Carbon and Its Compounds

Carbon is a chemical element like hydrogen, oxygen, nitrogen etc. It is versatile non-metal.

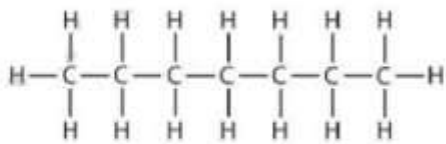
Properties of Carbon:
1. Atomic Number: 6
2. Electronic configuration: 2, 4.
3. Valency of Carbon:

- To complete the octet, either carbon can gain 4 electrons or lose 4 electrons.
- But if carbon gains electrons. it would be difficult for nucleus to hold 4 extra electrons as carbon atom is very small in size.
- If carbon loses its electron, it would require a large amount of energy to remove 4 electrons as attraction force of nucleus is more in carbon atom.
- Thus it is difficult for an atom of carbon to either gain or lose electrons. Carbon makes four covalent bonds and attains the noble gas configuration by sharing its valence electrons.

4. Self -combination (Catenation):

- Due to small size of carbon, it has a unique ability to combine with other carbon atoms to form long chains.
- This ability of carbon is known as 'Catenation".

For example,



Octane (C_8H_{18})

Occurrence of Carbon:
Carbon occurs in two forms in nature

Free state: Graphite, Diamond, Fullerene.

Combined State: Carbon Combines with other elements to form compounds such as carbon dioxide (CO_2), glucose ($C_6H_{22}O_6$), sugar ($C_{12}H_{22}O_{11}$) etc.

Allotropes of Carbon:
Different forms of an element which have different physical appearance and properties but their chemical properties are same are called allotropes.
There are three allotropes of carbon:
a. Diamond b. Graphite c. Fullerene

Diamond:
Diamond is a three dimensional network of strong carbon – carbon covalent bands.

Properties of Diamond:

- Due to the presence of this large 3-D network of C – C covalent bonds, diamonds is very card and have high melting point (around 4827°C).
- As all the 4 electrons are utilized in making covalent bonds, no free electron is available for conduct electricity and therefore, diamond is a bad conductor of electricity.
- Diamond is transparent and shines in presence of light.

Uses of Diamonds:

- Due to its high hardness it is used in making cutting and drilling tools (far cutting glasses).
- Due to its brilliant shine it is used in making jewellery.
- Diamond is used in surgical instruments to remove cataract from eyes.

Graphite:

- In graphite each carbon atom is bonded with three other carbon atoms to form hexagonal rings.
- These hexagonal rings join together to form layers.
- These layers containing hexagonal rings are hold together by weak Vander Waal Forces.
- Due to weak Vander Waal forces, these layers can slide over each other and therefore graphite can be used as a dry lubricant for machine parts at high temperature.

Properties of Graphite:

- Due to its layered structure, graphite is soft and has soapy touch.
- As the layers are bonded through weak Vander Waal forces it can act as lubricant.
- Due to presence of one free electron, it is a good conductor of electricity and heat.

Uses of Graphite:

- It is used in lead pencils as it is soft and leaves black mark on the paper.
- Powered graphite is used as dry lubricant for machine parts which operate at high temperature where oil can't be used because graphite is non-volatile.
- It is used in making electrode in the cells.

Fullerene:

- Fullerene is a closed hollow cage in the form of sphere, tube and ellipsoid or of many other form.
- Structure of fullerene is same as graphite.
- It is composed of a sheet of linked hexagonal rings (each carbon atom is bonded with three other carbon atoms). But they also contain pentagonal or sometimes heptagonal rings that prevent the sheet from being p1aner.
- Spherical fullerenes are usually called Buckyballs, while cylindrical fullerenes are called Bucky tubes or Nanotubes.
- C_{60} is the smallest fullerene molecule that forms the shape of a football.
- Since it looks like the geodesic dome designed by the US architect Buckminster Fuller, it was called Buckminster fullerene/ fullerene.

Properties of Fullerene:

- Fullerenes are stable, but not totally unreactive.
- Fullerenes are soluble in many solvents like CO_2 etc.
- But insoluble in other those have a small bond gap between the excited state and ground state.
- Fullerenes are the only known allotrope of carbon that can be dissolved in common solvents at room temperature like C_{28}, C_{36} etc.

Uses of Fullerene:

- Artificial photosynthesis
- In cosmetics
- In surface coating
- Drug delivery system

Compounds of Carbon:

Compounds of carbon are classified into two types:

1. Organic Compounds:

Organic compounds are the compounds made up of carbon (C), hydrogen (H) and Oxygen (O) generally. Organic compounds contains at least one C — H bond.

Examples: Methane (CH_4), Methanol (CH_3OH), Glucose ($C_6H_{12}O_6$ {j).

2. Inorganic Compounds:

Inorganic compounds do to have any C — H bonds.

Examples: Carbon mono oxide {CO), Carbon dioxide (CO_2).

