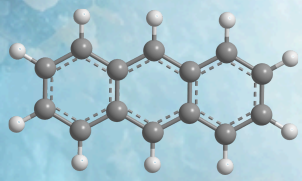
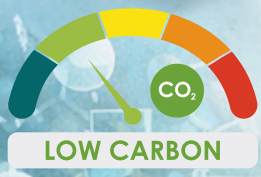
PARMAR SSC

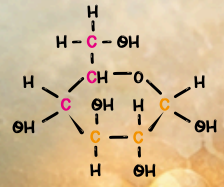
CARBON AND ITS COMPOUND

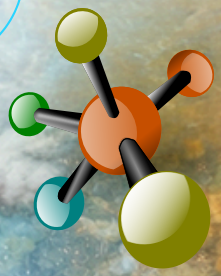
Lecture - 8









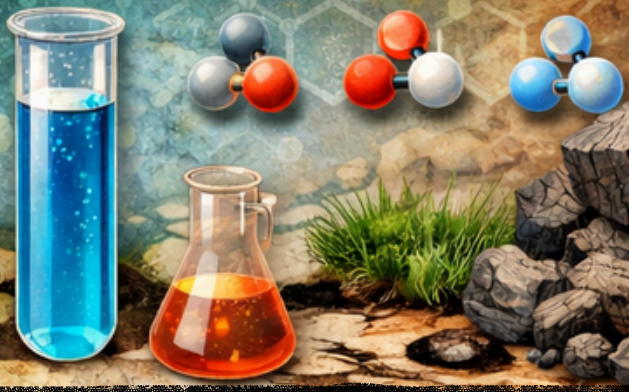








$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$



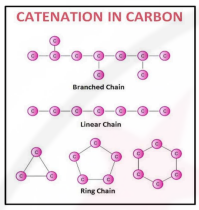
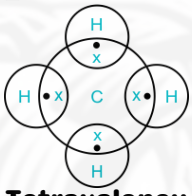


BY PARMAR SIR

Carbon Content

- In Earth's Crust- 0.025%
- In atmosphere - 0.03%

Basic Features of Carbon

Catenation	Tetravalency
Unique ability to form long chains of C-C bond	Capability to form 4 bonds with other atom of carbon or other monovalent
No other element exhibit catenation property as much as Carbon	Carbon forms a strong and stable bond due to its small size
	 Tetravalency

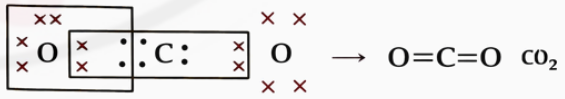
Carbon's Ability to Catenate

- The electronic configuration of carbon plays a key role in its ability to exhibit catenation.
- Carbon has a total of 6 electrons, with 2 in inner shell and 4 in the outer shell.
- Its small atomic size allows it to form stronger C-C bonds compared to other elements, making carbon the most effective element in catenation.

- Carbon is the first element of Group 14 in the periodic table.
- **The other members of this family are:** Carbon (C), Silicon (Si), Germanium (Ge), Tin (Sn), Lead (Pb), and Flerovium (Fl).

Bonding of Carbon with Oxygen

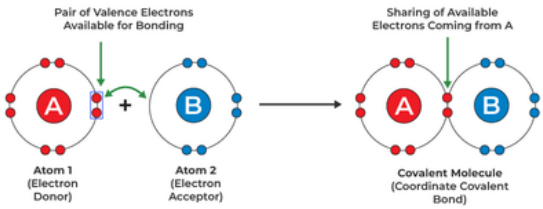
- Oxygen has 6 e- and requires 2 more electrons to complete its Octet. Carbon requires 4 more e- to complete its octet.
- Here, sharing of electrons takes place.



Covalent Bond

- A covalent bond is a chemical bond that involves the sharing of electron pairs between atoms.
- Covalent compounds exhibit weak boiling and melting point because the intermolecular forces between their molecules are weak.
- Covalent bonds are usually formed between non-metals.

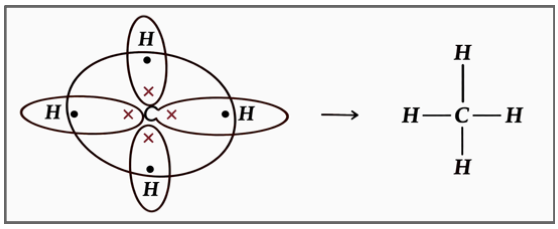
Coordinate Covalent Bond



An electrovalent (ionic) bond is formed between a metal and a non-metal.

