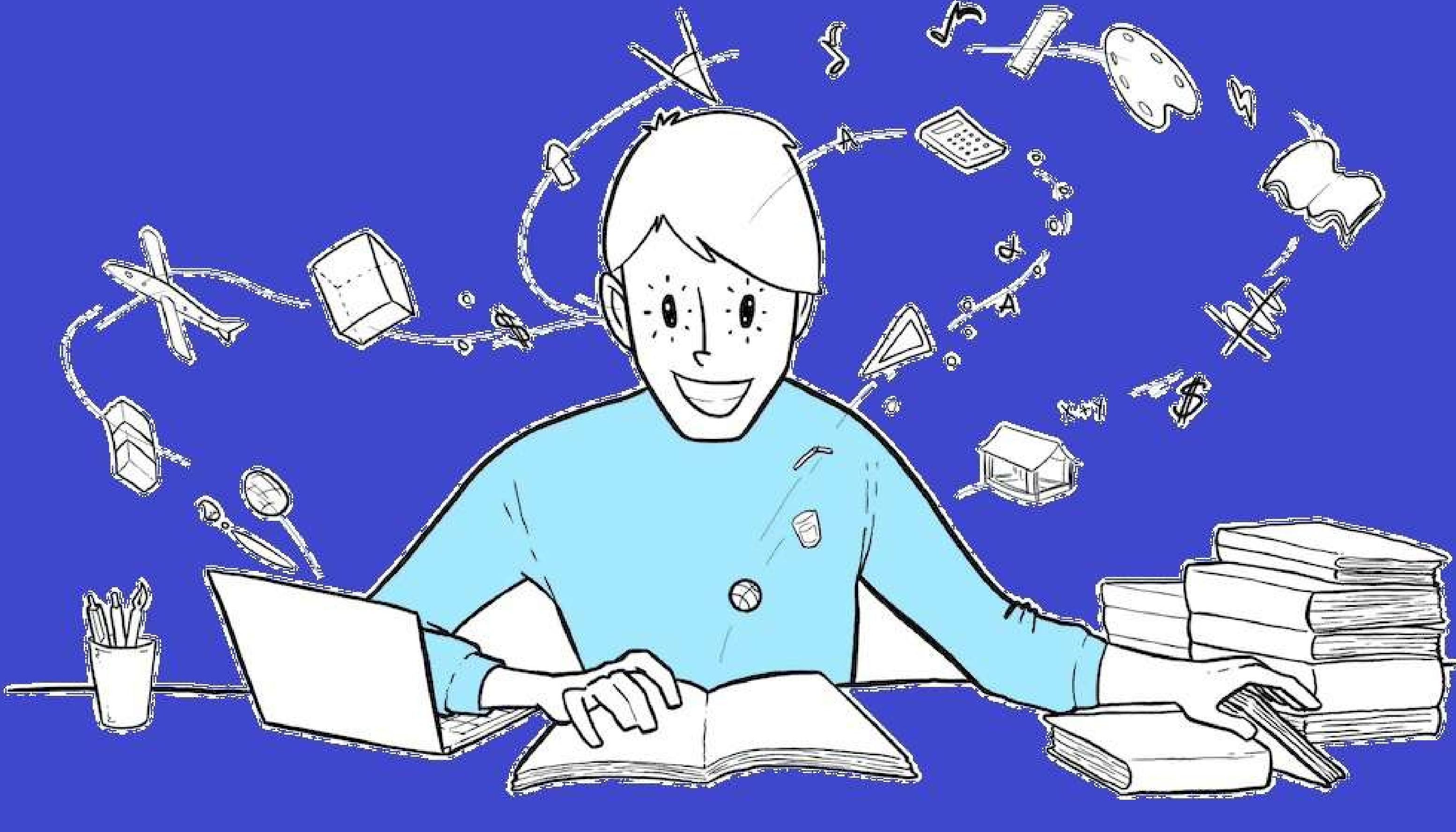
LAST MOMENT PREPARATION/REVISION PART II



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Dear Students,

Teachers always motivate and guide the students to learn all the content of the book so that scoring highest in the exams is ensured, still some students lag behind when it comes to effective preparation of the Chemistry subject and many find it tough to decide what to revise just before the final exam.

An effort has been made to select the most repeated short questions and highlights of long questions which students need to keep in their mind before appearing for the final exam. Under some topics you will find the statement written **LONG QUESTION** and then you will see some short questions. Learning the answers to those short questions will help you learn good portion for long question. Long questions are given in minimum possible length. This will enable you to avoid getting no credit for answer to any question. Getting reasonable marks is better than getting no marks. In every answer, some words have been kept in **bold** font style**.** Combining those words will give you the key words to remember so you may never fail in attempting any question correctly. It may help you in learning the shortest answer so there are no blank sheets left by you in the answer book.

The total of 321 pages excluding glossary of your textbook have been reduced to 102 pages. Make sure that it is a preparation material for those who, due to many reasons, couldn't touch the book even. Moreover, it is meant to help in last moment revision plan. Once you have memorized all the content given in this book you are encouraged to learn the chapters thoroughly. You are advised to prepare from all the files which are available on the FCCU website.

Teachers always wish and strive to see their students achieving their best and heading towards their goals successfully. Prayers for your glorious future. Amen.

God Bless You!

THE STUDY MATERIAL IS GIVEN ACCORDING TO THE LATEST PAIRING SCHEME OF BISE, LAHORE

Chapter 1

Periodic Classification of Elements and Periodicity

Historical Background and Improvements in Mendeleev's Periodic Table

(Long Question)

Q. Give two defects of Mendeleev's periodic table.

1. The elements were arranged in increasing order of their atomic masses.

2. Another confusion in Mendeleev's table was that elements like Be, Mg, Ca, Sr, Ba and Zn, Cd, Hg were placed in a single vertical group, while according to their properties they belonged to two different categories. The same was true for so many other elements placed in the same vertical group.

Q. Give four improvements made in Mendeleev's periodic law.

1. After the discovery of atomic number by Moseley in 1911, it was noticed that **elements could be classified more satisfactorily by using their atomic numbers rather than their atomic masses**.

2. The periodic table was improved by **arranging the elements in ascending order of their atomic numbers instead of their atomic masses**.

3. Another improvement was the addition of an **extra group (group VIIIA) at the extreme right of the periodic table**. This group contains noble gases, which had not been discovered in Mendeleev's time.

4. In modern periodic table, the confusion of placing elements with different properties in same group was removed by **dividing the elements in two types of vertical groups, A and B**. In modern periodic table, **Be, Mg, Ca, Sr and Ba are placed in group IIA and Zn, Cd, Hg in group IIB**.

The Modern Periodic Table

Q. Define Periodic table. How many groups and periods are in it?

The periodic table provides a **basic framework to study the periodic behaviour of physical and chemical properties of elements as well as their compounds**.

There are **eight groups** and **seven periods** in the periodic table.

Periodic Trends in Physical Properties

Atomic Radius

(Long Question)

Q. Why ionic radii of negative ions are larger than parent atoms?

A negative ion is always bigger than its parent atom. The reason is that **addition of one or more electrons in the shell of a neutral atom enhances repulsion between the electrons causing expansion of the shell**. Thus, the radius of fluorine atom is 72pm and that of the fluoride ion (F^-) is 136pm.

Q. Why ionic radii of positive ions are smaller than parent atoms?

The removal of electrons causes an imbalance in proton-electron ratio. Due to **the greater attraction of the nuclear charge, the remaining electrons of the ion are drawn closer to the nucleus**. A positive ion is always smaller than the neutral atom from which it is derived. The radius of Na is 157pm and the radius of Na+ is 95pm.

Q. What is the trend of atomic radius in the periodic table?

Atomic radius **decreases from left to right in periods** of the periodic table as the **shielding effect remains constant and effective nuclear charge increases so hold of nucleus on outermost shell electrons increases**. Atomic radius **increases from top to bottom in a group** because **shielding effect increases and effective nuclear charge decreases so hold of nucleus on outermost shell electrons decreases**. The trend of ionic radius is same.

Points to Remember for Long Question

- Half of the distance between the centers of two bonded atoms is considered to be the radius of the atom.
- The **gradual decrease in the atomic size of the elements in the lanthanide series is significant and is called lanthanide contraction**.
- This contraction controls the size of 6th and 7th period elements.

Ionization Energy

(Long Question)

Q. Define ionization energy.

The ionization energy of an element is the **minimum quantity of energy which is required to remove an electron from the outermost shell of its isolated gaseous atom in its ground state**. For example,

$$\mathrm{Na\,(g)} \longrightarrow \mathrm{Na^{+}\,(g)} + e^{-} \qquad \Delta H_i = +496\ \mathrm{kJ\ mol^{-1}}$$

Q. Discuss the trend of ionization energy in the periodic table.

Ionization energy **decreases from top to bottom in a group because shielding effect increases, effective nuclear charge decreases and size of atom increases** so less energy is required to remove electron from the outermost shell as the hold of nucleus on the outer shell electron decreases. Ionization energy **increases from left to right in a period as the shielding effect remains constant, effective nuclear charge increases and size of atom decreases** so more energy is required to remove electron from the outermost shell as the hold of nucleus on the outer shell electron increases.

Electron Affinity

(Long Question)

Q. Define electron affinity.

The electron affinity is the **energy released or absorbed, when an electron is added to a gaseous atom to form a negative ion**. For example,

$$\mathrm{F\,(g)} + e^{-} \longrightarrow \mathrm{F^{-}\,(g)} \quad \mathrm{E.A} = -337\ \mathrm{kJ\ mol^{-1}}$$

Q. What is the trend of electron affinity in the periodic table?

Electron affinity **increases from left to right in periods of the periodic table because effective nuclear charge increases, shielding effect remains constant, size of atom decreases** so hold of nucleus on outermost shell electrons increases. Electron affinity **decreases from top to bottom in the periodic table because effective nuclear charge decreases, shielding effect increases, size of atom increases** so hold of nucleus on outermost shell electrons decreases.

Points to Remember for Long Question

- The first value of electron affinity is shown with a positive sign while the **second value of electron affinity is shown with a negative sign as the incoming electron is repelled by the already present electron.**

Metallic and Non-Metallic Character

Q. Why metallic character increases from top to bottom in a group of metals?

Metallic character increases from top to bottom in a group of metal **because atomic size increases, shielding effect increases and effective nuclear charge decreases from top to bottom in a group**. As a result, the removal of electrons from the outermost shell becomes easier as hold of nucleus on the outermost shell electrons decreases.

Melting and Boiling Points

Q. Explain the variation in melting points along the short periods.

Across the short periods, **the melting and boiling points of elements increase with the number of valence electrons up to group IVA and then decrease up to the noble gases**. Since carbon has the maximum number of binding electrons, thus, it has a very high melting point in diamond in which each carbon is bound to four other carbon atoms. In general, the elements which exist as giant covalent structures have very high melting points.

Hydration Energy

Q. What is hydration energy? Give an example.

The hydration energy is the **heat absorbed or evolved when one mole of gaseous ions dissolve in water to give an infinitely dilute solution**. For example, when one mole of gaseous hydrogen ions is dissolved in water to give an infinitely dilute solution and a large amount of heat is liberated:

$$H^+ (g) + H_2O (l) \longrightarrow H_3O^+ (aq) \quad \Delta H_h = -1075 \text{ kJ mol}^{-1}$$

Q. Hydration energies of ions are in the following order. $Al^{+3}>Mg^{+2}>Na^{+1}$. Justify it.

Hydration energy depends upon the **charge to size ratio, greater the charge to size ratio greater the hydration energy**. Hence, in the given order ($Al^{+3}>Mg^{+2}>Na^{+1}$), Al^{+3} has greater charge to size ratio than Mg^{+2} and Na^{+1}. That's why, the hydration energies are in this order:

$$Al^{+3}>Mg^{+2}>Na^{+1}$$
$$-4613>-1903>-510$$

Q. What is the trend of hydration energy in the periodic table?

Hydration energies highly depend upon charge to size ratio of the ions. **Charge to size ratio decreases from top to bottom in a group, the hydration energy also decreases** in the same fashion. The hydration energy **increases significantly by moving from left to right in a period as the charge to size ratio increases**.

Oxidation State

Q. Why the oxidation states of noble gases are usually zero?

The oxidation states of noble gases are usually zero because their outermost shell is complete and they are inert.

Q. AlF_3 has higher melting point thanAlI_3. Why?

AlF_3 is purely **ionic compound** having **melting point 1290 °C** and fairly a good conductor, whereas, **AlI_3** is predominantly **covalent** with **melting point 198 °C** and electrically a non-conductor.

Q. Why $PbCl_2$ is ionic but $PbCl_4$ is fairly covalent compound?

When a metal forms more than one halide, **the halides in which metal has lower oxidation state tends to be ionic while that in higher oxidation state is covalent**. Similarly, high polarizing power of Pb^{+4} as compared to Pb^{+2} makes $PbCl_2$ mainly ionic, but, $PbCl_4$ fairly covalent.

Electrical Conductance

Q. Why diamond is a non-conductor and graphite fairly a good conductor of electricity?

Carbon, in the form of **diamond is non-conductor** because all of its **valence electrons** are tetrahedrally bound and **unable to move freely**, while in the form of **graphite**, carbon is fairly a **good conductor** because one of its **four valence electrons** is relatively **free to move**.

Periodic Relationship in Compounds

Halides

(Long Question)

Q. Define halides.

Halides are **the binary compounds which halogens form with other elements**. For example, NaCl, KBr, NaI.

Q. How are halides classified?

Halides can be **classified** into two general classes: **ionic and covalent**. In between the two, there is another class of halides in which the halogen atom acts as a bridge between the two atoms of the other element. Such halides are termed as **"Polymeric" halides**.

Q. What is the trend of halides from left to right and top to bottom in the periodic table?

On moving across the periodic table from **left to right, the electronegativity difference reduces and the trend shifts towards covalent halides**. **Ionic halides are formed by elements on the right side of the periodic table (IA and IIA)**.

For a metal the order of decreasing ionic character of the halides is:

fluoride > chloride > bromide > iodide

Points to Remember for Long Question

- Strongly electropositive elements, having greater electronegativity difference with halogen atom, form ionic halides.
- Less electropositive elements, such as Be, Ga and Al form polymeric halides having partly ionic bonding with layer or chain lattices.
- The intermolecular forces in covalent halide molecules are weak van der Waal's forces so they are often gases, liquids or low melting point solids.

Hydrides

(Long Question)

Q. What are hydrides?

The **binary compounds of hydrogen with other elements are called hydrides**. For example, NaH, H_2O, H_2S.

Q. How hydrides are classified?

Hydrides may be broadly classified into three classes: **ionic, covalent and intermediate**.

Q. What is the trend of hydrides from left to right in the periodic table?

The elements **on the left side of the periodic table** (IA and IIA) form **ionic hydrides**. The tendency towards **covalent character increases by moving from left to right in the periodic table**. Hydrides of beryllium and magnesium represent the class of **intermediate hydrides**. Their properties are **in between the ionic and covalent hydrides**.

Points to Remember for Long Question

- The elements of group IA and the heavier members of group IIA form ionic hydrides.
- The covalent hydrides are usually gases or volatile liquids.
- The boiling points of covalent hydrides generally increase on descending a group.

Oxides

(Long Question)

Q. Define oxides.

The **compounds which oxygen forms with other elements are called oxides**. For example, P_2O_5, Na_2O, CO_2.

Q. How oxides are classified?

Oxides can be classified based upon the type of bonding they have as well as their acidic or basic character. On the basis of acidic and basic character they are categorized as **acidic, basic and amphoteric oxides**.

Q. What are acidic oxides and what are basic oxides?

Metals form basic oxides. When oxides of metals are dissolved in water they give bases. For example:

$$Na_2O\ (s) + H_2O\ (l) \longrightarrow 2NaOH$$

Non-metals give acidic oxides. When oxides of non-metals are dissolved in water they form acids. For example:

$$SO_3\ (g) + H_2O\ (l) \longrightarrow H_2SO_4\ (aq)$$

Q. What are amphoteric oxides?

The oxides having **both acidic and basic properties are called amphoteric oxides.**

$$ZnO\ (s) + H_2SO_4\ (aq) \longrightarrow ZnSO_4\ (aq) + H_2O\ (l)$$

$$ZnO\ (s) + 2NaOH\ (aq) + H_2O\ (l) \longrightarrow Na_2[Zn(OH)_4]\ (aq)$$

Q. What happens when acidic and basic oxides combine with each other?

Basic oxides and acidic oxides react with one another to give salts e.g,

$$Na_2O + SO_3 \longrightarrow Na_2SO_4$$

Points to Remember for Long Question

- In a given period, the oxides progress from strongly basic through weakly basic, amphoteric, and weakly acidic to strongly acidic.
- The basicity of main group metal oxides increases on descending a group of the periodic table.
- The acidity of $MnO < Mn_2O_3 < MnO_2 < Mn_2O_7$

The Position of Hydrogen

(Long Question)

Q. Discuss position of hydrogen with respect to IA.

Similarities

1. Like alkali metals hydrogen atom has one electron in Is sub-shell, which it can lose to form H^+.

2. Both hydrogen and alkali metals have a strong tendency to combine with electronegative elements such as halogens.

3. Similar to alkali metals hydrogen also forms ionic compounds, which dissociate in water. **Dissimilarities**

1. Hydrogen is a nonmetal in true sense. It does not lose electron as easily as most of the alkali metals do.

2. Unlike alkali metals molecular hydrogen exists in open atmosphere.

Q. Discuss position of hydrogen with respect to VIIA.

Similarities

1. Hydrogen is a gas like most of the halogens and is stable in diatomic form such as F_2, Cl_2 and Br_2.

2. As required by halogens, hydrogen also needs one electron to complete its outermost shell.

3. By accepting one electron hydrogen forms H^- (Hydride ion) similar to F^-, Cl^- and Br^-.

4. Both hydrogen and halogens form stable ionic compounds with alkali metals.

Dissimilarities

1. By losing its only electron, hydrogen forms H + but halogens do not form positive ions.

2. Combining with oxygen, hydrogen forms very stable oxides while halogens lack this property.

Q. Discuss position of hydrogen with respect to IVA.

Similarities

1. Valence shell of hydrogen is half filled like those of group IVA elements.

2. Both, hydrogen and group IV elements combine with other elements through covalent bonding.

3. Like carbon, hydrogen also possesses remarkable reducing properties.

$$CuO(s) + H_2(g) \longrightarrow Cu(s) + H_2O(l)$$

$$SnO_2(s) + C(s) \longrightarrow Sn(s) + CO_2(g)$$

Dissimilarities

1. Carbon and silicon form long chain compounds, when their atoms combine with each other, while hydrogen does not form such compounds.

2. Carbon can simultaneously form bonds with more than one elements, whereas, hydrogen due to having only one electron can combine with only one element at a time.

Chapter 2

s-Block Elements

Alkali Metals and Alkaline Earth Metals

Q. Give formulae of Natron and Halite.

Natron	$Na_2CO_3.H_2O$
Trona	$Na_2CO_3.2NaHCO_3.2H_2O$

Peculiar Behaviour of Lithium

(Long Question)

In case of long question learn minimum 8 points

Q. Give four points in which lithium differs from its own family members?

1. Lithium is much **harder and lighter** than the other alkali metals.

2. The **lithium salts of anions with high charge density are generally less soluble in water** than those of the other alkali metals, e.g. $LiOH$, LiF, Li_3PO_4, Li_2CO_3.

3. Lithium forms **stable complex compounds**. One of the stable complexes formed by lithium is $[Li(NH_3)_4]^+$

4. Lithium **reacts very slowly with water** while other alkali metals react violently.

(Long Question)

Q. Give four reactions in which Lithium behaves differently from its own groups.

1. Decomposition of lithium nitrate gives different products than nitrates of other alkali metals as shown below:

$$4LiNO_3\,(s) \longrightarrow 2Li_2O\,(s) + 4NO_2\,(s) + O_2\,(g)$$

$$2NaNO_3\,(s) \longrightarrow 2NaNO_2\,(s) + O_2\,(g)$$

2. Lithium is the only Group IA metal that combines with nitrogen and carbon to form nitride and carbide, respectively.

$$6Li\,(s) + N_2\,(g) \longrightarrow 2Li_3N\,(s)\ \text{Lithium nitride}$$

$$4Li\,(s) + C\,(s) \longrightarrow Li_4C\,(s)\ \text{Lithium carbide}$$

3. Only lithium burns in air to form the normal oxide, Li_2O.

$$4Li\,(s) + O_2\,(g) \longrightarrow 2Li_2O\,(s)\ \text{Lithium oxide}$$

4. Lithium hydroxide when strongly heated forms lithium oxide but the other alkali metal hydroxides do not show this behaviour.

$$2LiOH\ (s) \longrightarrow Li_2O\ (s) + H_2O\ (l)$$

Peculiar Behaviour of Beryllium

(Long Question)

Q. Write two points of difference of Beryllium with its family members.

1. Beryllium metal is almost as hard as iron and **hard enough to scratch glass**.

2. The **melting and boiling points of beryllium are higher** than other alkaline earth metals.

General Behaviour of Alkali Metals and Alkaline Earth Metals

Q. Prove that decomposition of lithium nitrate gives different products than nitrates of other alkali metals?

Decomposition of lithium nitrate gives different products than nitrates of other alkali metals as shown below:

$$4LiNO_3\ (s) \longrightarrow 2Li_2O\ (s) + 4NO_2\ (s) + O_2\ (g)$$

$$2NaNO_3\ (s) \longrightarrow 2NaNO_2\ (s) + O_2\ (g)$$

Q. What happens when?

a. Li_2CO_3 is heated

b. Na_2CO_3 is heated

a. $Li_2CO_3 \longrightarrow 2Li_2O + CO_2$

b. $2Na_2CO_3 \longrightarrow$ No decomposition on heating

Q. What happens when LiOH is heated to red hot?

$$2LiOH\ (s) \longrightarrow Li_2O\ (s) + H_2O\ (l)$$

Q. BeO is Amphoteric. Prove it.

BeO is amphoteric in nature since it reacts with both acids and bases.

$$BeO\ (s) + H_2SO_4\ (aq) \longrightarrow BeSO_4\ (s) + H_2O\ (l)$$

$$BeO\ (s) + 2\ NaOH\ (aq) \longrightarrow \underset{\text{Sodium beryllate}}{Na_2BeO_2\ (aq)} + H_2O\ (l)$$

Q. Why KO_2 is used in breathing equipment used by mountaineers and astronauts?

Potassium superoxide (KO_2) has a very interesting use in breathing equipments for mountaineers and in space craft. **It has the ability to absorb carbon dioxide while giving out oxygen at the same time.**

$$4KO_2\ (s) + 2CO_2\ (g) \longrightarrow 2K_2CO_3\ (s) + 3O_2\ (g)$$

Q. Why lime water turns milky by passing CO_2 gas but becomes clear with excess of CO_2?

Lime water turns milky by passing CO_2 gas due to formation of insoluble $CaCO_3$

$$Ca(OH)_2\ (aq) + CO_2\ (g) \longrightarrow CaCO_3\ (s) + H_2O\ (l)$$

On further addition of CO_2 insoluble $CaCO_3$ changes into soluble $Ca\ (HCO_3)_2$

$$CaCO_3\ (s) + H_2O\ (l) + CO_2 (g) \longrightarrow Ca(HCO_3)_2 (aq)$$

Q. Why is the aqueous solution of Na_2CO_3 alkaline in nature?

The solution of Na_2CO_3 in water is basic due to hydrolysis of carbonate ion.

$$Na_2CO_3\ (s) + 2H_2O \longrightarrow 2NaOH\ (aq) + H_2CO_3\ (aq)$$

NaOH is a strong base and H_2CO_3 is a weak acid. So the solution is alkaline in nature.