Organic Compounds:

Hydrocarbons:

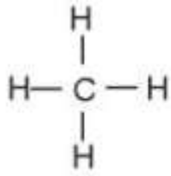
Compounds made up of carbon and hydrogen only, are known as Hydrocarbons can further classify into types –

1. **Saturated Hydrocarbons**
2. **Unsaturated Hydrocarbons**

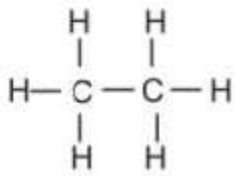
Saturated Hydrocarbons:

The saturated hydrocarbons are hydrocarbons in which carbon atoms are linked together by single bonds only

For example:



Methane (CH_4)



Ethane (C_2H_6)

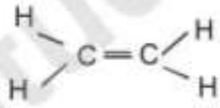
All saturated hydrocarbons are known as "ALKANES".

Unsaturated Hydrocarbons:

The hydrocarbons containing multiple bonds between two carbon atoms are called Unsaturated Hydrocarbons.

Unsaturated hydrocarbons can be further divided into two categories –

1. Alkenes: Hydrocarbons having at least one double bond between two carbon atoms are known as Alkenes. For example:



Ethene (C_2H_4)

2. Alkynes: Hydrocarbons having at least one triple bond between two carbon atoms are known as Alkynes. For example:

Ethyne (C_2H_2)

Naming and Structure of Saturated Hydrocarbons / Alkanes

The name of an alkane is made up of two parts:

(a) a prefix (first part of the name, *alk)*

(b) a suffix (last part of the name, ane)

The prefix is dependent on the number of carbon atoms in the chain of carbon atoms

Number of carbon atoms:	1	2	3	4	5	6	7	8	9	10
Prefix:	meth	Eth	prop	but	pent	hex	hept	oct	non	dec
Suffix:	ane	Ane	ane	ane	ane	ane	ane	ane	ane	ane

General formula of saturated hydrocarbons (Alkanes) is C_nH_{2n+2}.

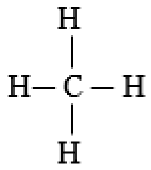
Here, n is number of carbon atom

Value of n	Molecular Formula	Members
n = 1	$C_1H_{(2\times1+2)} = CH_4$	Methane
n = 2	$C_2H_{(2\times2+2)} = C_2H_6$	Ethane
n = 3	$C_3H_{(2\times3+2)} = C_3H_8$	Propane
n = 4	$C_4H_{(2\times4+2)} = C_4H_{10}$	Butane
n = 5	$C_5H_{(2\times5+2)} = C_5H_{12}$	Pentane
n = 6	$C_6H_{(2\times6+2)} = C_6H_{14}$	Hexane
n = 7	$C_7H_{(2\times7+2)} = C_7H_{16}$	Heptane

Structure of Alkanes:

1. If number of carbon atom (n) = 1
   Then. C_nH_{2n+2} = CH 4

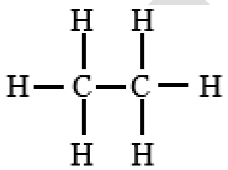
The compound made is Methane.



Methane (CH_4)

2. If number of Carbon atom (n) = 2
   Then, $C_nH_{2n+2} = C_2H_6$

The compound made is Ethane.

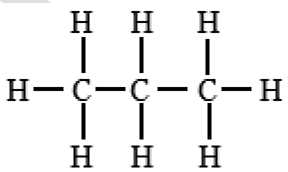


Ethane (C_2H_6)

Ethane can also be written as $CH_3 — CH_3$ or CH_3CH_3 .

3. If number of carbon atoms (n) = 3
   Then, $C_nH_{2n+2} = C_3H_8$

The compound made is Propane.

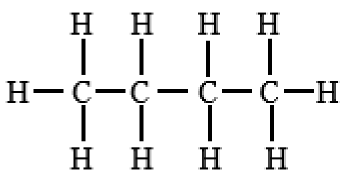


Propane (C_3H_8)

Propane can also be written as $CH_3 – CH_2 – CH_3$ or $CH_3CH_2CH_3$.

4. If number of carbon atoms (n) = 4
   Then $C_nH_{2n+2} = C_4H_{10}$

The compound made is Butane.

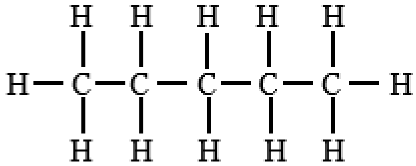


Butane (C_4H_{10})

Butane can also be written as $CH_3 - CH_2 - CH_2 - CH_3$ Or $CH_3CH_2CH_2CH_3$.

5. If number of carbon atoms (n) = 5
Then, $C_nH_{2n+2} = C_5H_{12}$

The compound made is Pentane.

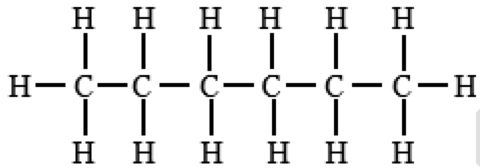


Pentane (C_5H_{12})

Pentane can also be written as $CH_3 - CH_2 - CH_2 - CH_2 - CH_3$ or $CH_3\,CH_2CH_2CH_2CH_3$.

6. If number of carbon atoms (n) = 6
Then, $C_nH_{2n+2} = C_6H_{14}$

The compound made is Hexane.