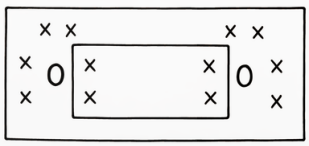
Bonding of Carbon with Hydrogen

- Carbon and hydrogen form a covalent bond (specifically, a nonpolar covalent bond) by sharing electrons, where carbon shares its outer valence electrons with up to four hydrogens to complete their outer shells and this allows both carbon and hydrogen to achieve stable electronic configurations.



Oxygen

- Oxygen cannot form long chains of bonding like carbon because of its small size and high electronegativity, and because it lacks d-orbitals.



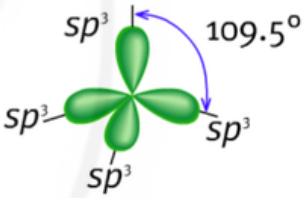
O_2

Allotropes of Carbon

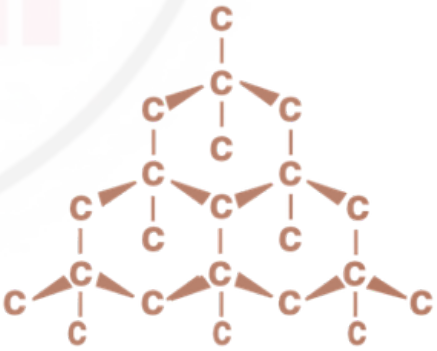
Allotropy

- Allotropy is the property of some chemical elements to exist in two or more different forms, in the same physical state, known as allotropes of the elements.
- Allotropes have similar chemical properties but different physical properties.
- Allotropes of carbon are:- Diamond, Graphite, Fullerene, Graphene

1. Diamond



- It has a 3D-Tetrahedral structure with sp^3 hybridisation.
- Diamond is a bad conductor of electricity.
- In the structure of diamond, each carbon atom is bonded to 4 other carbon atoms.
- It can be synthesized by subjecting pure carbon to very high temperature and pressure.
- Diamond is the hardest naturally occurring substance.
- Diamond and crystalline silicon is isomorphous.
- It has the highest refractive index (2.42)



Uses of Diamond

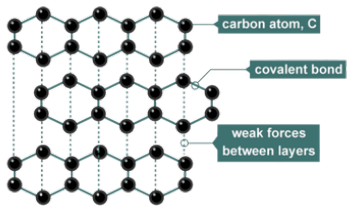
- It is used for cutting glasses.
- It is used for sharpening hard tools.
- It is used for manufacturing Tungsten (W) filament.

Diamond is covalent, yet it has high melting point because it has 3D network involving strong C-C Bonds that are difficult to break.

2. Graphite

- It has a 2-D layered structure (held by Van der Wall forces) and sp^2 hybridisation.
- It features carbon arranged in hexagonal plane array.

- Each carbon is bonded to three other carbon atoms, forming a hexagonal lattice. The fourth electron remains delocalized, contributing to electron conductivity.
- Graphite is a good conductor of heat and electricity.
- It is the most stable form of carbon.



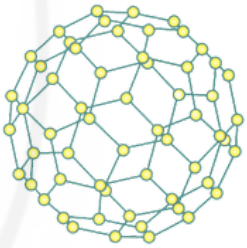
Uses of Graphite

- Graphite is used in making electrodes.
- Graphite is used in pencil lead.
- Graphite is used as a dry lubricant.
- Graphite is used as a moderator for fast moving neutron in atomic reactors.

Graphite is soft and slippery because it has a layered structure weakly bonded together because of which they could slide over each other and that is why mostly used in lubricants.

