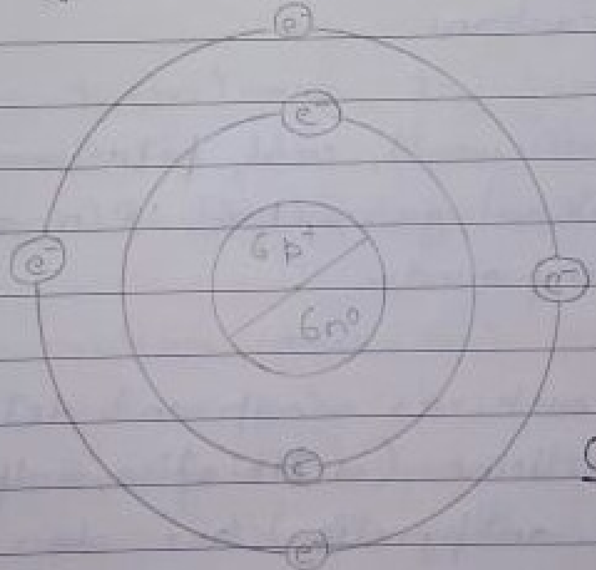
Chapter - 4

Carbon and it's compounds

Carbon -

⇒ Carbon is a chemical element with symbol 'C' and atomic number - 6. It is a non-metal which lies in Group-14 and it is one of the p-block elements.

- Latin name - Carbonium (Carboneum).
- Discovered by - Antoine Laurent de Lavoisier.



K	L
2	4

Carbon atom

⇒ Carbon has 6 electrons, 6 protons and 6 neutrons.

So, it is electrically neutral, because the number of protons is equal to number of electrons.

- Atomic mass of Carbon = 12u.

- Melting point of carbon ⇒ 3823 K.
- Boiling point of carbon ⇒ 5100 K.

Occurence of carbon:

⇒ It is a very versatile element. It is present everywhere either in elemental or in combined form.

- All living systems are made up of carbon, like carbohydrates, fats, proteins, vitamins, hormones.
- Various food items such as grains, pulses, fruits contain carbon.
- Fuels like wood, coal, petroleum (gasoline), kerosene, diesel, natural gas, CNG, LPG are made up of carbon compounds.
- Materials such as soap and detergents and most of the medicines (antibiotics, sulpha drugs, analgesics, antipyretics) are also made up of carbon compounds.

⇒ The Earth's crust has only 0.02% carbon in the form of minerals (carbonates, HCO_3^-, coal, petroleum).

⇒ The atmosphere has 0.03% carbon in the form of carbon dioxide.

Covalent bonds-

⇒ A chemical bond formed between two atoms by mutual sharing of electrons between the two atoms so that each atom aquires the stable electronic configuration of the nearest noble gas is called a covalent bond.

- Covalency - The number of electrons contributed by each atom for sharing is known as its covalency.

- Covalent compounds- The compounds formed by sharing of electrons are called covalent compounds

Examples - CH_4, C_2H_6, C_6H_{12}, etc.

⇒ Each atom contributes equal number of electrons for sharing. These shared electrons form common pairs or shared pairs.

⇒ The pair of electrons which are not involved in bond formation are called unshared pairs or lone pairs.

Why Carbon forms covalent bonds?

⇒ Carbon and some other elements form covalent bonds because of their special electronic configuration. It has 4 electrons in its outermost shell of its atom. Now, at this position carbon can either gain or lose 4 electrons to complete its octet or duplet respectively. But:

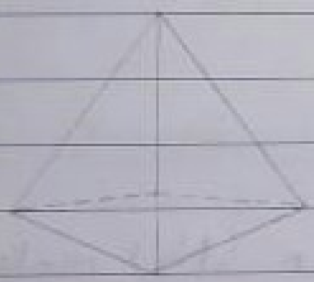
(i) If it gains 4 electrons, to form C^{4-}, it would be highly unstable due to the large amount of energy required to overcome the forces of repulsion between $4e^-$ being added and the $6e^-$ already present.

(ii) If it loses 4 electrons to form C^{4+}, it would be highly unstable due to the large amount of energy required to remove 4 electrons.

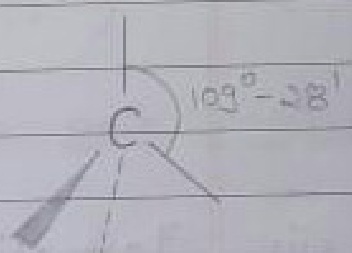
So, carbon does not gain or lose 4 electrons, rather, to become stable with gaining or losing electrons, it shares the valence electrons ~~to~~ with the atoms of other element or with ~~its~~ the atom of another carbon.

Carbon is tetrahedral-

⇒ Dutch scientist, J. van't Hoff and French scientist, C. Le Bel both independentally in 1874 pointed out that the four valencies of carbon does not lie in a plane, but it is directed towards the four corners of a regular tetrahedron, i.e., carbon is tetrahedral. The angle between any two adjacent valencies is 109°-28', which is also known as tetrahedral angle.



Tetrahedron



4 valencies of carbon

Types of covalent bonds-

⇒ There are 3 types of covalent bonds-

(i) Single bond (—) ⇒ If each atom contributes 1 electron, then the covalent bond formed is called single bond.

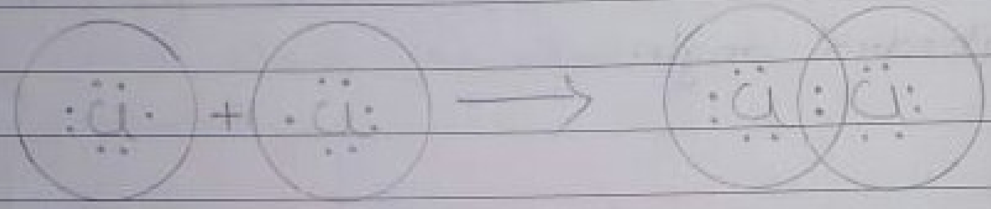
(ii) Double bond (=) ⇒ If each atom contributes 2 electrons, then the covalent bond formed is called double bond.

(iii) Triple bond (≡) ⇒ If each atom contributes 3 electrons then the covalent bond formed is called triple bond.

Note – Two atoms cannot mutually share more than 3 electron pairs because the electron-electron repulsions between four and more shared pairs make the molecules unstable.

Examples of formation of covalent bonds –

(i) Formation of Chlorine (Cl_2) molecule –

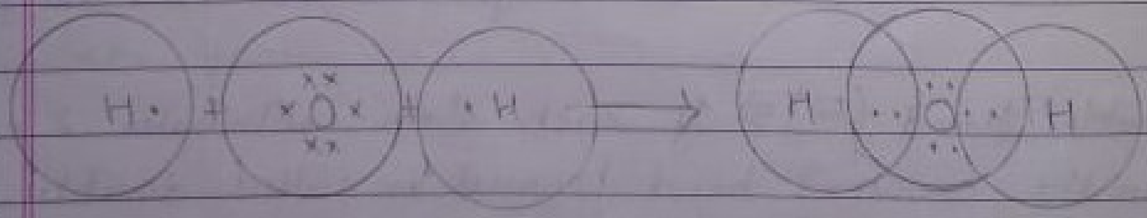


or $Cl-Cl$.

(ii) Formation of nitrogen (N_2) molecule –

or, $N\equiv N$

(iii) Formation of water (H_2O) molecule.



or, $H-O-H$

- Homoatomic molecules ⇒ The molecules which are made up of only one kind of atoms are called homoatomic molecules.

Examples → H_2, Cl_2, N_2, O_2, I_2, Br_2, etc.

- Heteroatomic molecules ⇒ The molecules which are made up of more than one type of atoms are called heteroatomic molecules.

Examples → H_2O, NH_3, CH_4, HCl, etc.

<u>Difference between ionic compounds and covalent compounds</u>:-

Ionic compound	Covalent compound
• Mode of formation ⇒ Formed by complete transfer of electrons.	• Mode of formation ⇒ Formed by mutual sharing of electrons.
Example - $NaCl$, KCl, etc.	Example - HCl, H_2O, etc.
• Physical state. ⇒ These are generally solids.	• Physical state. ⇒ The compounds may be solid (I_2), liquid (Br_2) or gas (O_2).

