CARBON AND ITS COMPOUNDS

IMPORTANCE OF CARBON

Carbons forms Covalent compounds

COVALENT COMPOUNDS

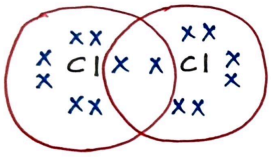
- A compound formed by sharing of electrons between two atoms.

formation of Cl_2

Cl(17) = 2,8,7 → valence shell

e⁻ dot structure

2,8,8



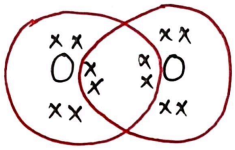
Cl ← Cl

single covalent Bond

formation of O_2

O(8) = 2,6

e⁻ dot structure



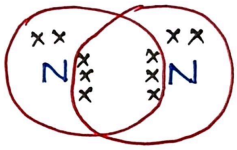
O = O

Double Covalent Bond

formation of N_2

N(7) = 2,5

e⁻ dot structure



N ≡ N

Triple Covalent bond

CBSE (2011, 2013, 2012, 2017, 2021, 2022, 2023, 2025)

- Covalent Compound is formed between Non-metal + Nonmetal.
  (C, S, N, O, H, Cl, F, Br)

e.g: H_2, O_2, N_2, Cl_2

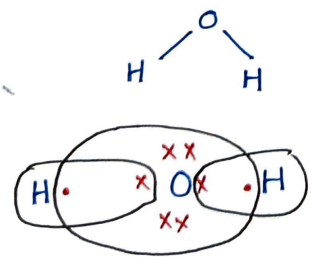
H_2O (water) NH_3 (Ammonia) CH_4 (Methane)

formation of H_2O (water)

O(8) ⟶ 2,6 +2

H(1) ⟶ 1 Duplet

e⁻ dot structure



H — O — H

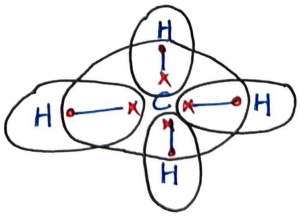
2 single covalent Bond

formation of CH_4 (Methane)

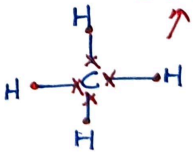
C(6) ⟶ 2,4 +4

H(1) ⟶ 1 Duplet

e⁻ dot structure



4 single Covalent Bond



Properties of covalent Compounds :-

1. Generally Poor Conductor of Electricity.
   - e^- are shared between atoms and no charged particles are formed. Hence there is Absence of ions.
2. Generally Low melting and Boiling points
   - because they have weak intermolecular forces

Intermolecular force ⇒ weak

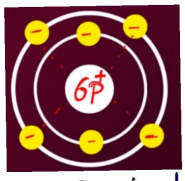
H—H - - - H—H - - - H—H

strong Covalent Bond

Note :-

✓ Covalent Bond is strong.
✓ Intermolecular forces are weak.

Why carbon forms Covalent Compounds ?



Atomic no. ⟶ 6

C(6) ⟶ 2, 4

To attain Noble gas configuration - 8e or 2e in last shell

carbon has to
- C^{4+} lose 4e⁻ → Requires lot of energy as 6 protons in nucleus will pull e⁻ strongly
- C^{4-} Gain 4e⁻ → difficult to hold 10e⁻ with 6 protons in nucleus.

so carbon shares 4e⁻ and forms covalent Bonds and covalent compounds

Nomenclature - IUPAC

C ⟶ 4 valency C(6) = 2, 4

—C— (Tetra(4)- valency)

carbon ke sath kuch laga hai to theek, varna H laga ke valency khatam karo. 'C' or 'H' bhai bhai

1C	Meth
2C	Eth
3C	Prop
4C	But
5C	Pent
6C	Hex
7C	Hept
8C	Oct
9C	Non
10C	Dec

carbon - carbon single bond — ane

Formula = C_nH_{2n+2}

Simple Structure	Alkane	Homologous Series
CH_4	Methane	CH_4 ①
CH_3-CH_3	Ethane	C_2H_6 ②
$CH_3-CH_2-CH_3$	Propane	C_3H_8 ③
$CH_3-CH_2-CH_2-CH_3$	Butane	C_4H_{10} ④
$CH_3-CH_2-CH_2-CH_2-CH_3$	Pentane	C_5H_{12} ⑤