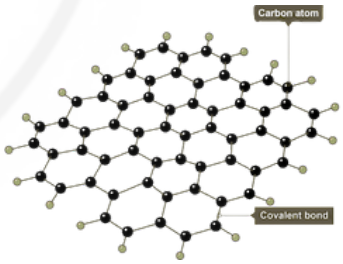
3. Fullerenes

- It is also known as Buckminsterfullerene (C60).
- It is known for its hollow, cage-like structures arranged in patterns of 20 hexagonal rings and 12 pentagonal rings.
- A hexagonal ring can be fused with hexagonal or pentagonal ring, but a pentagonal ring can only be fused with hexagonal ring.
- It has sp^2 hybridisation.
- It contains both single and double bond with other 3 carbon atoms.
- Fullerenes is the purest form of carbon



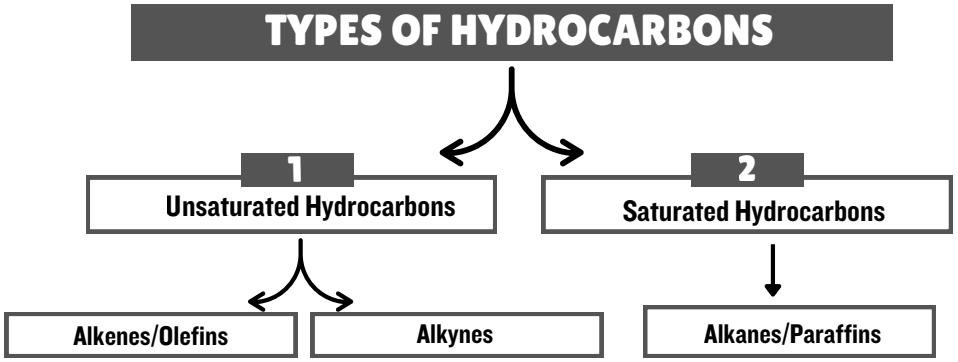
4. Graphene

- Graphene is a single-atom-thick layer of carbon atoms arranged in a hexagonal lattice, making it the thinnest material known. It exhibits exceptional electrical and thermal conductivity, making it an outstanding material for various technological applications.

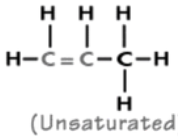


Hydrocarbons

- Compounds that are made up of only carbon and hydrogen are called hydrocarbons.



Unsaturated Hydrocarbons

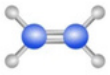

(Unsaturated)

- More than 1 bond between carbon atoms
- Burns with yellow sooty flame

1. Alkenes/Olefins

- They contain a double bond
- E.g. Ethene (Double bonds)
- **Other examples:** Benzene, anthracene, camphor

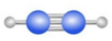
ALKENE C_nH_{2n}

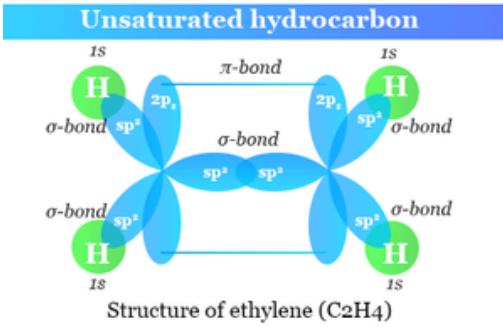

ALKENE

2. Alkynes

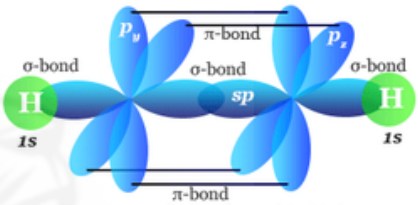
- They contain a triple bond.
- E.g. Ethylene (Triple bonds)

ALKYNE C_nH_{2n-2}


ALKYNE

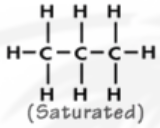


Structure of ethylene (C_2H_4)



Structure of acetylene (C_2H_2)

Saturated Hydrocarbons


(Saturated)

- Single bond between carbon atoms
- Gives clean blue flame however in limited supply of air gives sooty flame

1. Alkanes/Paraffins

- They contain a single bond.
- E.g. Ethane (Single bond)
- **Other examples:** Hexane, butane

ALKANE C_nH_{2n2}


ALKANE

- Ethene play an important role in fruit ripening.
- LPG gas contains butane and propane.
- Ethyl mercaptan is added to LPG so that its smell can be detected easily.
- Acetylene is used for welding of metals.

