

Unit #15:

Organic compounds

Q: What are the two main classes of chemical compounds? Define them.

Ans: There are two main classes of compounds.

- (i) Organic compounds
- (ii) Inorganic compounds

(i) **Organic compounds:**

The compounds which were of vegetable or animal origin were called organic compounds.

* For example:

- Acetic acid (from vinegar)
- Alcohol (from wine)
- Tartaric acid (from grapes), etc.

(ii) **Inorganic compounds:**

The compounds which were of mineral origin were known as inorganic compounds.

* For example:

- Marble
- Table salt
- Carbon dioxide, etc.

Q: Write down the old definition of organic chemistry.

Ans: Organic chemistry is now defined as the chemistry of compounds of carbon as carbon is the essential element in all organic compounds.

Because these compounds are not component of animal and plant kingdom.

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

→ Modern chemistry of organic compound:

Organic chemistry is that branch of chemistry which deals with the study of compounds of carbon and hydrogen (Hydrocarbons) and their derivatives.

Sources of organic compounds

Q. What are the main sources of organic compounds?

Ans: The main sources of organic compounds are coal, petroleum and natural gas. These are called fossil fuels.

(i) Coal:

Coal is one of the major sources of organic compounds. It yields coke and coal-tar, on pyrolysis or destructive distillation. More than 200 organic compounds have been directly isolated from coal-tar. These 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:

In some parts of the world, a black thick sticky liquid seeps out of the ground. This liquid is called petroleum or crude oil. Petroleum is a complex mixture of hydrocarbons whose composition varies according to its place of occurrence.

Natural Gas:

It is a mixture of low boiling hydrocarbons. Major portion of the natural gas is methane (CH_4 about 85%); other gases include ethane, propane and butane. It is formed by the decomposition of organic matter.

In Pakistan there are vast reserves of gas at Sui in Baluchistan, Sindh and Punjab.

What is the difference between partial and total synthesis of organic compounds?

Partial synthesis:

In this synthesis an intermediate product of reaction is

used to synthesize the required product
Bio-molecules are treated with
other reagents to get the targeted
drugs or medicines, etc.

Example:

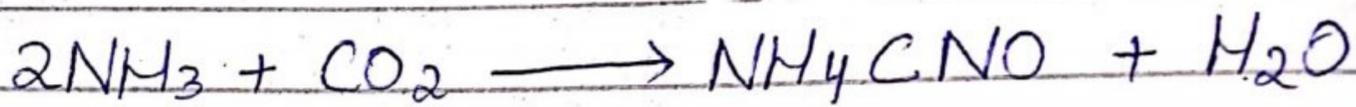
Preparation of vegetable ghee
and formation of soap.

Total synthesis:

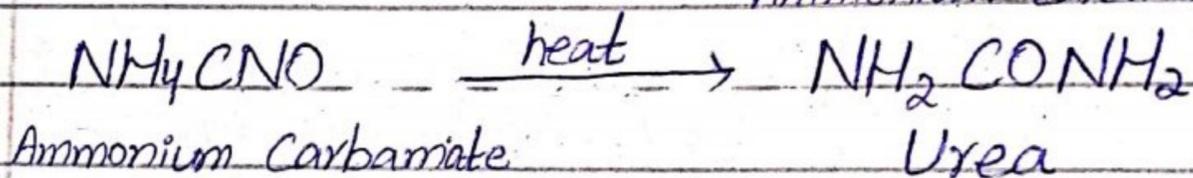
In this synthesis,
the starting material is converted
through many steps into targeted
product.

Example:

Synthesis of urea: by Wohler (1828)



Ammonium Carbamate



Ammonium Carbamate

Urea

→ **Fermentation / Biotechnology:**

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

The field of applied biology that
deals with the study of the use
of living organisms and bio processes
in medicines, technology and engineering
is called biotechnology.

Biotechnology is the use of living organisms to develop useful products.

Example:

For example, the fermentation of molasses or sugar produces, alcohol, vinegar and many other products.

Quick Quiz #1



Define modern definition of organic chemistry.

Organic chemistry is that branch of chemistry which deals with the study of compounds of carbon and hydrogen (Hydrocarbons) and their derivatives.

Anlist different sources of organic compounds.

The main sources of organic compounds are coal, petroleum and natural gas. These are called fossil fuels.

Write important products from petroleum?

Important products obtained from petroleum.

Methane

Ethylene

Acetylene

Propene

Benzene

Toluene

Xylene

1) What are alkaloids?
Naturally occurring organic compounds containing nitrogen are called alkaloids.

2) Define fermentation?
The chemical breakdown of an organic compound with the help of micro-organisms such as bacteria, yeast etc. is called fermentation.
For example, the fermentation of molasses or sugar produces alcohol, vinegar and many other products.

Coal (as a source of organic compound)