(Long Question)

$$Be\ (s) + 2NaOH \longrightarrow Na_2BeO_2\ (aq) + H_2\ (g)$$

Sodium beryllate

$$2Be\ (s) + O_2\ (g) \xrightarrow{800\ ^{o}C} 2BeO\ (s)$$

$$2\ Mg\ (NO_3)_2\ (s) \longrightarrow 2MgO\ (s) + 4NO_2\ (g) + O_2\ (g)$$

$$Ca\ (OH)_2 + SiO_2 \longrightarrow CaSiO_3 + H_2O$$

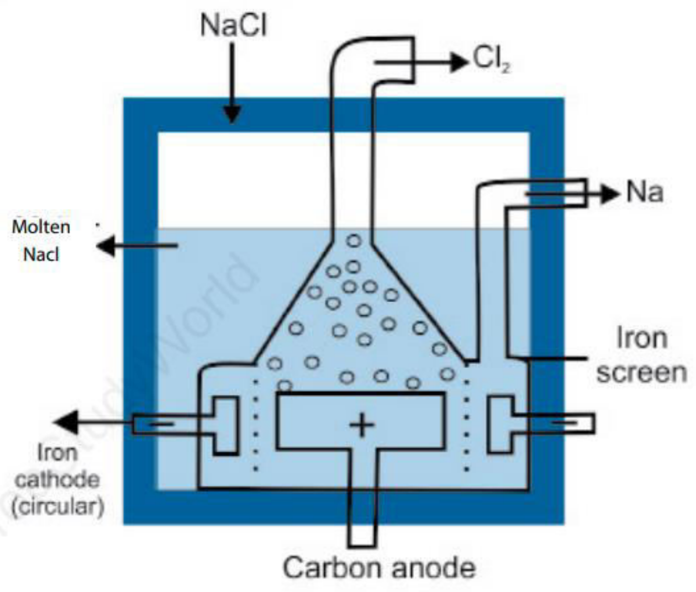
$$Na_2O + H_2O \longrightarrow 2NaOH$$

$$2NaNO_3\ (s) \longrightarrow 2NaNO_2\ (s) + O_2\ (g)$$

Commercial Preparation of Sodium by Down's Cell

(Long Question)

- Sodium metal is produced by the **electrolysis of fused sodium chloride**.
- **Melting point of sodium chloride is 801 ^{o}C** some **calcium chloride** is added to **lower its melting point to about 600 ^{o}C**.
- The **large block of graphite at the centre is the anode** above which there is a dome for the collection of chlorine.
- The **cathode is a circular bar of copper or iron** which surrounds the anode but is separated from it by an iron screen.



$$\mathbf{NaCl \longrightarrow Na^{+} + Cl^{-}}$$

$$\textbf{At cathode } \mathbf{Na^{+} + e^{-} \longrightarrow Na}$$

$$\textbf{At anode } \mathbf{Cl^{-} \longrightarrow \tfrac{1}{2}\,Cl_2 + 1e^{-}}$$

Q. Give advantages of Down's Cell.

Following are the advantages of Down's cell:

(a) The metallic fog is not produced.

(b) Liquid sodium can easily be collected at 600 °C.

(c) Material of the cell is not attacked by the products formed during the electrolysis.

Commercial Preparation of Sodium Hydroxide by the Diaphragm Cell

(Long Question)

Q. Give two major problems that may arise in Nelson's cell.

1. Chlorine produced can react with hydroxide ions in cold giving hypochlorite ions.

$$Cl_2\,(g) + 2OH^{-}\,(aq) \longrightarrow OCl^{-}\,(aq) + Cl^{-}\,(aq) + H_2O$$

2. Hydroxide ions may be attracted towards anode, where they can be discharged releasing oxygen gas. This oxygen gas may contaminate the chlorine and renders it impure.

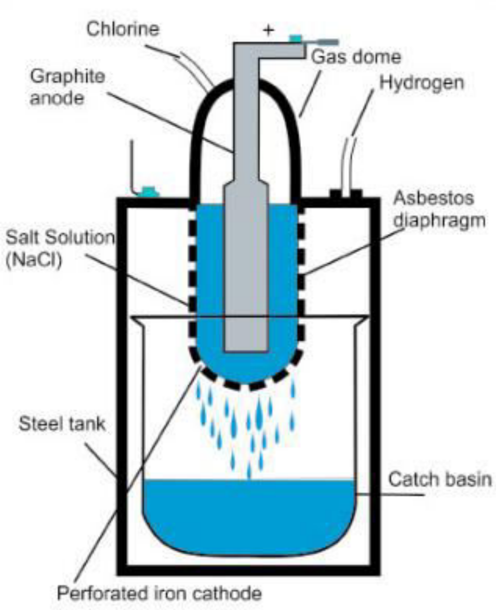
Points to Remember for Long Question

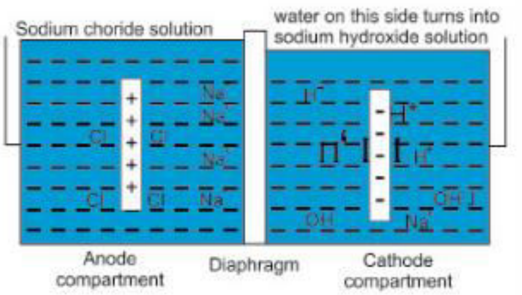
- It is prepared by the **electrolysis of brine solution**.
- An **oblong perforated steel vessel lined inside with asbestos diaphragm serves as a cathode**.
- **Constant level device** is provided.
- **A graphite anode** is held within the U shaped diaphragm and it projects into the salt solution.
- Reaction at anode

$$2Cl^- (aq) \longrightarrow Cl_2 (aq) + 2e^-$$

- Reaction at cathode

$$2\ H_2O + 2e^- \longrightarrow 2\ OH^- (aq) + H_2 (g)$$





- **The first problem is solved by using asbestos diaphragm**. This keeps the two solutions separate and the movement of ions keeps the current following through the external current.
- **The second problem is solved keeping the level of brine in anode compartment slightly higher**. This keeps the direction of flow of liquid toward the cathode and thus prevents the possibility of hydroxides ions to reach the anode.

Role of Gypsum in Agriculture and Industry
(Long Question)

Q. How gypsum is converted into Plaster of Paris?

Calcium sulphate occurs in nature as gypsum $CaSO_4.2H_2O$. When it is heated above 100°C, it loses three quarters of its water of crystallization, giving a white powder called Plaster of Paris.

$$2CaSO_4.\ 2H_2O \longrightarrow (CaSO_4)_2.\ H_2O + 3H_2O$$

Q. Give two uses of Plaster of Paris.

- Used for making **plaster walls, casts of statuary, coins**, etc.
- It is used in surgery. **Plaster of Paris bandages are used for holding in place fractured bones**.

Q. Why 2% gypsum is added into the cement?

About 2% of gypsum is added during grinding of cement clinkers which prevents the cement from hardening too rapidly. **It increases the setting time of cement**.

Q. Mention the types of Plaster.

(1) Cement Plaster

It is plaster of Paris to which usually **glue or other oils have been added as retarders to prolong the time of setting.**

(2) Hard Finish Plasters

These are made by the **calcination of the anhydrous sulphate with alum or borax**. These plasters are **set very slowly but give a hard finish**. When mixed with wood pulp and allowed to set in the form of boards, it forms a material, **much used in the construction of buildings as wall boards and partitions.**

Points to Remember for Long Question

- **Gypsum is applied to the soil as a source of calcium and sulphur**. The calcium supplied by gypsum in fertilizers is of importance in crop production in area where soils are subject to extensive leaching.
- **Plants deficient in sulphur exhibit a pale green colour**. The root systems of several plants have been observed to be greatly enlarged by the application of sulphur. It helps in synthesis of proteins.

Role of Lime in Agriculture and Industry

(Long Question)

Q. What is lime mortar? How is it formed?

Ordinary mortar, also called lime mortar, is prepared by **mixing freshly prepared slaked lime (one volume) with sand (three or four volumes) and water to form a thick paste**. This material when placed between the stones and bricks hardens, thus, binding the blocks firmly together.

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$$

$$Ca(OH)_2 + SiO_2 \longrightarrow CaSiO_3 + H_2O$$

Q. What is lime water and milk of magnesia?

A saturated solution of $Ca(OH)_2$ in water is called lime water and is used as a test for CO_2. **A suspension of $Mg(OH)_2$ in water is called milk of magnesia** and it is used for the treatment of acidity in stomach.

Q. Why lime is added to acidic soil?

Large quantities of calcium oxide are used in agriculture for **neutralizing acidic soils**. It has been found that application of lime (CaO) to acidic soils **increases the amount of readily soluble phosphorus.**

Q. How lime and sand are used to make glass?

The ability of lime to react with sand at high temperature forming calcium silicate ($CaSiO_3$) serves as an important basis for glass manufacture. **Lime is added in sand and on heating gets converted to calcium silicate. Addition of lime in glass increases the hardness and chemical durability of glass.**

Points to Remember for Long Question

- Large quantities of lime are used in the extraction and refining of metals.

- Lime is also used in paper, cement and leather industries.
- Lime is used in ceramic industry for producing different types of sanitary materials.
- Lime is also used in refining of sugar and other food products.
- Lime is used in the manufacturing of bleaching powder, which is used for the bleaching of the fabric and paper pulp.
- Lime is often employed as a dehydrating agent, for example, in the preparation of absolute alcohol and the drying of ammonia gas.

Chapter 3

Group IIIA and Group IVA Elements

Group IIIA Elements

Q. Write the formulas of borax, colemanite and bauxite.

Borax: $Na_2B_4O_7.10H_2O$

Colemanite: $Ca_2B_6O_{11}. 5H_2O$

Bauxite: $Al_2O_3. 2H_2O$

Q. Give four differences of boron from other elements of group IIIA.

1. **Only non-metal element** in Group IIIA.
2. **Only non-metal element with less than four electrons** in the outermost shell.
3. Boron uses three of its valence electrons for bonding and **its common oxidation states are + 3 and -3**.
4. It has **ability to form molecular addition compounds**.

Compounds of Boron

Q. How would you prepare borax from colemanite?

Finely **powdered colemanite** is **boiled** with **Na_2CO_3 solution**, when **$CaCO_3$ precipitates** out and a mixture of **borax** and **sodium metaborate** is formed.

$$Ca_2B_6O_{11}(s) + 2Na_2CO_3(s) \longrightarrow 2CaCO_3(s) + Na_2B_4O_7(s) + 2NaBO_2(s)$$

Q. Explain chemistry of borax bead test.

Borax, when **fused**, is **decomposed** into **sodium metaborate** and **boric anhydride**.

$$Na_2B_4O_7(s) \longrightarrow 2NaBO_2(s) + B_2O_3(s)$$

The **metallic oxide** combines **with B_2O_3** giving the **coloured metallic borates**. **Cupric borates** are **blue in colour**.

$$CuO(s) + B_2O_3(s) \longrightarrow Cu\,(BO_2)_2(s)$$

Q. Write four uses of borax.

1. It is used to **prepare borate glass**, which is heat resistant.
2. It is used in **softening of water**.
3. It is employed in borax bead test for the **detection of metallic cations**.
4. It is used in **metallurgical operations**.

Q. Why aqueous solution of borax is alkaline?

Borax when dissolved **in water ionizes** as:

$$Na_2B_4O_7(s) + 7H_2O(l) \longrightarrow \underset{\text{Strong alkali}}{2NaOH(aq)} + \underset{\text{Weak acid}}{4H_3BO_3(s)}$$

Boric Acids

Q. Write the formulae of four boric acids.

(i) Orthoboric Acid, H_3BO_3

(ii) Metaboric Acid, HBO_2

(iii) Tetraboric Acid, $H_2B_4O_7$

(iv) Pyroboric Acid, $H_6B_4O_9$

Q. How will you convert boric acid into borax and vice versa?

It is **partially neutralized by caustic soda** to give borax.

$$4H_3BO_3(aq) + 2NaOH(aq) \longrightarrow Na_2B_4O_7(aq) + 7H_2O(l)$$

Borax on **hydrolysis** gives **boric acid**.

$$Na_2B_4O_7(s) + 7H_2O(l) \longrightarrow \underset{\text{Strong alkali}}{2NaOH(aq)} + \underset{\text{Weak acid}}{4H_3BO_3(s)}$$

Q. What is the effect of heat on boric acid?

$$H_3BO_3(s) \xrightarrow{100^{o}\ C} \underset{\text{Metaboric Acid}}{HBO_2(s)} + H_2O(l)$$

$$4HBO(s) \xrightarrow{140^{o}\ C} \underset{\text{Tetraboric acid}}{H_2B_4O_7(s)} + H_2O(l)$$

$$H_2B_4O_7(s) \xrightarrow{\substack{\text{Red}\\ \text{hot}}} \underset{\text{Boric anhydride}}{2B_2O_3(s)} + H_2O(l)$$

Q. Give uses of boric acid.

1. **Boric acid** is used in medicines as an **antiseptic**.

2. It is used in **pottery** as a **glaze**.

3. It is also used in **candle industry** for **stiffening of wicks**.

Q. Why borate glazes are preferred over silicate glazes?

It is **used in pottery as a glaze** because **borate glazes are more fusible than silicate glazes** and possess a **higher coefficient of expansion**.

Q. Write the reactions of boric acid with i. Ethyl alcohol ii. Sodium hydroxide.

$$H_3BO_3(s) + 3C_2H_5OH(l) \longrightarrow (C_2H_5)_3BO_3(l) + 3H_2O(l)$$

$$4H_3BO_3(aq) + 2NaOH(aq) \longrightarrow Na_2B_4O_7(aq) + 7H_2O(l)$$

Reactions of Aluminium

Q. Write any four uses of aluminium.

1. It is **non-magnetic** and is **used in navigational equipment**.

2. It is found in the form of **cooking utensils**, **window frames** and **kitchen foil**.

3. Used for **making food** and **brewing equipments** and **in packaging**.

4. **Forms alloys** with other metals like copper, magnesium, nickel and zinc.

Group IVA Elements

Q. Give two similarities between carbon and silicon.

1. Carbon and silicon **both form acidic oxides**, whereas, the oxides of germanium, tin and lead are amphoteric in nature.

2. Both carbon and silicon **form covalent bonds**. Their oxides are acidic and both form hydrides and chlorides.

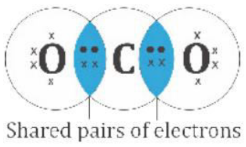
Q. How carbon shows peculiar behaviour as compared to rest of the group members?

1. **Carbon and silicon** are **non-metals** while the **other members** of the family are **metalloids or metals**.

2. **Catenation or self-linkage** is shown **by carbon** and it decreases down the group.

Q. Explain structure of CO_2.

Carbon dioxide exists in the **gaseous** state as **linear molecules**. The observed **C-O bond distance** is **115 pm**. Solid CO_2 has a **face-centered cubic structure**. Being **linear** its **dipole moment** is **zero**.



Q. What is vitreous silica?

When **crystalline silica** is **heated** sufficiently it melts to give **a viscous liquid** having a **random structure**, presumably with **the silicon atoms** still on the average **close to four oxygen atoms** and **the oxygen atoms close to two silicon atoms**. It is then **super cooled** to give a **rigid structure** called **vitreous silica or silica glass**.

Q. How sodium silicate is prepared?

$$Na_2CO_3(s) + SiO_2(s) \longrightarrow \underset{\text{Sodium silicate}}{Na_2SiO_3(s)} + CO_2(g)$$

Q. Give four uses of sodium silicate.

1. It is used as **filler for soap** in soap industry.

2. It is used **in textile as a fire proof**.

3. It is used **as furniture polish**.

4. It is also used **in calico printing**.

Q. What is chemical garden?

When crystals of **soluble coloured salts** like nickel chloride, ferrous sulphate, copper sulphate or cobalt nitrate, etc. are placed **in a solution of sodium silicate**, they produce **a very beautiful growth, like plant**, which is called **chemical garden**.

Q. What are the products of weathering of potassium feldspar?

$$K_2O.Al_2O_3.6SiO_2(s) + H_2CO_3(aq) + H_2O(l) \longrightarrow K_2CO_3(s) + 4SiO_2(s) + Al_2O_3.(SiO_2)_2.2H_2O(s)$$

Silicones

Q. Why liquid silicones are preferred over ordinary organic lubricants?

If the **temperature** is dropped **from 100°C to 0°C** the **viscosity** of petroleum oil may **increase about one hundred folds**, whereas, **that of silicone oil will increase less than four folds**. In the presence of air or oxygen **at temperature as high as 300 °C**, **silicone oils remain free from acid formation**, oxidation and similar phenomena, which frequently limit the usefulness of petroleum products and other synthetic organic liquids.

Q. Give two uses of silicones.

1. Some of the **methyl silicones are oily liquids** and they **become more viscous as the chain length increases**. They are used as lubricants, either incorporated in greases or as oils, in bearings, gears, etc. They are also **used in hydraulic brakes and other hydraulic systems**.

2. If the **temperature** is dropped **from 100°C to 0°C** the **viscosity** of petroleum oil may **increase about one hundred folds**, whereas, **that of silicone oil will increase less than four folds**. In the presence of air or oxygen **at temperature as high as 300 °C**, **silicone oils remain free from acid formation**, oxidation and similar phenomena, which frequently limit the usefulness of petroleum products and other synthetic organic liquids.

Semiconductors

Q. Define semiconductor. Write its properties.

A **semiconductor** is a substance that has **different resistances to the passages of an electric current** under different circumstances.

In semiconductors **flow of electricity increases by increasing temperature** because as the temperature increases the number of free moving electrons increase in case of semiconductors, thereby, increasing the flow of electricity.

Uses of Lead Compounds in Paints

Q. Give uses of lead suboxide.

It is used as a **pigment**.

It is also used in the manufacture of **lead storage batteries**.

Chapter 4

Group VA and Group VIA Elements

Group VA Elements

Q. Write four differences of nitrogen from its family.

1. Nitrogen shows the **typical properties of non-metals**.

2. **Poor conductor** of heat and electricity and

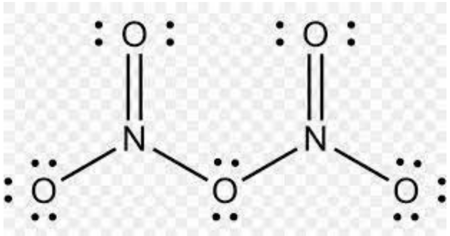
3. It gives **acidic oxides**.

3. **Compounds** are predominantly **covalent**.

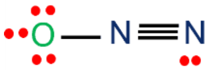
4. Nitrogen has the **greatest tendency to attract the electrons**.

Oxides of Nitrogen

Q. Draw structural formulas of dinitrogen pentoxide and dinitrogen oxide.



Dinitrogen pentoxide



Dinitrogen oxide

Q. What happens when NO_2 is dissolved in water?

In the absence of air, it dissolves in water to form nitric and nitrous acids.

$$2NO_2\,(g) + H_2O\,(l) \longrightarrow HNO_3\,(aq) + HNO_2\,(aq)$$

In the presence of air or oxygen, nitric acid is the final product.

$$4NO_2\,(g) + 2H_2O\,(l) + O_2\,(g) \longrightarrow 4HNO_3\,(aq)$$

Q. Give two reactions which show oxidizing behaviour of NO.

$$H_2S\,(g) + 2NO\,(g) \longrightarrow H_2O\,(g) + N_2O\,(g) + S\,(s)$$

$$H_2SO_3\,(aq) + 2NO\,(g) \longrightarrow H_2SO_4\,(aq) + N_2O\,(g)$$

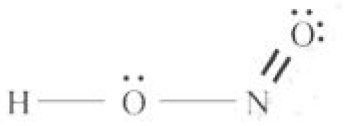
Q. Describe Ring test for the confirmation of presence of nitrate ions in the solution.