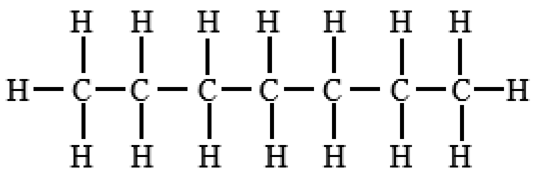


Hexane (C_6H_{14})

Hexane can also written as $CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$ or
$CH_3\,CH_2\,CH_2\,CH_2\,CH_2\,CH_3$.

7. If number of carbon atoms (n) = 7
Then, $C_nH_{2n+2} = C_7H_{16}$

The compound made is Heptane.

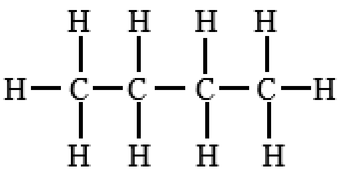


Heptane (C_7H_{16})

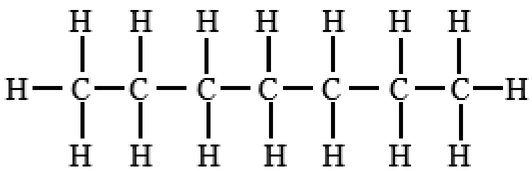
Heptane can also be written as $CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$ or $CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$ or $CH_3 - (CH_2)_5 - CH_3$.

Straight Chain Alkanes:

In the straight-chain alkanes, there are only single covalent bonds joining one carbon atom to another carbon atom in straight line. For examples, methane, ethane, propane, butane, heptane etc.



Butane (C_4H_{10})

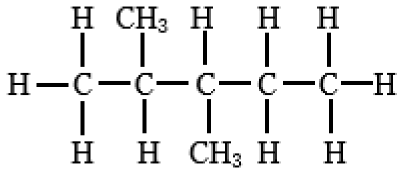


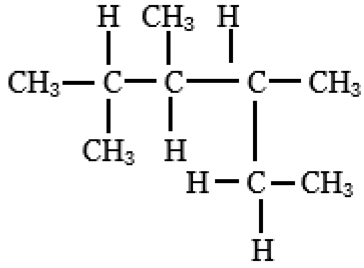
Heptane (C_7H_{16})

The prefix *n*- is used before each straight chain hydrocarbon. For example, *n*-hexane, *n*-heptane, *n*-octane, *n*-nonane etc.

Branched chain Alkanes:

Branched chain alkanes are derived from the straight-chain alkanes system by removing one of the hydrogen atoms from a methylene group ($-CH_2-$) and replacing it with an alkyl group.





The straight chain joining all carbon atoms is called parent chain and branches of branched chain alkanes are called substitute groups.

For naming of branched chain alkanes, we have to follow certain rules:

1. Longest Chain Rule:

- Select longest possible chain containing C atoms.
- This will give you the parent name of the alkane.

2. Numbering of Chain:

- Numbering of chain is done from the end from which the substituent is closer.
- If there are substituent that are the same number of carbons in from either end, start the numbering from the end nearest the next substituent.
- The carbon number where the substitute group is attached appears in the name of the compound.

3. Naming of Substituent Group:

- The hydrocarbon groups attached to the parent chain are called alkyl groups, such as methyl, ethyl, propyl, etc.
- Name the substituent as an alkyl group based on the number of carbons in this chain.
- Place the name of the branched substituent, preceded by a number indicating the carbon of the parent – chain carbon to which it joins.

Name of Compound:

- The name of parent chain alkanes is made up of two parts:
  Word root / preffix – depends on number of carbon atoms in parent chain.
  Suffix – depends on type of hydrocarbon. Here suffix is *"ane"*.
- Now to name the compound, place the name of substituent in parentheses.
  preceded by a number indicating the carbon of the carbon to which it joins.

Naming and Structure of Unsaturated Hydrocarbons:

Alkenes: Alkenes are hydrocarbons with at least one double bond.

The name of an *alkene* is made up of two parts.

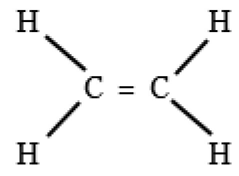
(a) a prefix (first part of the name, *alk)*
(b) a suffix (last part of the name, ene)

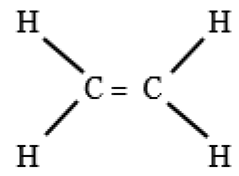
The prefix is dependent on the number of carbon atoms in the chain of carbon atoms.

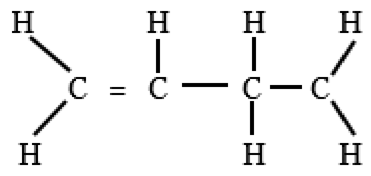
Number of carbon atoms:	1	2	3	4	5	6	7	8	9	10
Prefix:	meth	eth	prop	but	pent	hex	hept	oct	non	dec
Suffix:	ene	ene	ene	ene	ene	ene	ene	ene	ene	ene

General formula of Alkenes is C_nH_{2n} . Here, n is number of carbon atoms.

