ORGANIC CHEMISTRY

Organic chemistry is the branch of chemistry deals with the study of compounds of carbon except CO, CO_2, metal carbonates and bicarbonates (e.g. Na_2CO_3, $NaHCO_3$), CYnide (CaCN) and carbides (Ca_2C).

It may be defined as,

"Organic chemistry is the study of hydrocarbons and their derivatives."

Organic compounds are obtained from living substances (plants and animals) and they can be prepared by inorganic compounds in laboratories and industries.

History of organic compounds and vital force theory:

In old days before 1828 the term organic chemistry was used for those compounds which were obtained from living sources i.e. plants and animals.

It was thought that there is natural or mysterious force called "Vital Force" present in living substances that prepare organic compounds in living things and organic compounds cannot be prepared without living cell. This theory is called "Vital Force Theory".

Vital force theory was rejected when a German Chemist Wholer in 1828 prepared urea an organic compound from Ammonium cyanate (NH_4CNO) which is an inorganic compound. Wholar prepared urea by boiling ammonium cynate with water. It was happened accidently.

$$NH_4CNO \longrightarrow NH_2 - CO - NH_2 \text{ (Urea)}$$

Urea was previously obtained from animal urine. After this experiment many organic compounds were prepared in laboratories and it was found that carbon is the essential element of all organic compounds.

NATURAL SOURCES OF ORGANIC COMPOUNDS

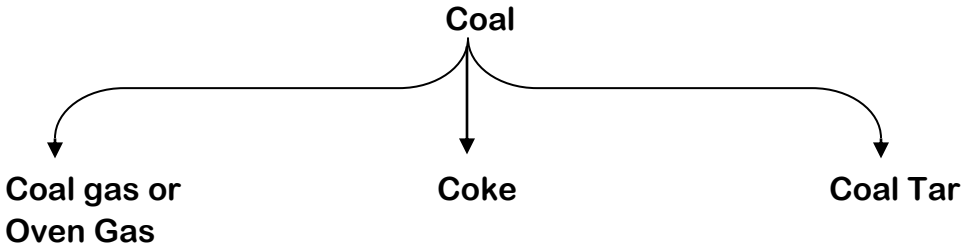
There are four main sources of organic compounds.

1. ANIMALS AND PLANTS:

Large numbers of organic compounds are obtained from animals and plants. Animals produce fats, proteins, urea, vitamins etc. Plants synthesize sugar, starch, glucose, citric acid, acetic acid, oils, vitamins, dyes, drugs etc.

2. COAL

Coal is a complex material. It is solid fuel which is obtained from mines. Many organic compounds are obtained from coal by the process of destructive distillation i.e. heating the coal in absence of air in an oven.



a. Coal Gas Or Oven Gas:

It is the mixture of CH_4, H_2, and CO gases. It is used as fuel.

b. Coke:

It is pure carbon. It is used in the manufacture of steel and calcium carbide.

c. Coal Tar:

It is black viscous liquid. It contains about more than 215 different aromatic organic compounds. Main compounds obtained by the fractional distillation of coal are benzene, toluene, xylene etc.

3. NATURAL GAS:

It is also one of the important sources of simple organic compounds like CH_4. It is found in porous rock in the earth crust where petroleum deposits occur.

It contains methane (CH_4) about 93% - 95% along with small quantities of ethane, propane, butane and nitrogen. It is used as fuel in homes, industries and into thermal electric power stations. In Pakistan large quantity of natural gas is found at Sui in Balouchistan, thus it is also called Sui gas.

4. PETROLEUM: (PETRA = ROCK , OLEUM = OIL)

In latin language petroleum means rock oil. In unrefined form it is also called crud oil or mineral oil. It is found below the surface of the earth. It has different color shades and bad smell. It is most abundant and important of all natural sources of organic compounds. It is extremely complex mixture or organic and some inorganic compounds. More than 500 organic compounds are obtained by refining of petroleum.

For Example: Petrol, kerosene oil, diesel oil, lubricating oil, wax and pitch or bitumen etc.