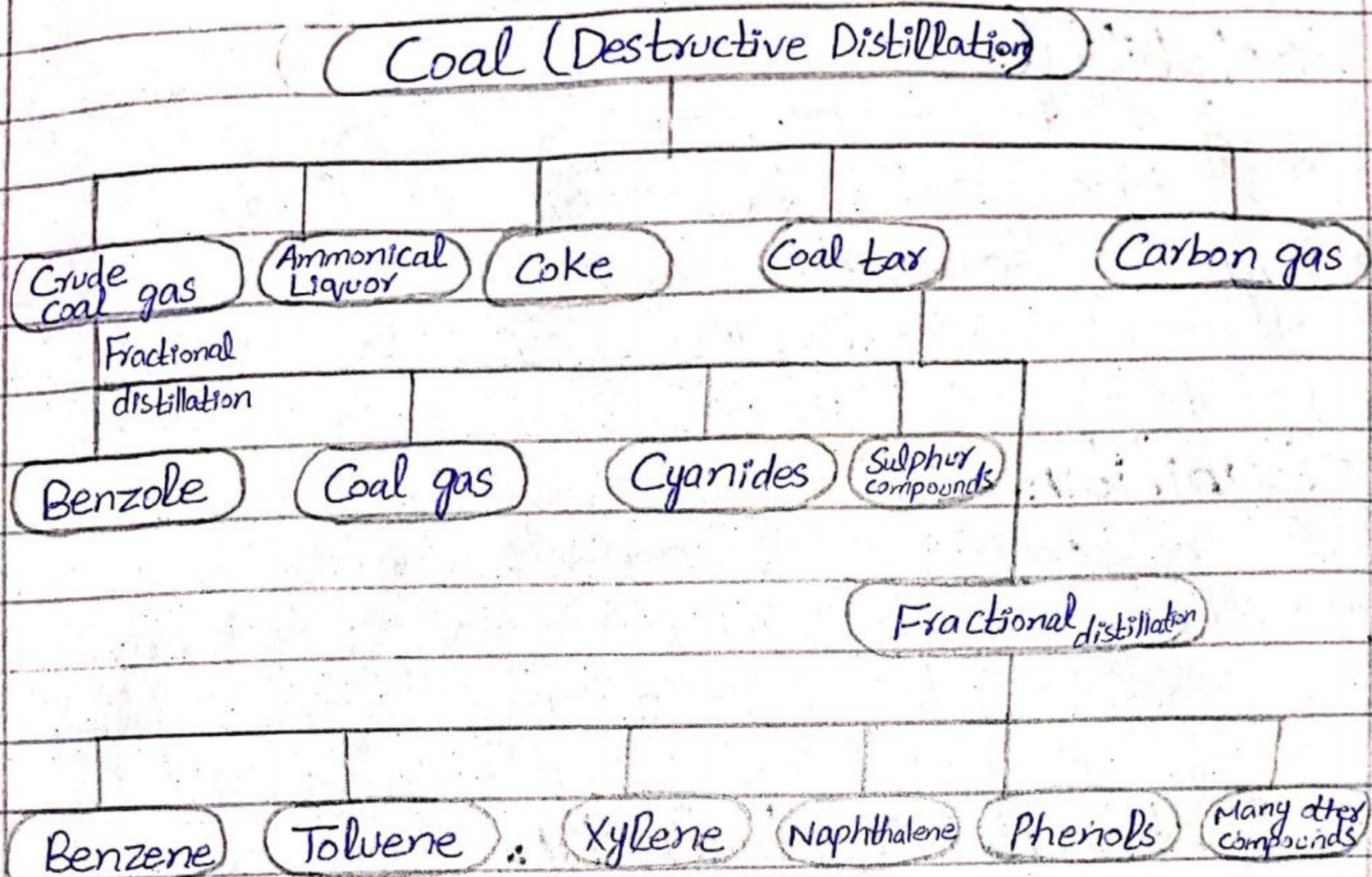
Q: What is coal. How is coal is used as source of organic compound?
A: Coal:

Coal is produced by the decaying of trees buried under the earth crust under the influence of temperature and high pressure.

⇒ Destructive Distillation of Coal

When coal is heated in the absence of air (temperature ranging from $500 - 1000^{\circ}\text{C}$); it is converted into coke, coal gas and coal tar.

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



Characteristics of Organic Compounds

How organic compounds are differ from inorganic compounds?

Organic compounds have entirely different properties from inorganic compounds:

Some of their general properties are described below:

Composition:

Carbon is an essential constituent of all organic compounds.

Combustion:

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

(iii) Melting and Boiling points:

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

(iv) 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.

(v) Stability:

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

(vi) Electrical Conductivity:

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

(vii) Source:

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

(viii) Rate of Reaction:

Their rates of reaction are very slow and need specific conditions.

Quick Quiz #2

1) What is coal?

Coal is produced by the decaying of trees buried under the earth's crust under the influence of temperature and high pressure.

2) What are the products of fractional distillation of coal tar?

Benzene

Toluene

Xylene

Naphthalene

Phenols

Many other compounds

3) What we obtain by fractional distillation of coal gas?

Benzole

Coal gas

Cyanides

Sulphur compounds



⇒ Uses of Organic compounds;

Q: How organic compounds are used in our daily life?

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

(i) **Food:**
(proteins, fats, carbohydrates, oils,)

(ii) **Clothing:**
(cotton, silk, wool, nylon, rayon, dacron).

(iii) The natural fiber like cotton, silk and wool have plant and animal origin. Synthetic fiber like rayon, dacron and nylon are prepared in the industry.

(iv) **Shelter:**
(Wood, paints, varnishes)

(v) **Power and Transportation:**
(natural gas, petroleum products, coal).

Natural gas, petroleum and gas used for power and transportation are organic substances.

(vi) **Medicines and Drugs:**
(Penicillin, streptomycin).

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

(vi) **Insecticides:** Insecticides like DDT, which are being widely used are organic substances.

(vii) **Hormones and Steroids:** Hormones and steroids are complex organic compounds.

(viii) **Vitamins and Enzymes:** All the vitamins which are dietary factors are organic compounds. Similarly enzymes are organic substances.

(ix) **Antiseptics and Anesthetics:** These are the families of the medicines and are organic in nature.

(x) **Pigments and Dyes:** Pigments and dyes are used for paints and are organic in nature.

(xi) **Paper and Inks:** Paper and inks are the sources of civilization and organic materials.

(xii) **Perfumes and Flavours:** Perfumes flavors and all cosmetics are organic in nature.

(xiii) **Plastics, Rubbers, and Resins:** Plastics, rubber and resins are organic in nature.

(xiv) **Propellents and Explosives:**
Propellants, explosives and refrigerants are well-known organic materials.

A. (xv) **Soap and Detergents:**
Soaps and detergent are organic compounds.

(xvi) **Herbicides:**

Teflon,
(xvii) **Photographic films and Developers:**
They are used as organic compounds.

Now Allotropes of Carbons: Bucky Balls

Q: What is the name of new allotropic form of carbon? Give its definition.

Ans. The full name of Bucky Balls is Buckminster Fullerenes.

• Scientists named it after an architect Buckminster, who designed a Bucky balls shaped building in Montreal.

• Bucky balls are used as semi-conductors and lubricants.

• In 1985, a new group of allotropic forms of carbon was discovered.

• These have carbon atoms ranging from forty to hundred.

• The carbon atoms are arranged

in a hollow cage like structure.

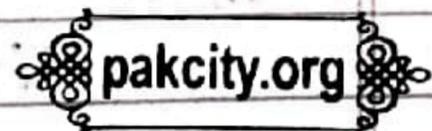
They are called Bucky Balls.

- The simplest of them is C_{60} and its molecule is made up of sixty carbon atoms.

- The carbon atoms fold around and make a ball shaped molecule.

- The new molecule looks just like a football.

- The carbon atoms join together to form pentagon and hexagon structures.



Quick Quiz #3

① What are allotropes?

