TOPIC

8

SEMESTER-II (Period-VI)

C12CH8

Review of Some Fundamental Topics Previously Treated

LEARNING OBJECTIVE

Upon completion of this revision exercise, learners will:

- Learners can utilize their skills to review topics in chemistry, including the WASSCE Chemistry papers.

8.1. INTRODUCTION TO ORGANIC CHEMISTRY

Organic chemistryis the study of hydrocarbons (compounds of carbon and hydrogen elements) and other compounds regarded as derivatives of hydrocarbons.

General Characteristics of Organic Compounds

1. Organic compounds have a high molecular weight and a complex structure.
2. They are mostly insoluble in water but soluble in organic solvents such as ether, carbon tetrachloride, toluene, etc.
3. They are highly inflammable in nature.
4. Organic compounds are less reactive compared to inorganic compounds. Hence, the reactions involving organic compounds proceed at slower rates.
5. Mostly organic compounds form covalent bonds in nature.
6. They have a lower melting point and boiling point when compared to inorganic compounds.

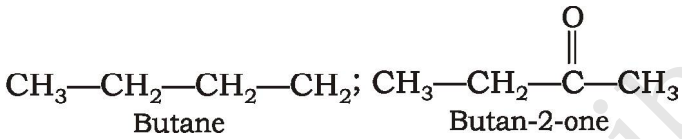
Classification of Organic Compounds

In order to simplify and systematize the study of organic chemistry the large number of existing organic compounds have been broadly classified into the following two main categories.

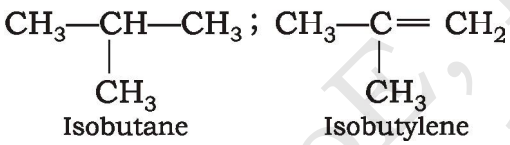
I. Acyclic or Open Chain Compounds

These compounds contains open chains of carbon atoms in their molecules.

Straight chain compounds



Branched chain compounds

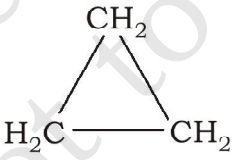


II. Cyclic or Ring or Closed Chain Compounds

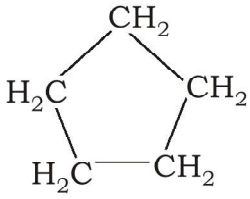
These compounds contain one or more **closed chains** or rings of atoms in their molecules. They are further divided into the following two categories.

(A) Carbocyclic or Homocyclic Ring Compounds: There compounds contain *ring skaletons* of *carbon atoms only.* They are further sub-divided into the following two categories.

(*a*) *Alicyclic compounds*: Resemble aliphatic compounds in most of their properties. Some examples are:

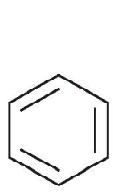


Cyclopropane

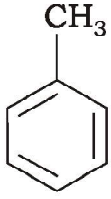


Cyclopentane

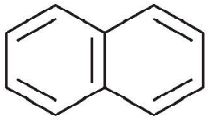
(*b*) *Aromatic compounds*: These are special type of compounds whose molecules contain *planar ring of carbon atoms with alternating* single and *double bonds* and (*4n + 2*) *pi-electrons delocalised* over the ring skeleton (*n* = 0, 1, 2 ….). Some examples are:



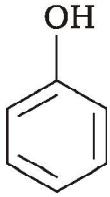
Benzene



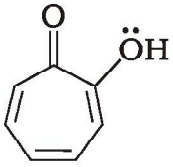
Toluene

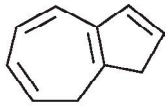


Napthalene
(Fused rings)



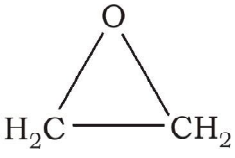
Phenol

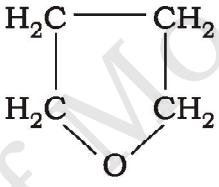

Tropolone

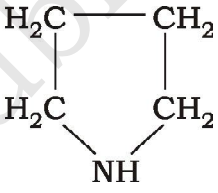

Azulene

(B) Heterocyclic Compounds: These are cyclic compounds which contain one or more atoms other than carbon-carbon atoms in the ring skeleton. The atom other than carbon atoms of the ring is called **heteroatom**. These compounds can be alicyclic in nature or aromatic in nature some examples are as follows:

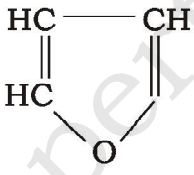
Alicyclic heterocyclic compounds

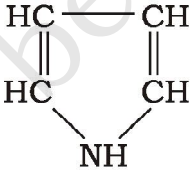

Oxirane

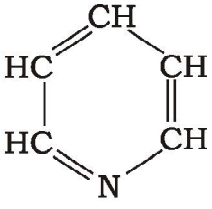

Oxolane


Pyrrolidine

Aromatic heterocyclic compounds


Furane


Pyrrole


Pyridine

Homologous Series and Functional Groups

Homologous Series

Homologous series may be defined as *a series of similarly constituted compounds in which the members have the same functional group and similar chemical characteristics and the consecutive members differ in their molecular formula by —CH_2.*

The members of same homologous series are called **homologues.**

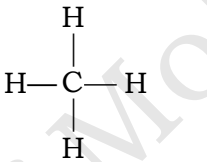
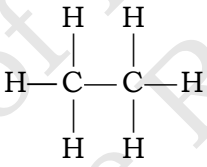
The **common characteristics of homologous series** are as follows:

1. All the members of a series can be represented by the same general formula. For example, general formula of alkanes is C_nH_{2n+2}.

2. Any two consecutive members differ in their formula by a common difference of —CH_2.
3. Different members in a series have a common functional group. For example, the members of the alcohol family have —OH group as their functional group.
4. The members of a particular series can be prepared almost by the identical methods, known as *the general methods of preparation.*

The first few members of the **alkane family** are as follows:

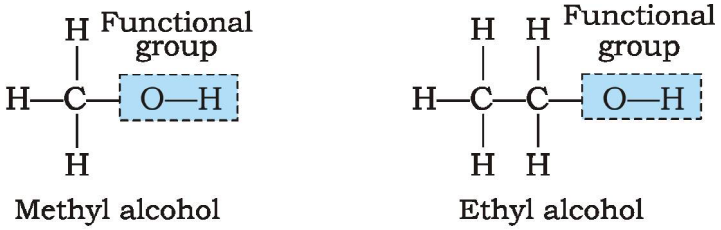
General formula: C_nH_{2n+2}.

Molecular Formula	*Structural Formula*	*Name*
CH_4		Methane
C_2H_6		Ethane

Functional Groups

Molecules of organic compounds except hydrocarbons can be broadly divided into two parts, *a reactive part* which is referred to as ***functional group*** and *a skeleton of carbon and hydrogen atoms* which is usually called ***alkyl radical.*** The properties of the compounds are controlled largely by the functional group. For example, the properties of ethyl alcohol are different from those of ethyl amine although their alkyl radicals are same.

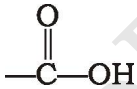
On the other hand, the properties of methyl alcohol and ethyl alcohol are similar due to the same functional group in both.



Methyl alcohol Ethyl alcohol

Same functional group—similar properties

Some of the common functional groups present in organic compounds are:

Class of compounds	Functional group	Example
Olefins (alkenes)	>C=C< (Carbon-carbon double bond)	$CH_2{=}CH_2$ (Ethene)
Acetylenes (alkynes)	—C≡C— (Carbon-carbon triple bond)	CH≡CH (Ethyne)
Alcohols	—OH (Hydroxyl)	C_2H_5OH (Ethanol)
Carboxylic acids	 (Carboxyl)	CH_3COOH (Ethanoic acid)

Hydrocarbons

A hydrocarbon is any of a class of organic chemicals made up of only the elements carbon (C) and hydrogen.The four general classes of hydrocarbons are: alkanes, alkenes, alkynes and arenes.

(A) Alkanes (C_nH_{2n+2})

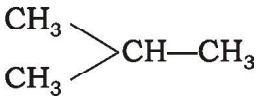
Alkanes are saturated hydrocarbons. Because of their low reactivity, they are also called paraffins (from Latin, meaning little affinity or reactivity). The open chain (aliphatic) alkanes have general formula C_nH_{2n+2} (where n =1, 2, 3, ...) while cycloalkanes have general formula C_nH_{2n}. All the carbon atoms in alkanes are sp^3-hybridized. Alkanes have **tetrahedral structure** around each carbon Petroleum and natural gases are major sources of alkanes.