C_6H_{14}

Carbon - Carbon Double Bond = ene

C= methene ✗

formula = C_nH_{2n}

Carbon-carbon triple Bond ≡ yne

C≡ Methyne ✗

formula = C_nH_{2n-2}

Simple Structure	Alkene ✓	Homologous Series
$CH_2=CH_2$	Ethene	C_2H_4 ①
$CH_3-CH=CH_2$	Propene	C_3H_6 ②
$CH_3-CH_2-CH=CH_2$	Butene	C_4H_8 ③
		C_5H_{10}

Simple Structure	Alkyne ✓	Homologous Series
$CH\equiv CH$	Ethyne	C_2H_2 ①
$CH_3-C\equiv CH$	Propyne	C_3H_4 ②
$CH_3-CH_2-C\equiv CH$	Butyne	C_4H_6 ③
		C_5H_8

functional groups :- atoms or groups of atoms which gives chemical properties to a compound.

Cl - chloro , Br - Bromo : 'Prefix' - **pehle** lagao

CH_3-Cl chloromethane

CH_3-CH_2-Cl chloroethane

$CH_3-CH_2-CH_2-Cl$ chloropropane

Homologous series :- same functional group increasing CH_2

① CH_3Cl → (+CH_2) ② C_2H_5Cl → (+CH_2) ③ C_3H_7Cl

OH → Alcohol 'ol' suffix (Baad me lagao)

CH_3-OH Methan✗ol Methanol

CH_3-CH_2-OH Ethan✗ol Ethanol

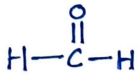
$CH_3-CH_2-CH_2-OH$ propan✗ol propanol

Homologous series :- same functional group increasing CH_2

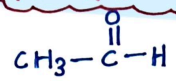
CH_3OH → (+CH_2) C_2H_5OH → (+CH_2) C_3H_7OH

$-CHO$ or $-\overset{O}{\overset{\|}{C}}-H$ Aldehyde 'al' suffix → Baad

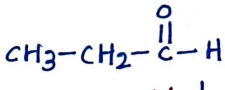
Formula = $C_nH_{2n}O$



Methanal



Ethanal



propanal

Homologous series :- same functional group increasing CH_2

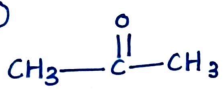
① CH_2O → (+CH_2) ② C_2H_4O → (+CH_2) ③ C_3H_6O

$-\overset{O}{\overset{\|}{C}}-$ Ketone 'one' suffix ye hamesha beech mein hoga

- Dono taraf carbon chahiye.
- Atleast 3 carbon chahiye.

Formula = $C_nH_{2n}O$

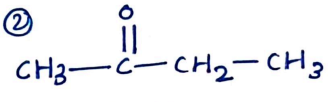
①



propanone

propanone

②



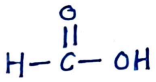
Butanone

Butanone

Homologous series :- same functional group increasing CH_2

① C_3H_6O → (+CH_2) ② C_4H_8O → (+CH_2) ③ $C_5H_{10}O$

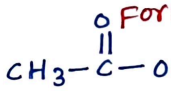
$-\overset{O}{\overset{\|}{C}}-OH$ or COOH Carboxylic acid 'oic acid' suffix



↓

Methane oicacid

Formula ✗



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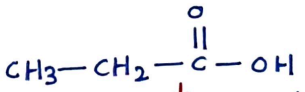
Ethanoic acid

imp CH_3-COOH



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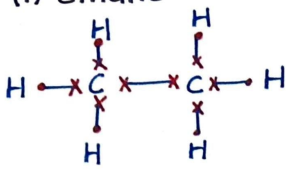
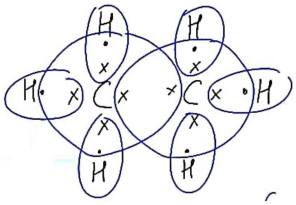
propanoic acid

Name	IUPAC	Structure	Formula
Alkane	ane	C–C	C_nH_{2n+2} → CH_4, C_2H_6
Alkene	ene	C=C	C_nH_{2n} → C_2H_4 (1st member, C=X)
Alkyne	yne	C≡C	C_nH_{2n-2} → C_2H_2
Chloro Bromo	~~prefix~~ Chloro, Bromo	C–Cl	X
Alcohol	ol	C–OH	X
Aldehyde	al	–CHO	$C_nH_{2n}O$ → $H-\overset{O}{\overset{\|}{C}}-H$ (Atleast 3C)
Ketone	one	$-\overset{O}{\overset{\|}{C}}-$	$C_nH_{2n}O$ → C_3H_6O, C_5 $-\overset{O}{\overset{\|}{C}}-CH_3$
Carboxylic acid	oic acid	$-\overset{O}{\overset{\|}{C}}-OH$ –COOH	X