Ans When an element exists in more than one form. These forms are called allotropes. Carbon has three allotropes.

- ① Diamond
- ② Graphite
- ③ Bucky Balls

② Why it was given the name Bucky balls?

Ans The full name of Bucky Balls is Buckminster Fullerenes. Scientists named it after an architect Buckminster, who designed a Bucky balls shaped building in Montreal.

(3) Define the third allotropic forms of carbon?

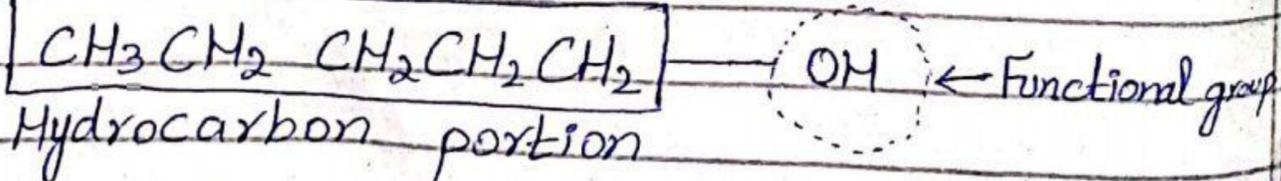
Ans In 1985, a new group of allotropic forms of carbon was discovered. These have carbon atoms ranging from forty to hundred. The carbon atoms are arranged in a hollow cage like structure. They are called Bucky Balls.

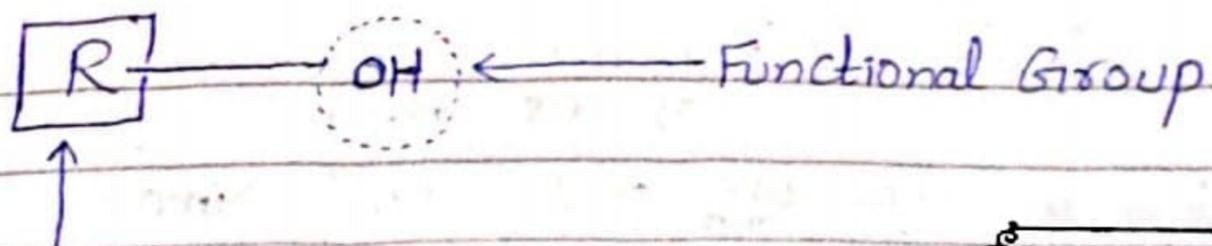
⇒ Functional Groups and Homologous Series.

Functional Group

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

- Double and triple bonds are functional groups.
- Other examples include $-Cl$, $-Br$, $-OH$, $-NH_2$ groups.
- Once the properties of the functional groups are known then the properties of any molecule containing a functional group may be predicted.





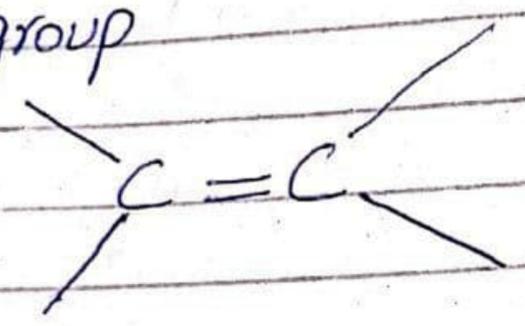
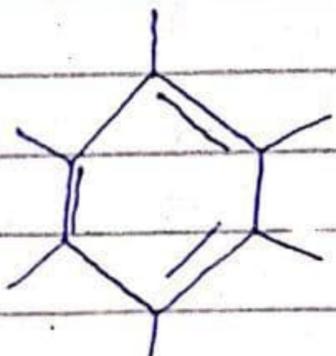
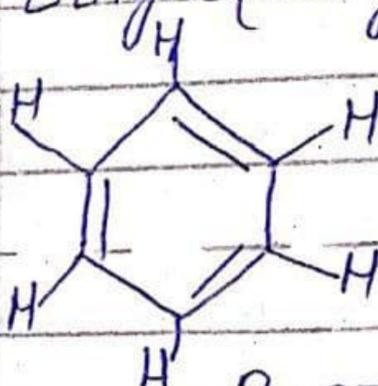
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Hydrocarbon portion