Nomenclature of alkanes

The first three members of this family have same common as well as IUPAC name.

Some alkanes and their common as well as IUPAC names are given in tabular form as follows:

Molecular Formula	*Common Name*	*IUPAC Name*
CH_4	Methane	Methane
$CH_3—CH_3$	Ethane	Ethane
$CH_3—CH_2—CH_3$	Propane	Propane

$CH_3—CH_2—CH_2—CH_3$	*n*-Butane	Butane
	*iso*-Butane	2-Methylpropane
$CH_3CH_2CH_2CH_2CH_3$	*n*-Pentane	Pentane

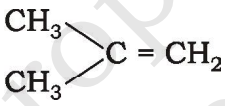
(B) Alkenes (C_nH_{2n})

Alkanes are unsaturated hydrocarbons. Their molecules have two hydrogen atoms less than the corresponding members of alkanes. Thus, their general formula is C_nH_{2n}. The functional group in alkenesis carbon-carbon double bond (C = C). Alkenes are also known as olefins (derived from Greek word olefiant means oil forming).

Nomenclature of alkenes

In **IUPAC system** the name of alkene is derived by replacing the suffix -***ane*** of the corresponding alkane by -***ene.***

In **common system,** the name of alkene is derived by replacing the suffix -***ane*** of the corresponding alkane by -***ylene.***

Molecular Formula	*Common Name*	*IUPAC Name*
$CH_2 = CH_2$	Ethylene	Ethene
$CH_3—CH = CH_2$	Propylene	Propene
$CH_3—CH_2—CH = CH_2$	α-Butylene	But-1-ene
$CH_3—CH = CH—CH_3$	β-Butylene	But-2-ene
	*iso*-Butylene	2-Methylpropene

(C) Alkynes (C_nH_{2n-2})

Alkynes are aliphatic unsaturated hydrocarbons. They are characterised by the presence of *triple bond* (C ≡ C) between the carbon atoms in their molecules. Each member of alkyne series has four hydrogen atoms less than the corresponding alkane. Thus, the general formula of alkynes is C_nH_{2n-2}. The first member of the series is acetylene and the family as a whole is also known as ***acetylenes.***

Nomenclature and Isomerism

The **IUPAC name** of an alkyne is derived from the name of the corresponding alkane by replacing suffix-*ane* by *yne*.

In **common system,** the name of the simplest alkyne is acetylene. The names of the higher alkynes are given as substituted acetylenes.

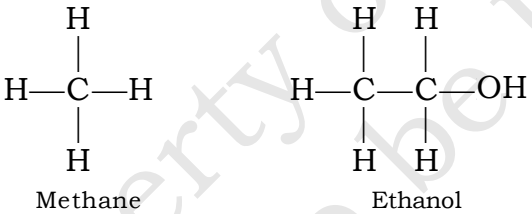
Some members of **homologous series of alkynes** are given below:

Molecular Formula	*Common Name*	*IUPAC Name*
$HC \equiv CH$	Acetylene	Ethyne
$CH_3—C \equiv CH$	Methylacetylene	Propyne
$CH_3CH_2—C \equiv CH$	Ethylacetylene	But-1-yne
$CH_3CH_2CH_2—C \equiv CH$	*n*-Propylacetylene	Pent-1-yne

Hydrocarbon Derivatives

Hydrocarbon derivatives are ***compounds that are made primarily of carbon and hydrogen atoms with specific groups of atoms attached***. These specific groups of atoms are called functional groups.

For example methane becomes the hydrocarbon derivative methanol when one of the hydrogen gets replaced with a hydroxyl (OH) group.



Methane Ethanol

Natural and Synthetic Organic Compounds

Natural organic compounds refer to those that are produced by plants or animals. Many of these are still extracted from natural sources because they would be more expensive to produce artificially. Examples include: most sugars, some alkaloids and terpenoids, certain nutrients such as vitamin B_{12}, and, in general, those natural products with large or stereoisometrically complicated molecules present in reasonable concentrations in living organisms.

Further compounds of prime importance in biochemistry are antigens, carbohydrates, enzymes, hormones, lipids and fatty acids, neurotransmitters, nucleic acids, proteins, peptides and amino acids, lectins, vitamins, and fats and oils.