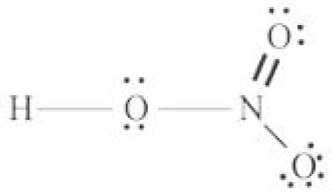
Nitrogen oxide forms a brown coloured addition compound with $FeSO_4$. **This test is used to confirm the presence of nitrates (Ring Test)**.

$$FeSO_4\,(aq) + NO\,(g) \longrightarrow FeSO_4.\,NO\,(aq)$$

Oxyacids of Nitrogen

Q. Explain the structure of HNO_2 and HNO_3.





HNO_2 Nitrous acid **HNO_3 Nitric acid**

Q. How does HNO_2 act as reducing agent?

$$2KMnO_4(aq)+3H_2SO_4(aq)+5HNO_2(aq)\rightarrow K_2SO_4(aq)+2MnSO_4(aq)+3H_2O(l)+5\,HNO_3(aq)$$

$$HNO_2(aq)+Br_2(aq)+H_2O(l)\rightarrow HNO_3(aq)+2\,HBr(aq)$$

Q. Write two reactions of preparation of nitrous acid.

1. It can be prepared by dissolving dinitrogen trioxide in water at 0 °C.

$$N_2O_3(g)+H_2O(l)\rightarrow 2HNO_2(aq)$$

2. Pure nitrous acid solution can be prepared by reaction between ice cold barium nitrite solution and ice cold dilute sulphuric acid.

$$Ba(NO_2)_2(aq)+H_2SO_4(aq)\rightarrow BaSO_4(s)+2HNO_2(aq)$$

Q. Write any four uses of Nitric acid.

1. as a **laboratory reagent**.
2. in the manufacture of **nitrogen fertilizers**.
3. in the manufacture of **explosives**.
4. for making **varnishes** and **organic dyes**.

Q. Give the names of four elements which do not react with nitric acid.

Gold, platinum, iridium and titanium do not react with nitric acid.

Q. What is aqua regia?

When **one volume of concentrated HNO_3** is mixed with **3 volumes of concentrated HCl**, aqua regia is formed. It is employed to dissolve gold and platinum.

$$HNO_3\,(conc) + 3HCl\,(conc.) \longrightarrow NOCl\,(aq) + Cl_2\,(g) + 2H_2O\,(l)$$

NOCI formed is decomposed giving NO and Cl_2

$$NOCl \longrightarrow NO\,(g) + [Cl]\,(g)$$

This liberated chlorine gas converts noble metals such as gold and platinum into their water soluble chlorides.

$$Au(s) + 3[Cl]\,(aq) \longrightarrow 2AuCl_3\,(aq)$$

Phosphorus and its Compounds

Q. How does P_2O_5 react with water in cold and hot state?

With cold water phosphorus pentoxide forms metaphosphoric acid.

$$P_2O_5(s) + H_2O(l) \rightarrow 2HPO_3(aq)$$

With hot water it forms orthophosphoric acid.

$$P_2O_5(s) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$$

Q. Give two methods for the preparation of PCl_3

1. It is usually prepared by melting white phosporus in a retort in an inert atmosphere of CO_2 and current of dried chlorine is passed over it. The vapours of PCl_3 are collected in a flask kept in an ice-bath.

$$2P(s) + 3C1_2(g) \rightarrow 2PC1_3(l)$$

2. It may also be prepared by the action of phosphorus with thionyl chloride.

$$2P(g) + 4SOC1_2(l) \rightarrow 2PC1_3(l) + 2SO_2(g) + S_2C1_2(s)$$

Q. P_2O_5 is powerful dehydrating agent. Give two examples.

$$2HNO_3(aq) + P_2O_5(s) \rightarrow N_2O_5(g) + 2HPO_3(aq)$$

$$H_2SO_4(aq) + P_2O_5(s) \rightarrow SO_3(g) + 2HPO_3(aq)$$

Q. What is the action of heat on orthophosphoric acid? Write chemical equation also.

$$\underset{\text{Orthophosphoric acid}}{2H_3PO_4} \xrightarrow[-H_2O]{240^\circ C} \underset{\text{Pyrophosphoric acid}}{H_4P_2O_7} \xrightarrow[-H_2O]{316^\circ C} \underset{\text{Metaphosphoric acid}}{2HPO_3}$$

Q. Give the reactions of phosphorous with: a. Thionyl chloride b. Cl_2 gas

a. Thionyl chloride

$$2P\,(g) + 4SOCl_2\,(l) \longrightarrow 2PCl_3\,(l) + 2SO_2\,(g) + S_2Cl_2\,(s)$$

b. Cl_2 gas

$$2P\,(s) + 3Cl_2\,(g) \longrightarrow 2PCl_3\,(l)$$

Q. Name three allotropic forms of phosphorus. How red phosphorous is prepared?

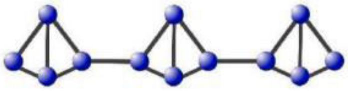
The three allotropic forms of phosphorus are:

White phosphorus

Red phosphorus

Black phosphorus

Red phosphorus **is much less reactive** and **less poisonous** than white phosphorus. It is prepared by **heating white phosphorus in the presence of a little iodine or sulphur** as a catalyst up to **250 °C** in **vacuum**. The tetra-atomic molecules of red phosphorus combine to form macromolecules.



Group VIA Elements

Q. Why the elements of VIA other than oxygen show more than two oxidation states?

Except oxygen the other members of the group show a covalency of **+2 ,+4, and +6**. +2 oxidation state is shown due to 2 unpaired electrons in the p-orbitals. +4 oxidation state is shown when 1 electron from p-orbilal is promoted to the next vacant d-orbital, while + 6 oxidation state is shown when another electron from s-orbital is also promoted to the next vacant d-orbital.

Q. Write two similarities and two dissimilarities of oxygen and Sulphur.

Similarities

1. Both **oxygen and sulphur** have same outer electronic configuration of ns^2p^4.

2. Both oxygen and sulphur are **usually divalent**.

Dissimilarities

Oxygen	Sulphur
1. There are two allotropic forms of oxygen O_2 and O_3	1. There are three allotropic forms of sulphur, rhombic, monoclinic and plastic
2. It is gas at ordinary temperature	2. It is solid at ordinary temperature

Sulphuric Acid

Q. Justify that sulphuric acid is king of chemicals.

Sulphuric acid is called king of chemicals because of its direct and indirect applications in manufacture of many chemicals including fertilizers. It dissolves its own compounds. It replaces salts from weaker acids. It acts as an oxidizing and dehydrating agent for a variety of compounds.

Q. Write down two chemical reactions which show that sulphuric acid is a dehydrating agent?

$$HCOOH(l) \xrightarrow{conc.\ H_2SO_4} CO(g) + H_2O(l)$$

$$C_2H_5OH(\ell) \xrightarrow[100^\circ C]{Conc.H_2SO_4} C_2H_4(g) + H_2O(\ell)$$

Q. Complete and balance the following chemical equation. $KMnO_4$+ $FeSO_4$+ H_2SO_4

$$\begin{array}{l} 2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O] \\ 10FeSO_4 + 5H_2SO_4 + 5[O] \rightarrow 5Fe_2(SO_4)_3 + 5H_2O \\ \hline 2KMnO_{4(aq)} + 8H_2SO_{4(aq)} + 10FeSO_{4(aq)} \rightarrow K_2SO_{4(aq)} + 2MnSO_{4(aq)} + 5Fe_2(SO_4)_{3(aq)} + 8H_2O_{(l)} \end{array}$$

Q. Give two reactions of sulphuric acid which show its oxidizing behaviour.

$$C(s) + 2H_2SO_4(conc) \rightarrow CO_2(g) + 2SO_2(g) + 2H_2O(g)$$

$$2HI(aq) + H_2SO_4(aq) \rightarrow I_2(g) + SO_2(g) + 2H_2O(g)$$

Q. Write any four properties of sulphuric acid.

1. Pure sulphuric acid is a **colourless oily liquid** without an odour.

2. Its **specific gravity is 1.834** at **18 °C**.

3. It **freezes** at **10.5 °C**.

4. Its **boiling point** is **338 °C**.

Q. Write four uses of Sulphuric acid.

1. In the manufacture of **fertilizers** like **ammonium sulphate** and **calcium superphosphate**.

2. In **refining of petroleum** to remove nitrogen and sulphur compounds.

3. In the **manufacture** of **HCl, H_3PO_4, HNO_3 and sulphates**.

4. In the **manufacture** of many **chemicals, dyes, drugs, plastics, disinfectants, paints, explosives, synthetic fibers**, etc.

Chapter 5

The Halogens and the Noble Gases

Q. Why iodine has metallic luster?

The size of iodine is big due to which outermost shell electrons are loosely bound. They absorb energy and excite. On de-exciting they release energy which is seen in the form of light.

Peculiar Behaviour of Fluorine

(Long Question)

Q. Give peculiar behaviour of fluorine.

1. Small size of F atom and of F^- ion.

2. High first ionization energy and electronegativity.

3. Low dissociation energy of F_2 molecule as compared to Cl_2 and Br_2.

4. Restriction of the valence shell to an octet.

5. Direct combination with inert gases.

Points to Remember for Long Question

- Due to the small size of the F atom (or F- ion), there will be a better overlap of orbitals.
- Ionic fluorides have higher lattice energies than the other halides.
- Due to the low dissociation energy of fluorine molecule, it is highly reactive.
- The fluorides are, however, more stable with respect to dissociation into elements.
- Due to the restriction of valence shell to an octet, many fluoro compounds show inertness.
- Fluorine is the only element that combines directly with noble gases.

Oxidizing Properties

(Long Question)

Q. Oxidizing power of halogens depends on which factors?

1. Energy of dissociation

2. Electron affinity of atoms

3. Hydration energies of ions

4. Heats of vaporization (for Br_2 and I_2)

Points to Remember for Long Question

Fluorine can oxidize all the halide ions to molecular halogens.

$$F_2 + 2e^- \longrightarrow 2F^- \qquad E^o = 2.87V$$

$$\underline{2Cl- \longrightarrow Cl_2 + 2e-} \qquad E^o = -1.36V$$

$$F_2 + 2Cl^- \longrightarrow Cl_2 + 2F- \qquad E^o = +1.51V$$

Chlorine will oxidize both bromide and iodide ions, while bromine can oxidize only iodide ion.

$$Cl_2 + 2Br^- \longrightarrow Br_2 + 2Cl^-$$

$$Br_2 + 2I^- \longrightarrow I_2 + 2Br^-$$

Compounds of Halogens

Q. How halogen acids are ionized in water?

Halogen acids ionize in water and form halide ions and hydronium ions. For example,

$$HF + H_2O \longrightarrow H_3O^+ + F^-$$

$$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$$

$$HBr + H_2O \longrightarrow H_3O^+ + Br^-$$

$$HI + H_2O \longrightarrow H_3O^+ + I^-$$

Q. What is disproportionation reaction. Give an example.

A reaction in which **a species (molecule, atom or ion) is simultaneously oxidized and reduced, is called a “disproportionation reaction”**

In cold (15°C) state chlorine will react with NaOH (aq) to form hypochlorite and a halide.

$$2NaOH\ (aq) + Cl_2\ (g) \xrightarrow{15\ ^oC} NaCl\ (aq) + \underset{\text{Sod. hypochlorite}}{NaClO\ (aq)} + H_2O\ (aq)$$

Zero oxidation state of chlorine atom in Cl_2, is converted to -1 in chloride and +1 in hypochlorite.

Q. How NaOH reacts with Cl_2 in cold and hot state?

In cold (15°C) state chlorine will react with NaOH (aq) to form hypochlorite and a halide.

$$2NaOH\ (aq) + Cl_2\ (g) \xrightarrow{15\ ^oC} NaCl\ (aq) + \underset{\text{Sod. hypochlorite}}{NaClO\ (aq)} + H_2O\ (aq)$$

Zero oxidation state of chlorine atom in Cl_2, is converted to -1 in chloride and +1 in hypochlorite.

Sodium hypochlorite which is produced in cold state in the above reaction decomposes forming sodium chloride and sodium chlorate at 70°C.

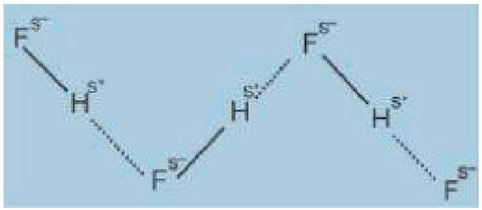
$$3NaClO\ (aq) \xrightarrow{70\ ^oC} 2NaCl\ (aq) + NaClO_3\ (aq)$$

$$\begin{array}{rcl} 6NaOH + 3Cl_2 & \longrightarrow & 3NaCl + 3NaClO + 3H_2O \\ \underline{3\ NaClO} & \underline{\longrightarrow} & \underline{2NaCl + NaClO_3} \\ 6NaOH\ (aq) + 3Cl_2\ (g) & \longrightarrow & 5NaCl\ (aq) + NaClO_3\ (aq) + 3H_2O \end{array}$$

Chlorine atoms are both reduced and oxidized.

Q. Why HF is a weaker acid than other halogen acids?

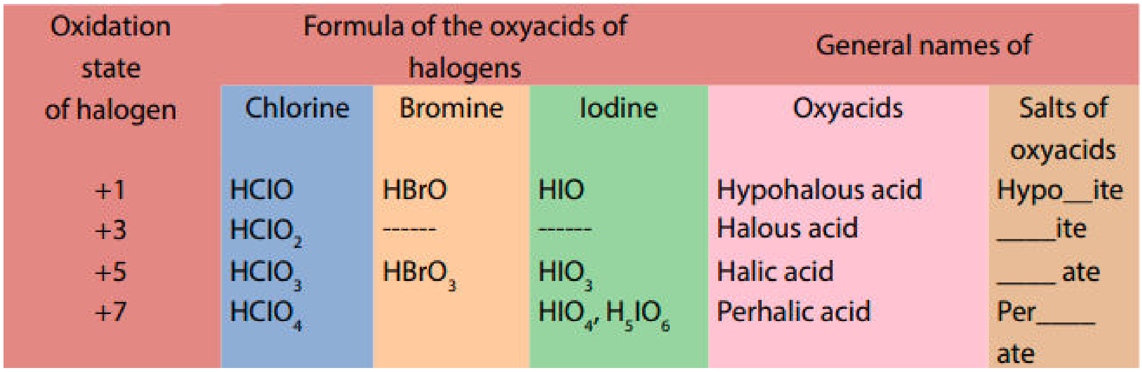
HF acts as a weak acid because it has a **zig-zag structure and hydrogen is trapped between two fluorine atoms so cannot be released easily**, thereby, decreasing the acidic strength of hydrogen fluoride.



Oxyacids

(Long Question)

Knowing this table can help in adding explanation



Oxidation state of halogen	Formula of the oxyacids of halogens			General names of	
	Chlorine	Bromine	Iodine	Oxyacids	Salts of oxyacids
+1	$HClO$	$HBrO$	HIO	Hypohalous acid	Hypo__ite
+3	$HClO_2$	------	------	Halous acid	____ite
+5	$HClO_3$	$HBrO_3$	HIO_3	Halic acid	_____ ate
+7	$HClO_4$		HIO_4, H_5IO_6	Perhalic acid	Per____ ate

Q. Arrange the following oxy acids in the increasing order of acid strength. $HClO_4$, $HClO_3$, $HClO_2$, HOCl

The oxyacids of halogens show their strength in the order given below:

$$HClO < HClO_2 < HClO_3 < HClO_4$$

Points to Remember for Long Question

- The **increase in the oxidation state of the halogen from +1 to + 7** is accompanied by:

(a) An increase in the thermal stability of the acid

(b) The decrease in oxidizing power of the acid

(c) The increase in acidic strength of the acid

- The **acid strength increases** with the **increase in the number of oxygen atoms**.

$$HXO_4 > HXO_3 > HXO_2 > HXO$$

Q. On what basis perchloric acid is considered a valuable analytical reagent?

Due to its **oxidizing effect, acidic strength and solubility of its salts**, perchloric acid is considered a valuable analytical reagent.

Q. How perchloric acid is prepared?

$$KClO_4 + H_2SO_4\,(conc.) \xrightarrow[\text{Reduced pressure}]{\Delta} KHSO_4\,(s) + HClO_4\,(l)$$

Bleaching Powder

(Long Question)

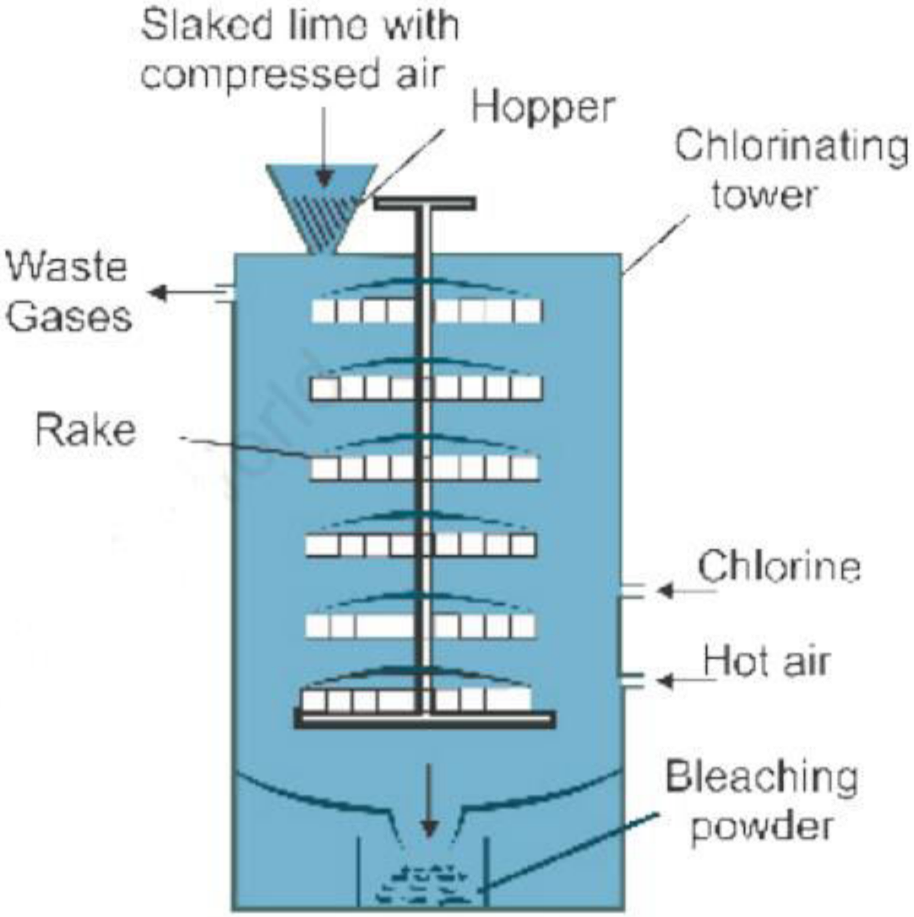
Bleaching powder can be manufactured by **the action of chlorine on dry slaked lime** using any one of the following methods:

(a) Hasenclever’s method (old method)

(b) Beckmann’s method (modern method)

$$Ca(OH)_2 + Cl_2 \longrightarrow Ca(OCl)Cl + H_2O$$

Beckmann’s method: a **cast iron tower** with **eight horizontal shelves**. In **each shelf** there is **a rotating rake**. **Powdered slaked lime is introduced through hopper at the top** with compressed air. **A mixture of hot air and chlorine are introduced from the base** of the tower. Bleaching powder is collected at the bottom of the tower.



In Hasenclever method there is no counter-current principle and no rotating rakes. Rest of the procedure is same.

Q. How bleaching powder acts as an oxidizing agent?

It is an oxidizing agent. This property is due to the generation of hypochlorite ion (^-OCl) in water.

$$CaOCl_2 \xrightarrow{H_2O} Ca^{+2} + Cl^- + ClO^-$$

Q. What is meant by available chlorine?

If excess of an acid (weak or strong) is added to bleaching powder, chlorine is given out.

$$CaOCl_2 + H_2SO_4\text{ (excess)} \longrightarrow CaSO_4 + H_2O + Cl_2\uparrow$$

The amount of chlorine thus set free is called "available chlorine". The activity of bleaching powder is measured in terms of available chlorine. The **average percentage of available chlorine in bleaching powder is 35-40 percent**.

Q. Mention any two uses of bleaching powder.

1. as a **disinfectant** and in the **sterilization of water**.

2. for making **unshrinkable wool**.

Commercial Uses of Halogens and their Compounds

Q. What is structural formula of Teflon? Mention its two uses.

Fluorine is used for the preparation of freons. **Freon is the commercial name of low molecular mass fluorochlorocarbons, CCl_2F_2, $CClF_3$**. These are being used as **refrigerants and aerosol propellants**. Fluorine is used to prepare **Teflon (-CF_2 — CF_2-)n**. It is a polymerized tetrafluoro ethylene compound. It is a **valuable plastic which resists the action of oxidants, acids and alkalies. Corrosion proof parts of machinery are made of it.**

Q. What is iodized salt?

To ensure the **presence of iodide ion in the diet, sodium or potassium iodide is added to the common salt** which is known as iodized salt.

Q. What is iodex and tincture of iodine?

Iodex and tincture of iodine are popular preparations of iodine. It is used as **a disinfectant and germicide**.

Noble Gases

Q. The elements of group VIIIA are called noble gases. Comment.

The **outermost shell of group VIIIA elements is complete and they are inert**. That is why, they are called noble gases.

(Long Question)

Q. Give four applications of noble gases.

Neon

Neon is largely used in making **neon advertising signs, in high voltage indicators and TV tubes**.

Neon and helium arc is used in making **glass lasers**.

Krypton

Krypton is used to fill **fluorescent tubes and in flash lamps for high speed photography**.

Xenon

Xenon is used in **bactericidal lamps**.

Q. Write two uses of each helium and argon.

Helium

1. Helium is used **in weather balloons, in welding and in traffic signal light**.
2. A mixture of **80% helium and 20% oxygen is used for breathing by the sea divers**.

Argon

Argon is used in **electric light bulbs, in fluorescent tubes, in radio tubes, and in Geiger counters**.