FRACTIONAL DISTILLATION

It is the process of separation of different liquids from their mixture by heating at their boiling points. Particular liquid change into vapors and then condense again into liquid.

FRACTIONAL DISTILLATION OF PETROLEUM OR REFINING OF PETROLEUM

Petroleum is refined by fractional distillation in a fractionating column. In this process petroleum or crude oil is heated above 400° to vaporize. The resulting vapors are then carried to a fractionating column having different temperature zones or several compartments of specific range of temperature.

Several fractions of petroleum condense and separate in these compartments. Some important fractions obtained by fractional distillation of petroleum are given below.

S.No:	Name Of Fraction	Boiling Range	Range Of C – Atoms	Uses
1	**Petroleum Gases:** Mixture of methane, ethane, propane and butane.	Below 20°C	$C_1 – C_4$	As a fuel for homes and industries.
2	**Petroleum Ether And Light Naptha** (Ligroin)	20°C – 60°C 60° – 120°C	$C_5 – C_6$ $C_6 – C_7$	Both products are used as organic solvents
3	**Gasolin Or Petrol**	40°C – 180°C	$C_6 – C_{10}$	As a fuel for automobiles engines and as solvents

4	**Kerosene Oil Or Paraffin Oil**	175°C – 325°C	$C_{11} – C_{18}$	As a fuel in domestic purpose, in jet engines as a solvents
5	**Diesel Oil Or Gas Oil**	250°C – 400°C	$C_{14} – C_{25}$	As a fuel for diesel engines for heating purpose.
6	**Lubricant Oils Or Heavy Oils**	Above 400°C	C_{20} – higher	As a lubricant of machines and engines
7	**Paraffin Wax**	Above 400°C	C_{20} – higher	For making candles, Vaseline, packing materials.
8	**Bitumen Or Pitch Or Asphalt**	Solid Residue left behind	Solid carbon	For surfacing roads

REFORMING OF PETROLEUM:

DEFINITION:

"The process in which the petrol of low quality which contains straight chain alkanes is converted into the petrol of high quality which contains branched chain alkanes by heating in the presence of catalyst is called reforming of petroleum."

EXPLANATION:

This process is used to increase the quality of petrol.

For Example:

When n – octane is heated at about 100°C in the presence of catalyst $AlCl_3$, then it is converted into 2,2,4 – trimethyl pentane.

$$CH_3 – (CH_2)_6 – CH_3 \xrightarrow[100°C]{} CH_3 – C(CH_3)_2 – CH_2 – CH_3$$

(n – octane) 2,2,4 – trimethyl pentane.

CRACKING OR PYROLYSIS

DEFINITION:

"The process in which larger alkanes molecules are decomposed into smaller alkane and alkene molecules on strong heating at high temperature and pressure in the presence of catalyst is called cracking or pyrolysis."

EXPLANATION:

This process is used to increase the quantity of petrol. Thermal decomposition of alkanes is called cracking where as thermal decomposition of other organic compounds is called pyrolysis.

For Example:

$$\underset{\text{Propane}}{CH_3 – CH_2 – CH_3} \xrightarrow{600°C} \underset{\text{Ethene}}{CH_2 = CH_2} + \underset{\text{Methane}}{CH_4}$$

HOMOLOGOUS SERIES

DEFINITION:

"A series of similar organic compounds which have same functional group and same structural feature but differ from each other by an integral number of methylene group ($– CH_2$) is called homologous series".

The members of a homologous series are called "Homologues" and the phenomenon is called "Homology". For Example: alkane, alkene, alkyne, alcohol, alkyl halide, ketone etc are homologous series because their members are differ from each other by an integral number of methylene group ($– CH_2$).