Synthetic compounds: Compounds that are prepared by reaction of other compounds are known as "synthetic". They may be either

compounds that are already found in plants/animals or those artificial compounds that do not occur naturally.

Most polymers (a category that includes all plastics and rubbers) are organic synthetic or semi-synthetic compounds.

8.2. CHEMISTRY, INDUSTRY AND ENVIRONMENT

In the 1960s Liberia was one of the biggest exporters of iron-ore, with deposits of 800 million tons of 35-to 67-percent purity ore, and new deposits of 1 billion tons of high grade ore had been discovered. Many international companies were exploiting the ore from Liberia, but in the 1980s the industry suffered from depressed steel prices and the parastatal NIOC closed in 1985.

Characteristics of the Chemical Industry

1. The cycle of petrochemical products is relatively long, the cycle of fine chemical products is relatively short, and the production method is typical of continuous large-scale production.
2. Production type is a combination of stock production and make-to-order.
3. Products consist of many materials and many by-products.
4. The company mainly does custom-made and design-to-order and outsources more.
5. With a high dependence on water, oil, minerals, and other resources, saving resources is the key to reducing product costs.

Factors to be considered in sitting of the Chemical Industry

The following factors are to be considered in siting chemical industry:

1. Nearness to the source of materials
2. Energy (power or fuel) supply
3. Human resources (labour force)
4. Transport costs
5. Nearness to the market
6. Nearness to a source of water
7. Conductive climate

Environmental Pollution

Environmental pollution, in general, may be described as the contamination of the environment with harmful wastes arising mainly from human activities. These activities release certain materials which produce pollution.

Environmental pollution may be defined as direct or indirect changes as a result of human activities, which adversely influence the biological and non-biological equilibrium of the environment. The environmental pollution may be caused by:

- Chemical agents (gases, pesticides, particulates),
- Physical agents (heat, noise, radiation) or
- Biological agents (micro-organisms).

Pollution produces adverse effect on living as well as non-living materials. For example, it can:

- cause illness or even death in case of humans and animals.
- retard the growth of plants and may cause them severe injury.
- result in corrosion of metals, marble and decolourize paints.

(A) *Air Pollution*

Air in the atmosphere is never pure and clean. It contains many chemical substances which arise because of natural or human activity. These substances include:

- gases like CO, CO_2, SO_2, NO_2, H_2S, NO, hydrocarbons (C_xH_y) along with many other volatile organic compounds and
- suspended particulate matter such as dust, smoke, fumes, and also some radioactive material.

(B) *Water Pollution*

Water pollution refers to *the presence of any foreign substance (organic, inorganic, radioactive or biological) in water which produce harmful effect and decrease the usefulness of water.*

The various water pollutants are as follows:

1. Sewage and other oxygen-demanding wastes.
2. Infectious or disease causing agents.
3. Synthetic organic chemicals.
4. Inorganic minerals and chemical compounds.

5. Suspended solids or sediments.
6. Radioactive substances.

(C) *Soil Pollution*

Any factor which deteriorates the quality, texture and mineral content ofthe soil or which disturbs the biological balance of the organisms in thesoil is referred to as Land or Soil pollutant. Pollution in soil has adverse effect on the plant growth. Pollution in soil is associated with

1. Indiscriminate use of fertilizers
2. Indiscriminate use of pesticides
3. Dumping of large quantities of waste materials
4. Deforestation

8.3. CHEMISTRY OF SELECTED METALS AND THEIR COMPOUNDS

Metals are substances that form naturally below the surface of the Earth. Most metals are lustrous or shiny. Metals are inorganic, which means they are made of substances that were never alive. Some examples of metals include: iron, sodium, calcium, copper and gold.

Physical Properties of Metals

- All the metals are good conductors of heat and electricity.
- Metals are ductility.
- All most all metals are malleable.
- Metals are sonorous, i.e. they produce sound when struck.
- Usually, all the metals have a shiny appearance.

Chemical Properties of Metals

- Only highly reactive metals react with water and not all the metals. For example, Sodium reacts vigorously with water and oxygen.
- Hydrogen gas is produced when metals react with acids. For example, when zinc reacts with hydrochloric acid it produces zinc chloride and hydrogen gas.
- Not all the metals react with bases and when they do react, they produce metal salts and hydrogen gas. When zinc reacts

with strong sodium hydroxide it gives sodium zincate and hydrogen gas.