Ionic compounds	Covalent compounds
• Melting and boiling points ⇒ Due to strong force of attraction b/w -ve and +ve ions, melting and boiling points are high.	• Melting and boiling points ⇒ Due to weak intermolecular force of attraction, melting and boiling points are low.
• Solubility. ⇒ Dissolve in polar solvents. Example- Water	• Solubility ⇒ Dissolves in non-polar solvents. Example- Petroleum, alcohol, etc.
• Electrical conductivity ⇒ Conduct electricity in molten and aqueous form, due to presence of ions.	• Electrical conductivity. ⇒ Do not conduct electricity or bad conductors of electricity, bcz they do not contain ions. Exception → Graphite.
• Nature of reactions. ⇒ Undergo ionic reactions which are very fast and always proceed to completion. Example- $NaCl + AgNO_3 \longrightarrow AgCl + NaNO_3$	• Nature of reactions ⇒ Undergo molecular reactions which are slow and never proceed to completion. Example- $CH_4 + Cl_2 \xrightarrow[\text{sunlight}]{\text{Diffused}} CH_3Cl + HCl$.

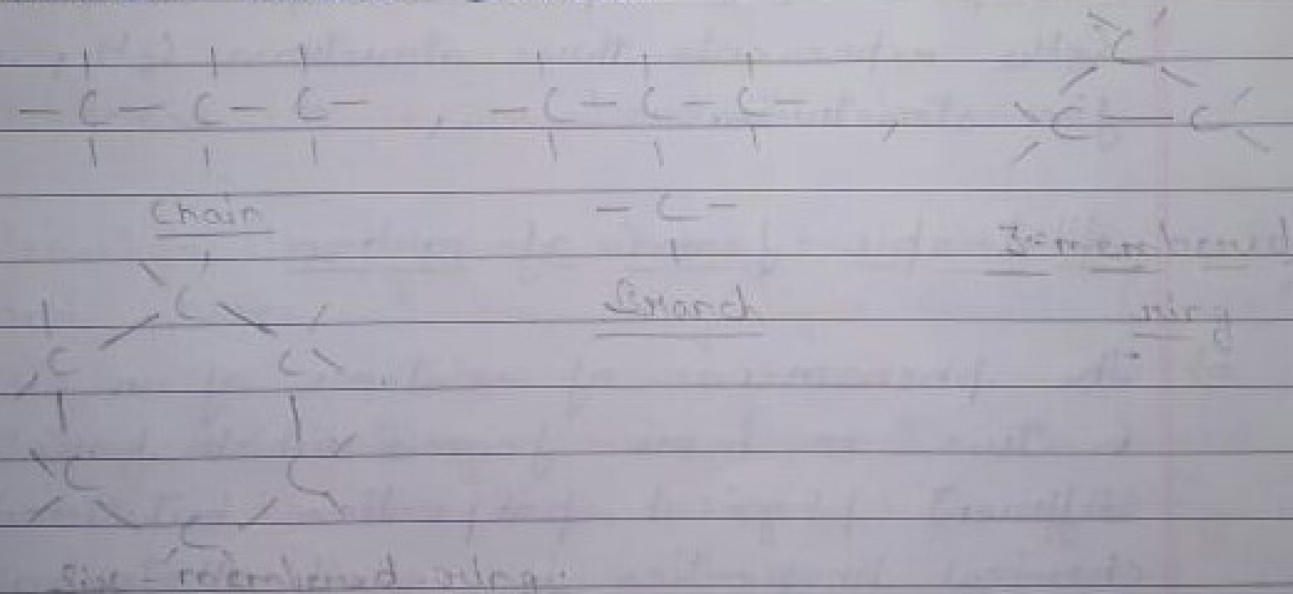
Versatile nature of carbon

⇒ The four main reasons for versatile nature of carbon are:

1) Catenation.

⇒ The unique property of self-linking of carbon atoms through covalent bonds to form long straight or branched chains and rings of different sizes is called catenation.

This property is due to - small size, unique electronic configuration and great strength between carbon- carbon bonds.



2) Tetracovalency of carbon.

⇒ Carbon has a valency of four. Due to the small size of carbon atom, it can hold its shared electrons strongly. This further increases the number of carbon compounds.

3) Tendency To form multiple bonds-

=> Due To small size, carbon forms multiple (double or triple) bonds with other carbon atoms or atoms of other elements which further increases number of carbon compounds.

4) Isomerism.

=> If a given molecular formula represents two or more structures having different properties, the phenomenon is called isomerism and the different structures are called isomers.

Example- C_4H_{10} represents two structures, C_5H_{12} represents three structures, C_6H_{14} represents five structures.

Allotropic forms of carbon

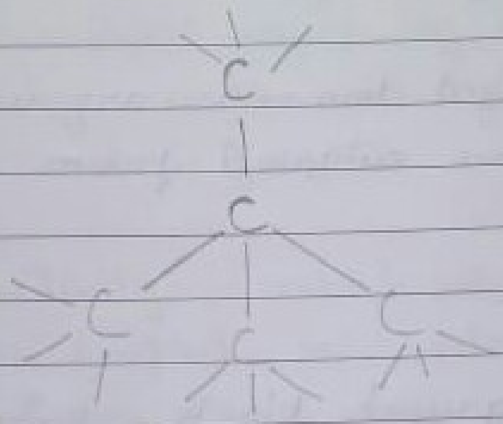
=> The phenomenon of existence of an element in two or more forms which have different physical properties but identical chemical properties is called allotropy and the different forms are called allotropic forms or simply allotropes.

Carbon occurs in 3 crystalline allotropic forms-

1) <u>Diamond</u>.

• Structure (3-dimensional).

⇒ In diamond, each carbon atom is attached to four other carbon atoms by strong single covalent bonds.



• Physical properties

(i) Hardness - It is the hardest substance.

(ii) Density - The carbon atoms are closely packed and hence it has very high density (3.51 g/cm^3).

(iii) Melting and boiling point - Due to its high density, diamond has a very high melting and boiling point.

(iv) Electrical conductivity - There are no free electrons in a diamond crystal. Therefore, it is a bad conductor of electricity.

(v) Thermal conductivity - It has the highest thermal conductivity.

• Uses -

(i) Because of its hardness, it is used for cutting glass and drilling rocks.

(ii) Due to its high refractive index, it is used for making jewellery.

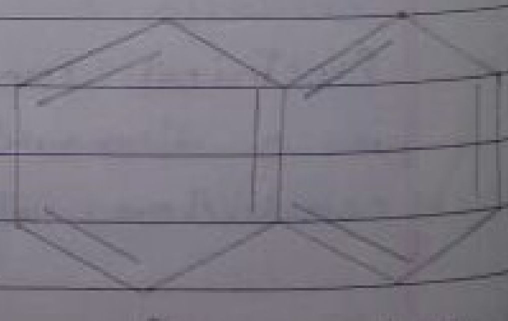
(iii) Sharp-edged diamonds are used by eye surgeons to remove cataract from eye.

2) <u>Graphite</u>

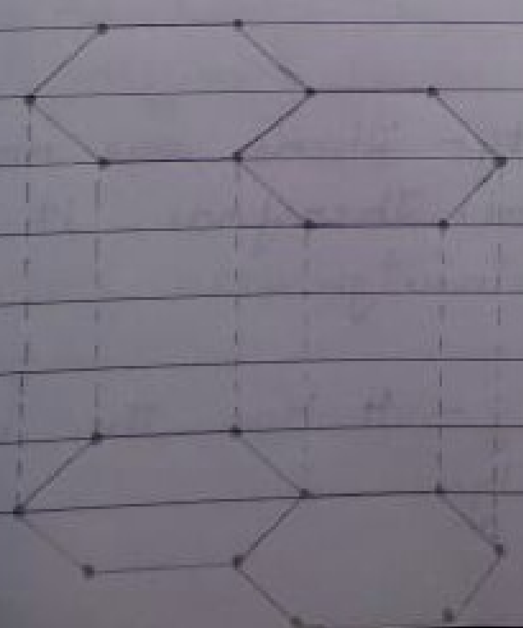
⇒ It is a greyish black substance and can be prepared artificially in an electric furnace.

• Structure (2-dimensional).

⇒ In graphite, each carbon atom is bonded to 3 other carbon atoms in the same plane, giving a hexagonal array. One of these bonds is a double bond, and hence satisfies the 4 valencies of carbon.