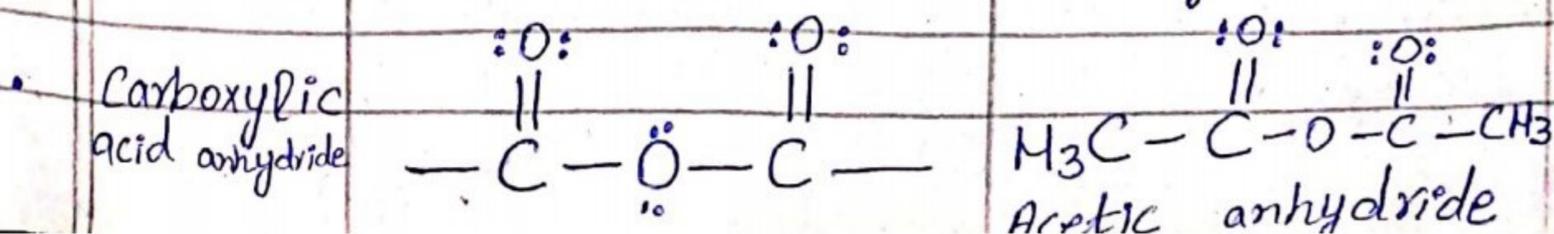
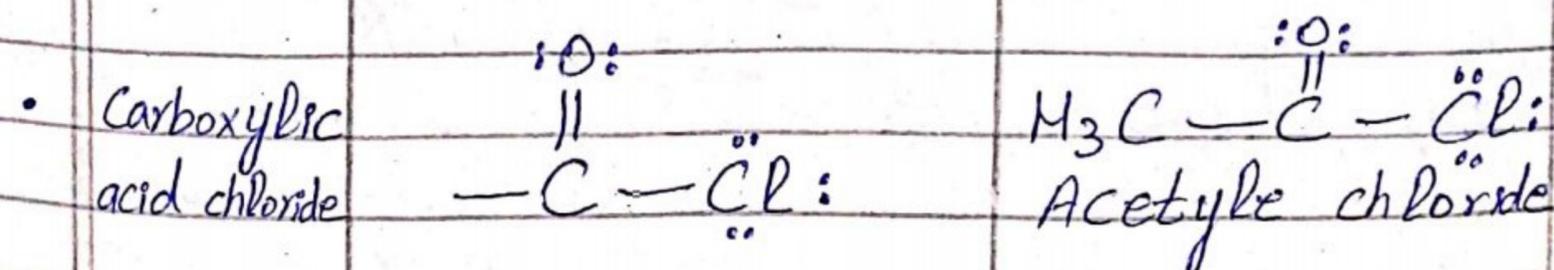
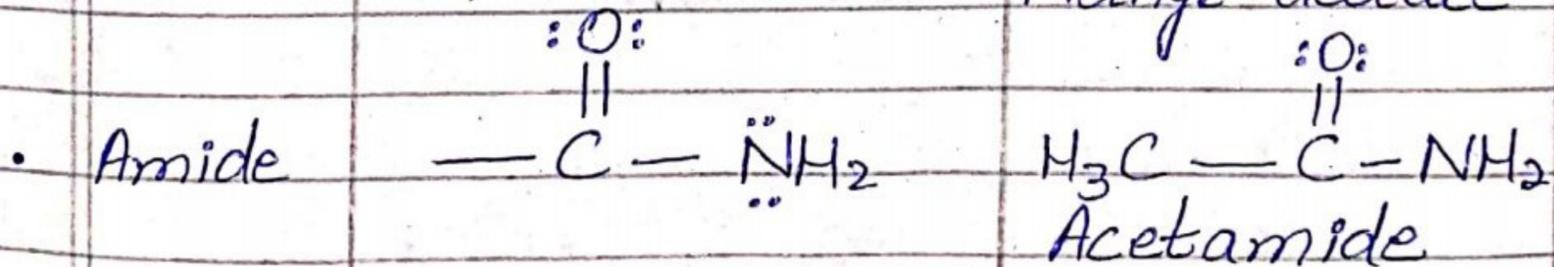
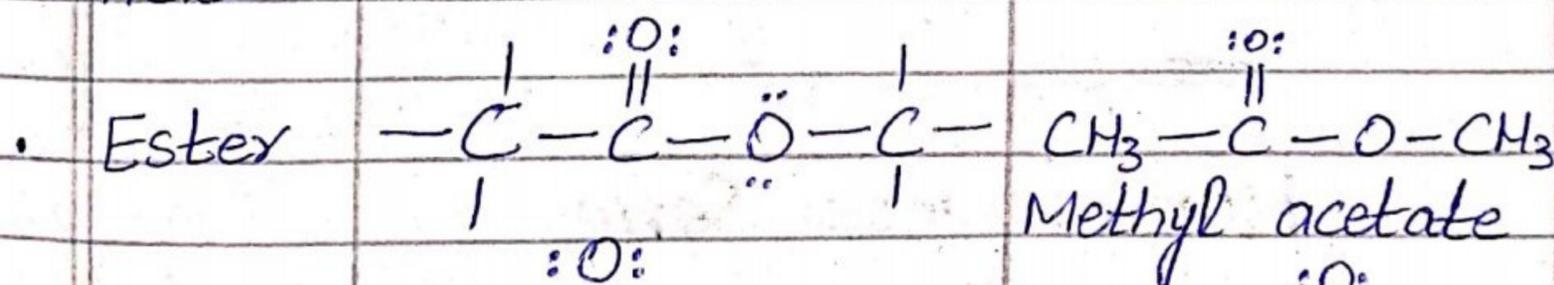
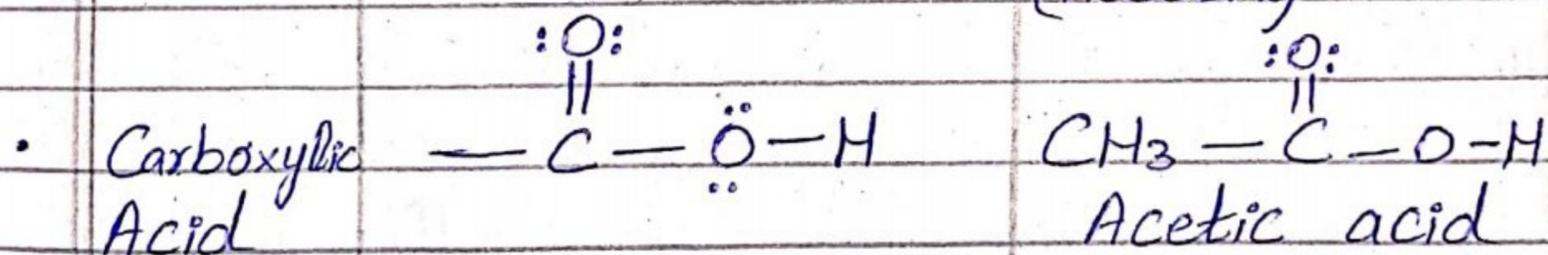
