CHAPTER # 15
ORGANIC COMPOUNDS

CLASSIFICATION

There are two main classes of chemical compounds
Organic compound
Inorganic compound

Organic compound: The compounds which were vegetable and animal origin were called organic compound.

Example:
Acetic acid (from vineger)
Alcohol (from wine)
Tartaric acid (from grapes)

Inorganic compound: The compounds which were of mineral origin were known as inorganic compound.

Example:
Table salt (NaCl)
Marble ($CaCO_3$)
Carbon dioxide (CO_2)

OLD DEFINITION OF ORGANIC CHEMISTRY

According to Berzelius "Study of carbon

compounds is called Organic chemistry."

Rejection:

However there are several compounds like CO, CO_2, CS_2, CO_3^{-2}, HCO_3^{-1}, CN^{-1}, SCN^{-1}, etc are studied in inorganic chemistry because of their properties.

Modern Definition of Organic Chemistry:

Branch of chemistry which deals with the study of Carbon and Hydrogen (Hydrocarbons) and their derivatives.

SOURCES OF ORGANIC COMPOUNDS

Main sources of organic compounds are fossil fuels. i.e.

- Coal
- Petroleum
- Natural gas

∴ Whate are main sources of organic compounds?

COAL

- Coal is one of the major sources of organic compounds.
- It yields/produce coal, coal tar and coal gas on pyrolysis or destructive distillation
- More than 200 organic compounds have been directly isolated from coal-tar.
- Coal-tar products form the starting materials for the manufacture of thousands of useful aromatic compounds including perfumes, drugs, dyes, photographic developers and others.

PETROLEUM

A black thick sticky liquid seeps out of the ground is called petroleum or crude oil.
It is a complex mixture of hydrocarbons whose composition varies according to its place of occurrence.
Important products produced from petroleum are methane, Ethylene, Propylene, Acetylene, Benzene, Toluene, Xylene.

NATURAL GAS

It is a mixture of low boiling hydrocarbons
Major portion of natural gas is methane (85%); other gases include ethane, propane, butane, N_2, CO_2.
It is formed by decomposition of organic matter
In Pakistan, there are vast reserves of gas at Sui in Baluchistan, Sindh, and Punjab.

PLANTS AND NATURAL PRODUCT CHEMISTRY

Many organic compounds are obtained directly from plant and animal sources by suitable methods of isolation.

Example:

Hormones
Vitamins
Perfumes
Carbohydrates (Cellulose, sugars, starches)
Proteins (Silk, wool, casein, food proteins)
Fat and oils (Cottonseeds, soybeen oils, lard, butter)
Alkaloids
flavours
Resins

"Naturally occuring organic compounds containing

nitrogen are called Alkaloids."
e.g. Quinine, morphine, strychinine)

PARTIAL SYNTHESIS

In this synthesis an intermediate product of reaction is used to synthesize the required product

Example:

Preparation of vegetable ghee and formation of soap.

TOTAL SYNTHESIS

In this synthesis, the starting material is converted through many steps into targeted product.

Example:

Synthesis of urea by Wohler (1828)

$$2NH_3 + CO_2 \longrightarrow NH_4CNO + H_2O$$

$$NH_4CNO \xrightarrow{\Delta} NH_2CONH_2$$

Ammonium Carbamate → Urea

What is the difference between Partial and total synthesis?

FERMENTATION/BIOTECHNOLOGY

The chemical breakdown of an organic compound with the help of micro-organisms such as bacteria, yeast, etc is called fermentation

Example:

The fermentation of molasses or sugar produces, alcohol, vinegar and many other products.

(Benzole) 

DATE

Distructive distillation of coal is also called Carbonization.

COAL (As a source of organic compound)

What is coal? How is it used as a source of organic compound?

"Coal is produced by the decaying of trees burried under the Earth crust under the influence of high temperature and pressure. These trees are converted into coal."

