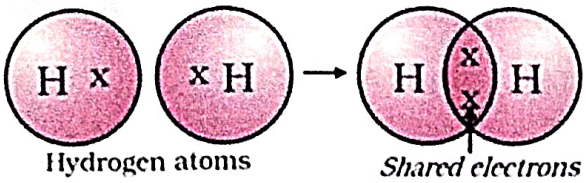
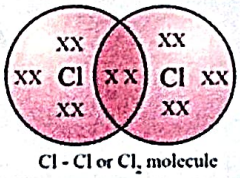


or H – H
Single bond

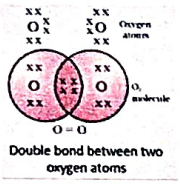
A molecule of Hydrogen

Electron dot structure of Chlorine

- Atomic number = 17.
- Electronic configuration= 2, 8, 7 (7 electrons in valence shell). It forms a diatomic molecule (Cl_2).



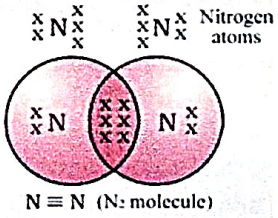
DOUBLE COVALENT BOND: The covalent bond formed by the sharing of two electrons from each atom is known as a double covalent bond



TRIPLE COVALENT BOND: The covalent bond formed by the sharing of three electrons from each atom is known as triple covalent bond

Electron dot structure of Nitrogen

- Atomic number = 7.
- Electronic configuration= 2, 5.
- It forms a diatomic molecule (N_2).
- To attain an octet, each nitrogen atom in a nitrogen molecule contributes 3 electrons forming **triple bond**



PROPERTIES OF COVALENT COMPOUNDS:

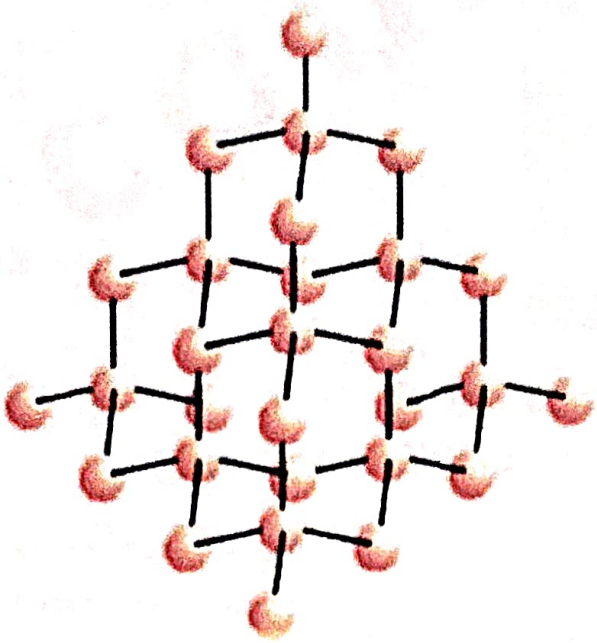
1. **PHYSICAL STATE:** They exist in solid (Glucose, Sugar, etc), liquids (water, alcohol etc) & gaseous state (Methane, CO2, CO etc..)
2. **MELTING AND BOILING POINTS:** As the forces of attraction between the covalently bonded molecules are weak, their melting and boiling points are lower
3. **SOLUBILITY:** They are soluble in non-polar solvents like CCl4. CS2, Benzene etc.,
4. **ELECTRICAL CONDUCTIVITY:** They do not conduct electricity in any state (s/l/g/aq) due to the absence of free ions or free electrons.

ALLOTROPY: The phenomenon of the existence of carbon (elements) in the same state (s/l/g) having the same chemical properties but different physical structures (arrangement) and properties is known as ALLOTROPY. Such structures are known as ALLOTROPES

ALLOTROPIC FORMS OF CARBON:

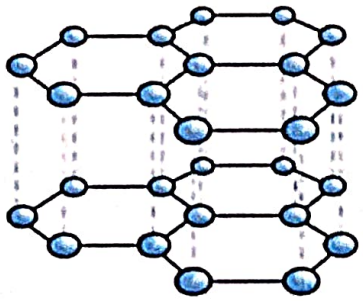
1. **DIAMOND:**
   a. In diamond, each carbon atom is bonded to four other carbon atoms to form a three-dimensional, rigid structure (the hardest naturally occurring substance)
   b. Due to the absence of free electrons, it is a poor conductor of electricity but due to its four bonds, it is a moderate conductor of heat

c. High density (3.5g/cc)