S.NO	ALKANES	ALCOHOLS	ALKYL HALIDES
1	CH_4 Methane	$CH_3 – OH$ Methyl alcohol	$CH_3 – Cl$ Methyl Chloride
2	$CH_3 – CH_3$ Ethane	$CH_3 – CH_2 – OH$ Ethyl alcohol	$CH_3 – CH_2 – Cl$ Ethyl Chloride
3	$CH_3 – CH_2 – CH_3$ Propane	$CH_3 – CH_2 – CH_2 – OH$ Propyl alcohol	$CH_3 – CH_2 – CH_2 – Cl$ Propyl Chloride

ISOMERISM

DEFINITION:

"The phenomenon by which different compounds have same molecular formula but different structural formulas due to different arrangements of atoms or functional groups is called isomerism." The different compounds are called isomers. Due to different structural formulas, isomers have different physical and chemical properties.

For Example:

n – butane and iso – butane have same molecular formula i.e. C_4CH_{10}, but different structures.

$CH_3 – CH_2 – CH_2 – CH_3$
(n – butane)

$CH_3 – CH(CH_3) – CH_3$
(Iso – butane)

Thus n – butane and iso – butane are isomers.

FUNCTIONAL GROUP

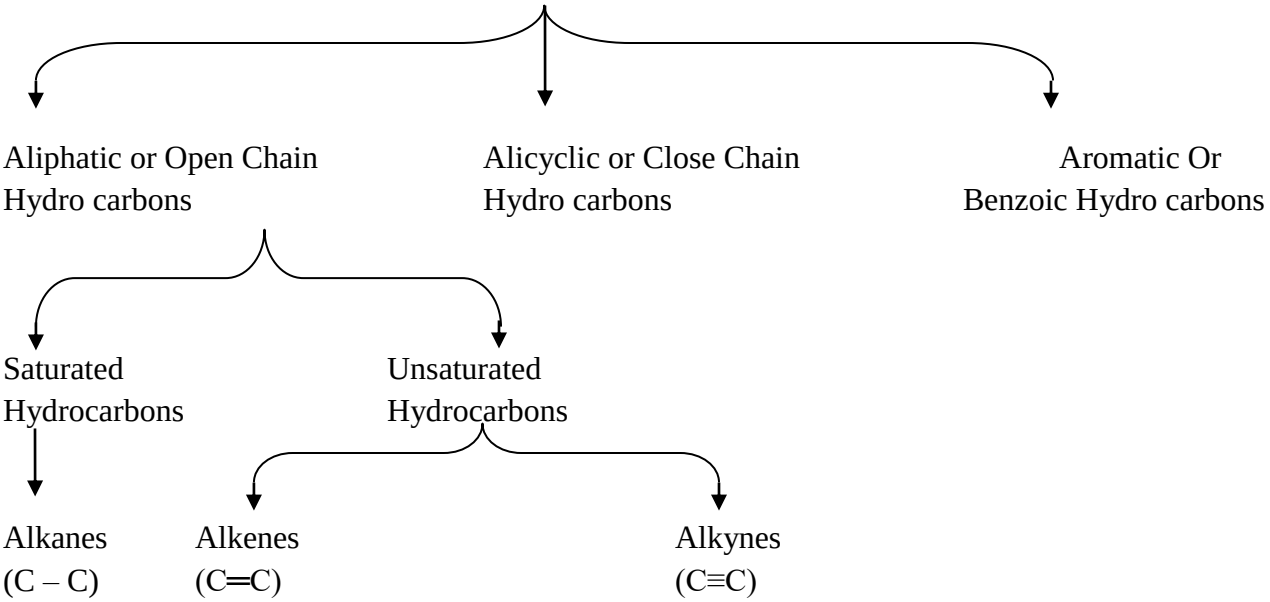
An atom or group of atoms which is present within the molecule of organic compounds and responsible for the characteristic properties of that organic compound is called functional group.

Functional group determines the basic chemistry of an organic compound. Each family of organic compound possesses its own functional group.

The function groups of some important organic compounds are given below.