Molecular formula and structure of some alkenes:

n = 1 C_2H_4  Ethane

n = 3 C_3H_6  Propene

n = 4 C_4H_8  Butene

Alkyne: Alkynes are hydrocarbons with at least one triple bond.
The name of an *alkyne* is made up of two parts:

(a) a prefix (first part of the name, alk)
(b) a suffix (last part of the name, yne)

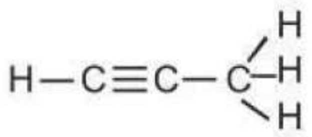
The prefix is dependent on the number of carbon atoms in the chain of carbon atoms.

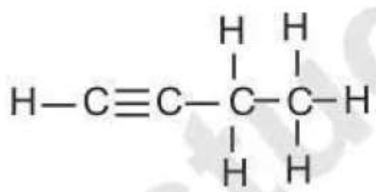
Number of carbon atoms:	1	2	3	4	5	6	7	8	9	10
Prefix:	meth	eth	Prop	but	pent	hex	hept	oct	non	dec
Suffix:	yne	yne	yne	yne	yne	yne	yne	yne	yne	yne

General formula of Alkenes is C_nH_{2n-2} Here, n is number of carbon atoms.

Molecular formula and structure of some alkynes.

n = 2 C_2H_2 $H-C\equiv C-H$ Ethyne

n = 3 C_3H_4  Proyne

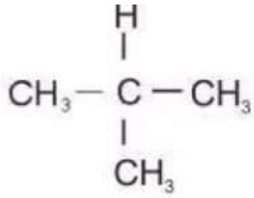
n = 4 C_4H_6  Butyne

Isomers:

The organic compounds which have same molecular formula but different structures are called “Isomers”.

$CH_3-CH_2-CH_2-CH_3$

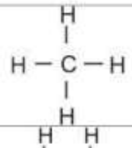
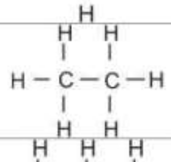
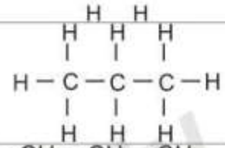
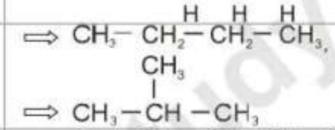
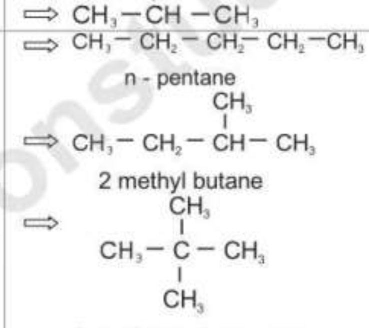
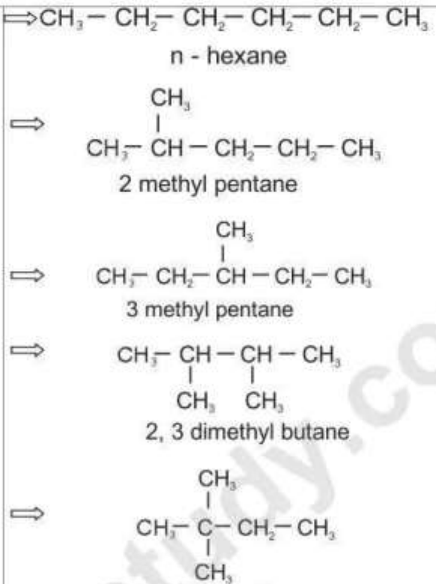
n – butane



Iso – butane

Note: At least4 carbon atoms are required for hydrocarbons to show Isomerism.

Isomers of Different Alkanes:

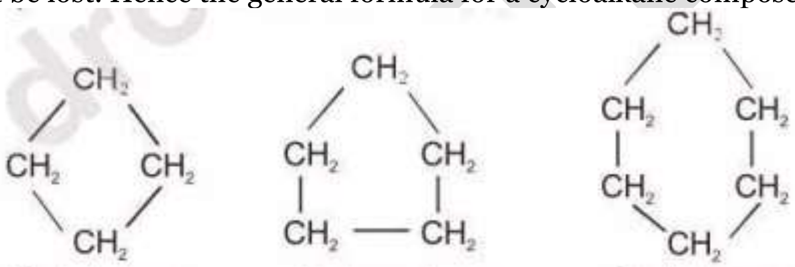
Compound	Structures	Number of Isomers
Methane (CH_4)		–
Ethane (C_2H_6)		–
Propane (C_3H_8)		–
Butane (C_4H_{10})		2
Pentane (C_5H_{12})	 n - pentane; 2 methyl butane; 2, 2 dimethyl propane	3
Hexane (C_6H_{14})	 n - hexane; 2 methyl pentane; 3 methyl pentane; 2, 3 dimethyl butane; 2, 2 dimethyl butane	5

Isomers of Different Alkenes:

Compound	Structures	Number of Isomers
Ethene (C_2H_4)	$CH_2=CH_2$	0
Propene (C_3H_6)	$CH_2=CH-CH_3$	0
Butene (C_4H_8)	⇨ $CH_2=CH-CH_2-CH_3$ But-1-ene ⇨ $CH_3-CH=CH-CH_3$ But-2-ene ⇨ $H_2C=C(CH_3)-CH_3$ 2- methyl prop-1-ene	3

Cyclic Structure:

- When a series of atoms is connected to form a loop or ring, it is called **cyclic structure.**
- When carbon atoms are connected in ring form, such hydrocarbon atoms are called **cyclic hydrocarbon.**
- A **cycloalkane** is a cyclic hydrocarbon in which all of the carbon -carbon bonds are single bonds.
- If a simple straight alkane is converted to a cycloalkane, two hydrogen atoms, one from each end of the chain, must be lost. Hence the general formula for a cycloalkane composed of n carbons is C_2H_{2n}.