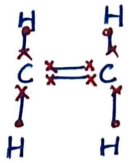
Electron Dot structure

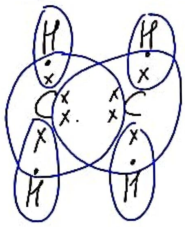
(1) Ethane





(2) Ethene





Homologous series (HS):–

A series of compound with same functional group, same general formula and similar chemical properties where each consecutive member differs by $-CH_2$

Alkane C_nH_{2n+2} : $CH_4 \xrightarrow[+14u]{+CH_2} C_2H_6 \xrightarrow{+CH_2} C_3H_8 \longrightarrow C_4H_{10}$

Alkene C_nH_{2n} : $C_2H_4 \longrightarrow C_3H_6 \underset{+14u}{\overset{+CH_2}{\rightleftharpoons}} C_4H_8 \longrightarrow C_5H_{10}$

C → 12u
H → 1u
O → 16u
N → 14u

1. Molecular mass increase moving up homologous series – 14 amu in each member.
2. Melting and boiling point increase up the series. Gradation in other physical properties like solubility.
   Reason - They increase with Molecular size and molecular mass.
3. Chemical properties are same for a homologous series.
   Reason - chemical properties are because of functional groups which remains same in Homologous series.

ISOMERS :– Isomers are compounds with same molecular formula but different structure formula.

(1) Butane:

C_4H_{10}

n-butane: $CH_3-CH_2-CH_2-CH_3$

isobutane: $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3$

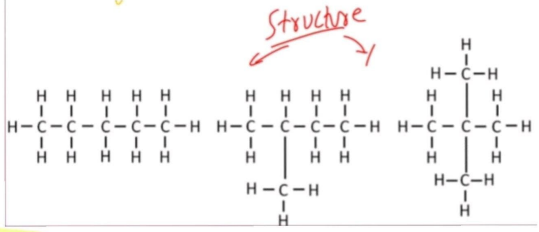
CBSE (2023, 2024)

(2) Pentane

C_5H_{12}

$CH_3-CH_2-CH_2-CH_2-CH_3$

$CH_3-CH_2-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3$



(3) Aldehyde and ketone

$-\overset{\displaystyle O}{\overset{\|}{C}}-H$ 'al' $-\overset{\displaystyle O}{\overset{\|}{C}}-$ 'one'

C_3H_6O

$CH_3-CH_2-\overset{\displaystyle O}{\overset{\|}{C}}-H$ propanal

$CH_3-\overset{\displaystyle O}{\overset{\|}{C}}-CH_3$ propanone

Saturated Compounds	Unsaturated Compounds
Which has Carbon - Carbon single bonds only	Which has Carbon - Carbon Double or Triple bond
C - C - C Alkane C_nH_{2n+2}	C = C Alkene C_nH_{2n} C ≡ C Alkyne C_nH_{2n-2}
Less Reactive	More Reactive
Shows Substitution reaction	Shows Addition reaction

C≡C Addition Reaction C=C	C-C Substitution Reaction
Occurs with unsaturated compounds (those with carbon–carbon double or triple bonds, e.g., alkenes and alkynes).	Occurs with saturated compounds (those with only carbon–carbon single bonds, e.g., alkanes).
$CH_2=CH_2 + H_2 \xrightarrow[\text{palladium catalyst}]{\text{Nickel catalyst}} CH_3-CH_3$ (ethene → ethane)	$CH_4 + Cl_2 \xrightarrow{\text{Sunlight}} CH_3Cl + HCl$ (methane → Chloromethane)
Atoms or groups of atoms are added across the double or triple bond, converting it into a single bond.	An atom or group of atoms on the hydrocarbon is replaced by another atom or group.

Hydrogenation :– Addition of hydrogen to unsaturated compounds to give saturated compound.
Reaction is used in hydrogenation of vegetable oil (long unsaturated carbon chains)
makes the oils more stable and less prone to oxidation and rancidity

$CH_2 \overset{\curvearrowleft}{=} CH_2 \overset{\curvearrowleft}{+} H_2 \xrightarrow[\text{Ni or Pd}]{\text{catalyst}} CH_3-CH_3$
Ethene → Ethane

$CH_4 + Cl_2 \xrightarrow[\text{sunlight}]{\text{Addition}} CH_3Cl + HCl$ (substitution)
chloromethane

Combustion:–

1) Complete Combustion (in supply of air) → $CO_2 + H_2O$ + Heat

$CH_4 + O_2 \longrightarrow CO_2 + H_2O + Heat$

$CH_3CH_2OH + O_2 \longrightarrow CO_2 + H_2O + Heat$

$C_4H_{10} + O_2 \longrightarrow CO_2 + H_2O + Heat$

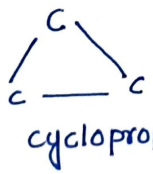
2) Saturated carbon Compounds (Alkanes) generally give a clean blue flame.
→ complete Combustion.