Functional Group	Organic Compounds	General Formula of Compound	Example Of Compound
– OH (Hydroxyl Group)	Alcohols	R – OH	CH3 – OH (Methyl Alcohol)
– X (Halide Group)	Alkyl Halides	R – X	CH3 – Cl (Methyl Chloride)
O – C – OH or – COOH (Carboxyl Group)	Carboxylic acids Or Organic acids	O R – C – OH or R – COOH	O CH_3 – C – OH or CH_3COOH (Acetic Acid)

HYDROCARBONS AND THEIR CLASSIFICATION:



1. ALIPHATIC OR OPEN CHAIN HYDROCARBONS:

Aliphatic hydro carbons are composed of open chain of carbon atoms they are futher classified into two types.

i. Saturated Hydrocarbons:

They contain only one single bond between carbon atoms. In these compounds four valences of carbon atoms are fully utilized or satisfied.

For Example:

Alkanes → methane (CH_4), ethane (C_2H_6).

ii. Unsaturated Hydrocarbons:

They contain at least one double or triple bond between carbon atoms. In these compounds four valences of C – atoms are not fully utilized or satisfied.

For Example:

a. Alkene → ethene ($CH_2 = CH_2$), Propene ($CH_2 = CH - CH_3$)
b. Alkyne → ethyne ($CH \equiv CH$), Propene ($HC \equiv C - CH_3$)

2. ALICYCLIC OR CLOSED CHAIN HYDROCARBONS:

In these hydrocarbons carbon atoms are arranged in closed rings. Their general formula is CnH_2n.

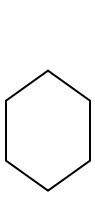
For Example:

Cyclo Propane Cycle Butane

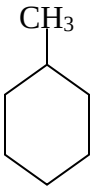
3. AROMATIC OR BENZENOID HYDROCARBONS:

They contain six membered carbon closed ring i.e. Benzene ring. Benzene and benzene ring containing compounds are called aromatic compounds.

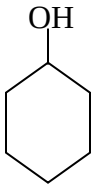
For Example:



Benzene
(C_6H_6)



Toluene
($C_6H_5 - CH_3$)



Phenol
($C_6H_5 - OH$)

ALKANES:

Alkanes are saturated hydro carbons in which carbon atoms are bonded by single covalent bond. In alkanes all four valences of carbon atoms are fully satisfied. i.e. each carbon atom is bonded with four atoms. They have general formula $CnH_2n + 2$. They are stable and unreactive. They are also called "Paraffin's".

S.No:	Name Of Compounds	Molecular Formula	Structure
1	Methane	CH_4	CH_4
2	Ethane	C_2H_6	$CH_3 - CH_3$
3	Propane	C_3H_8	$CH_3 - CH_2 - CH_3$
4	Butane	C_4H_{10}	$CH_3 - CH_2 - CH_2 - CH_3$
5	Pentane	C_5H_{12}	$CH_3 - CH_2 - CH_2 - CH_2 - CH_3$
6	Hexane	C_6H_{14}	$CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$
7	Heptane	C_7H_{16}	.....
8	Octane	C_8H_{18}	.....
9	Nonane	C_9H_{20}	.....
10	Decane	$C_{10}H_{22}$	.....

C_1 → Meth	C_2 → Eth	C_3 → Pro	C_4 → But
C_5 → Pent	C_6 → Hex	C_7 → Hept	C_8 → Oct
C_9 → Non	C_{10} → Dec		

ALKENES:

Alkenes are unsaturated hydro carbons which contain at least one double bond between carbon atoms. They have genral formula CnH_2n. They are also called "Olefins" (meaning oil making). They are more reactive then alkanes.

S.No:	Name Of Compounds	Molecular Formula	Structure
1	Methene	Not Possible	— —
2	Ethene	C_2H_4	$CH_2{=}CH_2$
3	Propene	C_3H_6	$CH_2{=}CH - CH_3$
4	Butene	C_4H_8	$CH_2{=}CH - CH_2 - CH_3$
5	Pentene	C_5H_{10}	$CH_2{=}CH- CH_2- CH_2 - CH_3$
6	Hexene	C_6H_{12}	$CH_2{=}CH- CH_2- CH_2- CH_2 - CH_3$
7	Heptene	C_7H_{14}	.....
8	Octene	C_8H_{16}	.....
9	Nonene	C_9H_{18}	.....
10	Decene	$C_{10}H_{20}$	.....