Q. Why solubility of noble gases increases down the group?

The solubility of the noble gases in water increases with increasing atomic number. This is because **the bigger atoms are more readily polarized by water molecules**.

Chapter 6

Transition Elements

Q. What is meant by outer transition metals and inner transition metals?

f-block elements, i.e., Lanthanides and Actinides are also called **inner transition metals**, whereas, **d-block elements** are called **outer transition metals**.

Q. Why d and f block elements are called transition elements?

The **d-block and the f-block elements** are called transition elements because they are **located between the s and p-block elements** and their **properties are in transition** between the metallic elements of the s-block and nonmetallic elements of the p-block.

Q. What are coinage metals?

Group **IB** elements (**Cu, Ag, Au**) are called **coinage metals**.

Q. What are typical and non-typical transition elements?

Group **IIB elements** (Zn, Cd and Hg) and group **IIIB elements** (Sc, Y and La) **do not show many of the properties associated with typical transition elements**. They are **non-typical transition elements**. The elements other than IIB and IIIB are called typical transition elements.

Properties of Transition Elements

Q. Define Paramagnetism, diamagnetism and Ferromagnetism.

Paramagnetism

Substances which are **weakly attracted by a strong magnetic field** are called paramagnetic substances.

Example

Mn^{2+}

Diamagnetism

Those substances which are **weakly repelled by a strong magnetic field** are called diamagnetic substances.

Example

Zn^{2+}

Ferromagnetism

A ferromagnetic substance contains **permanent atomic magnetic dipoles that are spontaneously oriented**. Ferromagnetism is a kind of magnetism that is associated with iron, cobalt, nickel, and some alloys or compounds containing one or more of these elements.

Q. Why transition elements have variable oxidation states?

They show variable valencies because of the **involvement of the unpaired d electrons** in addition to s electrons in bond formation.

Q. What is ligand? Give types of ligands.

The atoms or ions or neutral molecules which surround the central metal ion and **donate electron pairs** to it are called ligands. They may be anions or neutral molecules, e.g. $K_4[Fe(CN)_6]$, $[Ag(NH_3)_2]Cl$.

CN^- and **NH_3** are the **anionic and neutral ligands**. Ligands having **two donor atoms** are called **bidentate ligands**, e.g. Oxalate ion is a bidentate ligand

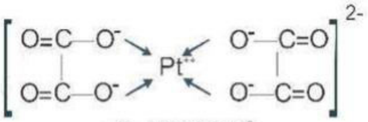
and its coordination with the metal ion occurs through its both negatively charged oxygen atoms.

Q. What are chelates? Give an example.

When **all the donor atoms of a polydentate ligand get coordinated with the same metal ion**, a complex compound is formed which contains **one or more rings in its structure** and hence is called a **chelate**.

For example,

When two oxalato ligands $C_2O_4^{2-}$ (bidentate ligand) get coordinated with Pt^{2+} ion, dioxalato platinate (II) ion is obtained. Each oxalate ligand forms a five membered ring with the cation.

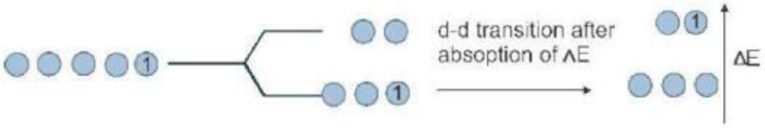


or $[Pt(C_2O_4)_2]^{2-}$

Dioxalato- platinate (II)ion

Q. Give reason for the development of colours in the transition metal complexes.

In transition elements, the **d orbitals are responsible for the colour development in their compounds**. When these orbitals are involved in bonding, they split up into two energy levels, one set has a higher energy than the other. The electrons residing in low energy d-orbitals absorb a part of the visible light and jump to high energy d orbitals. The process is called d-d transition.



In $[Ti(H_2O)_6]^{3+}$, yellow light is absorbed, while most of the blue and red lights are transmitted, therefore the solution of **$[Ti(H_2O)_6]^{3+}$ ions looks violet in color**.

Q. What is meant by interstitial compound and substitutional alloy?

Q. Give coordination number and oxidation number of iron (Fe) in $K_4[Fe(CN)_6]$.

The coordination number of iron (Fe) in $K_4[Fe(CN)_6]$ is 6 and the oxidation number is 2.

Iron

Q. Give formulas of Magnetite and Haematite.

Magnetite (Fe_3O_4)

Haematite (Fe_2O_3)

Q. Write carbon content in pig iron and cast iron.

Pig iron or cast iron has **2.5 to 4.5% carbon**.

Q. What is the %age of carbon in different types of steel?

1. Mild Steel (0.1 - 0.2 % C)

2. Medium Carbon Steel (0.2 - 0.7 % C)

3. High Carbon Steel (0.7 -1.5 % C)

Q. What is galvanizing or anode coating? How is it done? OR What is sacrificial corrosion?

Galvanizing is done by dipping a clean iron sheet in a zinc chloride bath and heating. The iron sheet is then removed, rolled into zinc bath and air cooled. In this case, if a protective layer of zinc is damaged a galvanic cell is established in the presence of moisture. Iron serves as a cathode and zinc as an anode. Electrons flow from zinc to iron, as a result of which Zn decays while Fe remains intact. This is called **sacrificial corrosion**.

$$Fe^{2+} + Zn \longrightarrow Zn^{2+} + Fe$$

Q. Why does damaged tin plated iron get rusted quickly?

If the protective coating is damaged, then a galvanic cell is established in which tin acts as a cathode and iron as an anode. **The electrons flow from iron to tin, where they discharge H^+ ions, leaving behind OH^- in the solution.** These hydroxide ions react with iron forming $Fe\,(OH)_3$, which dissolves rapidly in water.

Q. Give the prevention of metals from corrosion.

Coating it with **oil, paint, varnish or enamel**.

By **alloying** the metals or by **coating the metal** with **a thin layer of another metal**.

Chromates and Dichromates

Q. What is Stadeler's process?

In this method Cl_2 is passed through the green solution of K_2MnO_4 until it becomes purple due to the formation of $KMnO_4$. Here, **Cl_2 oxidizes K_2MnO_4 into $KMnO_4$**.

$$2K2MnO_4 + Cl_2 \longrightarrow 2KCl + 2KMnO_4$$

Q. How $KMnO_4$ can be prepared by electrolytic method.

Manganate is converted to permanganate by electrolytic oxidation. During electrolysis of an aqueous solution of K_2MnO_4, water is decomposed to evolve hydrogen gas at the cathode and oxygen gas at the anode. **Oxygen liberated at the anode oxidizes manganate ion $(MnO_4)^{2-}$ into permanganate ion $(MnO_4)^{1-}$, while hydrogen is liberated at the cathode.**

$$2K_2MnO_4 + H_2O + [O] \longrightarrow 2KMnO_4 + 2KOH$$

The purple solution of $KMnO_4$, obtained as above is filtered through asbestos, concentrated and allowed to crystallize when $KMnO_4$ deposits as deep purple-red rhombic prisms

Q. $KMnO_4$ acts as oxidizing agent. Show with two examples.

1.

$$\begin{array}{c}
2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O] \\
5H_2S + 5[O] \longrightarrow 5H_2O + 5S \\
\hline
2KMnO_4 + 3H_2SO_4 + 5H_2S \longrightarrow K_2SO_4 + 2MnSO_4 + 5S + 8H_2O
\end{array}$$

2.

$$2KMnO_4 + 10FeSO_4 + 8H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$$

Q. What is chromyl chloride test? Give chemical equation.

When **solid potassium dichromate** is **heated with solid metal chloride** in the presence of **concentrated sulphuric acid** **chromyl chloride is produced**.

$$K_2Cr_2O_7 + 4NaCl + 6H_2SO_4 \longrightarrow 2KHSO_4 + 4NaHSO_4 + \underset{\text{Chromyl chloride}}{2CrO_2Cl_2} + 3H_2O$$

Q. Write down any two uses of potassium dichromate.

1. $K_2Cr_2O_7$ finds extensive use in **dyeing**.

2. It is used in leather industries for **chrome tanning**.

Chapter 7

Fundamental Principles of Organic Chemistry

Q. What is vital force theory? Who rejected it?

Organic compounds could be manufactured only by and within living things and these compounds could never be synthesized from inorganic materials. This theory was referred to as **vital force theory**.

This theory was **rejected by Friedrick Wohler when he obtained urea $(NH_2)_2CO$**, an organic compound in the urine of mammals, **from ammonium cyanate, NH_4CNO**.

$$NH_4CNO \longrightarrow (NH_2)_2CO$$

Features of Organic Compounds

(Long Question)

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

1. Peculiar nature of carbon

The main reason for such a large number of compounds is its **unique property of linking with other carbon atoms to form long chains or rings**. This self-linking property of carbon is called **catenation**.

2. Non-ionic character of organic compounds

Organic compounds are generally covalent compounds, therefore, **do not give ionic reactions**.

3. Similarity in behaviour

There exists a **close relationship between different organic compounds**. This is exemplified by the existence of **homologous series**.

4. Complexity of organic compounds

Organic molecules are usually **large and structurally more complex**.

5. Isomerism

Very common phenomenon in organic compounds in which compounds are represented by **the same molecular formula but have different structural formulas**.

6. Rates of organic reactions

The **reactions** involving organic compounds are **slow** and in general the **yields are low**.

7. Solubility

Most organic compounds are **insoluble in water** and **dissolve readily in non-polar organic solvents**, such as, benzene, petroleum ether, etc.

Cracking of Petroleum

(Long Question)

Q. Define cracking.

It is defined as **breaking of higher hydrocarbons having high boiling points into a variety of lower hydrocarbons, which are more volatile (low boiling)**. For example,

$$\underset{\text{Alkane}}{C_{16}H_{34}} \xrightarrow[700\,^{0}C]{\text{Heat}} C_7H_{16} + 3CH_2{=}CH_2 + CH_3\text{-}CH{=}CH_2$$

Q. What is thermal cracking?

Breaking down of large molecules by heating at high temperature and pressure is called Thermal Cracking. It is particularly useful in the production of **unsaturated hydrocarbons such as ethene and propene.**

$$\underset{\text{Alkane}}{C_{16}H_{34}} \xrightarrow[700\,^{0}C]{\text{Heat}} C_7H_{16} + 3CH_2{=}CH_2 + CH_3\text{-}CH{=}CH_2$$

Q. What is catalytic cracking?

Higher hydrocarbons can be cracked at lower temperature (500°C) and lower pressure (2 atm), in the presence of a suitable catalyst. A typical catalyst used for this purpose is a **mixture of silica (SiO_2) and alumina (Al_2O_3)**. Catalytic cracking produces **gasoline of higher octane number** and, therefore, this method is used for obtaining better quality gasoline.

Q. What is steam cracking?

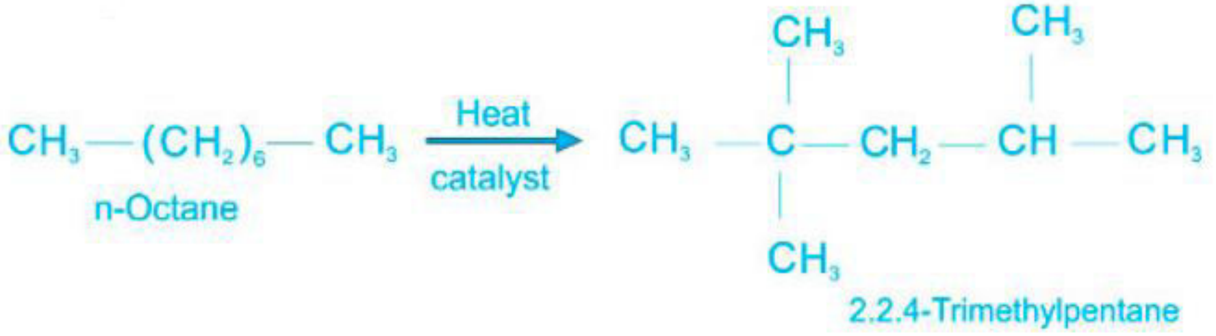
In this process, **higher hydrocarbons in the vapour phase are mixed with steam, heated for a short duration to about 900°C and cooled rapidly**. The process is suitable for obtaining **lower unsaturated hydrocarbons**.

Reforming

(Long Question)

Q. Define reforming.

The octane number of gasoline is improved by a process called reforming. It involves the **conversion of straight chain hydrocarbons into branched chain by heating in the absence of oxygen and in the presence of a catalyst**.



Q. What is octane number and how it can be improved?

Percentage by volume of isooctane relative to that of n-heptane in a fuel is called octane number. Octane number is improved by making isooctane through the process of reforming and adding it to a low octane number fuel.

Q. What is meant by knocking?

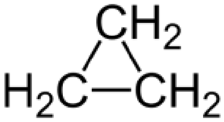
Straight chain hydrocarbons e.g., n-Heptane have low octane number and **burn rapidly in internal combustion engine producing sharp metallic sound called knocking**.

Classification of Organic Compounds

Q. Define homocyclic compounds. Give examples.

The compounds in which **the ring consists of only carbon atoms are Homocyclic or carbocyclic compounds**. Homocyclic compounds are further classified as:

1. Alicyclic compounds



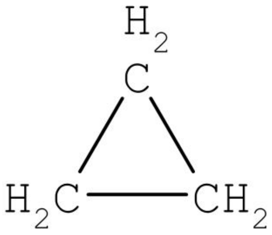
Cyclopropane

2. Aromatic compounds

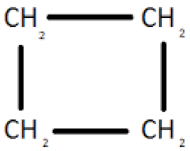
Benzene

Q. What are alicyclic compounds? Give two examples.

The **homocyclic compounds which contain a ring of three or more carbon atoms and resembling aliphatic compounds are called alicyclic compounds**. Typical examples of alicyclic compounds are given below:



Cyclopropane



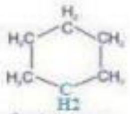
Cyclobutane

Q. What are aromatic compounds?

These **carbocyclic compounds contain at least one benzene ring**. Typical examples of aromatic compounds are given below. For example,

Benzene

Q. Differentiate between homocyclic and heterocyclic compounds.

	Homocyclic Compounds	Heterocyclic Compounds
1.	The compounds in which the ring consists of only one type of atoms	The compounds in which the ring consists of atoms of more than one kind
2.	Organic homocyclic compounds have ring made of carbon atoms only.	Generally one or more atoms of elements such as nitrogen (N), oxygen (O) or sulphur (S) are present in the ring.
3.	 Cyclohexane  Phenol	 Pyridine

Q. What are fused ring aromatic compounds?

Those **compounds in which the benzene rings are fused together at ortho positions**. For example, naphthalene, phenanthrene and anthracene.

Naphthalene

Phenanthrene

Anthracene

Functional Group

Q. Define functional group. Give two examples of functional groups containing oxygen.

An atom or a group of atoms or a double bond or a triple bond whose presence imparts specific properties to organic compounds is called a functional group. For example,

COOH carboxyl group carboxylic acid CH_3COOH Acetic acid

CHO aldehyde group HCHO formaldehyde

Hybridization of Orbitals and the Shapes of Molecules

(Long Question)

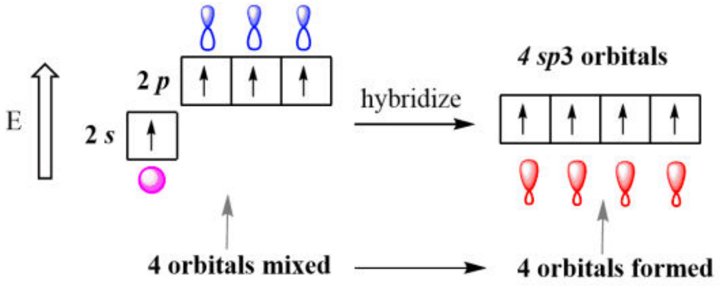
Q. Define hybridization.

When **atomic orbitals of different energy and shape intermix to form a new set of orbitals of same shape and energy** then it is called hybridization.

Q. Define sp^3 hybridization.

In sp^3 hybridization, **one s and three p atomic orbitals intermix to form four equivalent orbitals called sp^3 hybrid orbitals**. Examples CH_4, NH_3 and H_2O.

Q. Explain structure of methane according to sp^3 hybridization.



Geometry: Tetrahedral geometry with carbon at center.

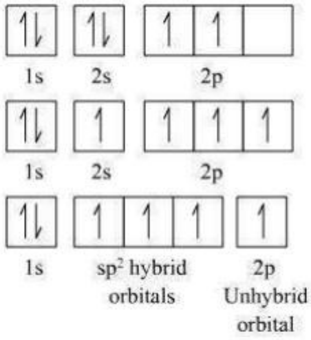
Bond angles: Total six bond angles of 109.5º

Total bonds: Four sigma bonds formed by the overlap of sp3 hybrid orbitals of carbon with 1s orbitals of four hydrogen atoms.

Q. Define sp^2 hybridization.

In sp^2 hybridization, **one 's' and two 'p' atomic orbitals of an atom intermix to form three orbitals called sp^2 hybrid orbitals**. Example, BF_3 and Ethene.

Q. Explain structure of ethene (ethylene).



Geometry: Trigonal planar.

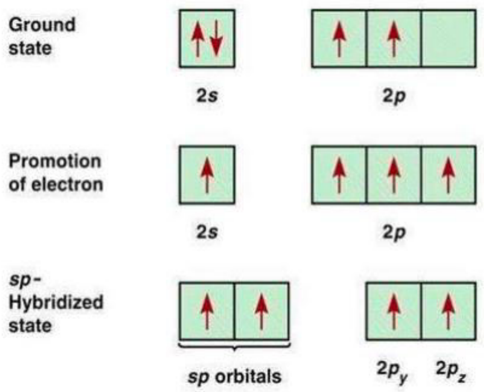
Bond angle: The bond angle between any two sp^2 hybrid orbitals is 120°

Overlap of orbitals: sp^2 hybrid orbital of each carbon overlaps to give sp^2 -sp^2 sigma bond and the other two sp^2 orbitals overlap with 1s orbitals of hydrogen to give sp^2 -s sigma bonds. The unhybridized 2pz orbitals overlap sideways to give a π-bond.

Q. Define sp hybridization.

In sp hybridization, **one ‘s’ and one ‘p’ orbitals intermix to form two sp-hybrid orbital called sp hybrid orbitals**. Examples $BeCl_2$ and ethyne.

Q. Explain structure of ethyne.



Geometry: Linear shape.

Total bonds: One sp-sp sigma bond and two sp-s sigma bonds. Two, 2py-2py and 2pz-2pz, π-bonds.

Bond angles: These orbitals have a bond angle of 180°.

Isomerism

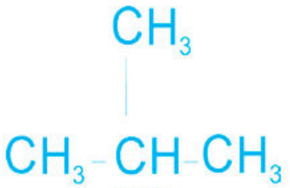
(Long Question)

Q. Define isomerism.

Two or more compounds having the same molecular formula but different structural formulas and properties are said to be isomers and the phenomenon is called isomerism.

$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3$

n-Butane



$CH_3\text{-}\underset{}{\overset{\overset{\displaystyle CH_3}{|}}{CH}}\text{-}CH_3$

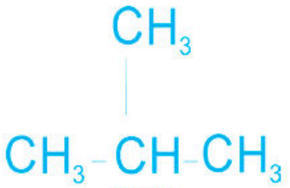
Isobutane

Q. Define structural isomerism./Two possible isomers of C_4H_{10}

The structural isomerism arises due to the **difference in the arrangement of atoms within the molecule**.

$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3$

n-Butane



$CH_3\text{-}\underset{}{\overset{\overset{\displaystyle CH_3}{|}}{CH}}\text{-}CH_3$

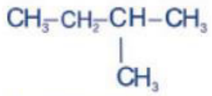
Isobutane

Q. Define chain isomerism.

This type of isomerism arises due to the **difference in the nature of the carbon chain**. For example, for pentane (C_5H_{12}), the following arrangements are possible.

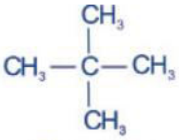
$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$

n-Pentane



$CH_3\text{-}CH_2\text{-}CH(CH_3)\text{-}CH_3$

Isopentane



$CH_3\text{-}C(CH_3)_2\text{-}CH_3$

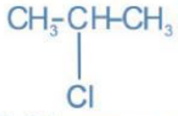
Neopentane

Q. Define position isomerism.

This type of isomerism arises due to the **difference in the position of the same functional group on the carbon chain**. For example,

$CH_3\text{-}CH_2\text{-}CH_2\text{-}Cl$

1-Chloropropane



$CH_3\text{-}CH(Cl)\text{-}CH_3$

2-Chloropropane

Q. Define functional group isomerism.

The compounds having the **same molecular formula but different functional groups** are said to exhibit functional group isomerism. For example,

$CH_3\text{-}O\text{-}CH_3$

Dimethyl ether

$CH_3\text{-}CH_2\text{-}OH$

Ethyl alcohol

Q. Define metamerism.

This type of isomerism arises due to the **unequal distribution of carbon atoms on either side of the functional group**. For example,

$CH_3-CH_2-O-CH_2-CH_3$

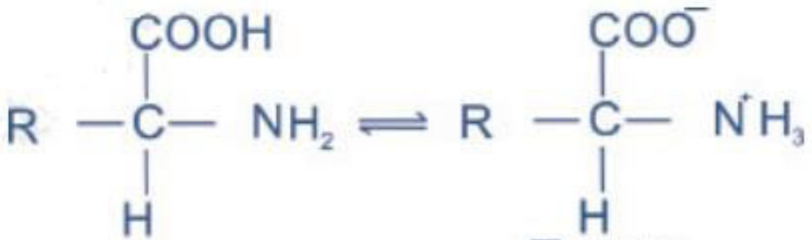
Diethyl ether

$CH_3-O-CH_2-CH_2-CH_3$

Methyl n-propyl ether

Q. Define tautomerism.

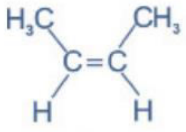
This type of isomerism arises **due to shifting of proton from one atom to other in the same molecule**.