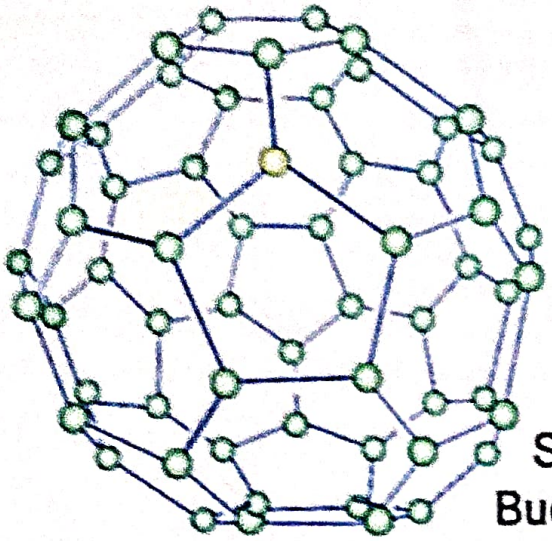
Structure of diamond

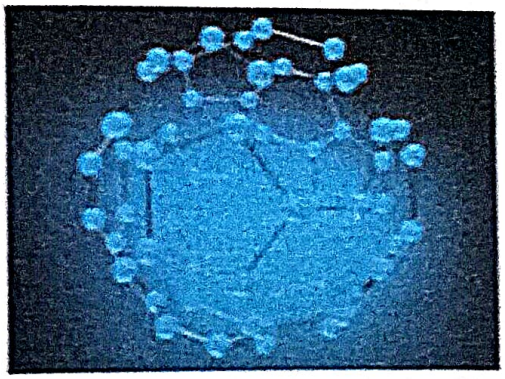
2. **GRAPHITE:**
   a. In graphite, each carbon atom is bonded to only three other carbon atoms, resulting in the formation of a two-dimensional planar structure.
   b. It forms a **layered structure**, where the forces of attraction between the layers are very weak; hence, graphite is slippery (used as a lubricant in machinery parts, used in pencils)
   c. Used in electrodes as it is a good conductor of electricity due to one free electron for each Carbon atom, these free electrons easily move between the layers and conducts electricity.



Structure of graphite

3. **FULLERENES:** Fixed number of carbon atoms in the form of 3-dimensional cage-like structures. (Nano applications – bulletproof materials, nano fibres, superconductivity etc.,)

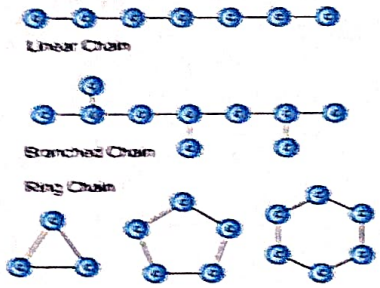




Structure of C-60
Buckminsterfullerene

VERSATILE NATURE OF CARBON: (3M)

1. **TETRAVALENCY:** Carbon is the only non-metal having four valence electrons, which results in the formation of a variety of bonds (single/double/triple) with atoms of the same or different elements (S/O/H/N/Cl etc)
2. **CATENATION: "Self-linking ability of Carbon is known as Catenation."** Due to this, Carbon can form long chains, branched chains as well as closed chain structures



3. **SMALL ATOMIC SIZE:** Due to the small atomic size, the bond formed will be strong and stable, which results in the formation of a large number of compounds.

HYDROCARBONS: Compounds of Carbon and Hydrogen are known as Hydrocarbons.

PROPERTY	SATURATED HYDROCARBONS	UNSATURATED HYDROCARBONS
DEFINITION:	Hydrocarbons consisting of a single covalent bond between carbon atoms (-C-C-)	Hydrocarbons consisting of either a double or triple covalent bond (one or more) between carbon atoms (-C=C-, -C≡C-) are known as unsaturated hydrocarbons
SATURATION TEST:	a) Saturated hydrocarbons do not decolourise - bromine water (brown), - alkaline potassium permanganate (pink) b) They burn with a clean blue flame	a) Unsaturated hydrocarbons decolourise - bromine water, - alkaline potassium permanganate b) They burn with sooty yellow flame
EXAMPLES	ALKANES	ALKENES, ALKYNES

HOMOLOGOUS SERIES: Series of **hydrocarbons (carbon compounds)** in which **any two successive members of the series** differ in "-CH2-", 14u molecular mass, with the same general formula, functional group, similar chemical properties and gradual change in physical properties