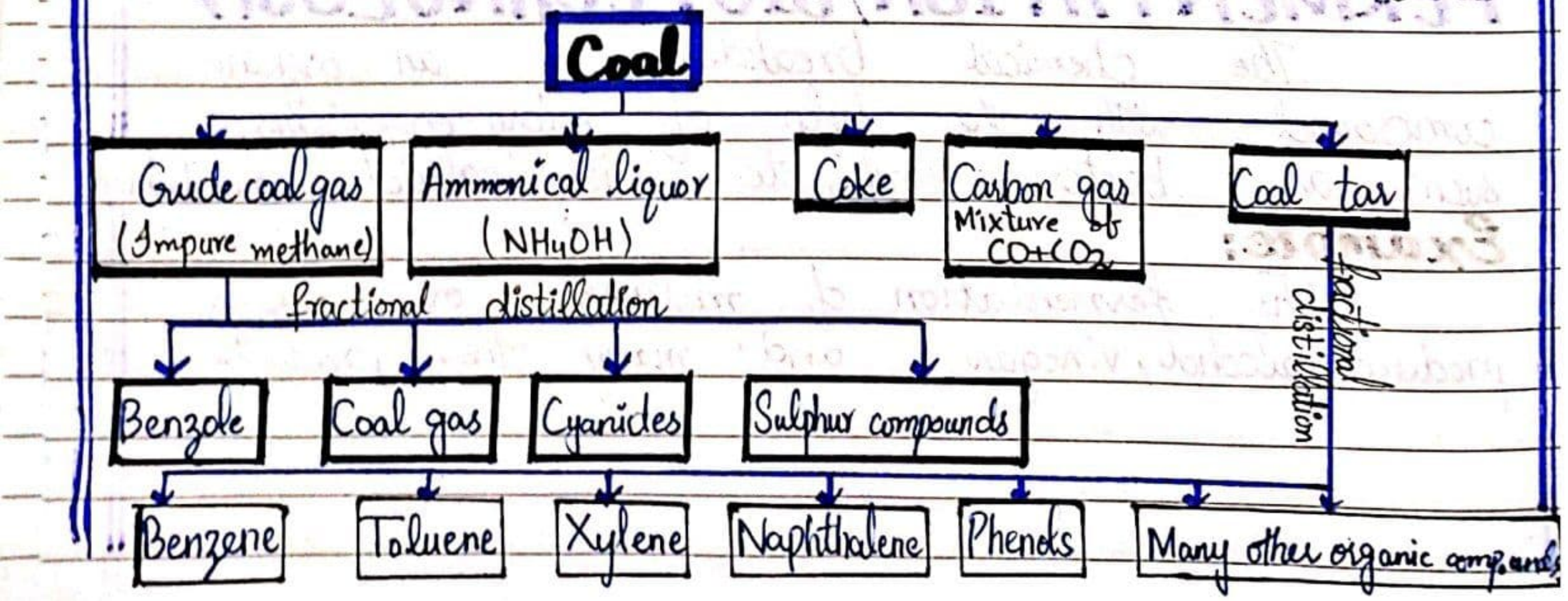
Distructive Distillation of Coal

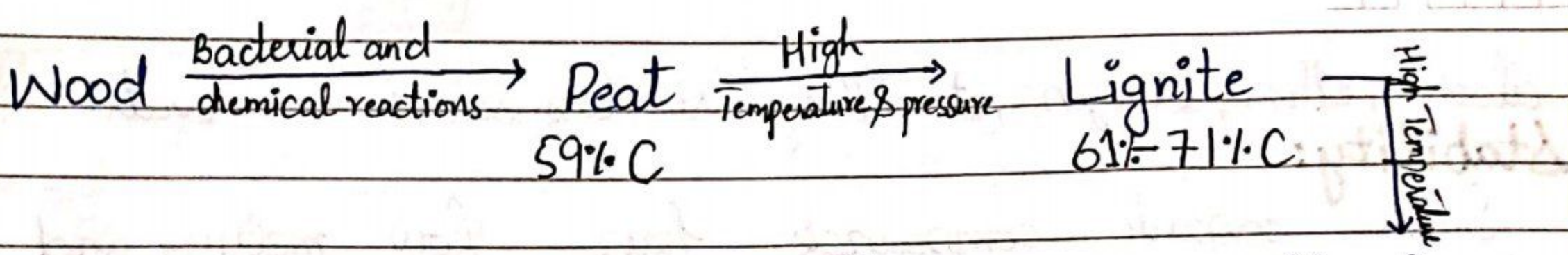
"When coal is heated in the absence of air (temperature ranging from 500 – 1000°C); it is converted into coke, coal gas, and coal tar."

Coal tar contains a large number of organic compounds which are seperated out on fractional distillation.

The total coal reserves of Pakistan are estimated by the geological survey of Pakistan to be 184 billion tones.

Distructive Distillation of Coal: (Carbonization)





∵ Conversion of wood into coal undes going different forms of coal.

CHARECTERESTICS OF ORGANIC COMPOUNDS

Write down characterestic of organic compound from inorganic compound?

Organic compounds have entirely different properties from inorganic compounds.

Some of their general properties are described below:

Composition:

Carbon is essential consituent of all organic compound.

Combustion:

Organic compounds with high percentage of carbon are generally combustible in nature.

Melting and Boiling Points:

Organic compounds generally have low melting and boiling points and are volatile in nature.

Solubility:

Organic compounds with non-polar linkages are generally soluble in organic solvents such as

alcohol, ether, benzene, etc. They are less soluble in water.

Stability:

Since organic compounds have low melting and boiling points, they generally unstable and decompose at high temperature into simple substances.

Electrical Conductivity:

Due to the presence of covalent bonds, organic compounds are poor conductor of electricity both in fused state and in solution form.

Source:

Most of the organic compounds are obtained from plants and animal sources.

Rate of Reaction:

Their rates of reaction are very slow and need specific conditions due to covalent bond.