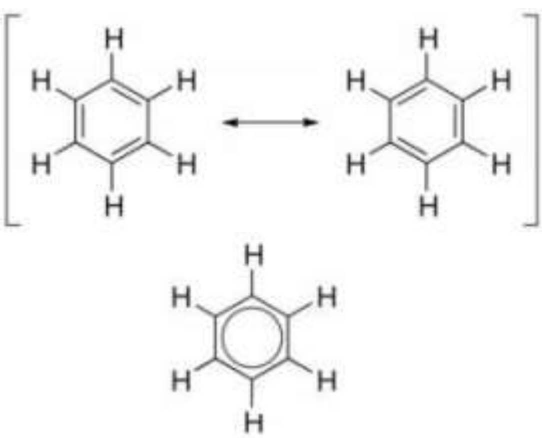


Cyclobutane Cyclopentane Cyclohexane

Note – Butene. and cyclobutane have same molecular formula C_4H_8. but different structural formulae so they are called structural isomers.

Benzene (C_6H_6):

- **Benzene** is an organic compound with the molecular formula C_6H_6.
- It is a six carbon ring hydrocarbon in which carbon atoms are joined by alternating double end single bonds.
- Sometimes a circle is used inside the hexagon as an alternative to represent the six pi electrons.



Homologous Series:

A series of organic compounds having similar properties in which the successive members differ by a —CH_2 group is called a Homologous series.

Homologous Series of Different Hydrocarbons:

Homologous series of Alkanes	Homologous series of Alkenes	Homologous series of Alkynes
CH_4 (Methane)	$CH_2 = CH_2$ (Methene)	$H - C \equiv C - H$ (Methyne)
$CH_3 - CH_3$ (Ethane)	$CH_3 - CH = CH_2$ (Ethene)	$CH_3 - C \equiv C - H$ (Ethyne)
$CH_3 - CH_2 - CH_3$ (Propane)	$CH_3 - CH_2 - CH = CH_2$ (Propene)	$CH_3 - CH_2 - C \equiv C - H$ (Propyne)
$CH_3 - CH_2 - CH_2 - CH_3$ (Butane)	$CH_3 - CH_2 - CH_2 - CH = CH_2$ (Butene)	$CH_3 - CH_2 - CH_2 - C \equiv C - H$ (Butyne)

Characteristics of Homologous Series

1. All the members of a Homologous series follow a general formula. For example;
   - All alkanes follow a general formula C_nH_{2n+2}.
   - All alkenes follow general formula C_nH_{2n} .
   - All alkynes follow a general formula C_nH_{2n-2} .
2. Two successive members of a series differ by a "— CH2" group.
3. All the members of a homologous series show similar chemical properties.
4. In a Homologous series, the molecular mass of members increases with increasing number of carbon atoms and the molecular mass differ by 14 between two successive members.
5. Members of a homologous series show gradual change in their physical properties like bailing point, melting point, solubility etc.

Melting point / boiling point α Molecular Mass

$$\text{Solubility} \propto \frac{1}{\text{Molecular Mass}}$$

Functional Group:

Atoms or group of atoms which provide certain specific properties when attached to a carbon chain is called a functional group.

Some Important Functional Groups

S. No.	Functional Group	Structure	Prefix	Suffix
1.	Halogen (X)	X = F,Cl,Br, I	Halo – Fluoro, Chloro, Bromo, Iodo	-
2.	Alcohol (- OH)	$-O-H$	–	"ol"
3.	Aldehyde	$-\overset{O}{\overset{\parallel}{C}}-H$	–	"al"
4.	Ketone	$-\overset{O}{\overset{\parallel}{C}}-C-$	–	"one"
5.	Carboxylic Acid	$-\overset{O}{\overset{\parallel}{C}}-O-H$	–	"oic acid"

1. Halogen Group (X = F, Cl, Br, I):

- When any halogen group is attached with alkanes they form haloalknes.
  C_2H_{2n+2} + .X ————> $C_2H_{2n+1}X$
  For example:
  CH_3-Cl Chloromethane
  CH_3-CH_2-Br Bromomethane
  CH_3-CH_2-CH_2-I Iodopropane

2. Alcoh ol (-OH) : -OH is called Hydroxyl group. When a hydroxyl group is attached with carbon backbone (like alkanes), they are named as alcohol.