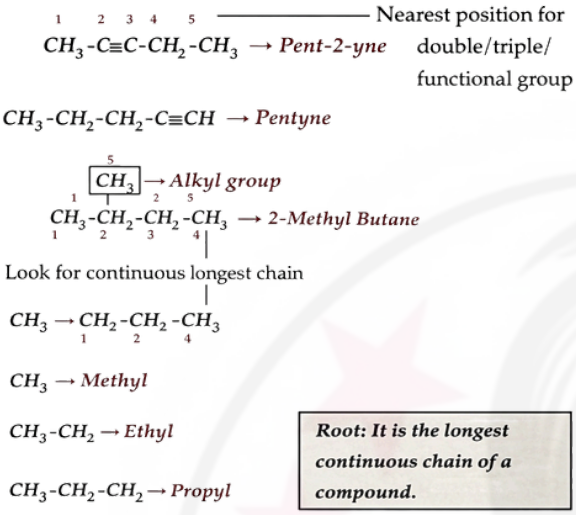
Naming of Hydrocarbons

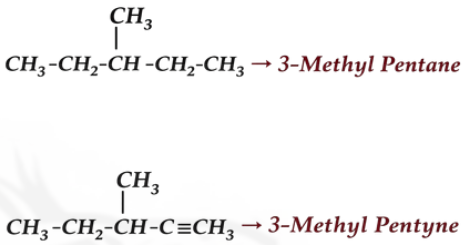
Number of carbon atoms	Stem	Suffix	Parent alkane	Formula
1	meth-	-ane	methane	CH_4
2	eth-	-ane	ethane	C_2H_6
3	prop-	-ane	propane	C_3H_8
4	but-	-ane	butane	C_4H_{10}
5	pent	-ane	pentane	C_5H_{12}
6	hex-	-ane	hexane	C_6H_{14}
7	hept-	-ane	heptane	C_7H_{16}
8	oct-	-ane	octane	C_8H_{18}
9	non-	-ane	nonane	C_9H_{20}
10	dec-	-ane	decane	$C_{10}H_{22}$

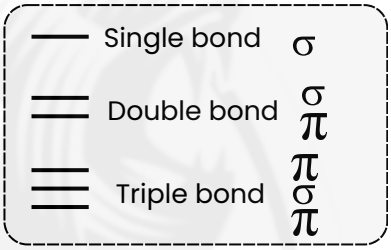
International Union of Pure and Applied Chemistry (IUPAC)

- It is a scientific organization that is responsible for naming hydrocarbons.
- It publishes several books often referred to as "IUPAC Color Books".

Blue Book: Nomenclature of organic compounds.
Red Book: Nomenclature of inorganic compounds.

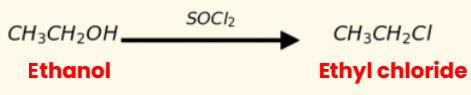






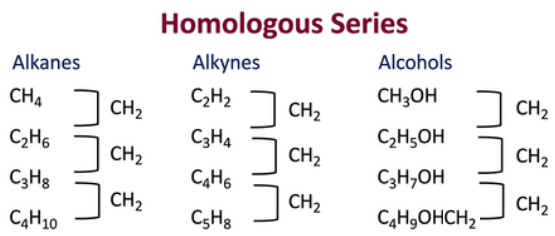
Functional Group	Structure	General Formula	Example	Suffix
Alcohol group	OH	R-OH	Ethanol, C_2H_5OH	-ol
Aldehyde	CHO	R-CHO	Acetaldehyde, CH_3CHO	-al
Ketone	CO	R-CO-R	Acetone, CH_3COCH_3	-one
Carboxylic acid	COOH	R-COOH	Acetic acid, CH_3COOH	-oic
Ester	R-COOR	R-COOR	Methyl acetate, CH_3COOCH_3	-oate
Ether	R-O-R	R-O-R	Dimethyl ether, CH_3OCH_3	---

For halogens (F, Cl, Br, I, At), prefixes are used when they act as functional groups.



Homologous Series

- It consist of one functional group, which decides the property of carbon compounds, regardless of length of carbon chain.
- Homologous series differs by -CH_2 unit and mass by 14 units.
- Chemical properties of homologous series remains same.
- As the molecular mass increases, the melting point and boiling point also increases.