Sodium and Its Compounds

Sodium is a soft, silvery white metal, lighter than water. It can beeasily cut with knife. Some of its compounds include:

Sodium Nitrate ($NaNO_3$)

Properties: (i) Sodium nitrate is crystalline solid which is white. (ii) This compound has a sweet odour. (iii) This compound is also highly soluble in ammonia. (iv) At high temperature, the compound is known to explosivelydecompose.

Uses: (i) This compound is widely used as a food additive since it acts as apreservative. (ii) Sodium nitrate is used as an oxidizer in several types offireworks. (iii) It is also a component of some instant cold packs.

Sodium Chlorate ($NaClO_3$)

Properties: (i) It is an odourless compound. (ii) Its color differs from light yellow to white crystalline solid. (iii) It is very soluble in water and heavier than water. (iv) It causes a highly exothermic reaction.

Uses: (i) It is used as a dying mash in the creation of the paper. (ii) It is used in the medical field for preparing different drugs. (iii)It is used in making fertilizers and explosives.

Calcium and Its Compounds

Calcium is a silvery white metal. It is ductile. Some of the calcium compounds are:

Calcium Carbonate ($CaCO_3$)

Calcium carbonate occurs in nature in different forms such aslimestone, marble and chalk.

Uses: (i) Limestone is used for the preparation of lime and cement. (ii) Limestone is also used as flux during smelting of iron ores. (iii) Specially precipitated calcium carbonate is used in themanufacture of high quality paper.(iv) Precipitated chalk is used in medicines and in tooth-pastes.

Calcium Sulphate ($CaSO_4$)

Calcium sulphate occurs in nature as anhydrite ($CaSO_4$) and as gypsum ($CaSO_4.2H_2O$). Calcium sulphate is sparingly soluble in water.

Uses: (i)Gypsum is used for making plaster of paris. (ii) Gypsum is also used for the treatment of soil. (iii) Anhydride is used for the manufacture of sulphuric acid.

8.4. CHEMISTRY OF SELECTED NON-METALS AND THEIR COMPOUNDS

Non-metals are elements that accept or gain electrons to generate negative ions. They often have 4, 5, 6, or 7 electrons in their outermost shell. Non-metals are materials that lack all of the characteristics of metals. They are excellent heat and electricity insulators. They are usually gasses, although they can also be liquids. Carbon, sulphur, and phosphorus, for example, are solid at normal temperatures.

Physical Properties of Non-Metals

- Non-metals (except graphite) are poor conductors of heat and electricity.
- Non-Metals are brittle.
- They have low melting point.

Chemical Properties of Non-Metals

- A non-metal does not react with water but it is usually very reactive in air.
- Non-metals do not react with acids.
- Non-Metals react with metal, generally forming Ionic compounds.

$$Na^+ + Cl^- \longrightarrow NaCl$$

Carbon and its Compounds

Carbon is the first element of group 14 of the periodic table. Its electronic configuration ($1s^2 2s^2 2p^2$) shows that it has four electrons in the outermost shell.

Carbon is widely distributed in nature both in free as well as incombined state.

In **free state**, it occurs as diamond, graphite and coal.

In **combined state**, it occurs as: Calcite ($CaCO_3$), Dolomite ($CaCO_3.MgCO_3$), and Hydrocarbons, etc.

Diamond

It is a crystalline allotropes of carbon. It is the purest form of carbon. It occurs in nature as such and is also artificially prepared.

Uses: (i) It is used for making tools for cutting and grinding other hard material. (ii) It is used in dies for the manufacture of tungsten filaments forelectric light bulbs. (iii) Diamond is used for making jewellery. (iv) Sharp-edged diamonds are used by eye surgeons to remove cataract from eyes with high precision.

Graphite

It occurs in nature and can also manufactured artificially by heating coke to 3275–3300°K in an electric furnace. The process in known as Acheson's process.

Uses: (i) Graphite is used as lubricant. (ii) Mixed with clay it is used in 'lead' pencils. (iii) It is a component of printers' ink. (iv) Graphite is used as moderator in nuclear reactors.