C_2H_{2n+2} + .OH ————> $C_2H_{2n+1}OH$ or $C_2H_{2n+2}O$
(General formula)

For example:

CH_3 — OH Methanol
CH_3 — CH_2 — OH Ethanol
CH_3 — CH_2 — CH_2— OH Propanol
CH_3 — CH_2 — CH_2— CH_2 — OH Butanol

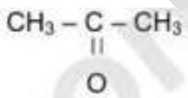
3. Aldehyde (— CHO): When an aldehyde group is attached with alkyl group, the compound is called an aldehyde.

C_2H_{2n+2} + .CHO ————> $C_2H_{2n}O$ (General Formula)

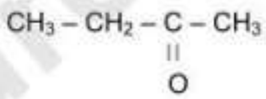
4. Ketone (— CO):

- In a ketone, the carbonyl carbon is doubly-bonded to an oxygen, and single bonded to two alkyl groups.
- Both groups should be alkyl groups. If either of the group or both groups are "H", it becomes an aldehyde.
- C_2H_{2n+2} + .CO ————> $C_2H_{2n}O$ (General Formula)

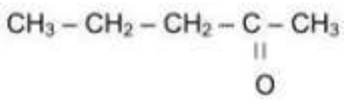
For Example:



Propanone or Acetone



Butanone

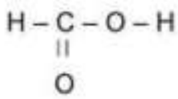


Pentanone

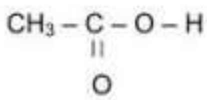
5. Carboxylic Acid (— COOH) :

- In Carboxylic acid, a carbon (C) atom is attached to en oxygen (O) atom by a double bond and to a hydroxyl group (-OH) by a single bond.
- The forth bond links carbon atom with hydrogen atom or with any alkyl group.

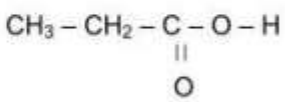
For example:



Methanoic Acid / Formic Acid



Ethanoic Acid / Acetic Acid



Propanoic Acid

Characteristics Properties of Carbon & it's Compounds:

1. Combustion:

- Burning of carbon or its compounds in presence of oxygen is called combustion.
- In combustion process, mainly two products are formed i.e. CO_2, and H_2O and energy is released in form of heat and light.

$$C + O_2 \longrightarrow CO_2$$

$$\underset{\text{(Methane)}}{CH_4} + 2O_2 \longrightarrow CO_2 + 2H_2O + \text{Energy}$$

$$\underset{\text{(Ethanol)}}{2CH_3CH_2OH} + 7O_2 \longrightarrow 4CO_2 + 6H_2O + \text{Energy}$$

Note: Most of the hydrocarbons are used as fuel as they release energy on burning in air.

For example:

a. Methane (CH_4) is used in Compressed Natural Gas (CNG).
b. Butane (C_4H_{10}) is used in Liquified Petroleum Gas(LPG).
c. Octane (C_8H_{18}) is used in Petrol as the main compound.

- Saturated hydrocarbons burn in air giving a clean blue flame.
- Unsaturated hydrocarbons burn in air giving a sooty flame (with lot of smoke).

Combustion are of two types:

1. Complete Combustion: In this combustion, sufficient amount of oxygen is present.

$C + O_2$ ——————> CO_2

2. Incomplete Combustion: Limited amount of oxygen is there.

$C + O_2$ ——————> $CO + CO_2$

- If combustion of saturated hydrocarbons is complete, they release clean blue
- If combustion of saturated hydrocarbons is incomplete, they release sooty flame.

Burning of Substance with and without flame:

The fuels which are vaporisable (can be converted to vapors) burns with flame.
For example: candle, petrol, naphthalene bum with flame.
The fuels which do not vaporise, burn without flame. For example: coal burns without flame.

Yellow Color of Candle Flame:

When wax is heated it melts and gets converted into vapors.
In candles there is no provision for the proper mixing of wax vapors and air so incomplete combustion occurs.
Also small unburnt carbon particles are produced which rise and get heated and glow to give out yellowish light.

Oxidation Reactions

Oxidation is addition of oxygen. Carbon compounds get easily oxidized on combustion.

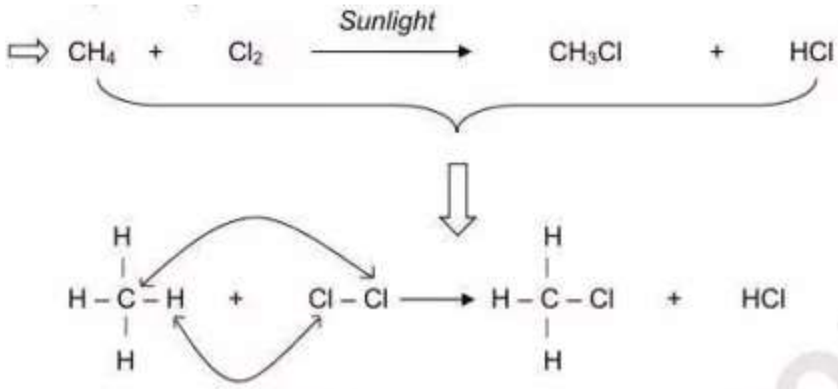
$CH_4 + O_2$ ——————> H_2O

(addition of Oxygen)
Alcohols undergo oxidation in presence of **oxidizing agents** like alkaline potassium permanganate ($KMnO_4$) to form carboxylic acid.