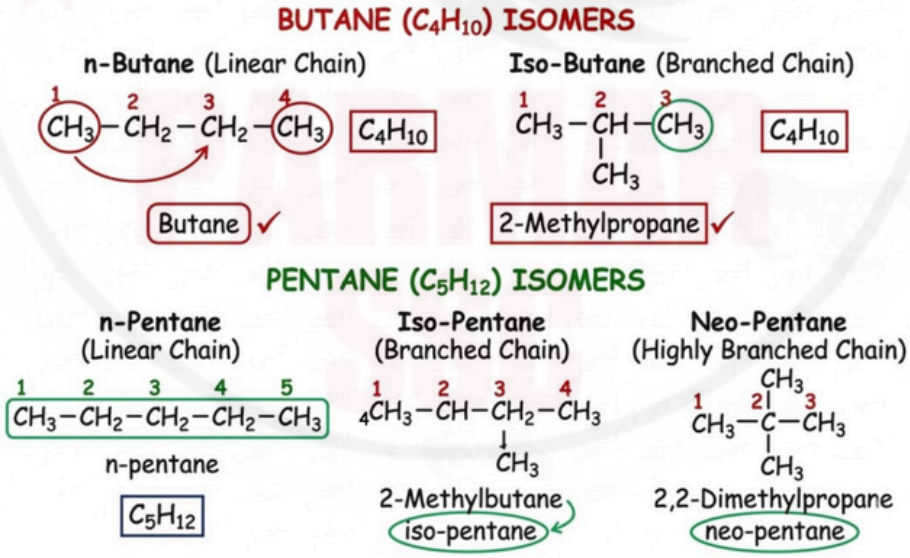
Isomers

- Isomers are chemical compounds that have identical chemical formulae but differ in properties and the arrangement of atoms in the molecule.

$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3 \rightarrow C_4H_{10} \rightarrow$ **Butane**

$CH_3\text{-}CH_2\text{-}CH(CH_3)\text{-}CH_3 \rightarrow C_6H_{14} \rightarrow$ **3-Methyl Pentane**

TRICK for Identifying No. of Isomers: $2^{(n-4)} + 1$



Isomers In

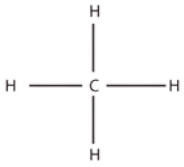
- Hexane: $2^{(6-4)} + 1 = 2^2 + 1 = 5$
- Heptane: $2^{(7-4)} + 1 = 2^3 + 1 = 9$
- Octane: $2^{(8-4)} + 1 = 2^4 + 1 = 16 + 1 = 18$
- Nonane: $2^{(9-4)} + 1 = 2^5 + 1 = 32 + 1 + 2 = 35$

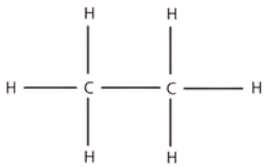
- **Single bond:** made of one σ bond
- **Double bond:** made of one σ and one π bond
- **Triple bond:** made of one σ and two π bond

Organic Compounds

Aliphatic/Acylic Compounds

- They are not aromatic (lacking ring structure).
- E.g. Alkane, Alkene, Alkyne (open chain compounds).


Methane


Ethane

Cyclic Compounds

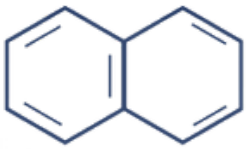
- They are compounds that form a ring structure.
- E.g. Benzene, Naphthalene.

Cyclical Formula

- Alkane: C_nH_{2n}
- Alkene: C_nH_{2n-2}
- Alkyne: C_nH_{2n-4}


Benzene

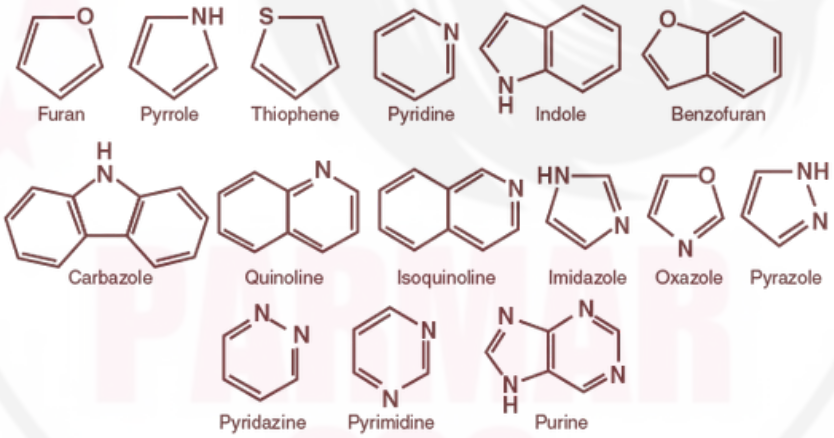
n = 1
(4 x 1 + 2) = 6π
Electrons


Naphthalene

n = 2
(4 x 2 + 2) = 10π
Electrons

Heterocyclic Compounds

- They are cycling compounds that have atoms of at least two different elements in their ring structure.