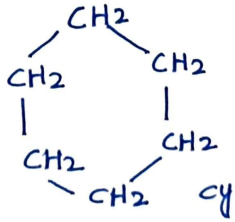
3) Unsaturated carbon compounds gives yellow flame with lots of black smoke. A sooty deposit on the metal plate (unburnt carbon)
↓ incomplete combustion

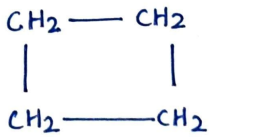
4) In limited supply of air → incomplete combustion of even saturated carbon compounds gives a sooty flame.

Rings of Carbon:–

saturated

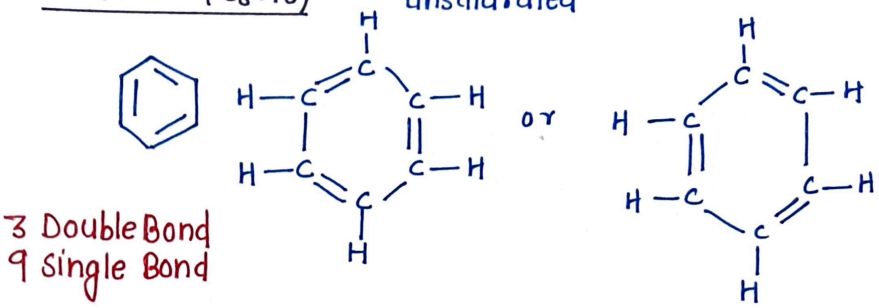

cyclopropane


cyclohexane (C_6H_{12})


Cyclobutane

Benzene (C_6H_6)

unsaturated



3 Double Bond
9 Single Bond

Allotropy

The phenomenon of existence of an element in two or more forms (because of difference in arrangement of atoms)
They have different physical properties but identical chemical properties.
The different forms are called Allotropes.
Carbon exists in different forms in nature.
like Diamond and Graphite

Graphite is smooth and slippery

Diamond is hardest substance

Reasons that carbon forms Millions of compounds

(1) catenation:- Property of carbon to self link and form long chains of carbon atoms, branched chains of carbon atoms or rings of carbon atoms.

(2) Tetravalency- Each carbon atom forms four covalent bonds.

(3) Small size of C-atom - Due to small size of carbon, its compounds are highly stable as the pull on electron cloud is very strong.

(4) Isomers- As carbon compounds shows isomers, with same sets of atoms it can have different structures and hence different types of compounds.

Reactions

ETHANOL

$CH_3—CH_2—OH$

Alcohol

ETHANOIC ACID

$CH_3—COOH$

Acetic Acid

↓

common name
Vinegar

ETHANOL CH_3-CH_2-OH ke Reactions

1) $2CH_3-CH_2-OH + 2Na \longrightarrow 2CH_3-CH_2-ONa + H_2$
(Acid jaisa) metal — sodium ethoxide (colorless)

Burns with a pop sound

imp

2) $CH_3-CH_2-OH \xrightarrow[\text{Excess conc. } H_2SO_4]{443K} CH_2=CH_2 + H_2O$
ethanol — Heat — ethene

conc. H_2SO_4 *dehydrating agent* hai (pani nikalne wala)
this reaction is called *Dehydration of Ethanol*. (Removal of H_2O)

imp

3) $CH_3-CH_2-OH \xrightarrow[\text{(Alkaline potassium permanganate)}]{\text{1. Alkaline KMnO}_4} CH_3-COOH$
ethanol — Ethanoic acid (colorless)

OR

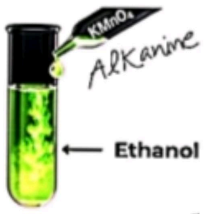
2. Acidified $K_2Cr_2O_7$
(Acidified potassium dichromate)

(H_2 nikalega O Add hoga)

1 and 2 are oxidising agent.
This is oxidation of ethanol.
Addition of oxygen to ethanol happens.
purple colour of Alkaline $KMnO_4$ disappears.

$CH_3-CH_2-OH \xrightarrow[443K]{\text{conc. } H_2SO_4} CH_2=CH_2 + H_2O$
Ethanol — dehydration, Removal of H_2O — Ethene.