Eg: Alkanes, Alkenes, Alkynes, Aldehydes, Alcohols, Ketones, Carboxylic acid etc.,

DIFFERENCE	SAME/ SIMILAR	GRADUAL CHANGE
1. -CH2- 2. **14u** molecular mass	1. General formula 2. **Functional group** 3. **Chemical properties**	Physical properties

HOMOLOGOUS SERIES: ALKANE – C_nH_{2n+2} (where n = number of C atoms)

Number of C atoms (n)	Formula	Name
1	CH_4	METHANE
	-CH2- (14u)	
2	C_2H_6	EHANE
	-CH2- (14u)	
3	C_3H_8	PROPANE

FUNCTIONAL GROUP: A Functional group is an atom or group of atoms bonded together in a unique way, which is usually the site of chemical reactivity

FUNCTIONAL GROUP	ATOM/ GROUP	NAME
Halo or Halogen group	**-X (F/Cl/Br/I)**	**Prefix** (Haloalkane) Ex: Chloromethane
Alcohol group	**-OH**	**(Prefix – Hydroxy; Sufix – Ol)** **Ex: Ethanol, Methanol, Butanol**
Aldehyde	**-CHO**	**(Suffix – al)** **Ex: Methanal, Ethanal**
Ketone	**-CO-**	**Minimum 3 C atoms** **(Suffix – One)** **Propanone, Butanone, Pentanone etc.,**
Carboxyl group or Carboxylic acid group	**-COOH**	**(Suffix – oic acid)** **Methanoic acid, Ethanoic acid, Propanoic acid etc.,**

ALKANE +OL = ALKANOL (METHANE +OL = METHANOL, PROPANE +OL = PROPANOL)

NOMENCLATURE: Naming of carbon compounds using **IUPAC (INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY)** rules is known as Nomenclature.

IUPAC NAME = PREFIX **ROOT NAME** SUFFIX

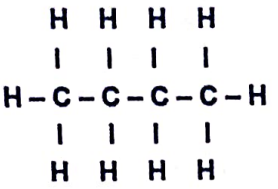
ROOT NAME (TABLE NO: 4.3; pg 66)

NUMBER OF CARBON ATOMS (n)	STRUCTURE ($C_nH_{(2n+2)}$)	ROOT NAME OR PARENT CHAIN NAME
1	CH_4	METHANE
2	C_2H_6	ETHANE
3	C_3H_8	PROPANE
4	C_4H_{10}	BUTANE

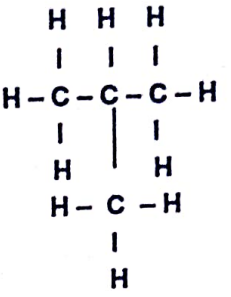
5	C_5H_{12}	PENTANE
6	C_6H_{14}	HEXANE
7	C_7H_{16}	HEPTANE
8	C_8H_{18}	OCTANE
9	C_9H_{20}	NONANE
10	$C_{10}H_{22}$	DECANE

ISOMERISM: The phenomenon of the existence of carbon compounds having the **same molecular formula but different structural formulae** is known as Isomerism, and such structures are known as Isomers.

Isomers of Butane: n-butane, Iso butane



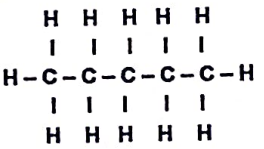
Normal butane



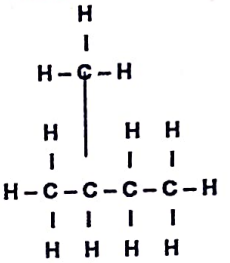
Iso butane

Pentane – C_5H_{12} has 3 Isomers. They are Normal pentane, Iso pentane and Neo pentane.

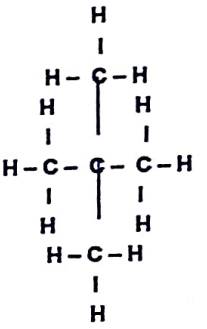
Normal pentane



Iso pentane



Neo pentane



n-pentane, Iso pentane, neo-pentane

CHEMICAL PROPERTIES OF CARBON COMPOUNDS:

1) COMBUSTION: The chemical reaction in which Carbon & its compounds burn in the presence of oxygen to form CO2, water vapour and energy in the form of heat & light is known as combustion