∴ How organic compounds are used in our daily life?

USES OF ORGANIC COMPOUNDS

The importance of organic compounds in modern everyday life is illustrated by following list:

Food:

Proteins, fats, oils, carbohydrates

Clothing:

(Cotton, silk, wool, nylon, rayon, dacron)

The natural fibre like cotton, silk, and wool have plant and animal origin. Synthetic fibre like rayon, dacron, and nylon are prepared in industry.

Shelter:

Wood, paints, varnishes

Power and Transportation:

(Natural gas, Petroleum products, Coal)

They are organic substances used for power and transportation.

Medicines and Drugs:

(Penicillin, Streptomycin)

All types of the medicines used in the allopathy, homeopathy and desi-tib involve the organic compounds.

Insectisides

Insecticides like D.D.T, which are being widely used are organic substances.

Hormones and Steroids:

Hormones and steroids are complex organic compounds.

Vitamins and Enzymes:

All the vitamins which are dietary factors are organic compounds. Enzymes are also organic compounds.

Antiseptics and Anesthetics

These are the families of the medicines and are organic in nature.

Pigments and dyes:

Pigments and dyes are used for paints and are organic in nature

Paper and inks:

Paper and inks are the sources of civilization and organic nature.

Perfumes and flavours:

Perfumes, flavours and all cosmetics are organic in nature.

Plastic, rubber and resins:

Plastic, rubber and resins are organic in nature.

Propellants and Explosives

Propellants, explosives and refrigerents are well-known organic materials.

Soaps and detergents:

Soaps and detergents are organic compounds.

Herbicides

Teflon

Photographic films and developers

They are also organic in nature.