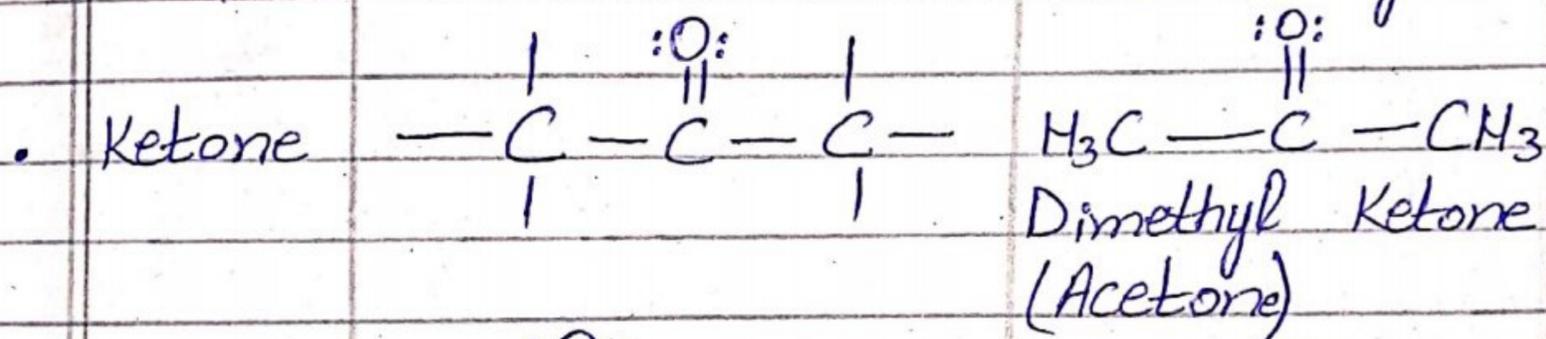
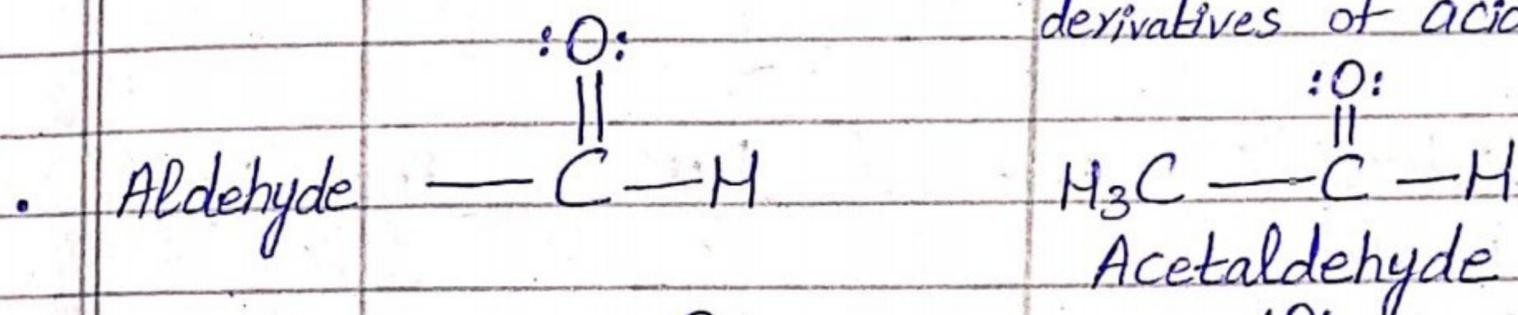
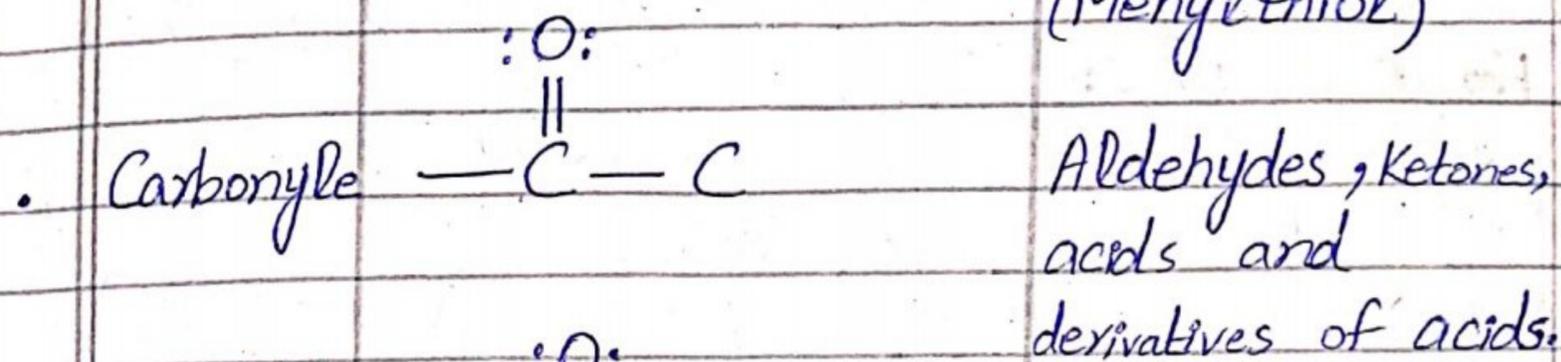
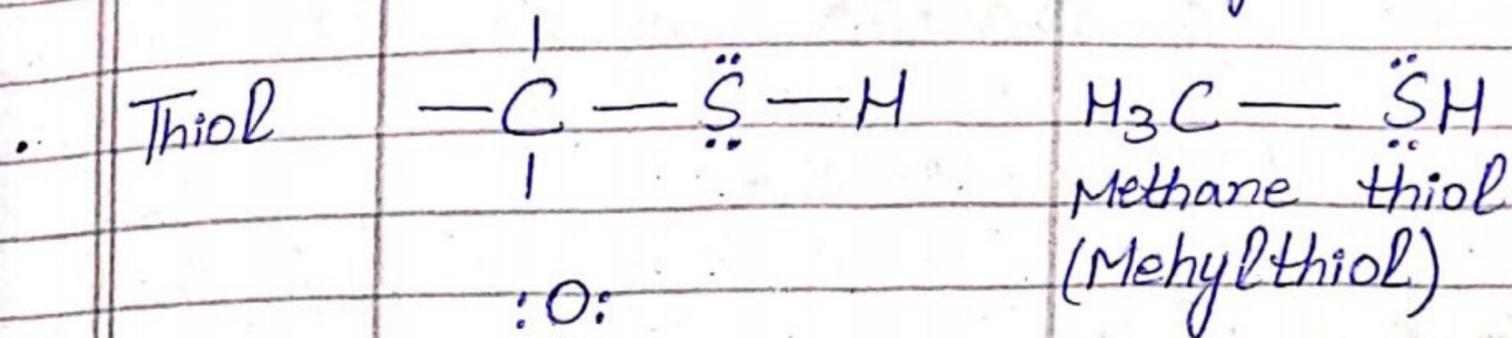
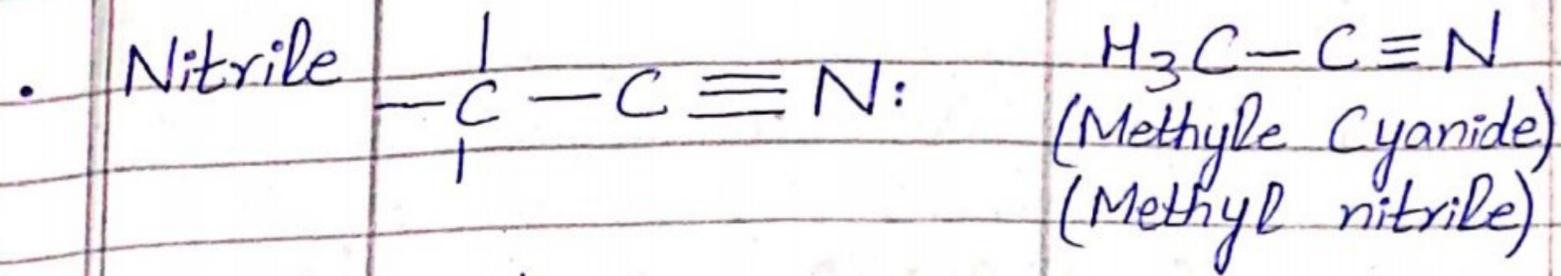