Carbon Monoxide (CO)

Carbon monoxide is formed by incomplete combustion of carbon or carbon containing compounds (such as hydrocarbons) in the limited supply of oxygen.

$$C + \frac{1}{2} O_2 \longrightarrow CO$$

Uses: (i) CO is an important industrial fuel. (ii) It is used as a reducing agent in many metallurgical processes. (iii) It is used in purification of nickel by Mond's process. (iv) It is used in the manufacture of methanol, formic acid, etc.

Nitrogenand its Compounds

Nitrogen forms many thousands of organic compounds. Most of the known varieties may be regarded as derived from ammonia, hydrogen cyanide, cyanogen, and nitrous or nitric acid.

Dinitrogen (N_2)

It is a colourless, tasteless, odourless and non-toxic gas. Its freezing point and boiling point are 63°K and 77.2 K respectively.

Uses: (i) It is used in the manufacture of ammonia. (ii) It also finds use where the presence of an inert atmosphere isrequired. For example,

in iron and steel industry. (iii) Liquid nitrogen is used as refrigerant to preserve biological materials.

Ammonia (NH_3)

Ammonia is hydride of nitrogen. It is present in small quantities in air and soil where it is formed by the decay of nitrogenous organic matter such as

Uses: (i) It is used mostly to produce various nitrogenous fertilizers (such as urea, ammonium and phosphate). (ii) It is used in the manufacture of some inorganic nitrogen compounds, themost important one being nitric acid, and sodium carbonate. (iii) Liquid ammonia is used as a refrigerant. (iv) It is used as a reagent in the laboratory.

Sulphur and its Compounds

Pure sulphur is a tasteless, odourless, brittle solid. It is poor conductor of electricity.

Sulphur dioxide (SO_2)

It is a colourless gas with a pungent, suffocating odour. It is heavier than air. It is highly soluble in water. It can be easily liquefied to a colourless

Uses: (i) It is used in the manufacture of sulphuric acid and paper from wood pulp (use of bisulphites). (ii) It is used as a bleaching agent for delicate articles like wool, silkand straw. (iii) It is used in refining of petroleum and sugar. (iv) As a disinfectant for killing disease germs, fungi and certainmoulds. (v) As a refrigerant in the form of liquid SO_2.

EXERCISE

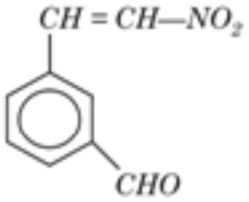
A. Multiple Choice Questions

1. This polymer is also known as styrene butadiene rubber.

(a) Buna-S (b) Teflon

(c) Styron (d) None of these

2. Name the functional group of the compound.



(a) —CO— (b) —NH2

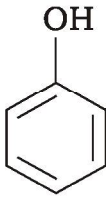
(c) —CHO (d) None of these

3. What are the isotopes of carbon?

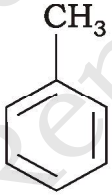
(a) ^{12}C (b) ^{13}C

(c) ^{14}C (d) All of these

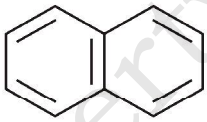
4. Which of the following is a non-benzoic compound?



(a) Phenol

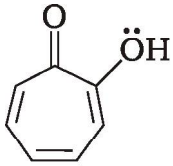


(b) Toluene



Napthalene

(c) (Fused rings)



(d) Tropolone

5. Which of the following is a chemical agent of environmental pollution?

(a) Heat (b) Noise

(c) Pesticides (d) None of these

6. Which allotropes of carbon is used as a moderator in reactor?

(a) Graphite (b) Diamond

(c) Both (a) & (b) (d) None of these

7. Which of the following is true about ammonia?

(a) Ammonia is a colourless gas.

(b) Ammonia is lighter than air.

(c) Ammonia is insoluble in water.

(d) Ammonia liquefies on cooling under pressure.

B. Fill in the Blanks

1. The members of same homologous series are called ..... .
2. ..... is an atom or group of atoms which largely determines the properties of the organic compound.
3. Liquid ammonia is used as a ..... .
4. Hydrocarbons are made up of ..... and ..... .
5. Sodium is ..... electropositive than potassium.

C. Answer the Following Questions:

1. List some general characteristics of organic compounds.
2. What are the uses of sodium nitrate?
3. What are the uses of diamond?
4. What are the main uses of graphite?
5. List some uses of sulphur dioxide.
6. Define environmental pollution and write the causes of environmental pollution?