CHEMICAL PROPERTIES OF CARBON COMPOUNDS

Combustion

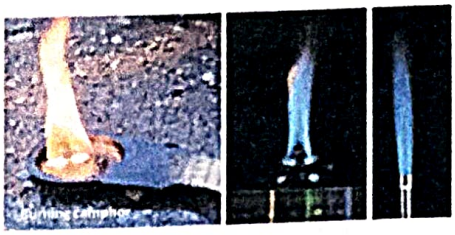
- Carbon (all allotropic forms) & most carbon compounds burn in oxygen to give CO_2 releasing heat and light. These are **oxidation reactions.**

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

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

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

- **Saturated hydrocarbons** generally give a **clean flame.**
- **Unsaturated carbon compounds** give a yellow flame with black smoke or sooty deposit (carbon). E.g. **Camphor** & **Naphthalene** (unsaturated hydrocarbons) burn with **yellow flame** and leave residues.
- **Alcohol** is **saturated** and burns with clean **blue flame.**



OXIDATION: Addition of oxygen (Removal of Hydrogen or electrons)

Oxidation

- Carbon compounds are easily oxidised on combustion.
- **Alcohols** can be oxidised to **carboxylic acids.** Here, oxidising agents like alkaline **potassium permanganate ($KMnO_4$)** or acidified **potassium dichromate ($K_2Cr_2O_7$)** are used.

  (***Oxidising agents:*** *The substances that can add oxygen to others*).
- E.g. Take 3 mL **ethanol** in a test tube and warm gently in a water bath. Add a 5% solution of alkaline **$KMnO_4$** drop by drop. **Purple** colour of $KMnO_4$ **disappears** initially.
- When more $KMnO_4$ is added, the colour persists because all the alcohol gets consumed and the reaction stops.

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

Ethanol (oxidising agent) Ethanoic acid

Q) **"All combustion reactions are oxidation, whereas not all oxidation reactions are combustion."** Comment on the statement. (Justify)

Ans) All combustion reactions are oxidation as there is an addition of oxygen, whereas not all oxidation reactions are combustion as energy may or may not be liberated.

ADDITION REACTION: "The reaction in which simple molecules (H2/Cl2/water) are added across the unsaturation **(double or triple bond)** of unsaturated hydrocarbons is known as Addition reaction.

Catalyst: A chemical substance that alters the rate of the reaction without taking part in the reaction is known as a catalyst.

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

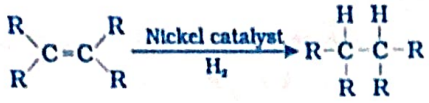
Ethene Ethane

HYDROGENATION: Addition of Hydrogen (across double or triple bond) of unsaturated hydrocarbon.

APPLICATION: Vegetable oil + H_2 $\xrightarrow{Ni/Pd}$ Vegetable fat (dalda/vanaspathi)

Addition Reaction

- **Unsaturated hydrocarbons** add hydrogen in the presence of **catalysts** such as **palladium** or **nickel** to give **saturated hydrocarbons.** (***Catalysts:*** *The substances that influences the rate of a reaction without changing itself*).
- This reaction is commonly used in the **hydrogenation** of vegetable oils using a **nickel catalyst.**



- **Vegetable oils** generally have long **unsaturated carbon chains (fatty acids).** So they are healthy.
- **Animal fats** generally contain **saturated fatty acids** which are harmful to health.

SUBSTITUTION REACTION: The chemical reaction in which H atom/s of **saturated hydrocarbons** are substituted with hetero atom/s is known as a substitution reaction.

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

$$CH_3Cl + Cl_2 \xrightarrow{\text{Sunlight}} CH_2Cl_2 + HCl$$
Dichloromethane

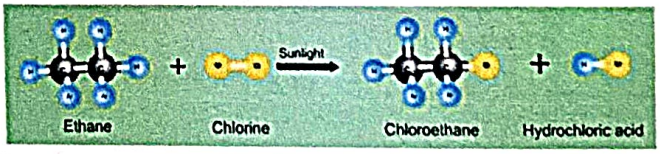
$$CH_2Cl_2 + Cl_2 \xrightarrow{\text{Sunlight}} CHCl_3 + HCl$$
Trichloromethane

$$CHCl_3 + Cl_2 \xrightarrow{\text{Sunlight}} CCl_4 + HCl$$
Tetrachloromethane

Substitution Reaction

- **Saturated hydrocarbons** are **unreactive** and **inert** in the presence of most reagents.
- However, in presence of sunlight, hydrocarbons undergo **substitution reaction** very fast. E.g.