BUCKY BALLS

1) In 1985, a new group of allotropic forms of carbon was discovered.
2) The full name of Bucky Balls is Buckminister Fullerenes.
3) Scientists named it after an architect Buckminister, who designed a Bucky Balls shaped building in Montreal
4) Bucky Balls are used as semi-conductors and lubricants.
5) These have carbon atoms ranging from 40 to 100.
6) The simplest of them C_{60} and its molecule is made up of sixty carbon atoms.
7) The carbon atoms are arranged in a hollow cage like structure. They are called Bucky Balls.
8) The carbon atoms join together to form Pentagon and Hexagon structures.

∴ What is functional group?

FUNCTIONAL GIROUP

A functional group is an atom or group of atoms in a molecule that gives characterestics properties to the molecule.

Example:

Double bond, Triple bond, -Cl, -Br, -NH_2, -OH, etc

$\underbrace{CH_3CH_2CH_2CH_2CH_2}$ — (OH) Amyl alcohol/Pentanol

Hydrocarbon Portion functional group

∴ Give reason for the importance of organic chemistry.

Importance:

Each functional group undergoes characterestic reactions. The concept of functional group is important in organic chemistry for three main reasons:

1— Functional groups serve as basis for nomenclature of organic compounds

2— Functional group serve to classify organic compounds into classes. All compounds with the same functional group belong to the same class.

3— A functional group is a site of chemical reactivity in a molecule.

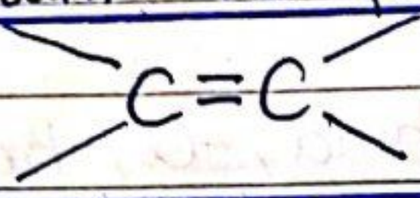
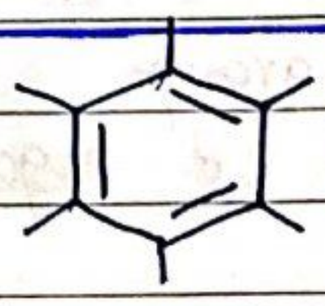
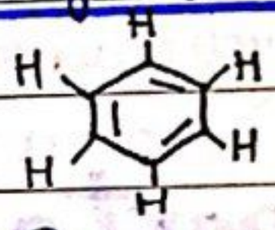
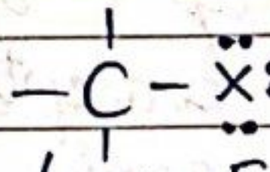
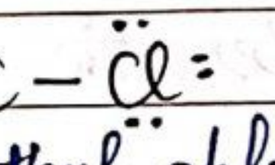
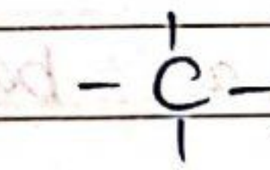
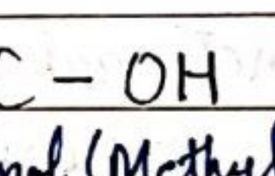
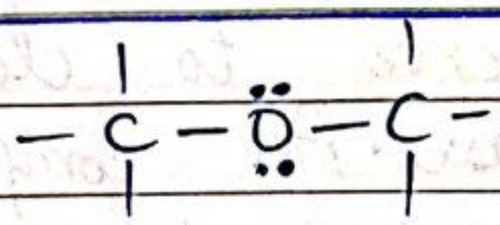
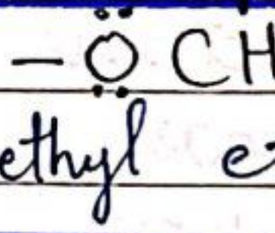
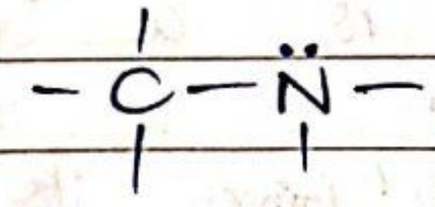
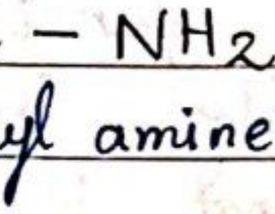
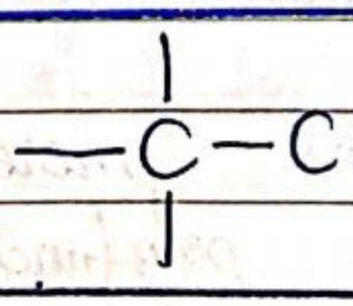
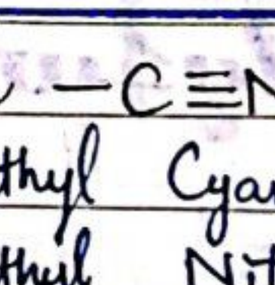
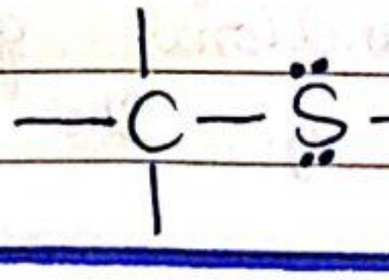
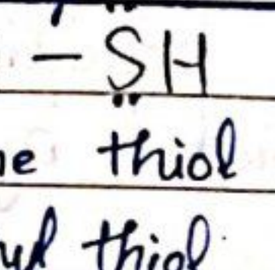
∴ What is functional group? Give its importance?