- Each functional group undergoes characteristic reactions.
- The concept of functional group is important in organic chemistry for three reasons:
 - (i) Functional groups serve as basis for nomenclature (naming) of organic compounds.
 - (ii) Functional groups serve to classify organic compounds into classes. All compounds with the same functional group belong to the same class.
 - (iii) A functional group is a site of chemical reactivity in a molecule.

A molecule can contain more than one functional group. It is then said to be **polyfunctional**, and the properties of each functional group may be modified by the presence of the others.

Table: 15.1: Some common functional groups are:

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 ₂ C=CH ₂ Ethene
Alkyne	$\text{—C}\equiv\text{C—}$	H-C≡C-H Ethyne (Acetylene)
Arene		 Benzene
Halide	$\begin{array}{c} \\ \text{—C—}\ddot{\text{X}}: \\ \end{array}$ (X = F ₂ , Cl ₂ , Br ₂ , I ₂)	H ₃ C— $\ddot{\text{C}}\text{l}:$ Methyl chloride
Alcohol	$\begin{array}{c} \\ \text{—C—OH} \\ \end{array}$	H ₃ C—OH Methanol (Methyl alcohol)
Ether	$\begin{array}{c} & & \\ \text{—C—}\ddot{\text{O}}\text{—C—} \\ & & \end{array}$	H ₃ C— $\ddot{\text{O}}\text{—C—CH}_3$ dimethyl ether
Amine	$\begin{array}{c} \\ \text{—C—}\ddot{\text{N}}\text{—} \\ \end{array}$	H ₃ C—NH ₂ Methyl amine



Quick Quiz #4

① What is organic compound?

A Ans The compounds which were of vegetable or animal origin are called organic compound.

→ For example::

(i) Acetic acid (from vinegar)

(ii) Alcohol (from wine)

(iii) Tartaric acid (from grapes)

② What is meant by a functional group?

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

Double and triple bonds are functional groups. Other examples include $-Cl$, $-Br$, $-OH$, $-NH_2$ groups.

⇒ 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 14amu by molar mass). The individual members are called Homolog". For example, the

homologous series of alcohols can be represented as:

- 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	$CH_3CH_2CH_2CH_2$	$CH_3CH_2CH_2CH_2OH$

* Characteristics:

The general characteristics of homologous series are:

- (i) All compounds in the series contain the same elements and the functional group.
- (ii) All compounds in the series can be represented by a general formula. For example; The general formula for Alkane is C_nH_{2n+2} , for alkene C_nH_{2n} and for alkyne C_nH_{2n-2} .
- (iii) The molecular formula of each Homologue series differs by CH_2 unit to the next one.
- (iv) All compounds in the series can be prepared by similar methods.
- (v) They have similar chemical properties.
- (vi) There is a gradual change in physical properties as the length of carbon chain increases in the same homologous series.

Quick Quiz #5

① What are general formulas for alkanes, alkenes and alkyne.

Ans The general formula for alkane is C_nH_{2n+2} , for alkene C_nH_{2n} and for alkyne C_nH_{2n-2} .

② What is Homologous series?

Ans 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.

For example, the homologous series of alcohols can be represented as:

* 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	$CH_3CH_2CH_2CH_2$	$CH_3CH_2CH_2CH_2OH$

③ Why do we arrange compounds in homologous series?

Ans We arrange compounds in

homologous series because:

- (i) All compounds in the series contain the same elements and the functional group.
- (ii) They have same chemical properties.
- (iii) All compounds in the series can be prepared by similar methods.

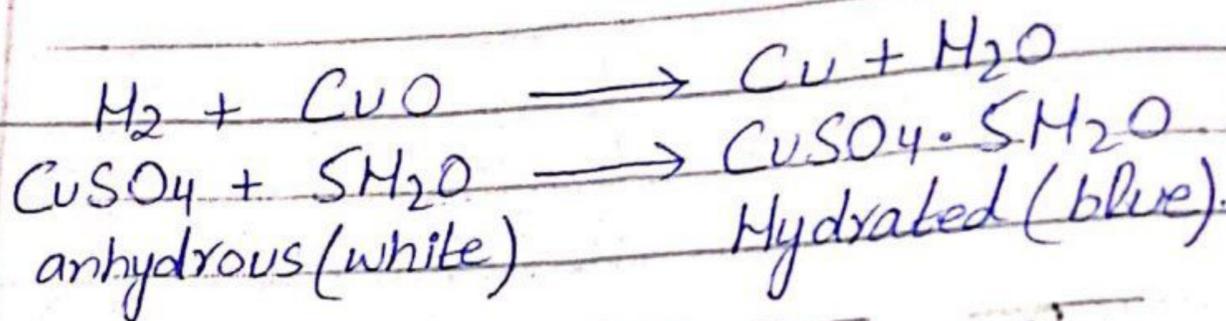
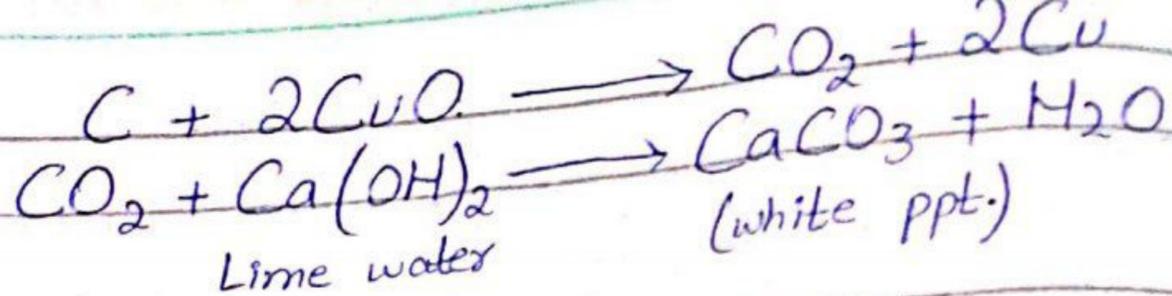
V.V.V. Imp

→ **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 nitrogen, sulphur, and halogen, oxygen, Phosphorus and Metals.

