydrocarbon ends are in the interior of the cluster and the ionic ends are on the surface of the cluster. This spherical aggregation of soap molecules in soap solution is called Micelles.



The oily dirt will be collected in the centre of the micelle. The micelles stay in solution as a colloid and will not come together because of ion-ion repulsion. Thus, the dirt suspended in the micelles is also easily rinsed away. The soap micelles are large enough to scatter light. Hence a soap solution appears cloudy.

Soap is not suitable for washing clothes with hard water. Hard water contains calcium and magnesium salts. When soap is used for washing with hard water, the form is formed with difficulty and an insoluble substance, scum is formed. (by the reaction of soap with Ca and Mg ions of hard water).

DETERGENTS

Detergents are generally ammonium or sulphonate salts of long chain carboxylic acids. The charged ends of these compounds do not form insoluble precipitate (scum) with Ca and Mg ions in hard water. Hence can be used for washing even with hard water.

Differences between soaps and detergents: -

Soaps	Detergents
Soaps are the sodium salts (or potassium salts) of long chain carboxylic acids.	Detergents are ammonium or sulphonate salts of long chain carboxylic acids.
Soaps are not suitable for washing when the water is hard.	Detergents can be used for washing even when the water is hard.
Soaps are biodegradable	Some of the detergents are not biodegradable
Soaps have relatively weak cleansing action	Detergents have a strong cleansing action.