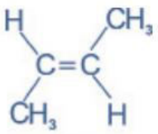
Zwitterion

Q. What is cis-trans or geometrical isomerism?

Such compounds which possess the same structural formula, but **differ with respect to the positions of the identical groups in space** are called cis-trans isomers and the phenomenon is known as the cis-trans or geometric isomerism.



Cis



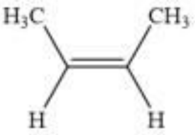
Trans

Q. Why free rotation is not possible in case of pi bond?

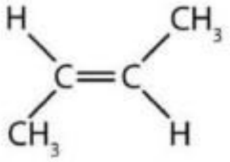
The parallel overlap of the orbitals in a pi bond restricts rotation of the double bonded carbon atoms in alkenes.

Q. 2-butene shows geometrical isomerism but 1-butene does not. Why?

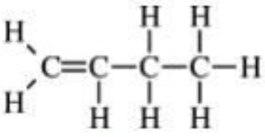
1- Butene has two hydrogen atoms on first carbon atom therefore it does not fulfill the condition necessary for geometric isomerism. Hence, it has no cis or trans isomers.



Cis-2-Butene



trans-2-Butene



1-Butene

Q. What are the conditions for cis-trans isomerism?

Restricted rotation of carbon atoms due to a double bond.

Two different groups attached to each carbon atom making the double bond.

Chapter 8

Aliphatic Hydrocarbons

(Most Repeated Reactions from Past papers are Focused which may come for both Short Questions and Long Question)

Alkanes

Write down structural formulas of the following:

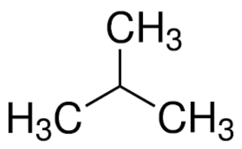
a. 2-Methyl propane

b. Neopentane

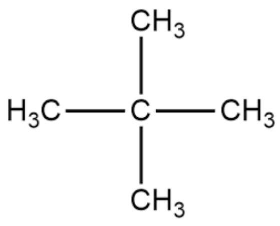
c. 3-Ethylpentane

d. 2,2-Dimethyl pentane

a.

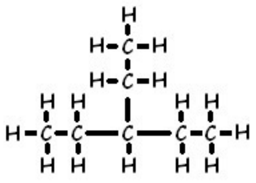


b.

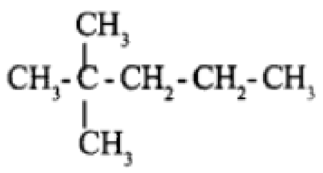


$$CH_3-\underset{CH_3}{\overset{CH_3}{C}}-CH_3$$

c.



d.



$$CH_3-\underset{CH_3}{\overset{CH_3}{C}}-CH_2-CH_2-CH_3$$

Q. Why sigma bond is inert?

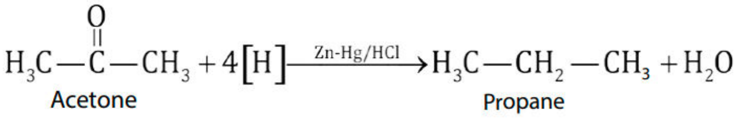
In a sigma bond the **electrons are very tightly held between the nuclei** which make it a very stable bond. A lot of energy is required to break it. The **electrons present in a sigma bond can neither attack on any electrophile nor a nucleophile can attack on them**. Both these facts make alkanes less reactive.

Q. Give any two uses of methane.

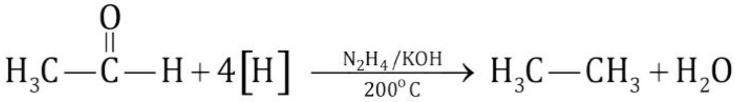
(i) As a fuel and as an illuminating gas.

(ii) For the preparation of methyl chloride, dichloromethane, chloroform and carbon tetrachloride.

Q. How would you prepare alkane from carbonyl compounds?



$$\underset{\text{Acetone}}{H_3C-\overset{\overset{O}{||}}{C}-CH_3} + 4[H] \xrightarrow{\text{Zn-Hg/HCl}} \underset{\text{Propane}}{H_3C-CH_2-CH_3} + H_2O$$



$$H_3C-\overset{\overset{O}{||}}{C}-H + 4[H] \xrightarrow[200^\circ C]{N_2H_4/KOH} H_3C-CH_3 + H_2O$$

Q. Alkanes are less reactive than alkenes. Comment.

Alkanes have sigma bond between them in which electrons are tightly held between the nuclei. In pi bond, π-electrons are less firmly held between the nuclei. A π-bond breaks comparatively easily rendering alkenes as reactive group of compounds.

Q. Convert methane into i. Formaldehyde ii. Nitromethane

Methane into Formaldehyde

$$CH_4 + [O] \xrightarrow[400^\circ C/200atm]{Cu} \underset{\text{Methyl alcohol}}{H_3C-OH}$$

$$H_3C-OH + [O] \xrightarrow[400^\circ C/200atm]{Cu} \underset{\text{Formaldehyde}}{HCHO + H_2O}$$

Methane into Nitromethane

$$CH_4 + HONO_2 \xrightarrow{450^\circ C} \underset{\text{Nitromethane}}{CH_3NO_2} + H_2O$$

Q. Prepare Ethane from i. Ethyl alcohol ii. Ethyl chloride

Ethane from Ethyl alcohol

$$\underset{\text{Ethyl alcohol}}{CH_3-CH_2-OH} \xrightarrow[140-170^\circ C]{75\%\ H_2SO_4} CH_2=CH_2$$

$$CH_2=CH_2 + H_2 \xrightarrow[200-300^\circ C]{Ni} \underset{\text{Ethane}}{CH_3-CH_3}$$

Ethane from Ethyl chloride

$$\underset{\text{Ethyl chloride}}{CH_3-CH_2-Cl} + Zn + HCl \longrightarrow \underset{\text{Ethane}}{CH_3-CH_3} + ZnCl_2$$

Q. How is Methane converted to Ethane and Ethane converted to Methane?

Methane to Ethane

$$CH_4 + Cl_2 \xrightarrow{hv} CH_3Cl + HCl$$

$$2CH_3Cl + 2Na \longrightarrow CH_3\text{-}CH_3 + 2NaCl$$

Ethane to Methane

$$CH_3\text{-}CH_3 + Cl_2 \xrightarrow{hv} CH_3CH_2Cl + HCl$$

$$CH_3CH_2Cl + KOH\ (aq) \longrightarrow CH_3CH_2OH + KCl$$

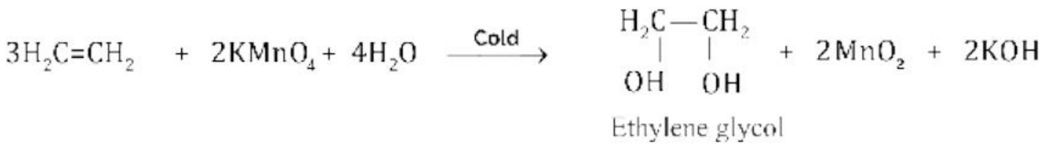
$$CH_3CH_2OH + [O] \xrightarrow{K_2Cr_2O_7/H_2SO_4} CH_3CHO + H_2O$$

Alkenes

Q. Give two uses of ethene.

1. For artificial ripening of the fruits.
2. As a general anesthetic.

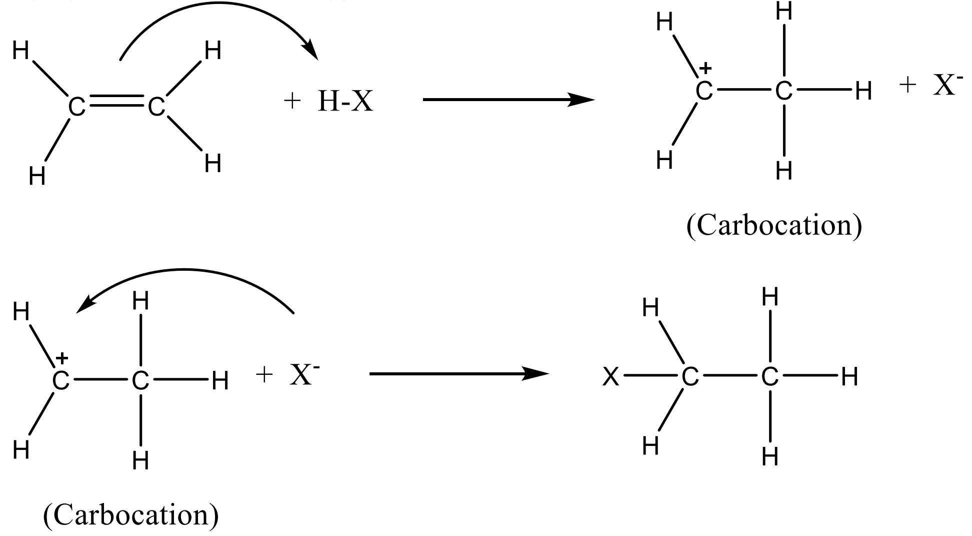
Q. Discuss hydroxylation of ethene.



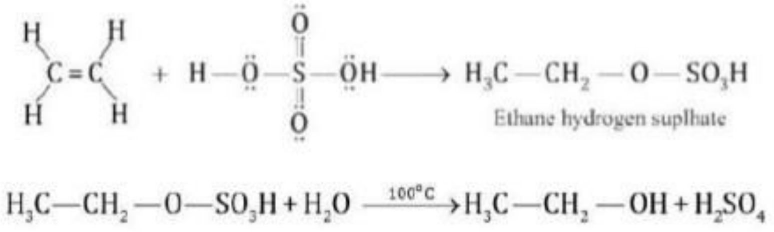
$$3H_2C{=}CH_2 + 2KMnO_4 + 4H_2O \xrightarrow{Cold} \underset{\text{Ethylene glycol}}{\underset{OH\qquad OH}{H_2C-CH_2}} + 2MnO_2 + 2KOH$$

Q. State Markownikov's rule. Give example.

In the addition of an unsymmetrical reagent to an unsymmetrical alkene, the negative part of the adding reagent goes to that carbon, constituting the double bond, which has least number of hydrogen atoms.



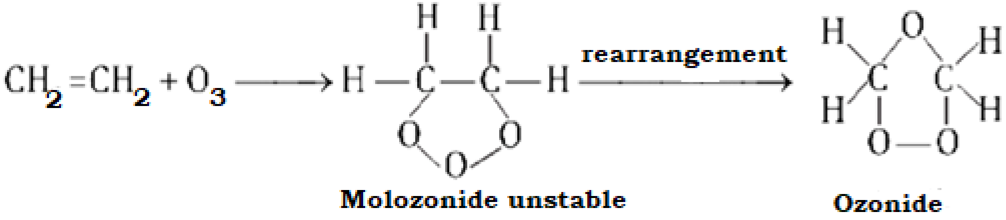
Q. Ethene can be converted to ethyl alcohol. Write equation.



$$H_3C-CH_2-O-SO_3H + H_2O \xrightarrow{100^\circ C} H_3C-CH_2-OH + H_2SO_4$$

Q. Ozonolysis of alkene is used to locate the position of double bond. Comment.

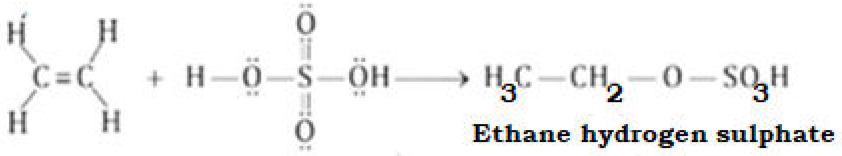
Ozone is added at the point of unsaturation which shows the presence of double bond.



Q. Give the chemical reactions of Ethene with the following.

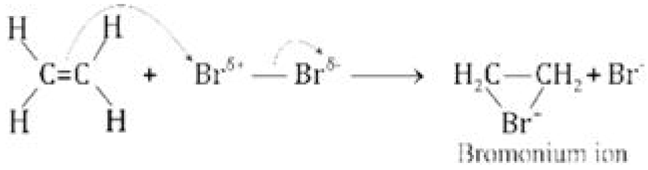
i. H_2SO_4 ii. Br_2 iii. O_3 iv. HOX v. HCl

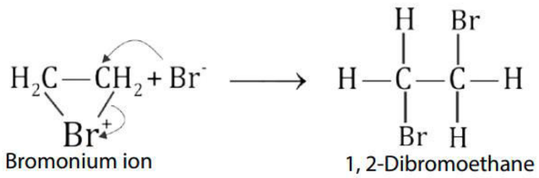
i.



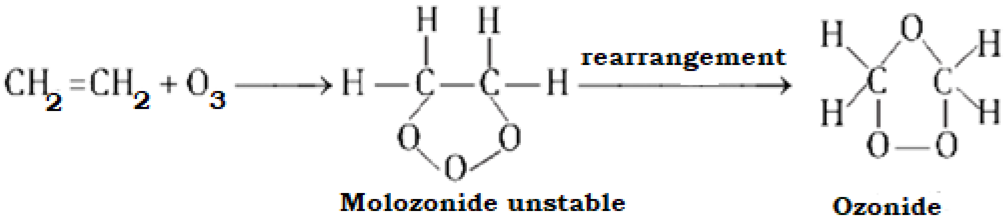
$$H_3C—CH_2—O—SO_3H + H_2O \xrightarrow{100^\circ C} H_3C—CH_2—OH + H_2SO_4$$

ii.



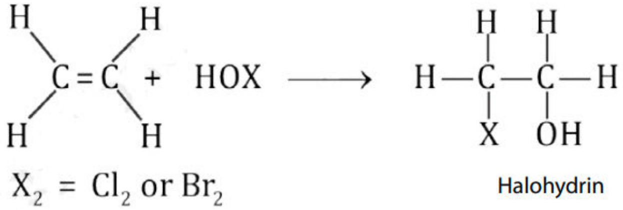


iii.



iv.

$$X_2 + H_2O \longrightarrow HOX + HX$$



X_2 = Cl_2 or Br_2

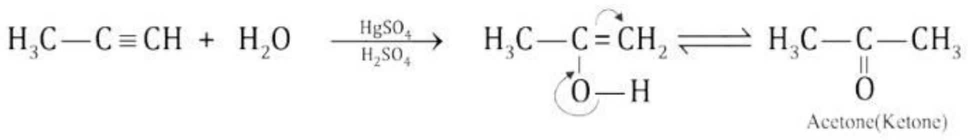
Alkynes

Q. Give two uses of ethyne.

1. In oxyacetylene torch which is in turn used for welding and cutting metals.

2. For the preparation of alcohols, acetic acid and acetaldehyde.

Q. How is water added to propyne?



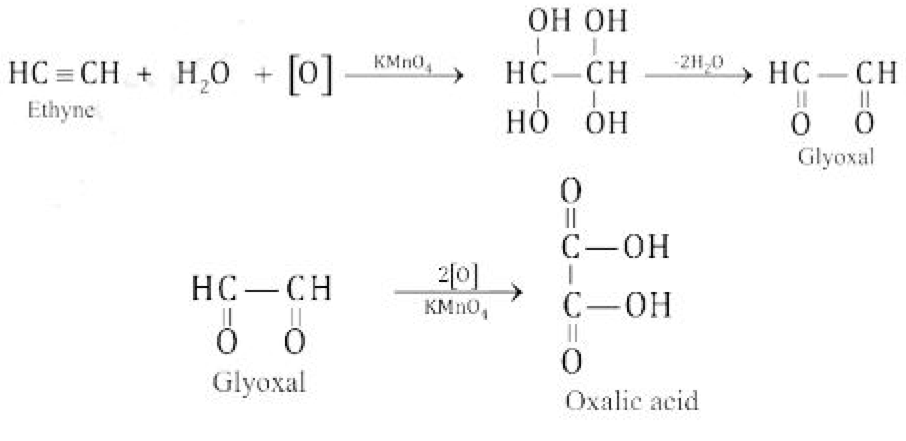
Q. How Ammonical solution of AgNO3 can be used to distinguish between 1-Butyne and 2- Butyne?

1-Butyne is a terminal alkyne and thus acidic in nature. It therefore reacts with cuprous chloride Cu_2Cl_2 in presence of NH_4OH to produce a red precipitate. In 2-Butyne triple bond is not terminal hence triple bonded carbon atoms do not have a hydrogen atom attached and therefore lack acidic character. It gives no reaction with cuprous chloride Cu_2Cl_2 in presence of NH_4OH.

$$\underset{\text{1-Butyne}}{2\,CH_3CH_2\text{-}C{\equiv}CH} + Cu_2Cl_2 + 2NH_4OH \longrightarrow \underset{\text{red ppt}}{CH_3CH_2\text{-}C{\equiv}CCu\downarrow} + 2NH_4Cl + 2H_2O$$

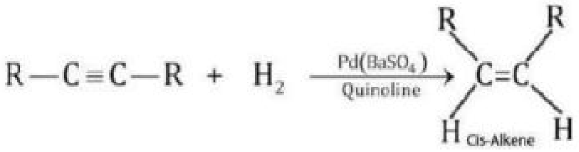
$$\underset{\text{2-Butyne}}{H_3C{-}C{\equiv}C{-}CH_3} + Cu_2Cl_2 + 2NH_4OH \longrightarrow \text{No reaction}$$

Q. Write the chemical equation when alkaline KMnO4 reacts with ethyne.

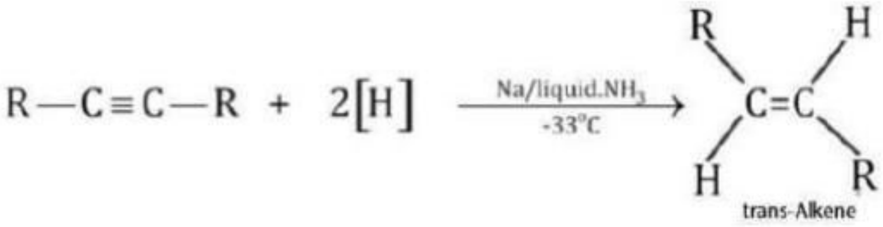


Q. How cis and trans alkenes are prepared from alkyne?

Controlled hydrogenation of alkynes with hydrogen gas in an equimolar ratio over heated catalysts, gives alkenes. The catalyst is finely divided palladium supported on $BaSO_4$ and poisoned by treatmentwith quinoline (Lindlar's catalyst).



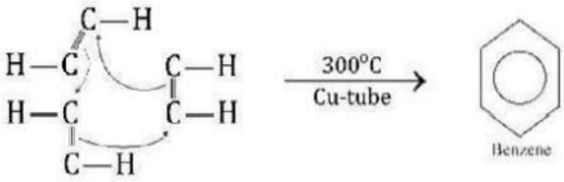
A trans alkene can be obtained by treating an alkyne with Na in liquid NH_3 at -33 °C.



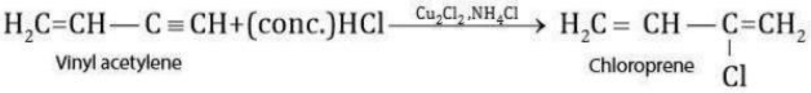
Q. How will you synthesize following compounds from ethyne (acetylene) i. Benzene ii. Chloroprene

(i) acetylene to benzene

When acetylene is passed through a copper tube at 300°C, it polymerizes to benzene.