Benzene rings



Structure of graphite

• **Physical properties**

(i) Density - Due to wide spacing between the two layers, the carbon atom in graphite are less closely packed, hence its density is very low ($2.22\ g/cm^3$).

(ii) Softness - The various layers of carbon atoms are held together by weak van der Waals forces of attraction. This makes graphite soft.

(iii) Electrical conductivity - Graphite is a good conductor of electricity. In graphite, one carbon atom is attached to 3 other carbon atoms and one of them is a double bond, so the valency of carbon is satisfied.

(iv) Thermal conductivity - It is a good conductor of heat.

• Uses -

(i) It is used as a lubricant for heavy machinery operating at very high temperatures because graphite is non-volatile.

(ii) Powdered graphite is used either as a solid or dry lubricant or mixed with petroleum jelly as graphite grease.

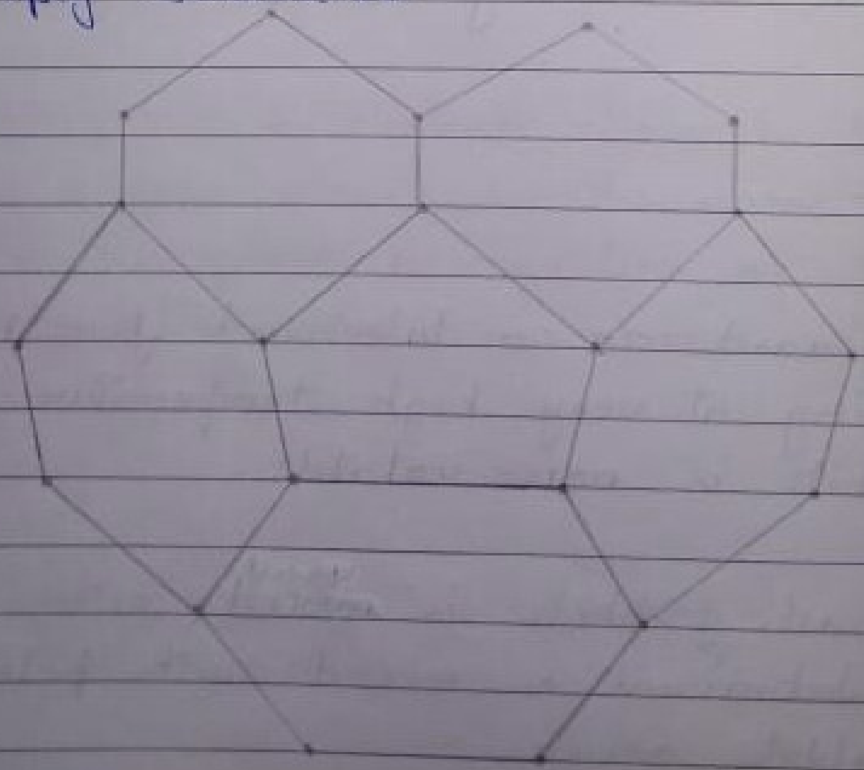
(iii) It is also used for making the cores of lead pencils.

3) Fullerenes.

=> They are spheroidal in shape and contain even number of carbon atoms ranging from 60-350 or above.

The C_{60} fullerene is the most stable and was the first to be identified. It contains 60 carbon atoms arranged in the shape of football, therefore it is also known as bucky ball. It contains 20 six-membered rings and 12 five-membered rings.

It looks like a dome shaped hall, designed by US architect, Buckminster Fuller, so the allotrope is named as Buckminster Fullerene or simply Fullerenes.



Structure of C_{60} fullerene

NOTEBOOK

⇒ It is dark solid at room temperature and it is neither very hard nor very soft.

Organic compounds

⇒ Compounds of carbon containing usually hydrogen and one or more other elements such as oxygen, nitrogen, sulphur, etc. are called Organic compounds.

The branch of chemistry which deals with the study of organic compounds is called Organic chemistry.

Note: In organic chemistry, the elements other than C and H such as O, N, S, P and X (halogens) are called Heteroatoms. ↳ (Group-17)

Vital Force theory-

⇒ This theory was proposed by a Swedish chemist, Berzelius in 1815.

According to this theory, organic compound are produced only under the influence of some mysterious force existing in the living organisms. This mysterious force was called the vital force.

This theory was later proved wrong when Freidrich Wohler accidentally prepared urea, which is an organic compound.

Wohler's Synthesis

⇒ In 1828, Friedrich Wohler, a German chemist, accidentally prepared urea, by heating aq. solution of two inorganic compounds — NH_4Cl and KCNO (Potassium Cyanate). NH_4CNO being unstable, on further heating, underwent a rearrangement to form urea.

$$NH_4Cl + KCNO \xrightarrow{\Delta} NH_4CNO + KCl$$

$$NH_4CNO \xrightarrow{\Delta} \underset{\text{(Urea)}}{H_2N-\overset{\overset{O}{\|}}{C}-NH_2}$$

So, the first organic compound synthesized in laboratory was urea.

- ## Hydrocarbons

⇒ The organic compounds of carbon and hydrogen are called hydrocarbons.

All other organic compounds may be regarded to have been derived by replacing one or more of their hydrogen atoms by other atoms or groups.

Saturated and Unsaturated compounds

(i) Saturated compounds-

⇒ Compounds of carbon which have only single covalent bonds between the carbon atoms are called saturated compounds.

Example - Methane, ethane, propane, butane, etc.

Since C-C single bonds are very strong, therefore, saturated compounds are usually not very reactive.

Note: Saturated hydrocarbons contain maximum number of hydrogen atoms.

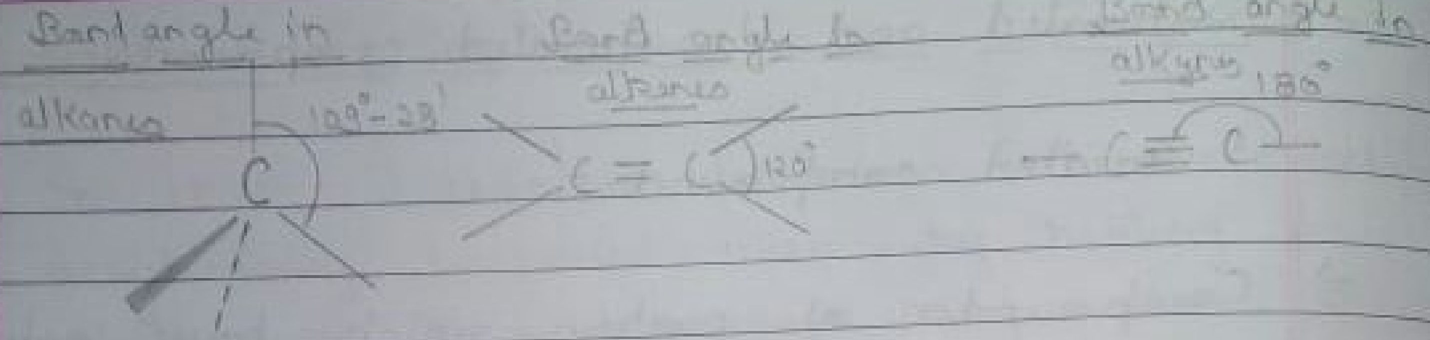
(ii) Unsaturated compounds-

⇒ Compounds of carbon which contain one or more double or triple bonds between carbon atoms are called unsaturated compounds.

Example - Ethene (ethylene), Ethyne (acetylene), etc.

Reactivity-

⇒ Unsaturated compounds are more reactive than saturated compounds. This is due to the angle strain as follows:



=> In alkanes, carbon has its usual tetrahedral angle. But in alkenes and alkynes, bond angles are higher than 109°-28', i.e., these molecules are under strain and hence are reactive.

Therefore, alkenes and alkynes add hydrogen in the presence of catalysts as palladium or nickel to give saturated compounds.

Example-

$$CH_2=CH_2 + H_2 \xrightarrow{Ni} CH_3-CH_3$$

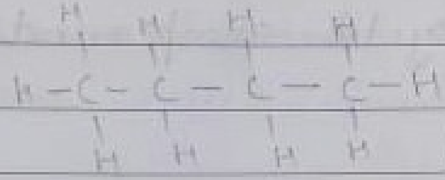
* Catalyst => Catalysts are substances that cause a reaction to occur or proceed at a different rate without the reaction itself being affected.