$$CH_3-CH_2-OH \xrightarrow[\Delta]{\text{Alkaline } KMnO4} \underset{\text{(Ethanoic Acid)}}{CH_3-\overset{\overset{O}{\|}}{C}-OH}$$

Substitution Reactions:

- The reactions in which one or more hydrogen atoms of a hydrocarbon are replaced by some other atoms are called substitution reactions.



$$\Rightarrow CH_4 + Cl_2 \xrightarrow{\text{Sunlight}} \underset{\text{(Chloromethane)}}{CH_3Cl} + HCl$$

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

$$\Rightarrow CH2Cl_2 + Cl_2 \xrightarrow{\text{Sunlight}} \underset{\text{(Chloroform)}}{CHCl_3} + HCl$$

$$\Rightarrow CHCl_3 + Cl_2 \xrightarrow{\text{Sunlight}} \underset{\text{(Carbon tetrachloride solvent)}}{CCl_4} + HCl$$

- These reactions are shown by saturated hydrocarbons only.
- Presence of sunlight is necessary for these substitution reactions.

Addition Reactions:

- The reactions in which an unsaturated hydrocarbon combines with other substances to form a single product is called addition reactions.

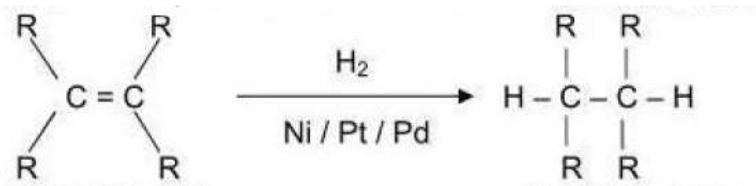
Alkene

- Only unsaturated hydrocarbons can show addition reactions.
- The reaction is named according to the name of substance added to unsaturated hydrocarbons.

For example: if hydrogen reacts with unsaturated hydrocarbons, the reaction is called hydrogenation. If chlorine reacts with unsaturated hydrocarbons, the reaction is called Chlorination.

Hydrogenation:

When **unsaturated hydrocarbons** react with hydrogen in presence of Ni, Pt or Pd (Catalyst) they get converted into **saturated hydrocarbons**.



Vegetable Oil (Unsaturated Fat)   Vegetable Ghee (Saturated Fat)

Commercially Important Compounds of Carbon
1. Ethanol (C_2H_5OH)
Physical Properties:
a. Physical State: Ethanol is a colorless liquid having a pleasant smell.
b. Boiling Point: Ethanol is volatile liquid having boiling 78°C.
c. Solubility in Water: Ethanol is soluble in water in all proportions, that's why it is the main component of alcoholic drinks and known as Alcohol.

Harmful Effects of Ethanol:

- Consumption of alcohol is not good for human health. It slows down the metabolic process.
- It depresses the central nervous system.
- It causes lack of coordination, metal confusion and drowsiness.
- It affects kidney and liver function.

Note: Pure ethanol (known as absolute alcohol) is very health hazardous.

2. Methanol (CH_3OH)
It is too a type of alcohol which is poisonous in nature. Methanol is colorless, volatile, with a distinctive odor similar to ethanol.

Poisonous Nature of Methanol:

- Methanol (CH_3OH) is poisonous as it is oxidized to Methanal (CH_3CHO) in liver, which rapidly reacts with the protoplasm (liquid present in cells) and coagulates it, like egg is coagulated on boiling.

  $$CH_3OH \xrightarrow{\text{Liver}} CH_3CHO$$
  (Methanol)   (Methanal)

- Methanol damages optic nerve causing permanent blindness in a person.

3. Denatured Alcohol:
Physical Properties:

- It is the ethyl alcohol which is made unfit for drinking by adding small amounts of poisonous methanol, copper sulphate etc.
- Sometimes a dye is also added to give it a blue color.

Chemical Properties:
a. Combustion:
Ethanol undergoes combustion giving CO_2 and H_2O along with release of energy.

$$2C_2H_5OH + 7O_2 \longrightarrow 4CO_2 + 6H_2O + \text{Energy}$$

As ethanol gives only carbon dioxide (CO_2) and water an combustion with no other gas it is a cleaner fuel.

b. Reaction with Metals:
Reaction of ethanol with metals shows its acidic nature.

$$\text{Ethanol} + \text{Metals} \longrightarrow \text{Hydrogen} + \text{Metal salt}$$

$$\underset{\text{(Ethanol)}}{2C_2H_5OH} + 2Na \longrightarrow \underset{\text{(Sodium ethoxide)}}{C_2H_5ONa} + H_2$$

c. Reaction with conc. H_2SO_4:
When ethanol is healed with concentrated sulphuric acid, ethene is collected over water. This is called dehydration of Alcohol.

$$C_2H_5OH \xrightarrow[443K]{\text{Conc. } H_2SO_4} CH_2 = CH_2 + H_2O$$

Here concentrated H_2SO_4 is acting as a dehydrating agent.

Uses of Ethanol:
Used as a solvent: Many organic compounds which are insoluble in water and soluble in ethanol.
It is used as a fuel in cars along with petrol. This mixture of alcohol and petrol is known as power alcohol.
It is used in alcoholic drinks like whisky, beer etc.
It is used as an antiseptic to sterilize wounds and syringes in hospitals.