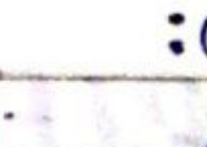
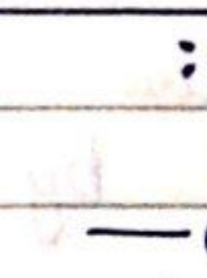
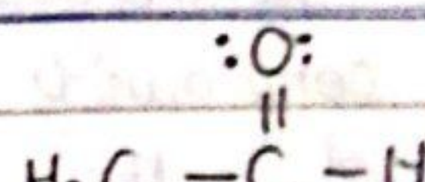
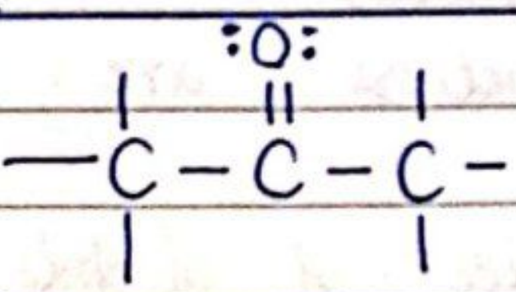
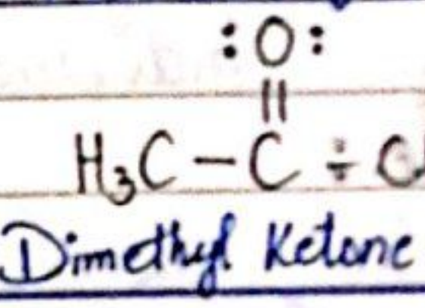
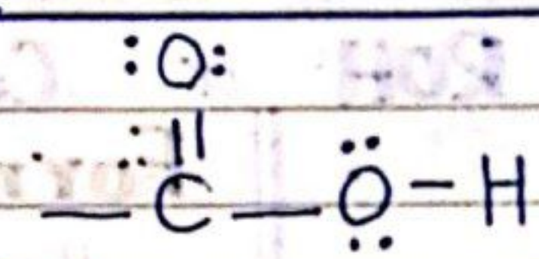
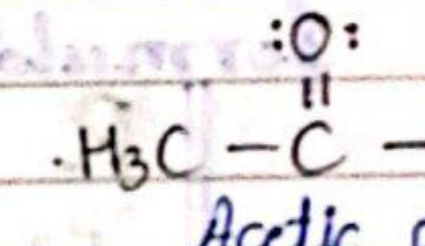
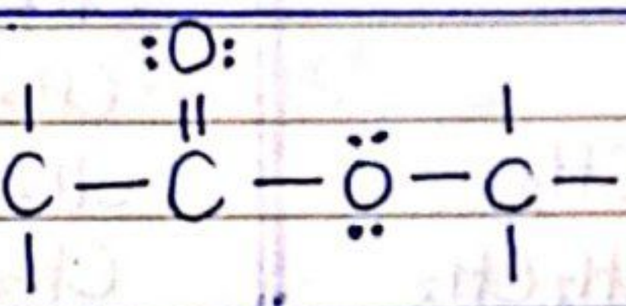