Chains, Branches and Rings

(a) Straight chain compounds-

⇒ The carbon compounds in which no carbon atom of the chain is linked to more than two other carbon atoms are called straight chain compounds.

Example-

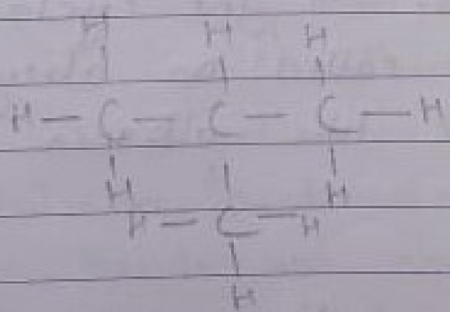


(Butane)

(b) Branched chain compounds-

⇒ The carbon compounds in which at least one carbon of the chain is linked to three or four other carbon atoms are called branched chain compounds.

Example-



(2-Methylpropane)

Note: The examples given in straight and branched chain compounds, have the same molecular formula (C_4H_{10}), but have different structures.

This phenomenon is called structural isomerism. More precisely, they are chain isomers.

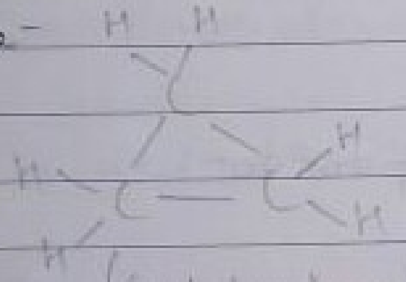
(c) Cyclic compounds–

=> The compounds of carbon in which carbon atoms are arranged in a ring, are called cyclic compounds.

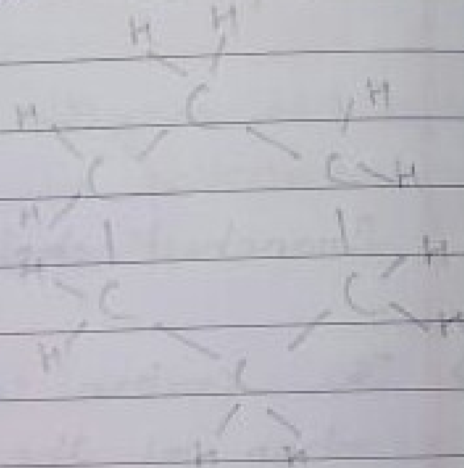
There are two types of cyclic compounds:

1) Saturated cyclic compounds– (C_nH_{2n})

Example–



(Cyclopropane)

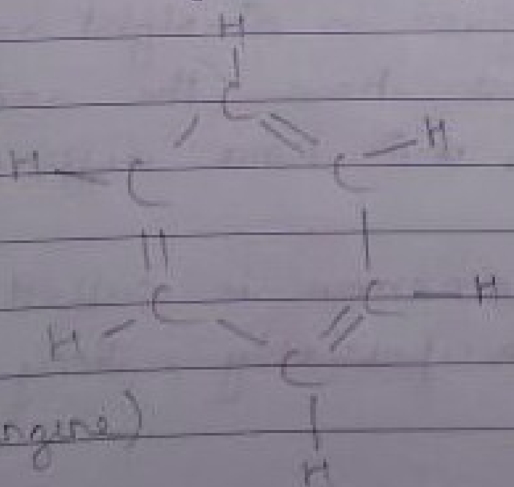


(Cyclohexane)

=> Saturated cyclic compounds are called cycloalkanes. All the cycloalkanes are collectively called as alicyclic compounds, because they behave like alkanes but possess cyclic structures.

2) Unsaturated cyclic compounds–

Example–



(Benzene)

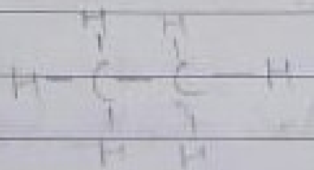
⇒ The structure of Benzene was first proposed by a German scientist, August Kekulé in 1865.

Different ways to represent structures

⇒ There are 3 ways to represent ~~any~~ structure:

1) Structural formulae - Such structures in which the bonds between different atoms are shown by dashes are called structural formulae.

Example -

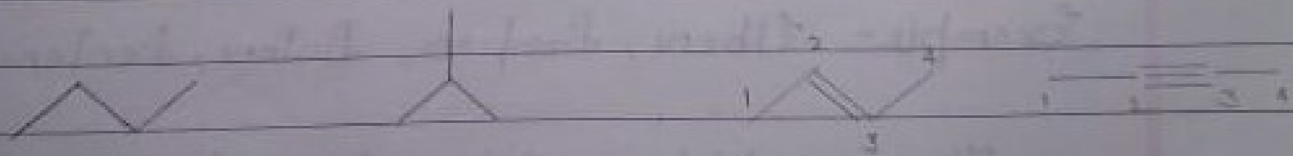


(Ethane)

2) Condensed structural formulae - The structural formulae can be further abbreviated by ommitting some or all the covalent bonds.

Example - CH_3-CH_3 or CH_3CH_3
(Ethane)

3) Bond-line notation - In bond-line notation, carbon-carbon bonds are shown by lines drawn in a zig-zag ~~and~~ manner. The carbon atoms are situated where the line ends and at intersections.



Butane , 2-Methylpropane , But-2-ene , But-2-yne

Alkanes, Alkenes and Alkynes

=> The compounds of hydrogen and carbon are called hydrocarbons. They are of 2 types:

1) Saturated hydrocarbons.

=> The hydrocarbons in which there is only single bonds between carbon-carbon atoms, are called saturated hydrocarbons. These are called alkanes.

General formula: C_nH_{2n+2}.

Example- Methane, Ethane, Propane, Butane, etc.

2) Unsaturated hydrocarbons.

=> The hydrocarbons in which there is at least one double or triple bonds between the carbon atoms, are called unsaturated hydrocarbons.

Those which contain at least one double bond are called alkenes. [General formula: C_nH_{2n}]

Example- Ethene, Propene, Butene, Pentene, etc.

Those which contain at least one triple bond are called alkynes. [General formula: C_nH_{2n-2}]

Example - Ethyne, Propyne, Butyne, Pentyne, etc.

Note: 'Methene' and 'Methyne' does not exist because it contains only one carbon atom and it cannot make double or triple bonds with hydrogen.

Molecular models

⇒ These are physical devices that are widely used for better visualization and perception of 3-dimensional structures of organic molecules. They are made up of wood, plastic or metal. Ball and stick/spring models are the most common.

Isomerism

⇒ If a given molecular formula represents two or more structures, having different properties, the phenomenon is called isomerism and the different structures are called structural isomers.

There are 3 types of structural isomers:

1) Position isomerism.

Example- $CH_3-CH_2-\underset{\underset{Cl}{|}}{CH_2}$ or, $CH_3-\underset{\underset{Cl}{|}}{CH}-CH_3$

1-Chloropropane. 2-Chloropropane

2) Chain isomerism.

Example- $CH_3-CH_3-CH_3-CH_3$ or, $CH_3-\overset{\overset{CH_3}{|}}{CH_3}-CH_3$

Butane. 2-Methylpropane

3) Functional isomerism.