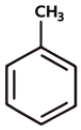
Examples of aromatic heterocyclic compounds

Aromatic Compounds

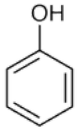
- They are group of compounds that have a cyclic conjugated structure and contain (4n+2) π electrons, making them particularly stable (Erich Huckel's Rule).


Benzene

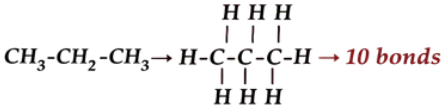
(Simplest aromatic compound)

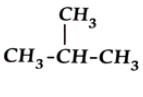

Toluene

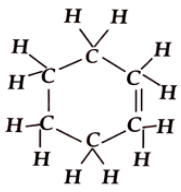
(Benzenoid aromatic compound)

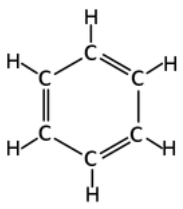

Phenol

Number of Covalent Compounds


→ 10 bonds


→ 13 bonds


→ 18 bonds


15 bonds

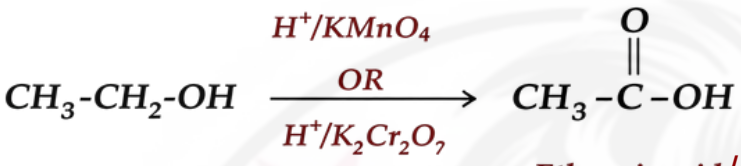
Chemical Properties of Carbon Compounds

1 Combustion

- Carbon in all its allotropic form burns in Oxygen to give Carbon Dioxide along with the release of Heat + Light.

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

2 Oxidation of Alcohol to Ethanoic Acid



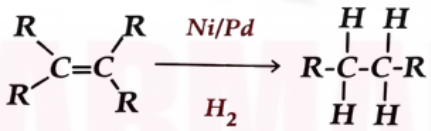
Ethanoic acid / Acetic acid

$KMnO_4$: Potassium permanganate
$K_2Cr_2O_7$: Potassium dichromate

**This reaction is carried out in presence of oxidising agent*

3 Addition Reaction

- Unsaturated hydrocarbons add hydrogen in presence of Catalyst (Ni, Pd) to give saturated hydrocarbons.

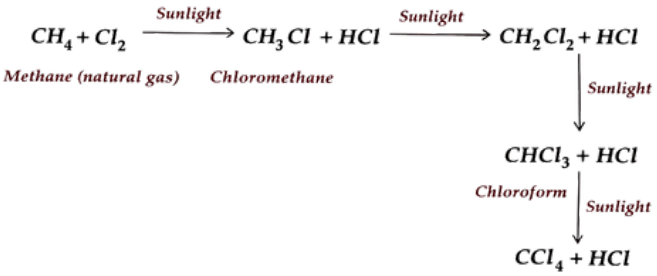


Vegetable Oil Vs Animal Fats

Vegetable Oil	Animal Fats
Long unsaturated carbon chains	Saturated fats
Preferred for cooking	Harmful for health

4 Substitution Reaction

- A hydrogen atom in a saturated hydrocarbon is replaced by a chlorine atom, forming a chlorinated derivative and hydrogen chloride, often in the presence of sunlight.



Boiling Point and Solubility of Hydrocarbons

- Alkynes generally have slightly higher boiling point than alkenes and alkanes (Alkyne > Alkene > Alkane) because of the stronger intermolecular forces arising from the triple bond.

$$\underset{\text{Ethane}}{CH_3{-}CH_3} < \underset{\text{Propane}}{CH_3{-}CH_2{-}CH_3} < \underset{\text{Butane}}{CH_3{-}CH_2{-}CH_2{-}CH_3}$$

- Alkenes have stronger intermolecular forces than alkanes due to the double bond, so their bo boiling point is higher than that of alkanes, but lower than alkynes.
- As the number of carbon in alkane increases, its boiling point increases significantly. Also, molecule with strong intermolecular forces will have high boiling points