(A) Detection of carbon and Hydrogen:

- Carbon hydrogen can be detected by heating small amount of organic compound with CuO in a glass test tube.
- On heating the mixture carbon and hydrogen are oxidized to CO_2 and H_2O respectively.
- CO_2 turns lime water milky which proves the presence of carbon and the water vapours turn white anhydrous copper sulphate blue shows the presence of hydrogen in the organic compound.



(B) Detection of Nitrogen, Sulphur and Halogens:

Preparation of Lassaigne's Solution/
Sodium Extract.

- (i) Cut a small piece of sodium metal with the help of knife.
- (ii) Put this piece of sodium metal in a fusion tube.
- (iii) Heat the fusion tube in a flame to melt sodium metal.
- (iv) When sodium metal is melted, then add a small amount of powdered organic compound into fusion tube.
- (v) Then Heat the fusion tube again till its bottom become red hot.
- (vi) Break this fusion tube in a China dish containing 20cm^3 of distilled water.
- (vii) Mix, boil and then filter the solution.
- (viii) The filtrate obtained is called Lassaigne's solution or sodium extract.
- (ix) Divide this filtrate into three

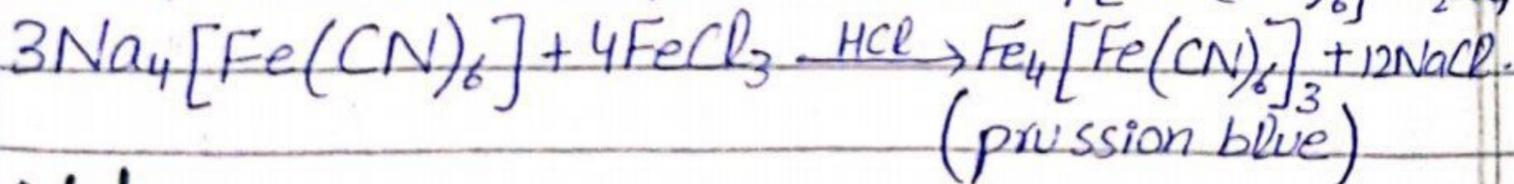
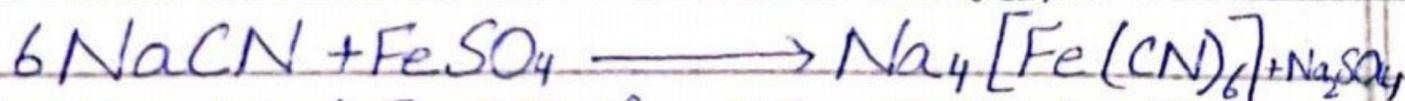
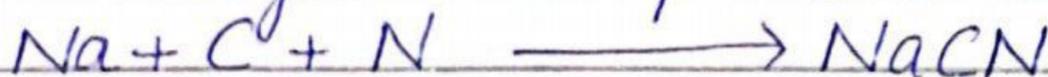
portion and test, the presence of C , N , S and (X) halogens respectively.

* Reactions:



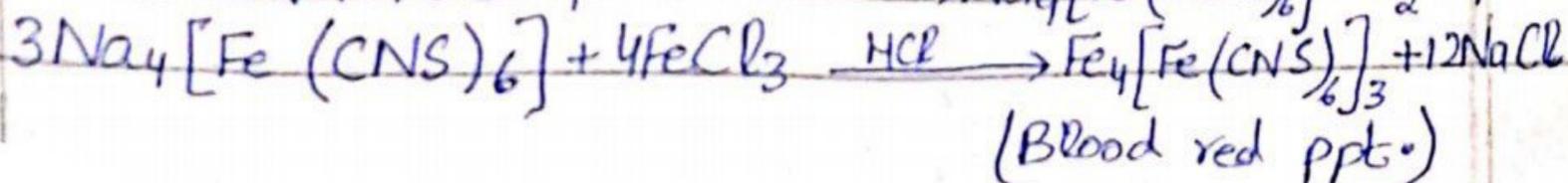
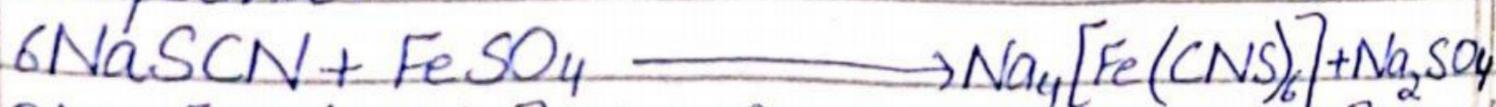
→ Nitrogen Test:

To one portion of Lassaigne's filtrate a few drops of NaOH is added to make it alkaline, then freshly prepared (FeSO_4) solution is added to it. The solution is boiled and a few drops of FeCl_3 solution and HCl are added to it. The appearance of blue or greenish blue (Prussian blue) color or ppt. proves the presence of nitrogen in the organic compound.



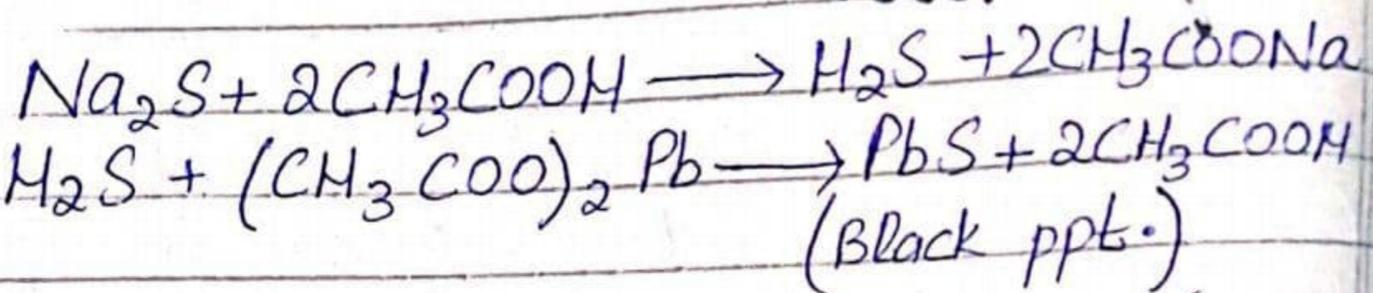
• Note:

If a blood red color is produced instead of prussian blue color then it proves that nitrogen and sulphur both are present in the organic compound.