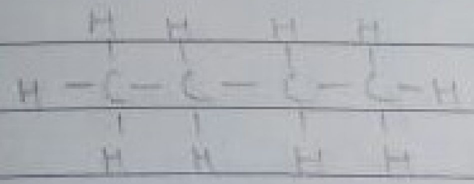
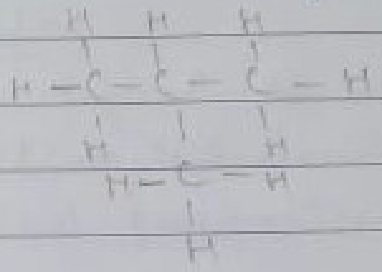
Example- $CH_3-\underset{\underset{O}{\|}}{C}-CH_3-CH_3-CH_3$ (Pentan-2-one)

or

$CH_3-CH_3-\underset{\underset{O}{\|}}{C}-CH_3-CH_3$ (Pentan-3-one)

Isomers of butane:

=) Butane has 2 isomers which are as follows:

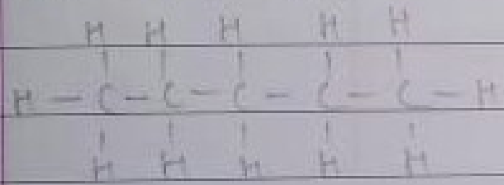
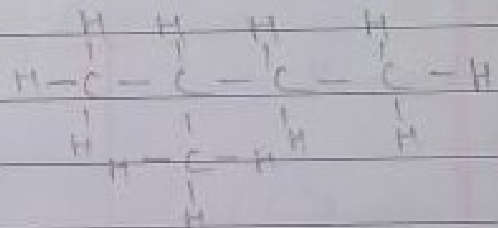
(i)  and (ii) 

Butane

2-Methylpropane

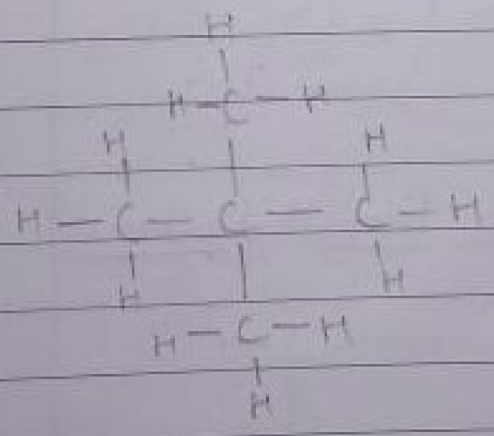
Isomers of pentane:

=) Pentane has 3 isomers which are as follows:

(i)  , (ii)  ,

Pentane

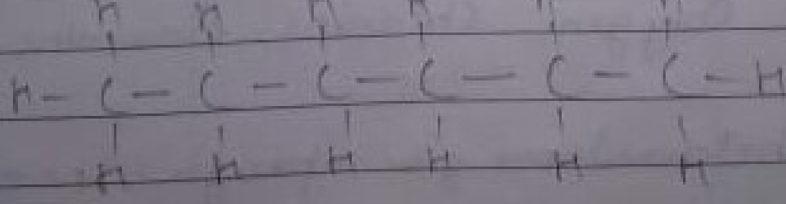
2-Methylbutane

(iii) 

2,2-Dimethylpropane

Isomers of hexane:

Hexane has 5 isomers which are as follows

(i)  Hexane

(ii) $CH_3 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_2 - CH_2 - CH_3$

2-Methylpentane

(iii) $CH_3 - CH_2 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_2 - CH_3$

3-Methylpentane

(iv) $CH_3 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_3$

2,3- Dimethylbutane

(v) $CH_3 - \overset{\displaystyle CH_3}{\overset{|}{\underset{\displaystyle CH_3}{\underset{|}{C}}}} - CH_2 - CH_3$

2,2- Dimethylbutane

Heteroatom-

=> The element replacing hydrogens of the parent hydrocarbon chain is referred to as heteroatom.

Example- Oxygen, Chlorine, Bromine, etc.

These heteroatoms give specific chemical properties to the new compounds formed.

Functional groups:-

⇒ A functional group may be defined as an atom or a group of atoms present in a molecule which largely determines its chemical properties.

	Heteroatom	Formula of the functional group	Name of the functional group
1)	Cl	$-Cl$	Chloro
2)	Br	$-Br$	Bromo
3)	O	$-OH$	Hydroxyl
4)	—	$-C\genfrac{}{}{0pt}{}{=O}{-H}$	Aldehydic
5)	—	$\underset{\overset{\Vert}{O}}{-C-}$	Ketonic
6)	—	$-\underset{\overset{\Vert}{O}}{C}-OH$	Carboxyl
7)	—	$-NH_2$	Amine
8)	—	$-\overset{\overset{O}{\Vert}}{C}-NH_2$	Amide
9)	—	$-C\equiv N$	Cyanides

10)	—	$-\overset{O}{\overset{\|}{C}}-O-R$	Ester

	Functional group	Suffix
1)	Alcohal	-ol
2)	Aldehydic	-al
3)	Ketonic	-one
4)	Carboxyl	-oic acid
5)	Amine	-amine
6)	Amide	-amide
7)	Cyanides	-nitrile
8)	Ester	Alkyl- oate

<u>Examples-</u>

(i) $CH_3-CH_2-\underset{OH}{\underset{|}{CH}}-CH_3 \Rightarrow$ Butan-2-ol

(ii) $CH_3-\underset{O}{\underset{\|}{C}}-H \Rightarrow$ Ethanal

(iii) $CH_3-\underset{O}{\underset{\|}{C}}-CH_3 \Rightarrow$ Propan-2-one

(iv) $CH_3-\underset{O}{\underset{\|}{C}}-OH \Rightarrow$ Ethanoic acid

<u>Note:</u> Branch (alkyl) is denoted by 'R'.

(v) $CH_3 - CH_2 - NH_2 \Rightarrow$ Ethanamine.

(vi) $CH_3 - CH_2 - \underset{\underset{O}{\parallel}}{C} - NH_2 \Rightarrow$ Propanamide.

(vii) $CH_3 - CH_2 - CH_2 - C \equiv N \Rightarrow$ Butane nitrile.

(viii) $\underbrace{CH_3 - CH_2 - \overset{\overset{O}{\parallel}}{C}}_{\text{Ethanoate}} - \underbrace{O - CH_2 - CH_3}_{\text{Ethyl}} \Rightarrow$ Ethyl ethanoate - 3.

Terminal and non-Terminal functional group:-

⇒ Carbon containing functional groups are of 2 types:

(i) Terminal functional groups- Functional groups which are always present at the end of carbon chain are called terminal functional groups.

Example- Aldehyde, carboxyl.

(ii) Non-Terminating functional groups- Functional groups which are always present in between the carbon chain are called non-Terminal functional groups.

Example- Ketone.

Homologous series :

⇒ A homologous series may be defined as a family of organic compounds having the same functional group, similar chemical properties and the successive (adjacent) members of which differ by a CH_2 unit or 14 mass units.

The individual members of a homologous series are called homologues and the phenomenon is called homology.

Characteristics of a Homologous series:

1> All the members of a homologous series can be represented by a general formula.

Example- The general formula of homologous series of alkanes is C_nH_{2n+2}.

2> The molecular formulae of any two successive members of a homologous series differ by a CH_2 unit.

Example- CH_4 and C_2H_6 are two successive members of the homologous series of alkanes and they differ by CH_2 unit.

$$[C_2H_6 - CH_4 = CH_2.]$$

3) The molecular masses of any two successive ~~of~~ members of a homologous series differ by 14 u.

Example- C_2H_6 and C_3H_8 are two successive members of the homologous series of alkanes. And, they differ by a CH_2 unit.

Mass of CH_2 unit-

Mass of 1 carbon atom = 12 u
Mass of 2 hydrogen atoms = 1 x 2 = 2 u

$\therefore$ Mass of CH_2 unit = 12 + 2 = 14 u.

4) All the members of a given homologous series have the same functional group.

5) All the members of a given homologous series show similar chemical properties.

6) The members of a homologous series show a gradation (gradual change) in physical properties as the molecular mass increases.

Example- Melting points and boiling points increases with increasing molecular mass. Also, solubility in a particular solvent show similar gradation.

Nomenclature of carbon compounds:

⇒ Many organic compounds have two names-

(i) Trivial or common names.

⇒ These names were given after the source from which the organic compounds were first isolated.

Example- Acetic acid got its name from Latin word 'Acetum' which means vinegar, formic acid got its name from Latin word 'Formicus' which means red ant, methyl alcohol is also called Wood Spirit because it was obtained from destructive distillation of wood.

(ii) IUPAC names.

⇒ International Union of Pure and Applied Chemistry (IUPAC) has given certain rules to systematize the nomenclature of organic compounds. The names based upon these rules are called IUPAC names and are most widely used.

Word roots-

=> Word roots determine number of carbon atoms present in the parent chain. Some word roots are as follows:

Number of carbon atoms	Word root	No. of carbon atoms	Word root
1	Meth	17	Heptadec
2	Eth	18	Octadec
3	Prop	19	Nonadec
4	But	20	Eicos
5	Pent	21	Henicos
6	Hex	22	Doicos
7	Hept	23	Tricos
8	Oct	30	Triacont
9	Non	31	Hetriacont
10	Dec	40	Tetracont
11	Undec	50	Pentacont
12	Dodec	60	Hexacont
13	Tridec	70	Heptacont
14	Tetradec	80	Octacont
15	Pentadec	90	Nonacont
16	Hexadec	100	Hectane

Alkyl group :

=) The removal of one hydrogen atom from the molecule of an alkane gives an alkyl group. Alkyl groups have the general formula C_nH_{2n+1}. These are often represented by 'R'.