ALKYNES:

Alkynes are unsaturated hydro carbons which contain at least one triple bond between carbon atoms. They have genral formula $CnH_2n - 2$. They are also called "Acetylene". They are more reactive then alkanes and alkenes.

S.No:	Name Of Compounds	Molecular Formula	Structure
1	Methyne	Not Possible	.....
2	Ethyne	C_2H_2	$HC{\equiv}CH$
3	Propyne	C_3H_3	$HC{\equiv}C - CH_3$
4	Butyne	C_4H_6	$HC{\equiv}C - CH_2 - CH_3$
5	Pentyne	C_5H_8	$HC{\equiv}C- CH_2- CH_2 - CH_3$
6	Hexyne	C_6H_{10}	$HC{\equiv}C- CH_2- CH_2- CH_2 - CH_3$
7	Heptyne	C_7H_{12}	.....
8	Octyne	C_8H_{14}	.....
9	Nonyne	C_9H_{16}	.....
10	Decyne	$C_{10}H_{18}$	.....

CHEMISTRY OF METHANE:

INTRODUCTION:

Methane is first and simplest compound of alkanes. It is present up to 94% in natural gas and also found in marshy place, thus it is also called marsh gas.

LABORATORY PREPARATION:

1. **From Sodium Acetate And Soda Lime:**

   Mixture of NaOH and CaO is called Soda lime. When anhydrous sodium acetate ($CH_3COO - Na$) is heated with soda lime (NaOH + CaO), it produces methane.

   $CH_3COO - Na + NaOH \xrightarrow{CaO} CH_4 + Na_2CO_3$

2. **By Heating Aluminium Carbide (Al_4C_3):**

   When aluminium carbide is heated with water it produces methane.

   $Al_4C_3 + 12H_2O \longrightarrow 3CH_4 + 4Al(OH)_3$

PHYSICAL PROPERTIES:

i. Methane is colorless, odourless and non poisonous gas.
ii. Its molecule is symmetrical and non polar.
iii. It is slightly soluble in water, about 5% but readily soluble in alcohol and other organic solvents.
iv. It is lighter than air.

CHEMICAL PROPERTIES:

Methane is non polar molecule. It is relatively uncreative. It reacts with halogens and oxygen. Important reactions of methane are halogenations and combustion reactions.

HALOGENATION REACTION OF CH_4:

The replacement of one or more H – atoms with halogen (X) atoms is called halogenations. It is the example of substitution reactions.

Halogenation reactions of methane are carried out in the presence of sunlight or ultra – violet light (UVL) which act as catalyst.

- **Reaction With Cl_2 Gas:**

  Methane gas reacts with Cl_2 gas in the presence of sunlight or UVL hydrogen atoms of methane molecule are replaces one by one and following products is formed.

i. $CH_4 + Cl_2 \xrightarrow{\text{sunlight}} CH_3 - Cl + HCl$ (chloro – methane)

ii. $CH_3Cl + Cl_2 \xrightarrow{\text{sunlight}} CH_2 - Cl_2 + HCl$ (Dichloro – methane)

iii. $CH_2Cl_2 + Cl_2 \xrightarrow{\text{sunlight}} CH - Cl_3 + HCl$ (Trichloro – methane)

iv. $CHCl_3 + Cl_2 \xrightarrow{\text{sunlight}} C - Cl_4 + HCl$ (Tetra chloro – methane or Carbon tetra chloride)

COMBUSTION OR OXIDATION OF CH_4:

Methane burns in excess of air or O_2 at high temperature and produces CO_2, H_2O (water vapors) and large amount of heat energy.

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

It is highly exothermic reaction.

USES OF METHANE:

1. It is used as an important industrial and domestic fuel.
2. It is used in the preparation of methanol ($CH_3 – OH$), carbon black, carbon tetra chloride ($C – Cl_4$), chloro form ($CH – Cl_3$) and Urea fertilizer.