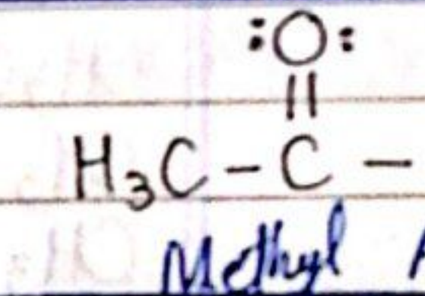
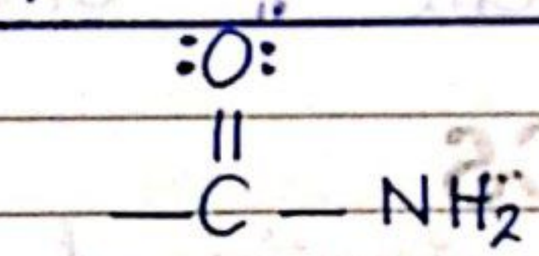
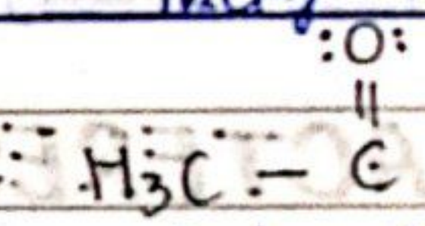
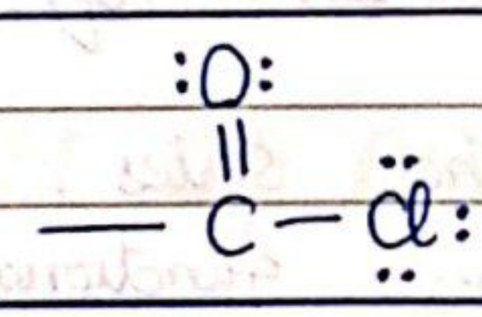
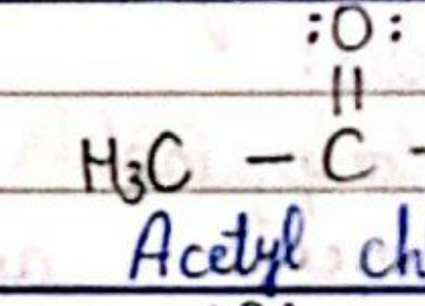
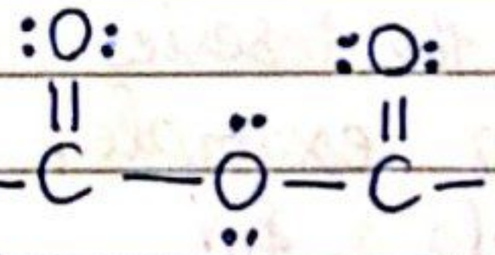
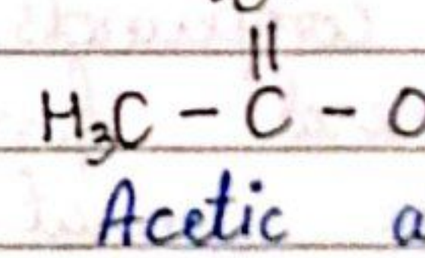
Polyfunctional