(ii) vinyl acetylene to chloroprene

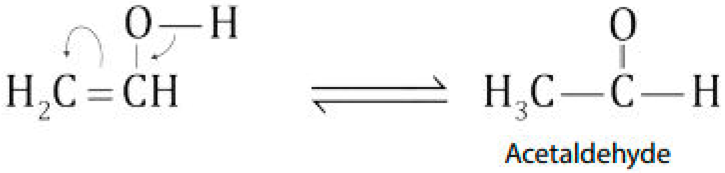


$$H_2C{=}CH{-}C{\equiv}CH + (\text{conc.})HCl \xrightarrow{Cu_2Cl_2, NH_4Cl} H_2C{=}CH{-}\underset{\substack{|\\ Cl}}{C}{=}CH_2$$

Q. Convert ethyne into acetaldehyde.

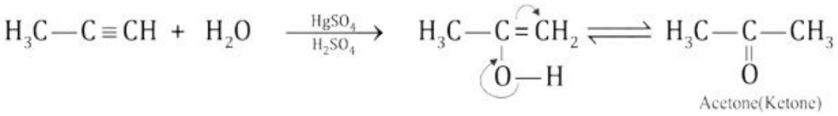
$$HC{\equiv}CH + H^{\delta+}{-}OH^{\delta-} \xrightarrow[H_2SO_4]{HgSO_4} H_2C{=}CH{-}O{-}H$$

Vinyl alcohol

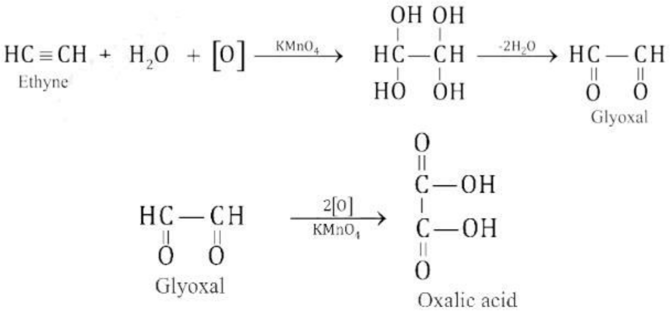


$$H_2C{=}\underset{}{CH}{-}OH \rightleftharpoons H_3C{-}\overset{\overset{O}{\|}}{C}{-}H$$

Q. How can you convert a. Propyne into acetone b. Ethyne into oxalic acid



$$H_3C{-}C{\equiv}CH + H_2O \xrightarrow[H_2SO_4]{HgSO_4} H_3C{-}\underset{\underset{O-H}{|}}{C}{=}CH_2 \rightleftharpoons H_3C{-}\underset{\underset{O}{\|}}{C}{-}CH_3$$



$$HC{\equiv}CH + H_2O + [O] \xrightarrow{KMnO_4} \underset{HO}{\overset{OH}{HC}}{-}\underset{OH}{\overset{OH}{CH}} \xrightarrow{-2H_2O} \underset{O}{\overset{}{\underset{\|}{HC}}}{-}\underset{O}{\underset{\|}{CH}}$$

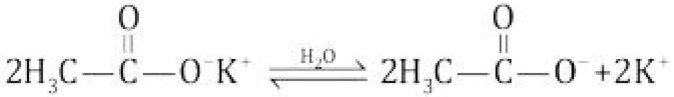
$$\underset{O}{\underset{\|}{HC}}{-}\underset{O}{\underset{\|}{CH}} \xrightarrow[KMnO_4]{2[O]} \begin{array}{l} O \\ \| \\ C{-}OH \\ | \\ C{-}OH \\ \| \\ O \end{array}$$

Alkanes, Alkenes and Alkynes

Q. Write mechanism for Kolbe's electrolytic method for preparation of an alkane, alkene and alkyne.

For alkane

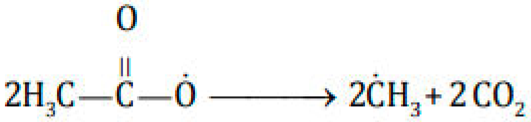
$$2RCOO^-Na^+ + 2H_2O \xrightarrow{\text{Electrolysis}} R{-}R + 2CO_2 + 2NaOH + H_2$$



$$2H_3C-\overset{\overset{\displaystyle O}{\|}}{C}-O^-K^+ \xrightleftharpoons{H_2O} 2H_3C-\overset{\overset{\displaystyle O}{\|}}{C}-O^- + 2K^+$$

At Anode

$$2H_3C-\overset{\overset{\displaystyle O}{\|}}{C}-O^- \xrightarrow{\text{Electrolysis}} 2H_3C-\overset{\overset{\displaystyle O}{\|}}{C}-\dot{O}+2e'$$



$$2H_3C-\overset{\overset{\displaystyle O}{\|}}{C}-\dot{O} \longrightarrow 2\dot{C}H_3+2\,CO_2$$

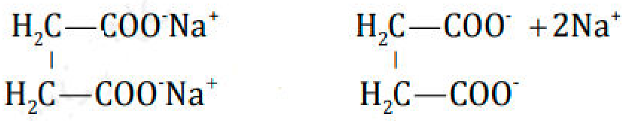
$$\dot{C}H_3+\dot{C}H_3 \longrightarrow H_3C-CH_3$$

At Cathode

$$2H_2O+2e^- \longrightarrow 2O\overline{H} + H_2$$

$$2K^+ + 2O\overline{H} \longrightarrow 2KOH$$

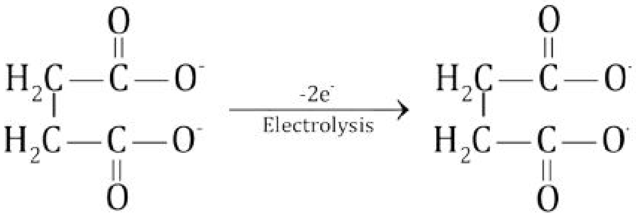
For alkene



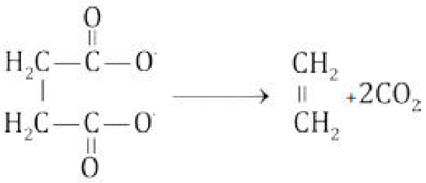
$$\begin{array}{l} H_2C-COO^-Na^+ \\ \quad| \\ H_2C-COO^-Na^+ \end{array} \qquad \begin{array}{l} H_2C-COO^- \\ \quad| \\ H_2C-COO^- \end{array} + 2Na^+$$

Disodium Succinate

At Anode



$$\begin{array}{l} H_2C-\overset{\overset{\displaystyle O}{\|}}{C}-O^- \\ \quad| \\ H_2C-\underset{\underset{\displaystyle O}{\|}}{C}-O^- \end{array} \xrightarrow[\text{Electrolysis}]{-2e^-} \begin{array}{l} H_2C-\overset{\overset{\displaystyle O}{\|}}{C}-\dot{O} \\ \quad| \\ H_2C-\underset{\underset{\displaystyle O}{\|}}{C}-\dot{O} \end{array}$$



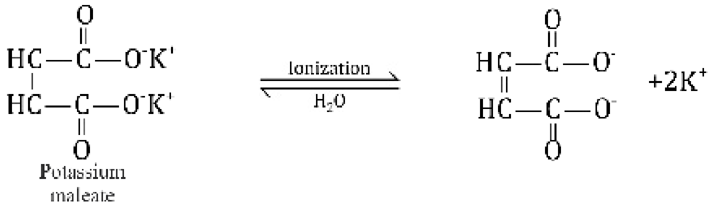
$$\begin{array}{l} H_2C-\overset{\overset{\displaystyle O}{\|}}{C}-\dot{O} \\ \quad| \\ H_2C-\underset{\underset{\displaystyle O}{\|}}{C}-\dot{O} \end{array} \longrightarrow \begin{array}{c} CH_2 \\ \| \\ CH_2 \end{array} + 2CO_2$$

At Cathode

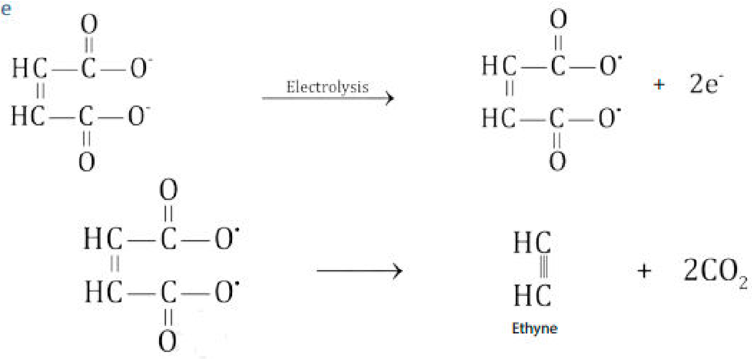
$$2H_2O + 2e^- \longrightarrow 2OH^- + H_2$$

$$2Na^+ + 2OH^- \longrightarrow 2NaOH$$

For alkyne



At Anode



At Cathode

$$2H_2O + 2e^- \longrightarrow 2OH^-$$

$$2K^+ + 2OH^- \longrightarrow 2KOH$$

Q. Explain acidic nature of alkynes with at least two examples.

The sp hybridized carbon atom of a terminal alkyne pulls the electrons more strongly making the attached hydrogen atom slightly acidic.

$$H—C\equiv C^{ä-}—H^{ä+}$$

$$R—C\equiv CH + NaNH_2 \xrightarrow{liq\ NH_3} R—C\equiv C^-Na^+ + NH_3$$

$$HC\equiv CH + 2Na \longrightarrow Na^+C^- \equiv C^-Na^+ + H_2$$

Sodium acetylide

$$HC\equiv CH + Cu_2Cl_2 + 2NH_4OH \longrightarrow CuC\equiv CCu + 2NH_4Cl + 2H_2O$$

Dicopperacetylide

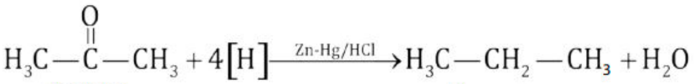
(Reddish brown ppt.)

Q. How can you convert (a) 2,3-Dibromo butane into 2-Butene (b) Acetone into propane (c) Acetylene into Disilver acetylide

$$H_3C-\underset{Br}{CH}-\underset{Br}{CH}-CH_3 + Zn \xrightarrow{CH_3OH} H_3C-CH{=}CH-CH_3 + ZnBr_2$$

2,3-Dibromobutane

2-Butene



$$H_3C-\overset{O}{\overset{\|}{C}}-CH_3 + 4[H] \xrightarrow{Zn\text{-}Hg/HCl} H_3C-CH_2-CH_3 + H_2O$$

Acetone

Propane

$$HC{\equiv}CH + 2AgNO_3 + 2NH_4OH \longrightarrow AgC{\equiv}CAg + 2NH_4NO_3 + 2H_2O$$

Disilver acetylide

(white ppt.)

Q. Convert acetylene to (a) Vinyl acetylene (b) Divinyl acetylene (c) Acetaldehyde

$$HC{\equiv}CH + HC{\equiv}CH \xrightarrow{Cu_2Cl_2,NH_4Cl} H_2C{=}CH-C{\equiv}CH$$

Vinyl acetylene

(1- Buten-3-yne

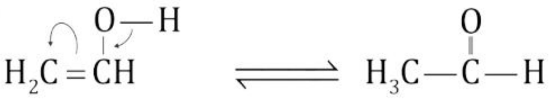
$$H_2C{=}CH-C{\equiv}CH + HC{\equiv}CH \xrightarrow{Cu_2Cl_2,NH_4Cl} H_2C{=}CH-C{\equiv}C-CH{=}CH_2$$

Divinyl acetylene

(l,5-Hexdiene-3-yne)

$$HC{\equiv}CH + H^{ä+}-OH^{ä-} \xrightarrow[H_2SO_4]{HgSO_4} H_2C{=}CH-O-H$$

Vinyl alcohol



$$H_2C{=}\overset{O-H}{\overset{|}{CH}} \rightleftharpoons H_3C-\overset{O}{\overset{|}{C}}-H$$

Acetaldehyde

Q. How will you distinguish between Ethane, Ethene and Ethyne?

Reagent	**Ethane**	**Ethylene**	**Acetylene**
Alkaline $KMnO_4$ soln.	No reaction	Decolourized	Decolourized
Bromine water	No reaction	Decolourized	Decolourized
Ammonical $AgNO_3$	No reaction	No reaction	White ppt. of silver acetylide
Ammonical Cu_2Cl_2	No reaction	No reaction	Red ppt. of copper acetylide
10% H_2SO_4 + $AgSO_4$	No reaction	Ethyl alcohol is formed	Acetaldehyde is formed

Chapter 9

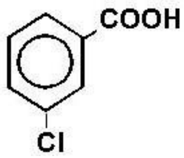
Aromatic Hydrocarbons

(Most Repeated Reactions from Past papers are Focused which may come for both Short Questions and Long Question)

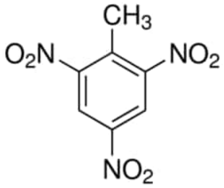
Q. Draw structural formulae of following compounds:

i. m-Chlorobenzoic acid ii. 2,4,6-Trnitrotoluene iii. p-Dibenzylbenzene iv. p-Nitroaniline

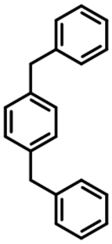
i.



ii.



iii.



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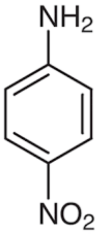
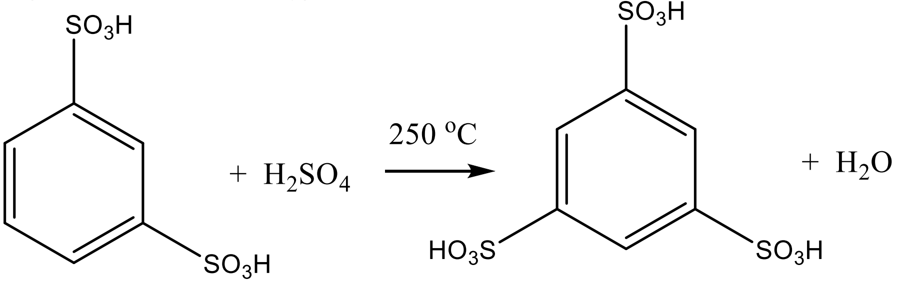


Q. What happens when:

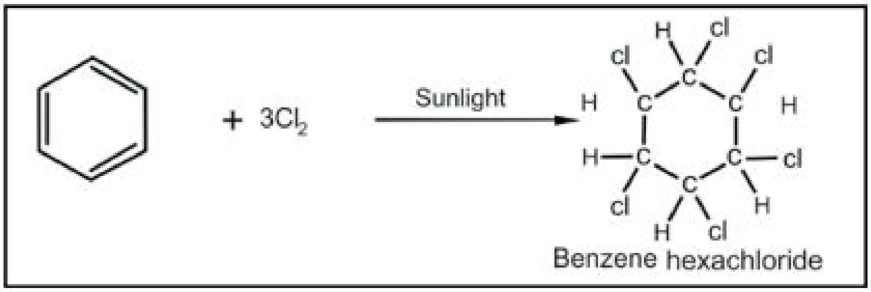
a. benzene is heated with conc. H_2SO_4 at 250 °C.

b. Chlorine is passed through benzene in sunlight

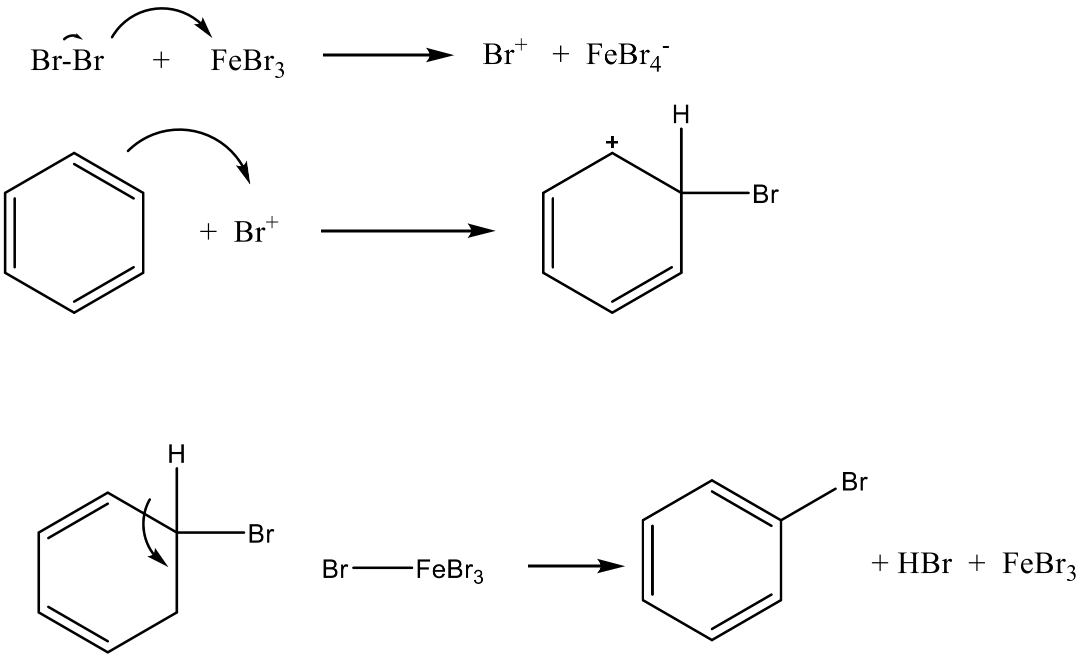
a.



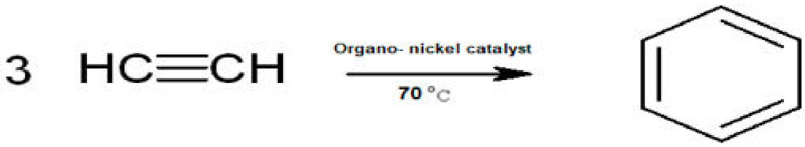
b.



Q. Predict major product of the bromination of benzene.



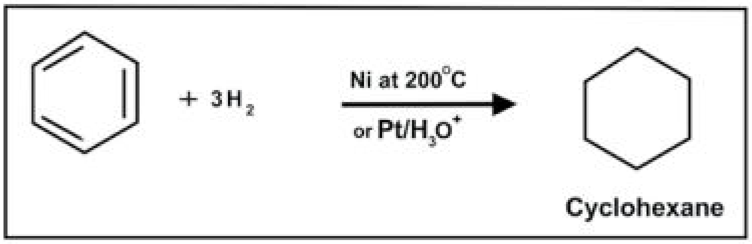
Q. Benzene can be prepared commercially from acetylene.



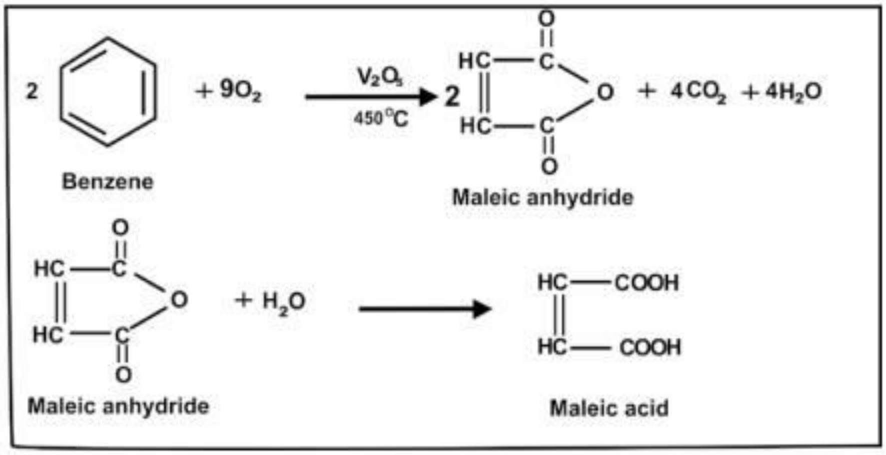
Q. Convert benzene into:

i. Cyclohexane ii. Maleic anhydride

i.



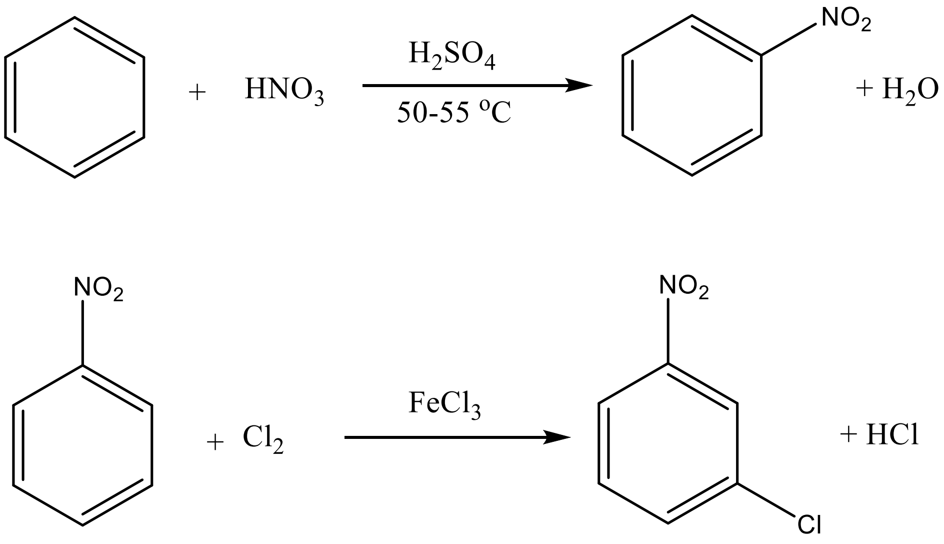
ii.



Q. How will you prepare following compounds from benzene in two steps?

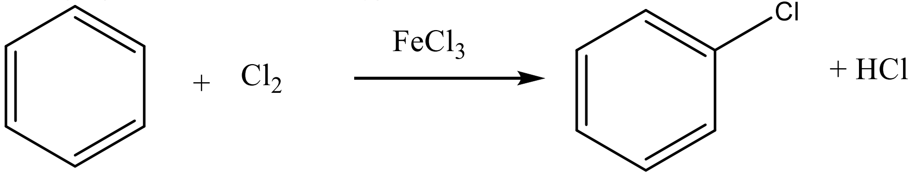
i. m-Chloronitrobenzene ii. p-Chloronitrobenzene

i.

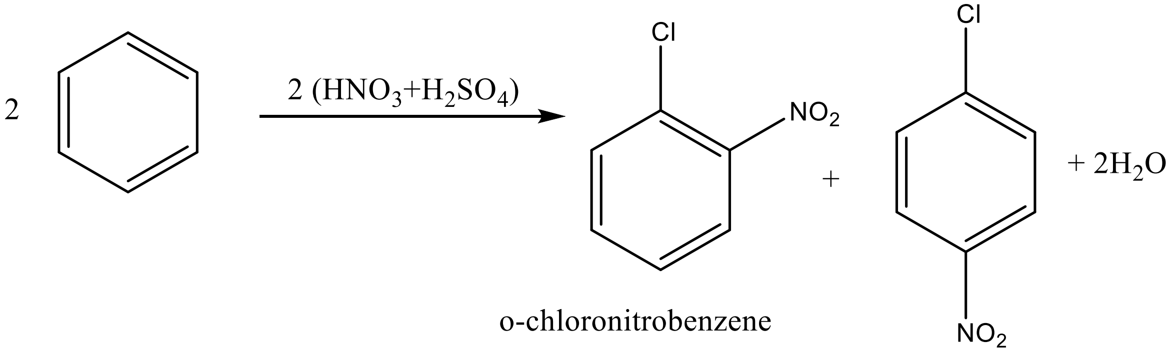


m-chloronitro benzene

ii.