Activity 4.5



Add drop wise alkaline $KMnO_4$ (Potassium Permanganate)

Observation : Purple colour of Alkaline $KMnO_4$ disappears

Reason : Ethanol reacts with Alkaline $KMnO_4$ to give ethanoic acid (colourless).

On adding excess of Alk $KMnO_4$ - Now purple colour doesn't disappear as there is no ethanol left now

$CH_3-CH_2-OH \xrightarrow[\text{Oxidising Agent}]{\text{1. Alkaline KMnO}_4\text{(Alkaline potassium permanganate)}} CH_3-COOH$
Ethanol — ethanoic acid (Colorless)

ETHANOIC ACID CH_3-COOH ke Reactions

Reaction of Acid ⟶ H^+ ions release

1. $CH_3-COOH + NaOH \longrightarrow CH_3COONa + H_2O$
   ethanoic acid — Base — sodium salt — water

2. $2CH_3-COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + CO_2 + H_2O$
   Acid — metal carbonate

   $2CH_3-COOH + NaHCO_3 \longrightarrow CH_3COONa + CO_2 + H_2O$
   Acid — Metal Bicarbonate — salt

3. Test for gas CO_2 ⟶ turns lime water milky and milkiness disappear in passing excess of gas

3. Esterfication – Ethanoic acid + Ethanol

$CH_3-COOH + CH_3-CH_2-OH \xrightarrow{\text{acid}} CH_3COO-CH_2-CH_3 + H_2O$

Acid ethanoic acid — Base (ethanol) — (Reversible Reaction) — Ester

Ester are sweet smelling substances, used in making perfumes and flavouring agents.

4. saponification – Ester + NaOH

↳ ethanol banana

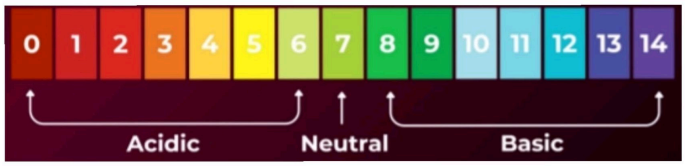
$CH_3COOCH_2-CH_3 + NaOH \longrightarrow CH_3-CH_2-OH + CH_3COONa$

ethanol — soap salt

Ethanoic Acid (CH_3COOH)

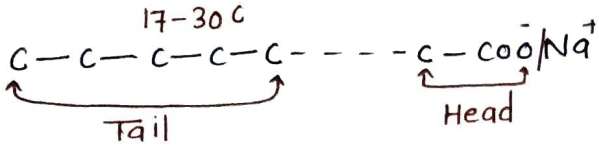
1. Commonly called Acetic Acid.
2. 5-8% Solution of Acetic acid in water ⟶ vinegar used as preservative in pickles.
3. Glacial acetic acid ⟶ melting point of pure ethanoic acid is 290K (17°C), hence it often freezes in winter in cold climates.
4. Carboxylic acids are weak acids compared to HCl.

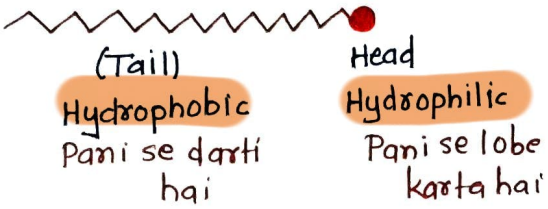
pH = 2.4 acetic acid
Colour: Red to yellow
Universal indicator



SOAPS :-

Molecules of soaps are sodium or potassium salts of long-chain carboxylic acids



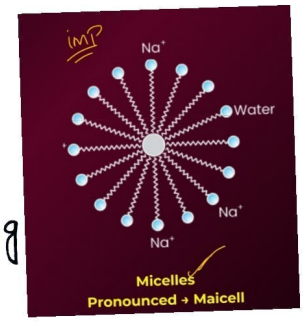


Most of the dirt is oil
Head – Towards water
Tail — Towards oil

Micelles

pronounced ⟶ Maicell

- The oil dirt is trapped inside micelle
- Washed away with water rinsing



HARD WATER

Water that contains salts of calcium and magnesium – bicarbonates, chlorides, sulphates.

Soaps are not effective with hard water. When soap is used with hard water, No foam is formed and dirt cannot be washed away. So detergents used with hard water.

S. No.	Soap	Detergents
1.	They are sodium salts of long chain fatty acids. K Carboxylic acid	These are sodium or potassium salts of sulphonic acids of hydrocarbons.
2.	Soaps cannot be used with hard water.	Detergents work well with hard and soft water both.
3.	Do not give foam with hard water	Give foam with hard water
4.	They form precipitate with salts present in Hard water.	Do not form precipitate with hard water.