Solubility of Hydrocarbons

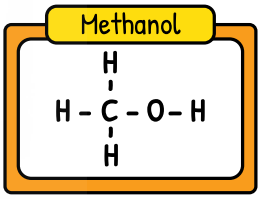
- Solubility decreases as the length of hydrocarbon chain increases.

$$\underset{\text{Ethane}}{C_2H_6} > \underset{\text{Propane}}{C_3H_8} > \underset{\text{Butane}}{C_4H_{10}}$$

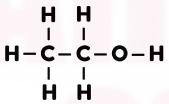
Important Carbon Compounds

Methanol

- Methanol also known as Methyl alcohol is also called "wood spirit" because it was obtained in the initial stage by the destructive distillation of wood.
- Intake of methanol in very small quantities can cause death. Methanol oxidises to methanal in liver and coagulates protoplasm.
- Methanol also affects optic nerves, causing blindness.



Ethanol



- It is a pleasant smelling carbon compound.
- It is an active ingredients in alcoholic drinks.
- Denatured spirit or alcohol is ethanol which is made unfit for drinking by adding poisonous substances like methanol to it, that imparts a bad taste, foul smell, or colour.
- A blue dye is also added to it, so that it is easily recognized.
- It is soluble in water in all proportion.

It is a good solvent and is used in medicines such as:

1. Tincture of iodine
2. Cough syrups

Reactions of Ethanol

Reaction with Sodium

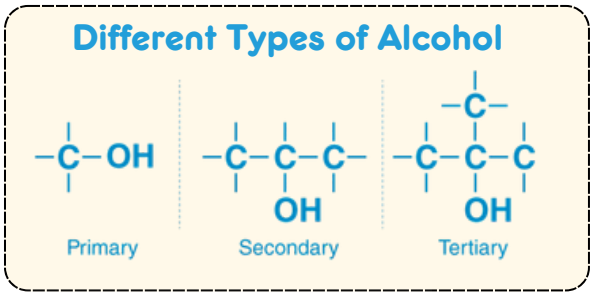
- Evolution of Hydrogen gas.

$$\underset{\text{Ethanol}}{C_2H_5OH} + Na \rightarrow C_2H_5ONa + H_2\,(g)$$

Dehydration of Ethanol

- On heating ethanol at 443K with excess Conc. Sulphuric acid (Dehydrating agent), it results in dehydration of ethanol to ethene.

$$\underset{\text{Ethanol}}{C_2H_5OH} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Ethene}}{CH_2=CH_2}$$



Ethanoic Acid (Acetic acid)

- A 5% solution of acetic acid in water is called vinegar and is used widely as a preservative in pickles.
- The melting point of pure ethanoic acid is 290K and hence it often freezes during winters and is called glacial acetic acid.

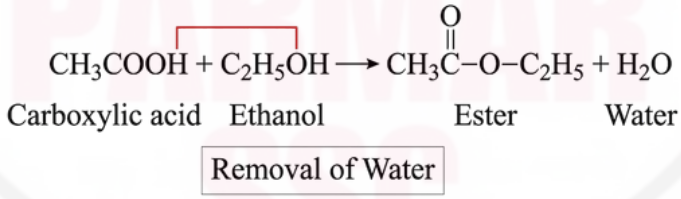
Reaction with Base

- When ethanoic acid reacts with a base, it undergoes a neutralization reaction, forming a salt (an ethanoate) and water.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Sodium hydroxide}}{NaOH} \rightarrow \underset{\text{Ethanoate}}{CH_3COONa} + H_2O$$

Esterification Reactions

- In an esterification reaction, a carboxylic acid reacts with an alcohol, typically in the presence of an acid catalyst, to form an ester and water.



Ester

1. It is formed by reaction of acid and alcohol.
2. It is a sweet smelling substance used in making perfumes and flavouring agents.