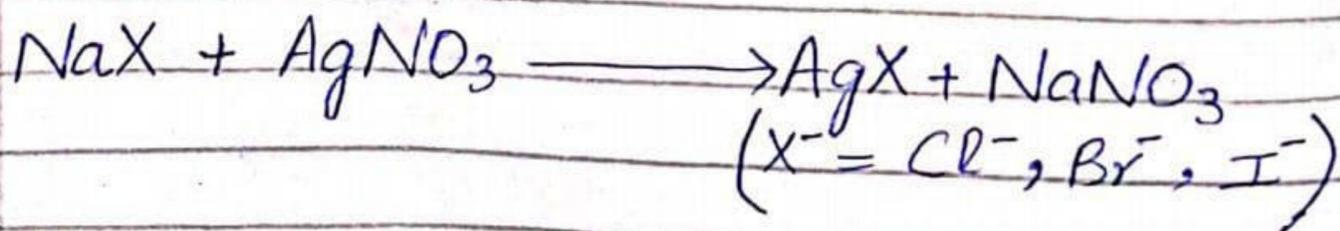
⇒ Sulphur Test:

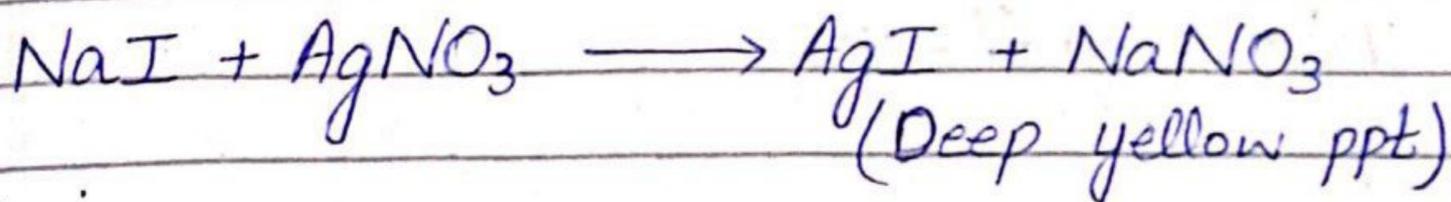
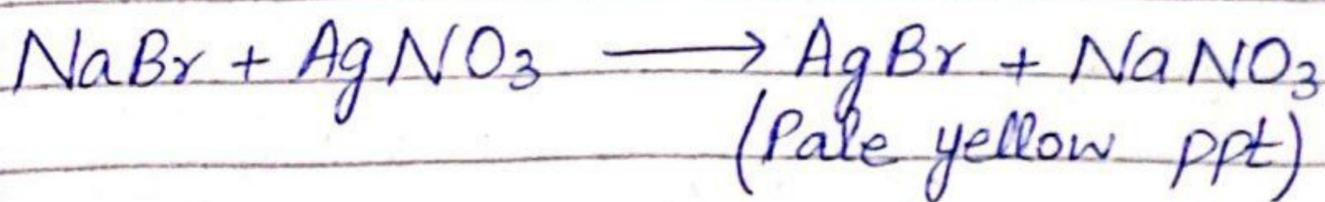
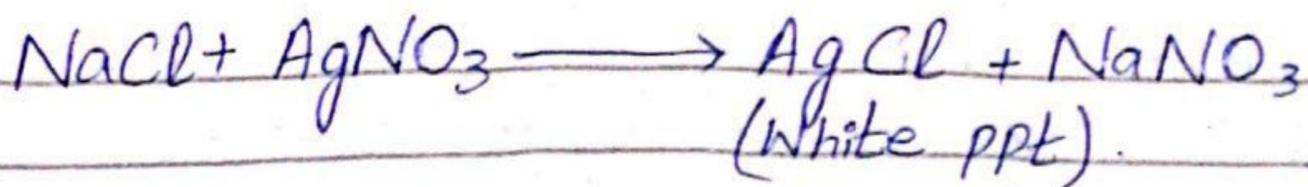
The second portion of Lassaigne's filtrate is acidified with acetic acid and boiled to expel H_2S gas which turns lead acetate paper black that indicates the presence of Sulphur in the compound.



⇒ Halogen Test:

A third portion of Lassaigne's solution is boiled with nitric acid to expel cyanide ions and sulphide ions, cool the solution and $AgNO_3$ solution is added. The formation of precipitate shows the presence of halogens, white ppt soluble in NH_4OH shows the presence of chlorine, a pale yellow ppt. partially soluble in NH_4OH shows the presence of bromine and a deep yellow ppt. insoluble in NH_4OH indicated iodine.





Exercise Ch # 15

Q2 Answer the following questions briefly.

(i) What is functional group?

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

Double and triple bonds are functional groups.

Other examples include $-\text{Cl}$, $-\text{Br}$, $-\text{OH}$, $-\text{NH}_2$ groups.

(ii) What is the difference between partial and total synthesis of organic compounds?

Partial synthesis:

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

EXERCISE

Q1: MCG'

- | | |
|-------------------------|---|
| i) methane (d) | ii) covalent bond (c) |
| iii) Benzene (d) | iv) Functional group (a) |
| v) All of above (d) | vi) $\text{CH}_3\text{-CH}_2\text{-OH}$ (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

iv) What is coal? How is coal used as a source of organic compounds?

Ans Refer to Page # 6.

v) What is name of new allotropic form of carbon? Give its definition.

Ans Refer to Page # 12.

vi What is Homologous series?

Ans Refer to Page # 19.

vii) How sulphur can be detected in organic compounds?

Ans Page # 23 (Paragraph Sulphur Test)

→ LONG QUESTIONS

Q3: Give the detailed answers for the following questions:

1. What are the main sources of organic compounds?

Ans Refer to Page # 2

2. Write down the characteristics of organic compounds from inorganic compounds.

Ans Refer to Page#8.

3. How organic compounds are used in our daily life?

Ans Refer to Page#9.

4. Write down any ten functional groups of organic compounds? Give reasons for the importance of organic chemistry.

Ans Refer to Page#13

5. Give the chemical tests for the detection of elements in organic compounds.

Ans Refer to Page#20.