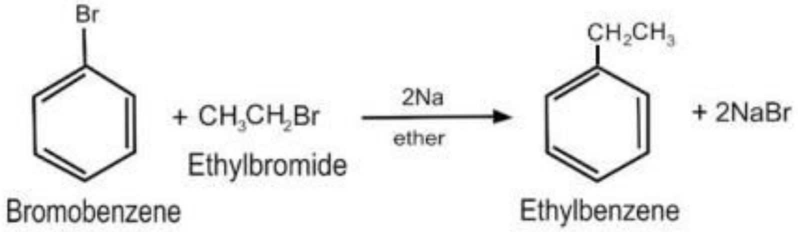
Chlorobenzene



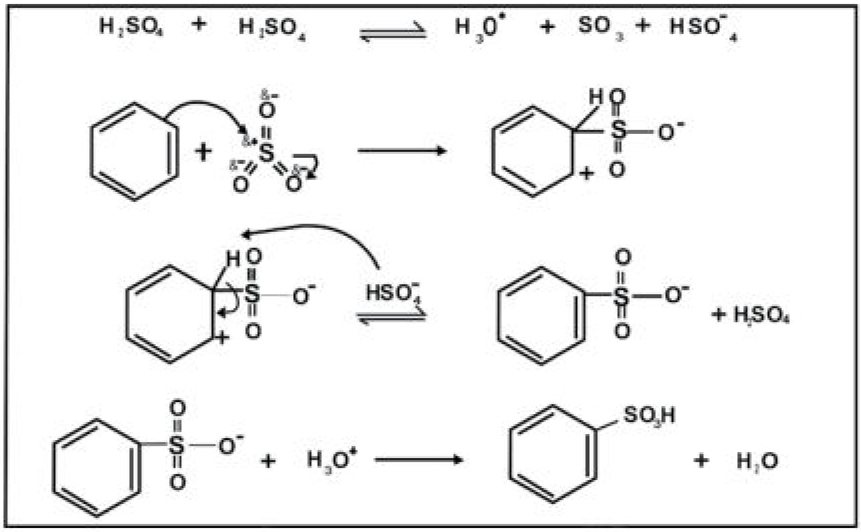
o-chloronitrobenzene

p-chloronitrobenzene

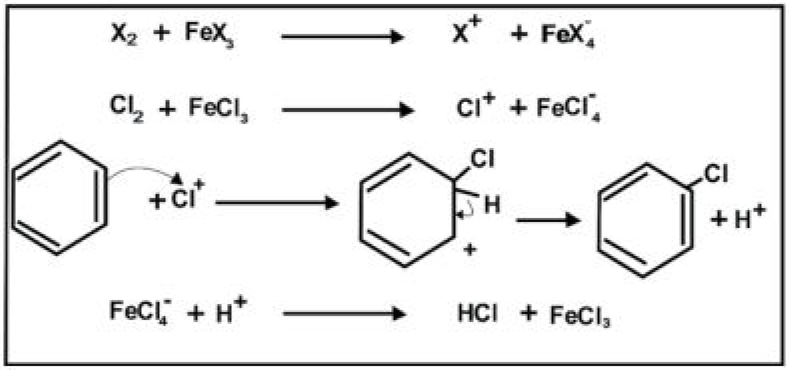
Q. What is Wurtz-Fittig reaction?



Q. Give mechanism of sulphonylation of benzene.

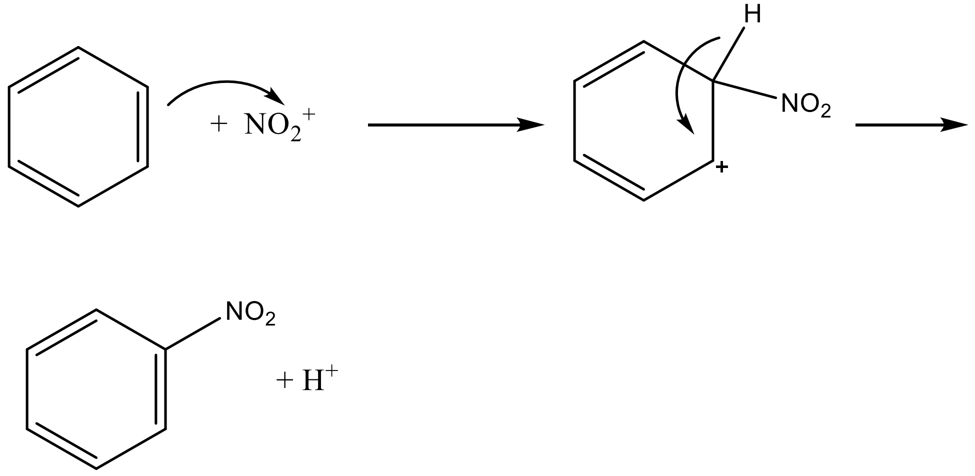


Q. Write down mechanism for Halogenation of benzene.



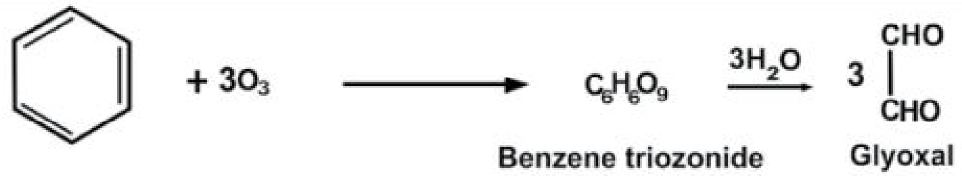
Q. Give mechanism for nitration of benzene.

$$HNO_3 + H_2SO_4 \xrightleftharpoons{50\text{-}55\ ^oC} NO_2^+ + H_2O + HSO_4^-$$



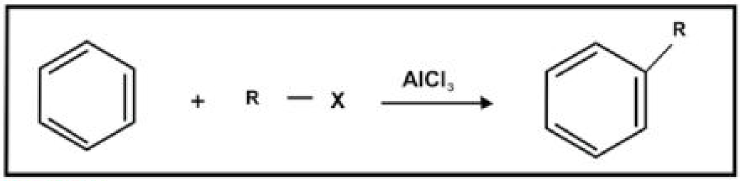
$$H^+ + HSO_4^- \rightleftharpoons H_2SO_4$$

Q. Give reaction of benzene with ozone.



Q. Give mechanism of Friedel -Craft's Acylation and Alkylation.

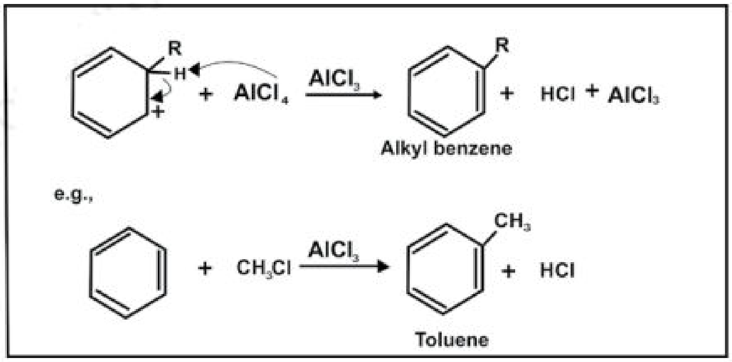
Alkylation



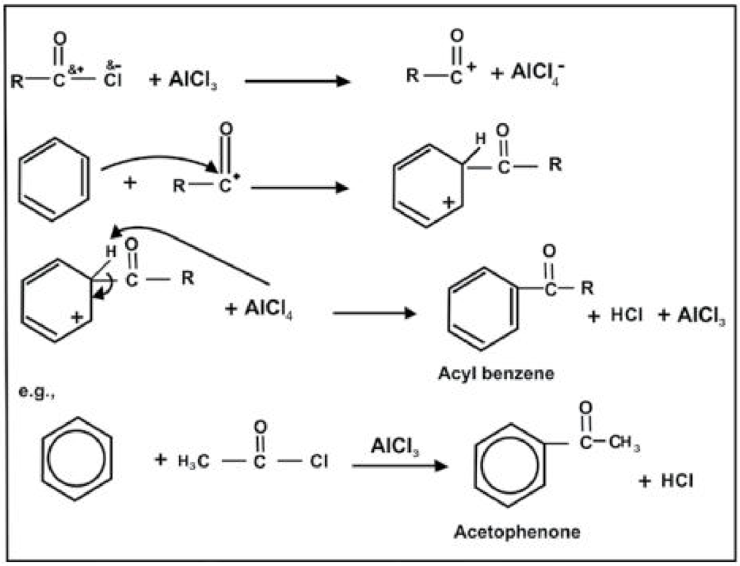
Mechanism:

$$R—Cl + AlCl_3 \rightarrow AlCl^-_4 + R^+$$

Carbocation



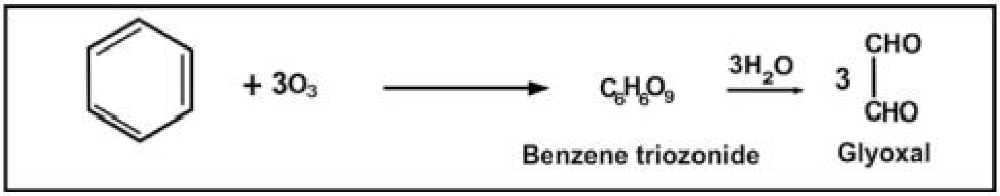
Acylation



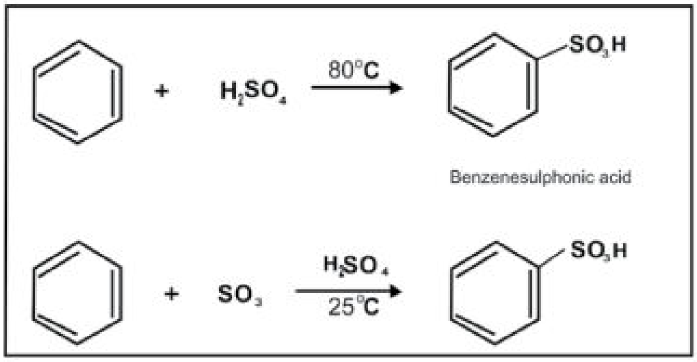
Q. What happens when toluene is reacted with i. Cl_2 in sunlight ii. $KMnO_4$ in presence of H_2SO_4.

Q. Convert benzene into

(a) Glyoxal

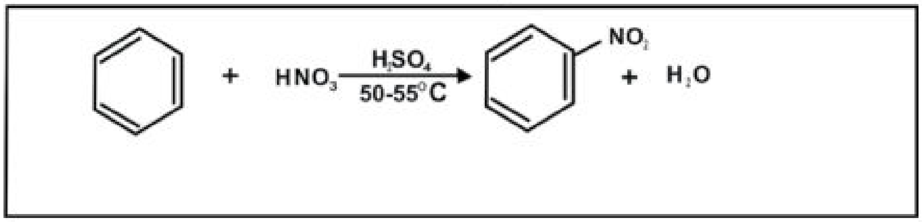


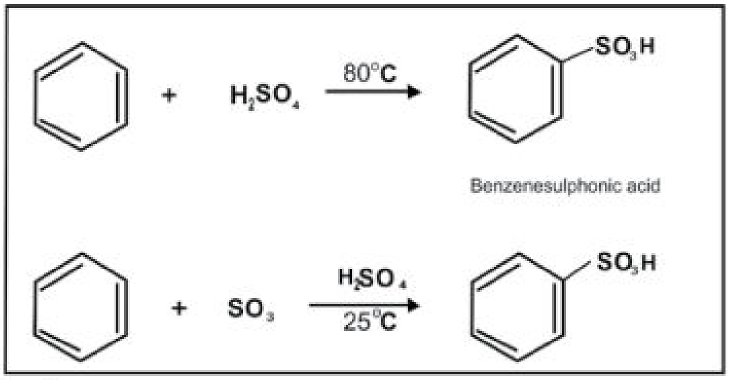
(b) Benzene sulphonic acid



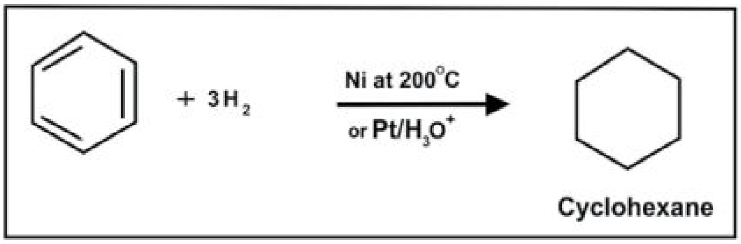
Q. Write down two reactions in which benzene behaves as saturated hydrocarbon and two reactions in which as unsaturated hydrocarbon.

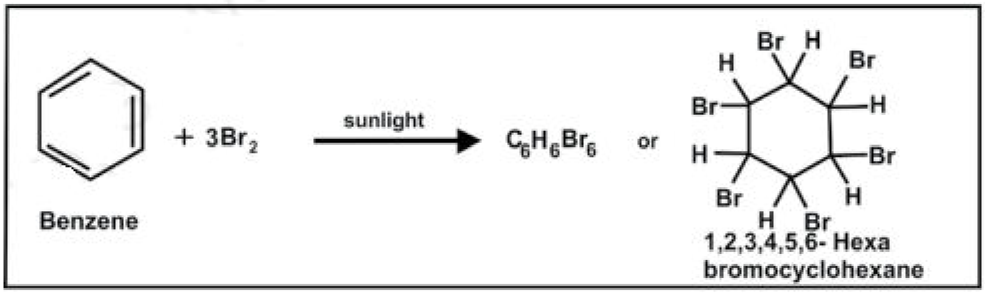
Saturated Hydrocarbon





Unsaturated Hydrocarbon



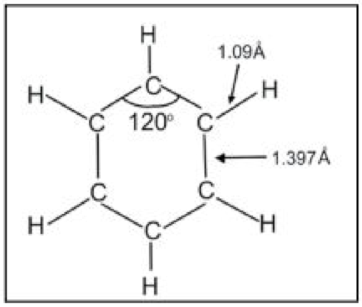


Structure of Benzene

(Long Question)

X-Ray Studies

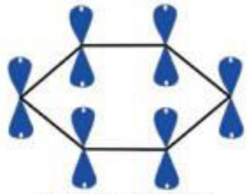
- Hexagonal structure
- All the angles are of 120°
- All C - C and C -H bond lengths are 1.397 °A and 1.09 °A, respectively



Atomic Orbital Treatment of Benzene

- Each carbon in benzene is sp^2 hybridized
- All the angles are of 120° which confirms the regular hexagonal structure of benzene
- The unhybridized 2pz orbitals partially overlap to form a continuous sheath of electron cloud, enveloping, above and below, the six carbon carbon sigma bonds of the ring.

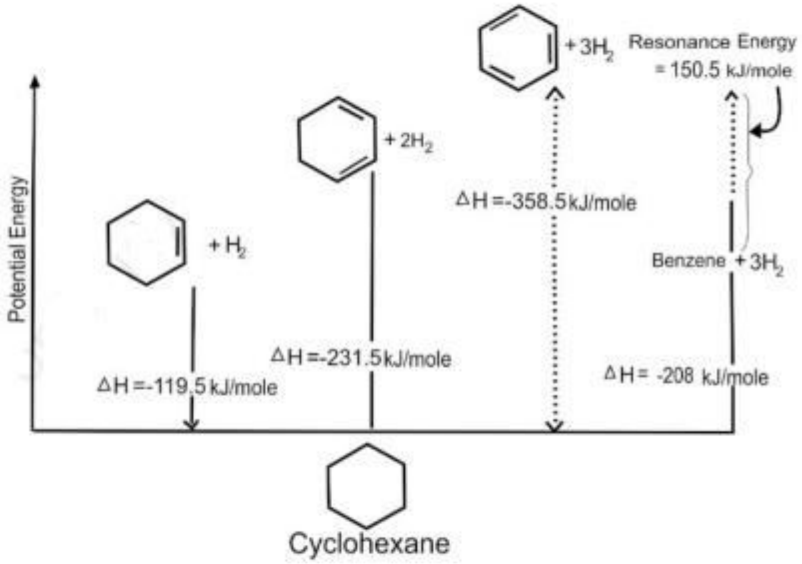
σ- Framework of benzene



Unhybridized 2p orbitals

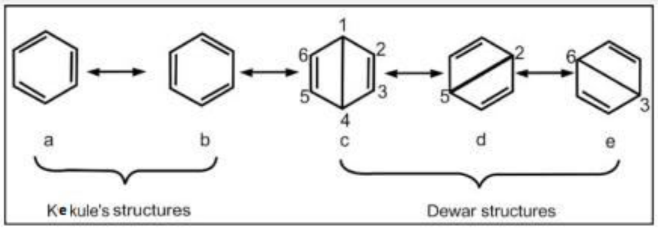
Delocalized π-orbital of benzene

Stability of Benzene



This difference between amount of heat actually released and that calculated on the basis of the Kekule’s structure is now called the ‘Resonance energy’ of the compound. It means benzene shows the phenomenon of resonance which makes it more stable than others.

The Resonance Method



Major contributor: Kekule’s structures
Minor contributor: Dewar structures

In benzene the C-C bond length is 1.397A. The C - C bond length in benzene is intermediate between those in alkanes and alkenes. The resonating single and double bonds in benzene can better be represented as a complete circle inside the ring.

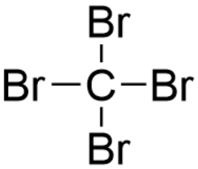
Chapter 10

Alkyl Halides

Q. Write IUPAC names of:

a. Carbon tetrabromide b. Chloroform c. Methylene chloride d. Methyl iodide

a.



b. $CHCl_3$

c. CH_2Cl_2

d. CH_3I

Q. How will you convert CH_3—CH_3 to $(CH_3\text{-}CH_2)_4NBr$?

$$CH_3CH_3 + Br_2 \xrightarrow{hv} CH_3CH_2Br + HBr$$
$$CH_3CH_2Br + NH_3 \longrightarrow CH_3CH_2NH_2 + HBr$$
$$CH_3CH_2Br + CH_3CH_2NH_2 \longrightarrow (CH_3CH_2)_2NH + HBr$$
$$CH_3CH_2Br + (CH_3CH_2)_2NH \longrightarrow (CH_3CH_2)_3N + HCl$$
$$CH_3CH_2Br + (CH_3CH_2)_3N \longrightarrow (CH_3CH_2)_4N^+Br^-$$

Q. Which method is considered best for the preparation of alkyl halides?

Alcohols react with thionyl chloride in pyridine as a solvent to give alkyl chlorides. This is the best method because HCl, and SO_2 gases escape leaving behind the pure product.

$$ROH + SOCl_2 \xrightarrow{Pyridine} R - Cl + SO_2 + HCl$$

Q. Define nucleophile, electrophile, leaving group and substrate molecule.

Nucleophile

Nucleophile means nucleus loving. **It has an unshared electron pair available for bonding and in most cases it is basic in character**. It may be negatively charged or neutral.

Electrophile

It is specie which attracts electrons. **The carbon atom of an alkyl group attached with the halogen atom and bearing a partial positive charge is called an electrophile or electrophilic center**. An electrophile may be neutral or positively charged. Example, C^+, Na^+, K^+, BF_3

Leaving Group

L is also a nucleopile. It is called leaving group because **it departs with an unshared pair of electrons**. Iodide ion is a good nucleophile as well as a good leaving group.

Substrate Molecule

The **alkyl halide molecule on which a nucleophile attacks** is called a substrate molecule.