$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ (in the presence of sunlight)



- Here, **chlorine** replaces the **hydrogen** atoms one by one.
- Higher homologues of alkanes can form many products.

SOME IMPORTANT CARBON COMPOUNDS:

ETHANOL: C_2H_5OH (CH_3CH_2OH)

PROPERTIES OF ETHANOL:

Physical:

a) Ethanol is a colourless liquid with an alcoholic smell
b) It is a good solvent
c) It is soluble in water in all proportions
d) Melting point = -156K; Boiling point = 351K

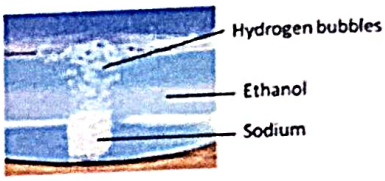
Uses:

A) Used as **ANTIFREEZE**
B) As **fuel**
C) As a **good solvent** in industries/ medicines
D) Medicines (Tincture Iodine - antiseptic)

SOME IMPORTANT CARBON COMPOUNDS: ETHANOL & ETHANOIC ACID

Properties of Ethanol: Reactions of Ethanol

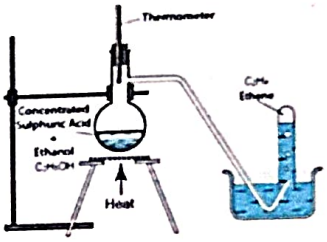
a. Reaction with sodium



- Alcohols react with sodium evolving **hydrogen.**
- E.g. Drop a small piece of sodium into pure ethanol. It produces **sodium ethoxide** ($2CH_3CH_2O{-}Na^+$) and H_2.

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

b. Reaction to give unsaturated hydrocarbon



- Heating ethanol at 443 K with excess **conc.** H_2SO_4 results in **dehydration of ethanol** to give **ethene.** Conc. H_2SO_4 is a **dehydrating agent** (removes water from ethanol).

$$CH_3 - CH_2OH \xrightarrow{Hot\ Conc\ H2SO4} CH_2 = CH_2 + H_2O$$

Properties of Ethanoic acid (Acetic acid)

- It belongs to **carboxylic acids (weak acids).**
- 5-8% solution of acetic acid in water is called **vinegar.** It is used as a **preservative** in pickles.

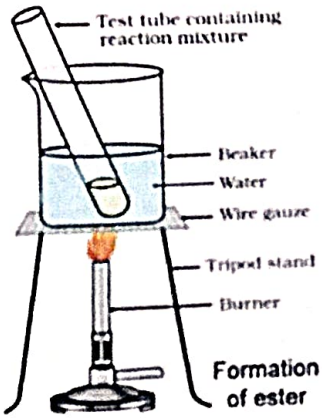
- The melting point of pure ethanoic acid is **290 K** and hence it often freezes during winter. So it is known as **glacial acetic acid.**
- Acetic acid is weak acid and HCl is strong acid.

Properties of Ethanoic acid (Acetic acid): Reactions of ethanoic acid

a. Esterification reaction

It is the formation of **esters** by reaction of an **acid** & an **alcohol**. E.g.

- Take 1 mL **absolute ethanol** + 1 mL **glacial acetic acid (ethanoic acid)** + few drops of **conc.** H_2SO_4 (acid catalyst) in a test tube.
- Warm in a water-bath for 5 minutes.
- Pour into a beaker containing 20-50 mL of **water.** The resulting mixture is an **ester.**



$$CH_3-COOH + CH_3-CH_2OH \underset{}{\overset{Acid}{\rightleftharpoons}} CH_3-C-\underset{\underset{O}{\|}}{C}-CH_2-CH_3 + H_2O$$

(Ethanoic acid) (Ethanol) (Ester)

- Esters have **sweet smell.**
- **Uses of esters:** To make **perfumes** & as **flavouring agents.**
- On treating with **NaOH** (an alkali), the **ester** is converted back to **alcohol** and **sodium salt of carboxylic acid.** This is called **saponification** because it is used to prepare **soap.**

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

b. Reaction with a base

Ethanoic acid reacts with a base like **NaOH** to give a **salt (sodium ethanoate or sodium acetate)** and **water.**

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

c. Reaction with carbonates & hydrogen carbonates

- Take a spatula full of **sodium carbonate** in a test tube and add 2 mL **dilute ethanoic acid.** Following reaction occurs:

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

(Sodium acetate)

Pass the gas produced through lime-water. It turns milky. i.e., the gas is CO_2.

- **Reaction with sodium hydrogen carbonate:**

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