CHEMISTRY OF ETHENE (C_2H_4)

INTRODUCTION:

Ethene is the first member of alkene series. Its molecular formula is C_2H_4. Commonly it is called Ethylene. It is unsaturated hydrocarbon because it contains one double bond between two carbon atoms.

PREPARATION:

By De – Hydration of Ethyl Alcohol:

The removal of water molecule from any compound is called dehydration.

When ethyl alcohol is heated with sulphuric acid (H_2SO_4) at 160° – 180°C and with aluminium oxide (Al_2O_3) at 300° - 350°C then water molecule is removed from ethyl alcohol and ethene is formed.

i. $CH_3 – CH_2 – OH \xrightarrow[160° - 180°C]{} CH_2 = CH + H_2O$

ii. $CH_3 – CH_2 – OH \xrightarrow[300° - 350°C]{} CH_2 = CH + H_2O$

PHYSICAL PROPERTIES:

1. It is colorless gas having pleasant smell.
2. It is slightly lighter than air and burns with luminous flame.
3. It is slightly soluble in water but radialy soluble in organic solvent like alcohol, ether etc.
4. It produces anesthesia on inhalation.

CHEMICAL PROPERTIES:

Ethene molecule contains double bond between two carbon atoms. Due to presence of double bond ethane is more reactive than methane. Ethene shows following types of reactions.

1. Addition reaction
2. Combustion reaction
3. Polymerization reaction

1. ADDITION REACTION OF C_2H_4:

Ethene adds one molecule of H_2, Cl_2 and HX (HCl, HBr, or HI).

i. Addition of Hydrogen or Hydrogenation:

Addition of hydrogen molecule is called *hydrogenation.*

Ethene adds one molecules of hydrogen in the presence of Ni as catalyst at 250° – 300°C and ethane is formed.

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

ii. Addition Of Halogen Or Halogenations Reactions:

Addition of halogen molecule is called *halogenations.*

Ethene adds one molecules of halogen i.e. Cl_2, Br_2 or I_2 at room temperature to form 1,2 – dihalo ethane.

i. $CH_2 = CH_2 + Cl_2 \longrightarrow CH_3 - CH_3$ (1,2 – dichloro ethane)

ii. $CH_2 = CH_2 + Br_2 \longrightarrow CH_3 - CH_3$ (1,2 – dibromo ethane)

iii. Addition Of Hydrogen Halide (HX): Or Hydro – Halogenation Reaction:

Addition of one molecule of hydrogen halide (HX= HCl, HBr, or HI) is called *Hydro – halogenations.*

Ethene adds one molecule of hydrogen halide (HX) i.e. HCl, HBr, or HI to form alkyl halide (R – X).

i. $CH_2 = CH_2 + HCl \longrightarrow CH_3 - CH_3 - Cl$ (Ethyl Chloride)

ii. $CH_2 = CH_2 + HBr \longrightarrow CH_3 - CH_3 - Br$ (Ethyl Bromide)

2. COMBUSTION REACTION:

Like methane, ethene burns in air or O_2 at high temperature and produces CO_2, H_2O (water vapors) and large amount of heat energy.

$CH_2 = CH_2 + 3O_2 \longrightarrow CO_2 + 2H_2O +$ heat

3. POLYMERIZATION REACTION:

When ethene molecules are heated at 200°C under 100 atmospheric pressure in the presence of few traces of O_2 then ethene molecule combine with each other by the process of polymerization and polyethene is formed.

$n[\underset{\text{ethene}}{CH_2=CH_2} + CH_2=CH_2 + \ldots\ldots] \xrightarrow[100\text{ atm}]{200^\circ} [\ldots - CH_2 - CH_2 - CH_2 - CH_2 - \ldots]$ (polythene)

Polyethene is common plastic. Its trade name is "Polyethylene" it is widely used in making polythene bags.

USES OF ETHENE:

1. It is used in making common plastic called polythene.
2. It is used as starting material for the preparation of alcohol, ethyl chloride and other organic compounds.
3. It is used in welding and cutting metals.
4. Ethene – oxygen mixture is used as general anesthetic compound.