4. Ethanoic Acid:
It is also called acetic acid.
Vinegar is 5 — 8% aqueous solution of acetic acid making acetic acid the main component of vinegar apart from water.

Physical Properties:
- It is a sour, colorless liquid having smell of vinegar.
- Its boiling point is 118°C.
- When pure ethanol is cooled, it freezes to give a solid which looks like a glacier, due to which it is known as **glacial acetic acid.**

Chemical Properties:
a. Action on Litmus:
- It converts blue litmus paper into red.
- Acetic acid is organic acid. That's why it is always weak in nature. Whereas hydrochloric acid (HCI) is a strong acid.

b. Reaction with Alcohol (Esterification):
- When acetic acid reacts with ethanol in the presence of an acid as a catalyst, ester (ethyl ethanoate) is produced.

$$CH_3COOH + C_2H_5OH \xrightarrow{\text{Acid}} \underset{\text{(Ester)}}{CH_3COOC_2H_5} + H_2O$$

- Since ester is formed in this process, the reaction is also known as Esterification.
- If ester again reacts with H_2O in presence of acid, acetic acid and ethanol is produced.
- Esters are sweet smelling compounds. Therefore, these are used in making perfumes.

c. Reaction with Base:
Acetic acid (CH_3COOH) when reacts with sodium hydroxide (a base), sodium acetate (CH_3COONa) a salt and H_2O are formed.

$$\underset{\text{(acetic acid)}}{CH_3COOH} + \underset{\text{(Base)}}{NaOH} \longrightarrow \underset{\text{(Sodium acetate)}}{CH_3COONa} + H_2O$$

This is an example of an acid-base neutralization reaction in which an acid and a base react to produce water plus a salt i.e. CH_3 COONa.

d. Reaction with Sodium Carbonate & Bicarbonate:

- When sodium carbonate sodium bicarbonate react with acetic acid, sodium acetate (CH_3COONa), H_2O and CO_2 is released.

$$Na_2CO_3 + 2CH_3COOH \longrightarrow 2CH_3COONa + CO_2 + H_2O$$
$$NaHCO_3 + CH_3COOH \longrightarrow CH_3COONa + CO_2 + H_2O$$

- CO_2 is the main product of reaction: it is released with brisk effervescence.

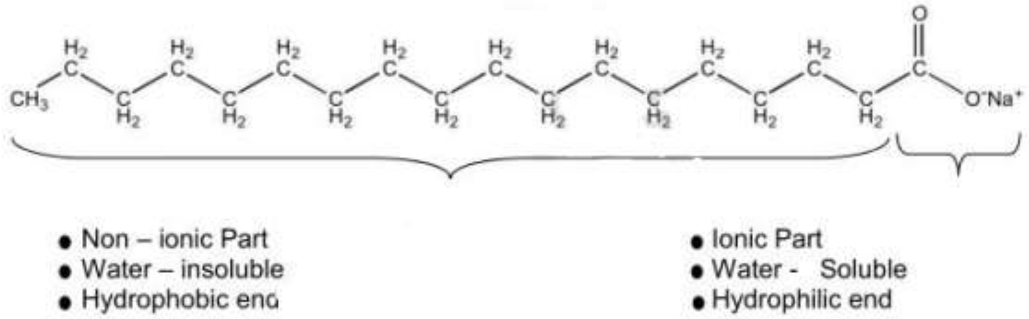
Use of CH_3COOH:

- It is used in form of vinegar as a preservative for food & pickles.
- Used to form esters which are used in perfumes and scents.

Soap and Detergents:
Soap:

- A soap is the sodium or potassium salt of a long chain carboxylic acid, which has cleansing property in water.
  Sodium stearate ($C_{17}H_{35}COO^-Na^+$) is the most common soap used in domestic purpose.

Structure of Sodium Carbonate



Detergent:
Any substance which has cleansing action in water is called detergent.

Cleansing Action of Soap:
When a cloth with dirt attached to it is immersed in water containing soap, then the hydrocarbon chain (hydrophobic end) is attached to the dirt particle whereas the ionic end (hydrophilic end) points outward, towards water.
So the dirt particles are surrounded by the soap molecules forming a micelle.
This micelle gets attached with water molecules through the ionic end and is washed away along with the dirt panicles.

Soft and Hard Water:

- Soft water easily generates lather/ foam with soap.
- But hard water contains salts of calcium and magnesium. When salts of calcium and magnesium react with soap molecules, they form a precipitate instead of lather.

$$C_{17}H_{35}Coo^- Na + MgCl_2 \longrightarrow \underbrace{(C_{17}H_{35}COO)_2Mg}_{\textbf{Scum}} + NaCl$$

- The precipitate formed in this reaction is called scum.
- Since the scum is insoluble in water, soap cannot form lather in hard water.
- Detergents on the other hand are less likely to form these scum.
- Detergents are the sodium salts of long chain benzene sulphonic acids which has more cleansing property in water than soap

Chemical formula of detergent: CH_3-(CH2)$_{11}$-C_6H_4-$SO_3^-Na^+$