* Fuel => A fuel is a substance that burns producing a large amount of heat and some light. This heat energy is used for various purposes.

Examples - Coal, petroleum, natural gas, etc.

Coal

=) It is a fuel which is widely used for different purposes. It is a complex mixture of carbon, hydrogen and oxygen with the traces of some other elements.

- It is formed by the decomposition of large plants and trees buried in the Earth millions of years ago.

- It was formed under the influence of moisture, high temperature and pressure, in the abs ce of air.

There are 4 different types of coal:

1) Peat.

2) Anthracite.

3) Bituminous.

4) Lignite.

Petroleum and Natural gas

⇒ Petroleum and natural gas is also widely used fuel, which were formed by the decomposition of tiny plants and animals that lived in the sea.

• When they died, their bodies sank into the sea and covered by silt. Under the high pressure of silt, the dead remains got converted in petroleum and natural gas.

* Petroleum ⇒ It is dark coloured foul smelling viscous oil. It is also known as crude oil or mineral oil.

* Natural gas ⇒ It mainly consists of methane (95%) along with decreasing amount of ethane, propane, butane and vapours of low boiling pentanes and hexanes.

Flames:

⇒ A flame is the region where combustion of gaseous substances take place.

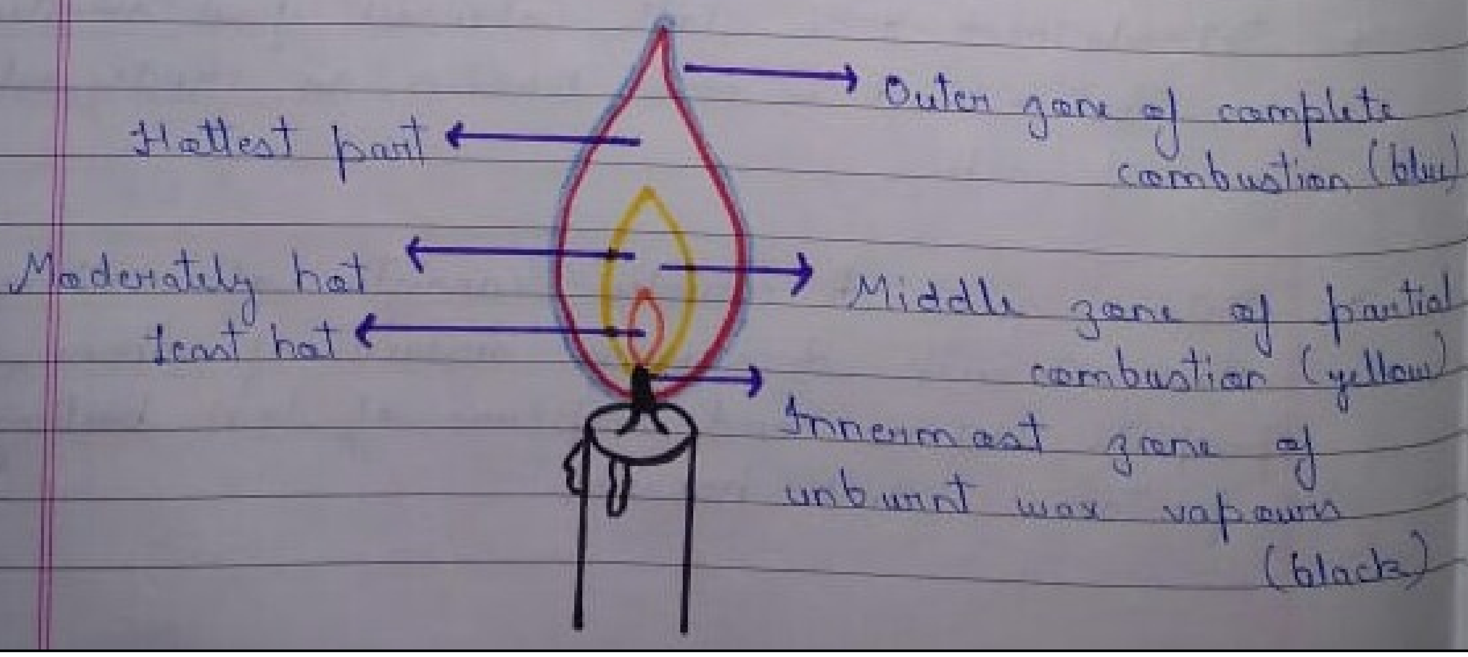
Depending upon the amount of oxygen available, flames are of 2 types:

1) Blue or non-luminous flame.
⇒ When the oxygen supply is sufficient, the fuels burn completely producing a blue flame and no light is produced.

Example- Burning of LPG in gas stove.

2) Yellow or luminous flame.
⇒ In the insufficient supply of air, the fuels burn incompletely and produce yellow flame because of presence of unburnt carbon particles

Example- Burning of wax vapours.



Why do substances with or without a flame?

=> The combustile substances which vapourize on burning produces a flame.

* The substance which vapourizes are known as volatile.

Example- Wax produces flame and charcoal does not produce flame.

Different types of organic reactions

1) Combustion reaction

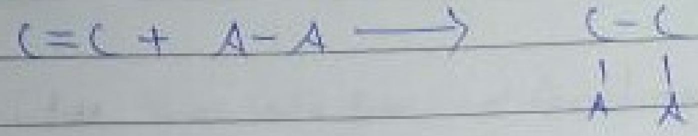
=> The reaction in which hydrocarbons burn with oxygen gas to form carbon dioxide and water with release of a large amount of heat and light is called combustion reaction.

Example- $CH_4 + O_2 \longrightarrow CO_2 + H_2O +$ Heat and light

- If O_2 gas is not sufficient then carbon monoxide is formed instead of carbon dioxide.

2) Addition reaction

=> The reactions in which a simple molecule is added to an unsaturated compound to form a single product, are called addition reactions.

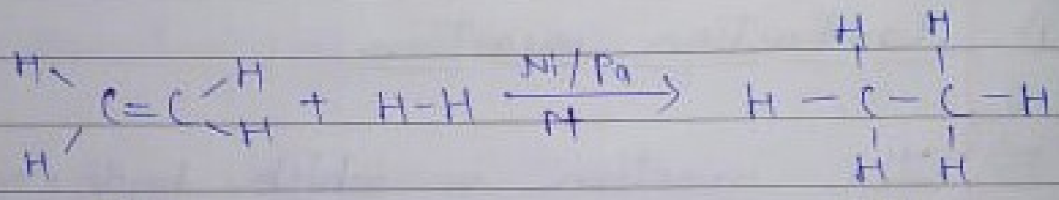
Example - 

A-A is a simple molecule.

There are 2 types of addition reactions:

(i) Hydrogenation

⇒ The addition of hydrogen to an unsaturated compound, is known as hydrogenation.

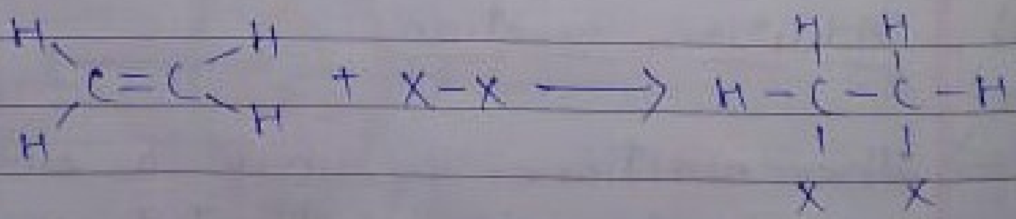
Example - 

Ethene Ethane

(Name of this reaction ⇒ Catalytic hydrogenation).

(ii) Halogenation

⇒ The addition of a halogen to an unsaturated carbon compound is known as, halogenation.

Example - 

* Halogens ⇒ Group-17 elements of periodic table, represented by 'X'. Examples - Cl, F, Br, I.

* Application of hydrogenation - Hydrogenation is used to convert vegetable oil into saturated vegetable ghee.