A molecule contains more than one functional group is called polyfunctional group.

* Properties of each functional group may be modified by the presence of the others.

Write down any ten functional groups of organic compounds?

Family	Structure of functional group	Simple Example
Alkane	Containing only C-H and C-C single bond Contain no functional group	CH_3-CH_3 Ethane
Alkene		$H_2C=CH_2$ Ethene
Alkyne		$H-C\equiv C-H$ Ethyne (Acetyne)
Arene		 Benzene
Halide	 (X = F, Cl, Br, I)	 Methyl chloride
Alcohol		 Methanol (Methyl alcohol)
Ether		 Dimethyl ether
Amine		 Methyl amine
Nitrile		 Methyl Cyanide (Methyl Nitrile)
Thiol		 Methane thiol Methyl thiol

Carbonyle		Aldehydes, Ketones, acids and derivative. of acids
Aldehyde		 Acetaldehyde
Ketone		 Dimethyl Ketone (Acetone)
Carboxylic acid		 Acetic acid
Ester		 Methyl Acetate
Amide		 Acetamide
Carboxylic acid Chloride		 Acetyl chloride
Carboxylic acid anhydride		 Acetic anhydride

What is Homologous Series?

HOMOLOGOUS SERIES

A homologous series is a series of organic compounds in which two successive members of the series differ by a CH_2 unit (or by 14 amu by molar mass)

The individual members are called Homolog.

Example:

The homologous series of alcohols can be represented

General formula is ROH or $C_nH_{2n+1}OH$

n	R	Formula
1	CH_3	CH_3OH
2	CH_3CH_2	CH_3CH_2OH
3	$CH_3CH_2CH_2$	$CH_3CH_2CH_2OH$
4	$CH_3CH_2CH_2CH_2$	$CH_3CH_2CH_2CH_2OH$

CHARACTERESTICS

The general characterestics of homologous series are:

1- All compounds in the series contain the same elements and the functional group.

2- All compounds in the series can be represented by a general formula. For example;

The general formula for

Alkane C_nH_{2n+2}

Alkene C_nH_{2n}

Alkyne C_nH_{2n-2}

What are general formulas for alkanes, alkenes, alkyne?

3- The molecular formula of each Homologue series differ by CH_2 unit to the next one.
4- All compounds in the series can be prepared by similar methods.
5- They have similar chemical properties.
6- There is a gradual change in physical properties as the length of carbon chain increases in the same homologous series.

Give the chemical tests for the detection of elements in Organic compounds?

DETECTION OF ELEMENTS IN ORGANIC COMPOUNDS

Carbon is an essential constituent of all organic compounds. Hydrogen is also present in almost all organic compounds but some of them may contain N, S, X, O, P and Metals.

DETECTION OF CARBON AND HYDROGEN

Small amount of organic compound + CuO + heat ⟶ CO_2 + H_2O

CO_2 ↓ Lime water (colar lex) ↓ $CaCO_3$ (white ppt)

H_2O ↓ $CuSO_4$ (Anhydrous) white ↓ $CuSO_4 \cdot 5H_2O$ (Hydrated) blue

$C + 2CuO \longrightarrow CO_2 + 2Cu$

$CO_2 + Ca(OH)_2$ [Lime water] $\longrightarrow CaCO_3$ [white ppt] $+ H_2O$

$H_2O + CuO \longrightarrow Cu + H_2O$

$CuSO_4 + 5H_2O \longrightarrow CuSO_4 \cdot 5H_2O$

Anhydrous (white) — Hydrated (blue)

DETECTION OF N,S,X

LASSAIGNE'S SOLU$TION

It is also called Sodium Extract.