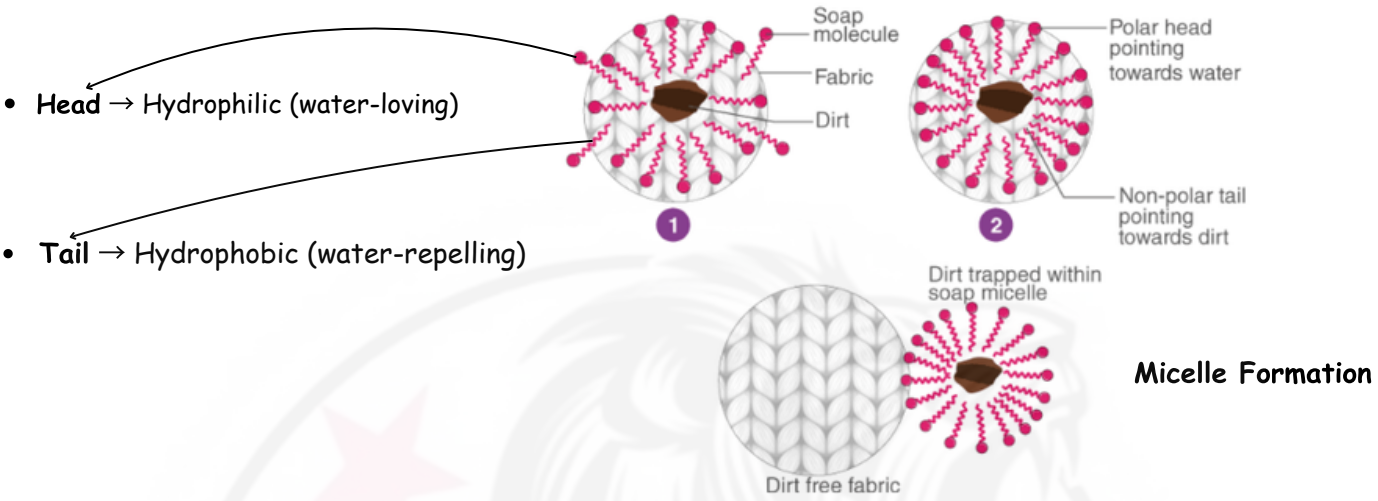
Soap and Detergents

Saponification Reaction

- This reaction is used in preparation of soaps. In this reaction, an ester is treated with a base (like sodium hydroxide) that breaks it down into an alcohol and a sodium salt of a carboxylic acid.
- The ester is converted back to alcohol and sodium salt of carboxylic acid

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

- Soaps are cleansing agents that are sodium or potassium salts of long-chain carboxylic acids (also known as fatty acids).
- Soap obtained remains in colloidal form and is precipitated from solution by adding NaCl.
- The solution left after removing the soap contains glycerol which is later recovered by fractional distillation.



Micelle Formation

Soap does not work in

1. Hard water

- Because in hard water it reacts to form Calcium & Magnesium salts (Bicarbonate, Chloride, Sulphate), which is an insoluble substance called Scum.

2. Acidic condition

- Because it forms insoluble long chain fatty acids.

Cleansing action of soap is due to formation of micelles. It forms an emulsion in water and does not come together to precipitate because of ion-ion repulsion. Soap micelle shows Tyndall Effect, thus soap solution appears cloudy.

Detergents

- Detergents are sodium salt of sulphonic acids or ammonium salts with Chloride, Bromide ions etc.
- Detergents work in both hard and soft water.
- They dissolve in water faster than soap.

- Sodium benzoate is used as preservative in many foods, medicine, and cosmetics.
- Friedrich Wohler in 1828 synthesised Urea (NH_2CONH_2) an Organic Compound from an Inorganic Compound named Ammonium Cyanate (NH_4CNO).



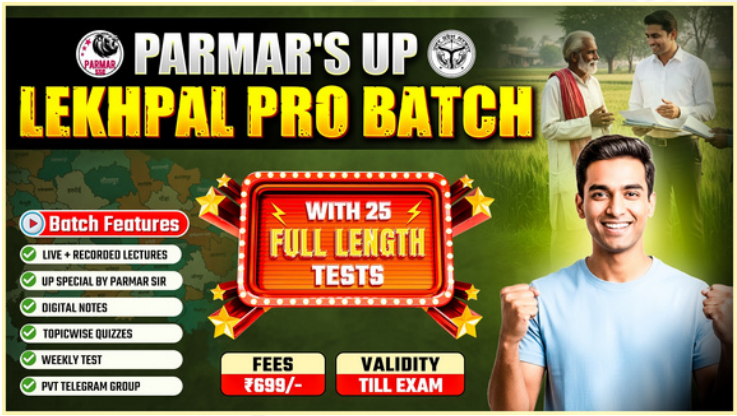


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