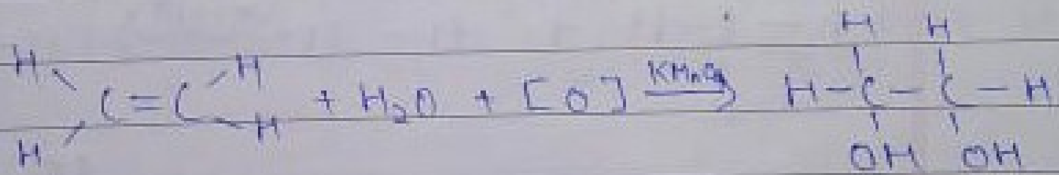
Vegetable oil (Unsaturated fatty acid) + H_2 $\xrightarrow{Ni}$ Vegetable ghee (Saturated fatty acid)

<u>Test for unsaturated compound (Hydrocarbon)</u> -

1) By treating it with Baeyer's reagent
=> Baeyer's reagent is alkaline $KMnO_4$ which is a strong oxidising agent.

On treating it with the unsaturated hydrocarbon, the colour of Alk. $KMnO_4$ fades. So we can say that the hydrocarbon is unsaturated.

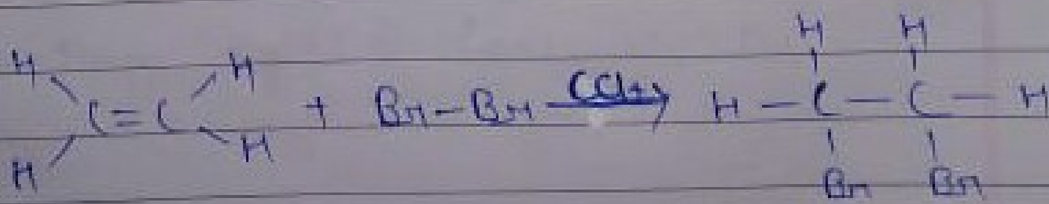
Example -



[Ethene] (Ethane-1,2-diol) [Glycol]

2) By treating it with bromine
=> On treating unsaturated hydro-carbon, the colour of Bromine (reddish-brown) fades.

Example -



(1,2- Dibromoethane)

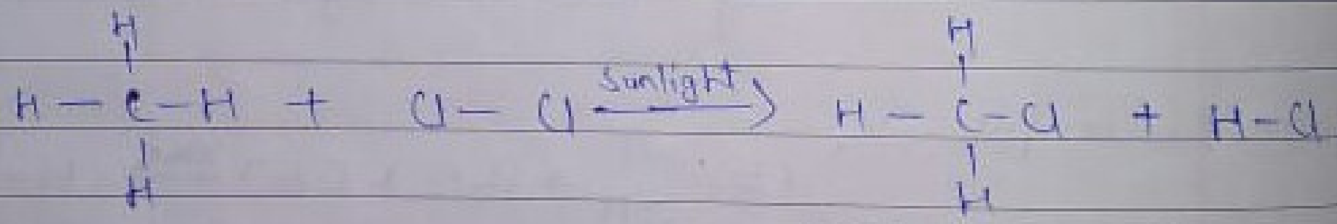
3) Substitution reaction.

⇒ The reactions which involve the direct replacement (substitution) of an atom or a group of atoms in an organic molecule by another atom or group of atoms without any change in the rest of the molecule, are called substitution reactions.

Example - $R-X + Y \longrightarrow R-Y + X$
where, 'R' is a branch of carbon.

* This reaction occurs only in saturated alkanes

Chlorination of methane (Example of substitution reaction) —



(Chloromethane)

If there is excess chlorine then it will again form $CH_2Cl_2 \rightarrow CH_3Cl_3 \rightarrow CCl_4$

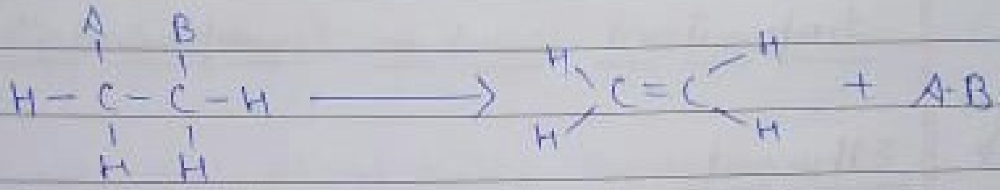
* CCl_4 (Carbon tetrachloride) is also known as pyrene and it is used as fire extinguisher

4) Elimination reaction.

⇒ The reaction in which a simple molecule like HCl, H_2O, NH_3, etc. is removed from a bigger molecule to form unsaturated compound is called elimination reaction.

- The product will always be unsaturated but the reactant could be either saturated or unsaturated.

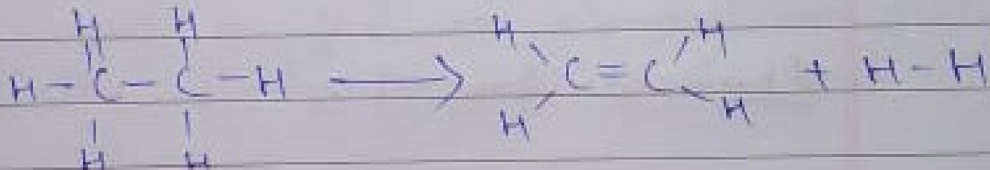
Example-



(Saturated) (Unsaturated) (Eliminated)

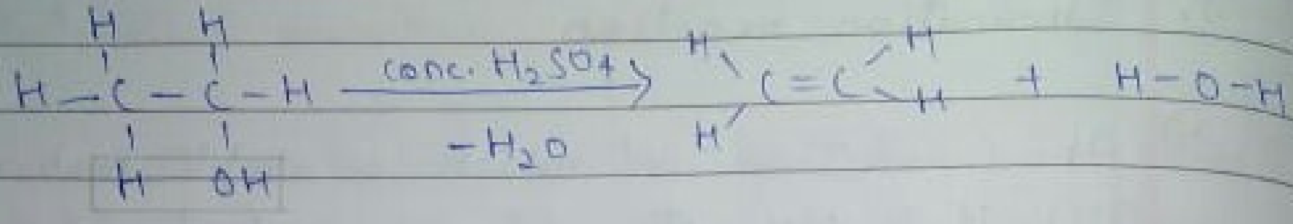
* Dehydrogenation ⇒ Removal of hydrogen.

Example-



* Dehydration of Alcohol ⇒ Removal of H_2O from alcohol.

Dehydrating agent ⇒ Conc. H_2SO_4.

⇒ 

Ethanol Ethene

* Catalysts ⇒ These are substances which change, usually increase the speed of a chemical reaction without being used up in that reaction.

Important carbon compounds:

1) Ethanol

⇒ It is a chemical compound and second member of homologous series of alcohol with chemical formulae - C_2H_5OH [CH_3-CH_2-OH].

Physical properties:

- It is liquid at room temperature.
- It is soluble in water in all proportions.
- It is highly inflammable.
- It is commonly called alcohol and it is active ingredient of all alcoholic drinks

Reaction of alcohol with metals-

1) $C_2H_5OH + Na \longrightarrow C_2H_5ONa + H_2\uparrow$

Sodium ethoxide

2) $C_2H_5OH + K \longrightarrow C_2H_5OK + H\uparrow$

Potassium ethoxide

Uses of Ethanol-

1) It is used in alcoholic beverages.

2) It is used as a solvent in industry for paints, tincture iodine, cough syrups, perfumes, etc

3) It is also used a fuel in internal combustion engines in the form of power alcohol.

4) It is used in form of rectified spirit as an antiseptic for wounds.

5) It is used in preparation of dyes, cosmetics, transparent soaps

Harmful effects of drinking alcohol-

- Consumption of small amount of dil alcohal causes drunkenness. Its consumption should be condemned because one started it leads to total disaster.

- Intake of even a small quantity of pure alcohol (absolute alcohol) can be lethal.

- To prevent misuse of ethanol produced for industrial use, it is made unfit for drinking by adding poisonous substances like methanol. Dyes are also added to colour alcohol blue, so it can be identified easily. This is called Denatured alcohol.

- Methanol also affects the optic nerve causing blindness.

- Methanol is oxidised to methanal in liver, then it reacts rapidly with components of cell.