1- Cut a small piece of sodium metal with the help of a knife.
2- Put thise piece of sodium metal in a fusion tube.
3- Heat the fusion tube in a flame to melt Na-metal.
4- When Na-metal is melted, then add small amount of powdered organic compound into fusion tube.
5- Then heat the fusion tube again till its bottom become red hot.
6- Break this fusion tube in a china dish containing $20 cm^3$ of distilled water.
7- Mixed, boil and then filter the solution.
8- The filtrate obtained is called Lassaigne's solution or sodium extract.
9- Divide this filtrate into three portion and test the presence of N, S, and X (halogens) respectively.

Reactions:

$$2Na + S \longrightarrow Na_2S$$
$$Na + C + N \longrightarrow NaCN$$
$$Na + N + C + S \longrightarrow NaSCN$$
$$Na + X \longrightarrow NaX \quad \text{where} \quad X = Cl, Br, I$$

Nitrogen test:

Lassaigne filtrate + NaOH + Freshly prepared $FeSO_4$ + boil + $FeCl_3$ + HCl
- → Prussian blue ppt (N)
- → Blood red color (N & S)

$$Na + C + N \longrightarrow NaCN$$

$$6NaCN + FeSO_4 \longrightarrow Na_4[Fe(CN)_6] + Na_2SO_4$$

$$3Na_4[Fe(CN)_6] + 4FeCl_3 \xrightarrow{HCl} Fe_4[Fe(CN)_6]_3 + 12NaCl$$

Prussian blue ppt

$$6NaSCN + FeSO_4 \longrightarrow Na_4[Fe(CNS)_6] + Na_2SO_4$$

$$3Na_4[Fe(CNS)_6] + 4FeCl_3 \xrightarrow{HCl} Fe_4[Fe(CNS)_6]_3 + 12NaCl$$

Blood red ppt

How sulphur can be detected in organic compounds?

Sulphur test:

Lassaigne's solution + Acetic acid + boil to expel H_2S ⟶ Lead Acetate paper (turns black) (S)

$$Na_2S + 2CH_3COOH \longrightarrow H_2S + 2CH_3COONa \text{ (Sodium Acetate)}$$

$$H_2S + (CH_3COO)_2Pb \longrightarrow PbS + 2CH_3COOH$$

Lead Acetate paper — Black ppt

Halogen test:

Lassaigne's solution + HNO_3 + boil to expel CN^-s + cool + $AgNO_3$ ⟶

- white ppt (Cl^-) — Soluble in NH_4OH
- pale yellow ppt (Br^-) — partially soluble in NH_4OH
- deep yellow ppt (I^-) — insoluble in NH_4OH

$$NaX + AgNO_3 \longrightarrow AgX + NaNO_3$$

$$NaCl + AgNO_3 \longrightarrow AgCl \text{ (white ppt)} + NaNO_3$$

$$NaBr + AgNO_3 \longrightarrow AgBr \text{ (pale yellow ppt)} + NaNO_3$$

$$NaI + AgNO_3 \longrightarrow AgI \text{ (Deep yellow ppt)} + NaNO_3$$

Q No 02:

(i)

See page # 10

(ii)

See page # 04

(iii)

See page # 05

(iv)

See page # 13

(v)

See page # 16

Q No 03:-

(Q No 1)

See page # 02

(Q No 02)

See page # 07

(Q No 03)

See page # 10,11,12

(Q No 04)

See page # 14

EXERCISE

Q1: MCQ's

i) methane (d)
ii) covalent bond (c)
iii) Benzene (d)
iv) Functional group (a)
v) All of above (d)
vi) CH_3-CH_2-OH (a)
vii) Sodium (b)
viii) Deep Yellow (d)
ix) Deep blue (b)
x) 60 (c)
xi) Poly-functional (b)

Q2: Give brief answers for the following questions:

i. What is functional group?

Ans Refer to Page# 13.

ii. What is the difference b/w partial and total synthesis of organic compounds?

Ans Refer to Page # 5

iii) How organic compounds are derived by fermentation process?

Ans Refer to Page # 6