2) Ethanoic acid

⇒ It is a chemical compound basically an acid and it is the second member of homologous series of carboxylic acid with chemical formulae - CH_3COOH $\left[CH_3-\overset{O}{\overset{\|}{C}}-O-H \right]$.

- It is commonly known as acetic acid.
- 5.8% solution of ethanoic acid and water is known as vinegar.

Physical properties

- Melting point - 290 K (17°C approx.)
- During winters, it often freezes in cold climate and it is called glacial acetic acid. It is the trivial name for anhydrous acetic acid.
- It is a weak acid, but stronger than alcohol. (R-OH).

Chemical reactions

1) Esterification reaction.

=) The chemical reactions in which carboxylic acid reacts with alcohol in presence of conc. H_2SO_4 to form ester and water, are called esterification reactions.

$$\text{Carboxylic acid} + \text{Alcohol} \xrightarrow[H_2SO_4]{conc.} \text{Ester} + \text{Water}$$

Example - $CH_3-\overset{O}{\overset{\|}{C}}-OH + HO-C_2H_5 \xrightarrow[H_2SO_4]{conc.} CH_3-\overset{O}{\overset{\|}{C}}-O-C_2H_5 + H_2O$

(Ethyl ethanoate, ester)

Saponification of ester

- This reaction is also known as hydrolysis.
- It is used to manufacture soap.

Example-

$$CH_3-\overset{O}{\overset{\|}{C}}-O-C_2H_5 + H_2O \longrightarrow C_2H_5OH + CH_3COOH$$

- Basically, it is the reverse of esterification.

Uses of acetic acid-

- It is used for making vinegar.
- It is widely used as preservative in sausages, pickles, etc.
- It is used for synthesis of other compounds such as ester, etc.

* Ester- Esters are sweet-smelling substances. It is used for making perfumes and flavouring agents.

* To manufacture soap, we use NaOH/KOH in place of H_2O in the hydrolysis.

Reaction - $CH_3COOC_2H_5 + NaOH \longrightarrow CH_3COONa + C_2H_5OH$
(Ester) Sodium acetate

* Hydrocarbons are non-polar (no charge) while water is polar (have charges).

Soap and Detergent

⇒ Soaps ⇒ Soaps are sodium and potassium salts of long chain carboxylic acids and have general formula - $RCOO^-Na^+$, where R is a long chain of carbon such as $C_{15}H_{31}$, $C_{17}H_{35}$, etc.

$$\boxed{R-\overset{O}{\overset{\|}{C}}-O^-Na^+ \Rightarrow \text{Soap}}$$

⇒ Detergents ⇒ Detergents are usually ammonium or sulphonate salts of long chain carboxylic acids. They are also called as soapless soap.

$$\boxed{R-SO_3^-Na^+ \Rightarrow \text{Detergent}}$$

Manufacture of soaps

=> Soap are made from animal fats or vegetable oils by heating it with sodium hydroxide, this process is called saponification.

$$\underset{\text{(Ester)}}{\text{Fat or oil}} + \underset{(NaOH/KOH)}{\text{Alkali}} \xrightarrow{\text{Heat}} \underset{\text{(Sodium salt of fatty acid)}}{\text{Soap}} + \underset{\text{(Alcohol)}}{\text{Glycerol}}$$

Reaction-

$$\begin{array}{l} CH_2-OCOC_{17}H_{35} \\ | \\ CH\ -OCOC_{17}H_{35} \\ | \\ CH_2-OCOC_{17}H_{35} \end{array} + 3NaOH(aq.) \longrightarrow \begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array} + 3C_{17}H_{35}COONa$$

(Triester or triglyceride)
(oil or fat)

(Glycerol)

(Soap)

* Hard water => Water that does not produces lather (foam) with soap readily is called hard water.

Examples: Sea water, river water, tube-well water, etc.

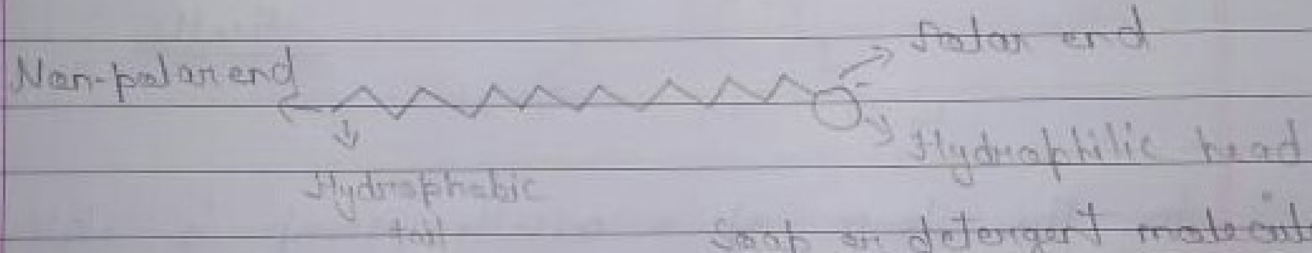
It contains ions such as Ca^{2+} and Mg^{2+} due to which it is hard water.

* Soft water => Water that produces lather (foam) with soap readily is called soft water.

Examples: Rain water, distilled water, demineralized water, etc.

Structure of a soap molecule-

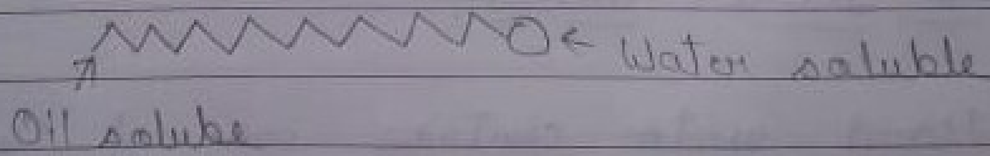
- A soap molecule is made up of two parts- a long hydrocarbon part (non-polar or non-ionic part) and a short ionic (polar) part containing $-COO^{-}Na^{+}$ group.



Soap or detergent molecule

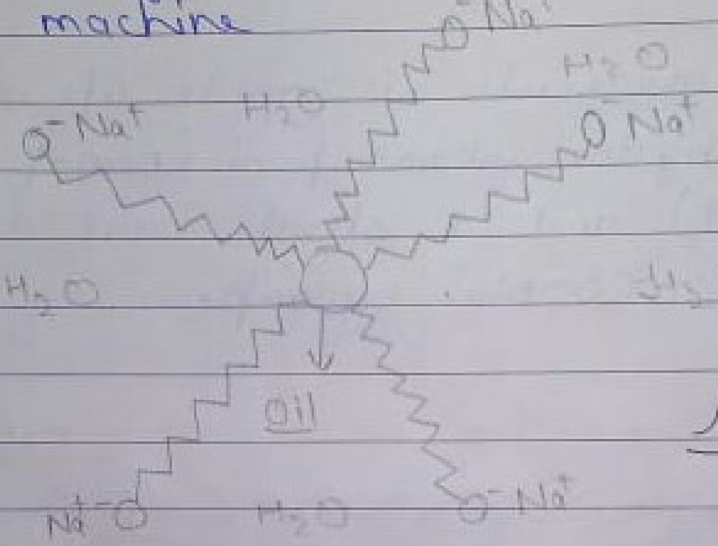
- The long hydrocarbon part is hydrophobic and therefore insoluble in water but soluble in oil.

- The ionic portion of soap molecule is hydrophilic, so soluble in water but insoluble in oil.



Cleansing action of soap:-

- The formation of cluster of molecule is called micelle. To wash away the loosened dirt particles in the form of miscelles from the surface of clothes, it is either scrubbed mechanically or beaten or agitated in washing machine



Micelle

- In the form of a micelle, soap is able to clean, since the oily dirt is being collected in the centre of micelle.

- Micelles stay as colloids in the solution and does not come together to precipitate due to ion-ion repulsions. Hence, the dirt suspended in the micelles is also rinsed away.

Why detergents are more effective than soap in hard water?

- Hard water contains ions of Ca^{2+} and Mg^{2+} in form of carbonates, chlorides, etc.

- When soap is immersed in hard water it reacts with the salts of Ca and Mg due to which it precipitates at the bottom and does not work as cleansing agent.

Example - $R{-}COONa + CaCl_2 \longrightarrow (R{-}COO)_2Ca + NaCl$

↳ It precipitates at bottom.

- But the detergents do not react with the salts and do not precipitates. Hence, it is effective than soaps in hard water.