Q. Convert Ethyl bromide into: (a) Ethane (a) n-Butane (c) diethyl amine (d) Propane (e) Ethyl alcohol

(a)

$$CH_3\text{-}CH_2\text{-}Br + 2[H] \xrightarrow{Zn + HCl} CH_3\text{-}CH_3 + HBr$$

(b)

$$CH_3-CH_2-Cl + 2Na + Cl-CH_2-CH_3 \xrightarrow{Ether} \underset{\text{n-Butane}}{CH_3-CH_2-CH_2-CH_2-CH_3} + 2NaCl$$

(c)

$$CH_3 - \overset{\delta^+}{CH_2} - \overset{\delta^-}{Br} + CH_3 - CH_2 - \ddot{N}H_2 \longrightarrow \underset{\text{Diethylamine}}{(CH_3 - CH_2)_2NH} + HBr$$

(d)

$$CH_3-CH_2-CH_2-Cl + Zn + H^+ + Cl \longrightarrow \underset{\text{Propane}}{CH_3-CH_2-CH_3} + ZnCl_2$$

(e)

$$CH_3 - \overset{\delta^+}{CH_2} - \overset{\delta^-}{Br} + \bar{O}H \longrightarrow \underset{\text{Ethyl alcohol}}{C_2H_5OH} + Br^-$$

Q. Write reactions of Ethanol with i) PBr_3 ii) PCl_3

$$3CH_3 - CH_2 - OH + PBr_3 \longrightarrow 3CH_3 - CH_2 - Br + H_3PO_3$$

$$CH_3 - CH_2 - OH + PCl_5 \longrightarrow CH_3 - CH_2 - Cl + POCl_3 + HCl$$

Q. What is Wurtz's synthesis?

$$CH_3-CH_2-Cl + 2Na + Cl-CH_2-CH_3 \xrightarrow{Ether} \underset{\text{n-Butane}}{CH_3-CH_2-CH_2-CH_2-CH_3} + 2NaCl$$

Q. Prepare from Ethyl bromide i. Ethyl thioalcohol ii. Ethyl acetate.

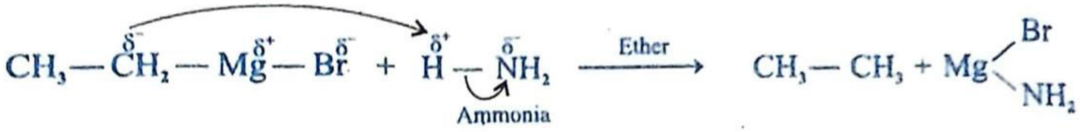
$$CH_3 - \overset{\delta^+}{CH_2} - \overset{\delta^-}{Br} + \bar{S}H \longrightarrow \underset{\text{Ethyl thioalcohol}}{C_2H_5SH} + Br^-$$

$$CH_3 - \overset{\delta^+}{CH_2} - \overset{\delta^-}{Br} + CH_3COO^-Na^+ \longrightarrow \underset{\text{Ethyl acetate}}{CH_3COOC_2H_5} + NaBr$$

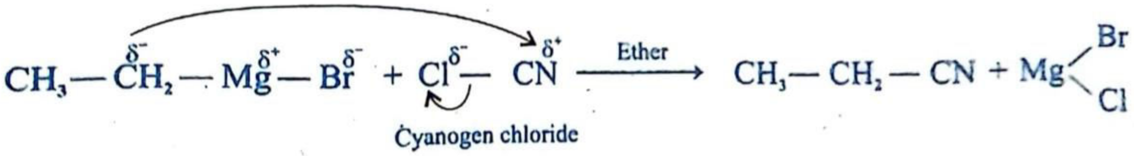
Q. How does ethyl magnesium bromide react with: a. CO_2 b. CH_3-CHO c. H_2O d. CH_3OH, e. CH_3COCH_3 f. HCHO g. ClCN h. H_2O i. Ammonia j. propanoic acid k. Ethane

(i) With water

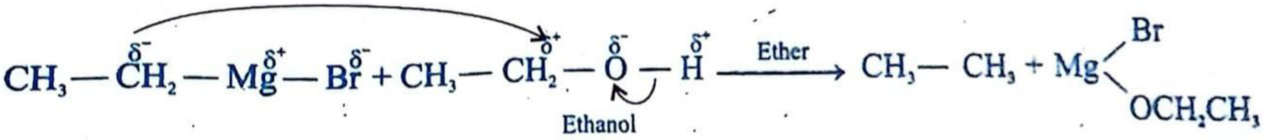
(ii) With ammonia



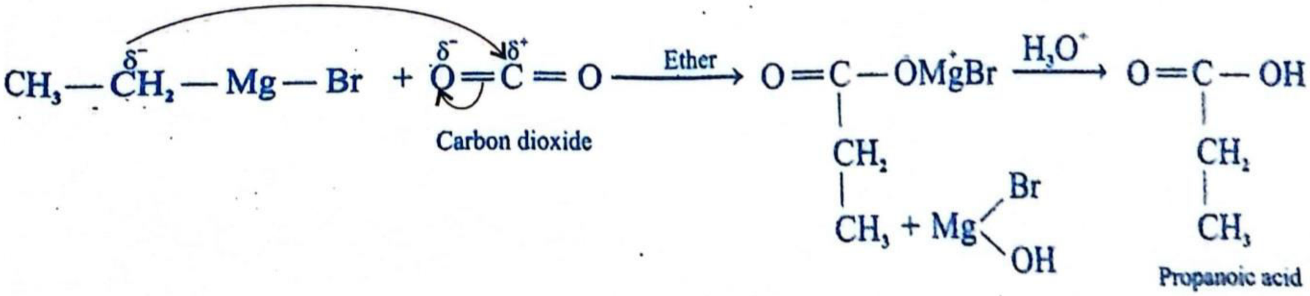
(iii) With cyanogen chloride



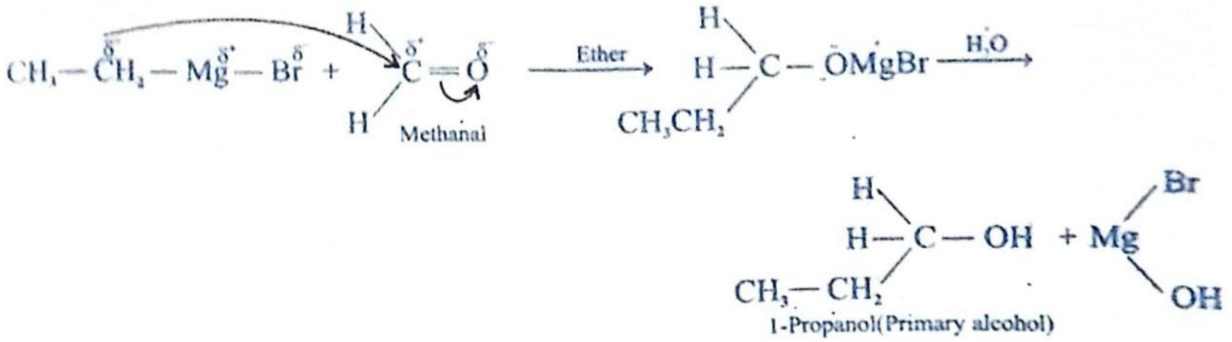
(iv) With alcohols



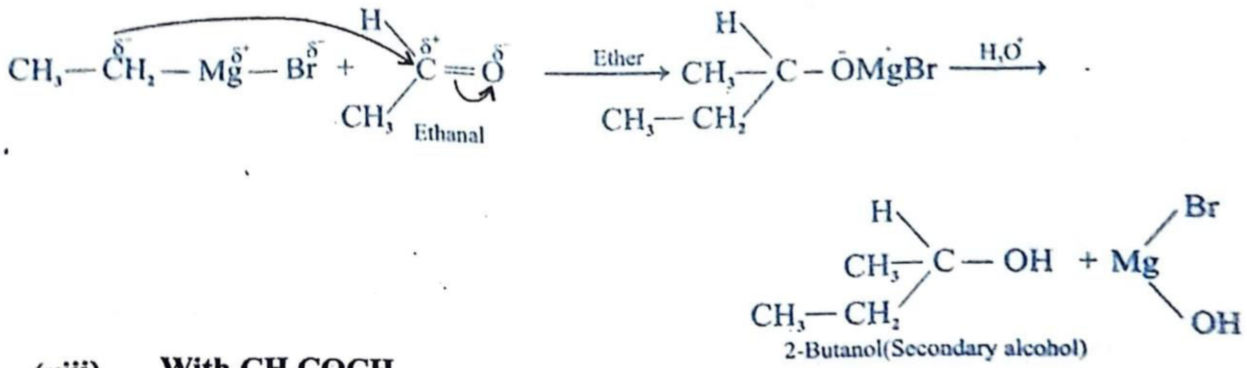
(v) With CO_2



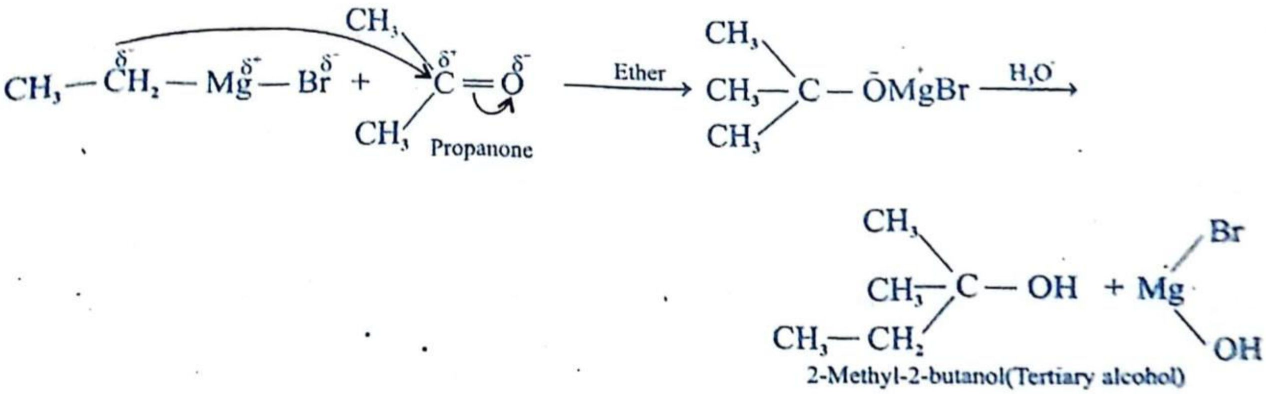
(vi) With HCHO



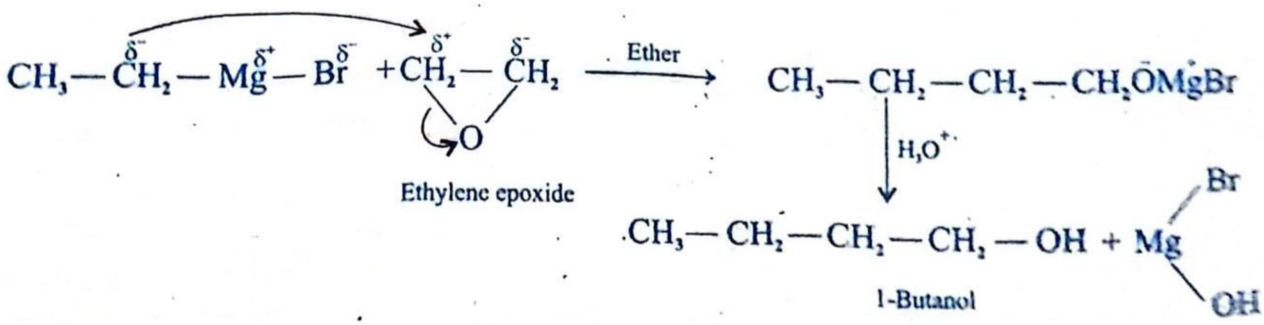
(vii) With CH_3CHO



(viii) With CH_3COCH_3



(ix) With Epoxide



Q. How will you bring about the following conversions from an alkyl halide? A. Diethyl ether b. Nitroethane

a.

$$CH_3\text{-}CH_2\text{-}Br + C_2H_5O^- \longrightarrow CH_3CH_2OCH_2CH_3 + Br^-$$

b.

Grignard Reagent

Q. What is the nature of C-Mg bond in R-Mg-X?

It is prepared in ether (dry) so hydrolysis may not occur resulting in formation of acids, alcohols and aldehydes

Magnesium is less electronegative that carbon so partial positive charge appears on magnesium and partial negative on carbon attached to it. This **negative charge on carbon is very unusual which makes alkyl group very reactive towards electrophiles.**

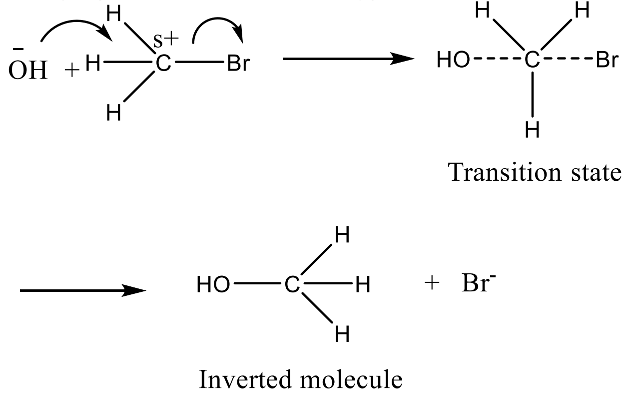
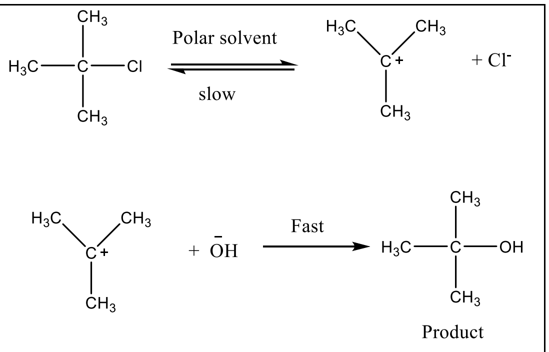
Nucleophilic Substitution Reactions and Elimination Reactions

(Long Question)

Substitution Reactions

Comparison of S_N1 and S_N2 reactions

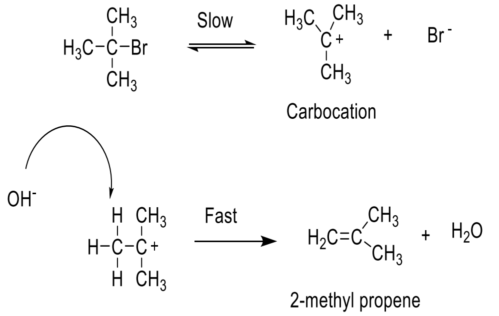
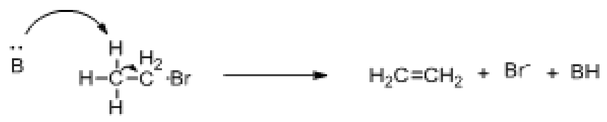
Sr No	S_N2	S_N1
1.	**Name** It is called nucleophilic substitution bimolecular	**Name** It is called nucleophilic substitution unimolecular
2.	**Number of steps** This is a single step mechanism	**Number of steps** This is a two step mechanism
3.	**Extent** The extent of bond formation is equal to the extent of bond breakage	**Extent** The extent of bond formation is not equal to the extent of bond breakage
4.	**Mechanism**	**Mechanism**

		 50% inversion
5.	As soon as the nucleophile starts attacking the electrophilic carbon of the substrate, the bond with which the leaving group is attached starts breaking	The first step is the reversible ionization of the alkyl halide in the presence of an aqueous ethyl alcohol. This step provides a carbocation as an intermediate. In the second step this carbocation is attacked by the nucleophile to give the product
6.	**Direction of attack of nucleophile** Nucleophile attacks from the side which is opposite to the leaving group	**Direction of attack of nucleophile** The intermediate carbocation is a planar specie allowing the nucleophile to attack on it from both the directions with equal ease
7.	**Configuration of product** 100% inverted product	**Configuration of product** 50% inversion of configuration and 50% retention of configuration in product
8.	**Hybridization** The substrate carbon atom changes its state of hybridization from tetrahedral sp^3 to planar sp^2 for a short time	
9.	**Molecularity** Two molecules are participating in this step so it is called a bimolecular reaction Molecularity= 2	**Molecularity** Only one molecule participates in the rate determining step (slow step) so it is unimolecular reaction. Molecularity=1
10.	**Rate of Reaction** Rate=k[Alkyl halide]^1[Nucleophile]^1	**Rate of Reaction** Rate=k[Alkyl halide]^1
11.	**Order of Reaction** 1+1=2 Second order reaction	**Order of Reaction** First order reaction
12.	Primary alkyl halides give SN2	Tertiary alkyl halides give SN1
	Secondary alkyl halides give both S_N1 and S_N2 depending on conditions	

Elimination Reactions

Difference between E1 and E2 Reactions

Sr No	E1	E2
1	It is a two step elimination reaction	It is a one step elimination reaction
2	It is unimolecular reaction	It is bimolecular reaction

3	It is carried out along with S_N1	It is carried out along with S_N2
4	It is given by tertiary alkyl halides	It is given by primary alkyl halides
	Secondary alkyl halides give both E1 and E2	
5		
	Nature of the product in both the cases is an alkene	
6	Molecularity of the reaction is 1	Molecularity of the reaction is 2
7	Rate=k[Alkyl halide]	Rate=k[Alkyl halide][Base]
8	Order of the reaction is 1	Order of the reaction is 2

Common points between E1 and E2 reactions

- In both elimination reactions a new C-C π bond is formed and a C-H bond and a C-leaving group bond is broken.
- In both elimination reactions a species acts as a base to remove a proton to form the new π bond.
- With increase of temperature we get elimination reactions.

Chapter 11

Alcohols, Phenols and Ethers

Q. Give structural formulas of (i) methoxy ethane (ii) ethoxy benzene (iii) carbolic acid (iv) glycerol.

(i)

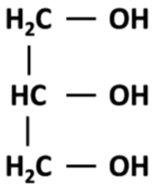
$CH_3OC_2H_5$

(ii)

$C_2H_5OC_6H_5$

(iii) C_6H_5OH

(iv)



$$\begin{array}{l} H_2C - OH \\ \quad | \\ HC - OH \\ \quad | \\ H_2C - OH \end{array}$$

Alcohols

Q. Ethanol reacts with sulphuric acid and gives different products at different temperatures. Comment.

At 180 °C with conc. H_2SO_4.

$$C_2H_5\text{-}OH \longrightarrow CH_2{=}\,CH_2 + H_20$$

At 140 °C with conc.H_2SO_4.

$$2C_2H_5\text{-}OH \longrightarrow C_2H_5\text{-}O\text{-}C_2H_5 + H_20$$

Q. How is ethyl alcohol prepared from molasses? Write equations.

The residue obtained after the crystallization of sugar from concentrated sugar cane juice is called **molasses**. It **undergoes fermentation in the presence of enzymes present in yeast to give ethanol**.

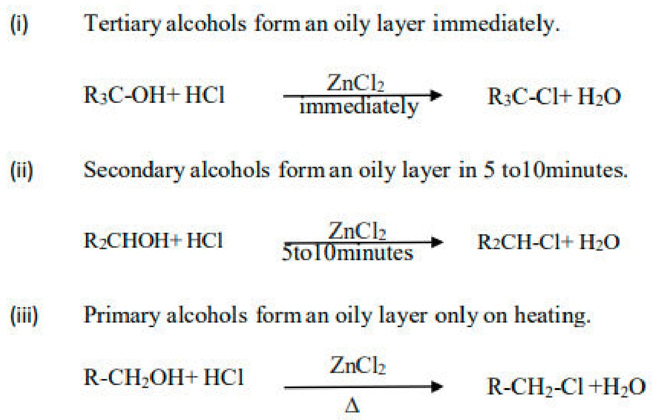
$$\underset{\text{Molasses}}{C_{12}H_{22}O_{11} + H_2O} \xrightarrow[\text{Yeast}]{\text{Invertase}} C_6H_{12}O_6 + C_6H_{12}O_6$$

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow[\text{Yeast}]{\text{Zymase}} 2C_2H_5OH + 2CO_2$$

Q. How is Lucas test used to distinguish between primary, secondary and tertiary alcohols?

Primary, secondary and tertiary alcohols are identified and distinguished by reacting them with **conc. HCI in anhydrous $ZnCl_2$**. An oily layer of alkyl halides separates out in these reactions.

1. **Tertiary alcohols** form an **oily layer** **immediately**.
2. **Secondary alcohols** form an **oily layer** in **five to ten minutes**.
3. **Primary alcohols** form an **oily layer** only **on heating**.



(i) Tertiary alcohols form an oily layer immediately.

$$R_3C\text{-}OH + HCl \xrightarrow[\text{immediately}]{ZnCl_2} R_3C\text{-}Cl + H_2O$$

(ii) Secondary alcohols form an oily layer in 5 to10minutes.

$$R_2CHOH + HCl \xrightarrow[\text{5to10minutes}]{ZnCl_2} R_2CH\text{-}Cl + H_2O$$

(iii) Primary alcohols form an oily layer only on heating.

$$R\text{-}CH_2OH + HCl \xrightarrow[\Delta]{ZnCl_2} R\text{-}CH_2\text{-}Cl + H_2O$$

Q. What is denaturing of alcohols? Or How methylated spirit is prepared?

Sometimes **ethanol is denatured** by addition of **10% methanol** to avoid its use for drinking purposes. Such alcohol is called **methylated spirit**. A small quantity of pyridine or acetone may also be added for this purpose.

Q. Write any four uses of ethyl alcohol.

(i) It is used as **solvent**

(ii) It is used as a **drink**

(iii) It is used as a **fuel**

(iv) It is used as a **preservative for biological specimen**

Q. Why ethanol has higher boiling point than diethyl ether?

Ethanol has higher boiling point than diethyl ether because **hydrogen bonding is present in ethanol which increases the boiling point**. No hydrogen bonding is present in diethyl ether.

Q. Define Absolute alcohol.

Alcohol is distilled again and again to obtain **95% alcohol** which is called **rectified spirit**. **Absolute alcohol** can be obtained by **re-distillation of rectified spirit in the presence of CaO which absorbs its moisture**.

Q. Why we cannot get ethanol beyond 12 or 14% through fermentation?

Alcohol obtained by fermentation is only up to 12% and never exceeds 14% because **beyond this limit enzymes become inactive**.

Q. How will you convert (i) Methanol into ethanol (ii) Ethanol into methanol.

(i) Methanol into ethanol

$CH_3OH \xrightarrow{HI} CH_3I$

$CH_3I + Mg \xrightarrow{Ether} CH_3MgI$

$CH_3MgI + HCHO \xrightarrow{H_3O^+} CH_3CH_2OH$

(ii) Ethanol into methanol

$CH_3CH_2OH + H_2SO_{4\,(conc.)} \xrightarrow{170-180C} CH_2{=}CH_2$

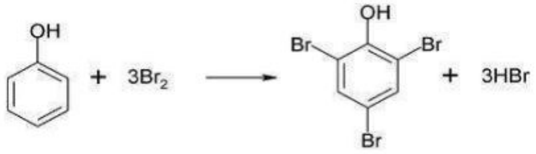
$CH_2{=}CH_2 + Zn/H_2O \xrightarrow{Ozonolysis} 2HCHO$

$HCHO \xrightarrow{LiAlH} CH_3OH$

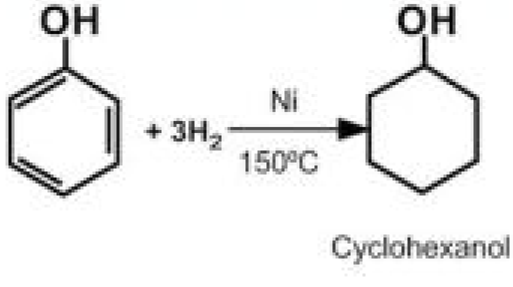
Phenols

Q. Convert phenol into (a) 2,4,6-Trbromophenol (b) Cyclohexanol

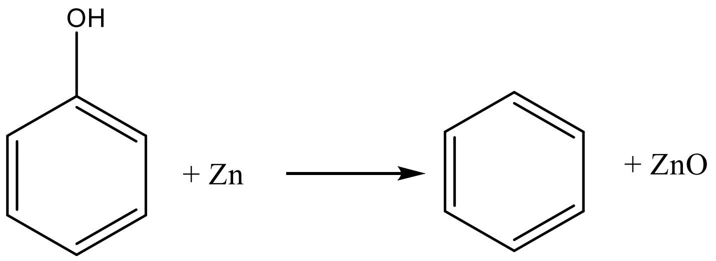
a.



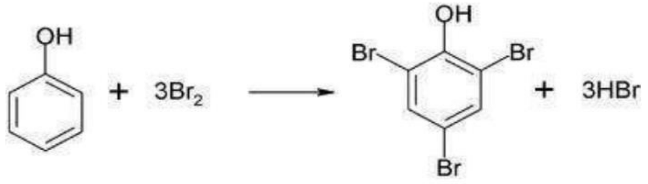
b.



Q. How phenol can be converted to benzene?

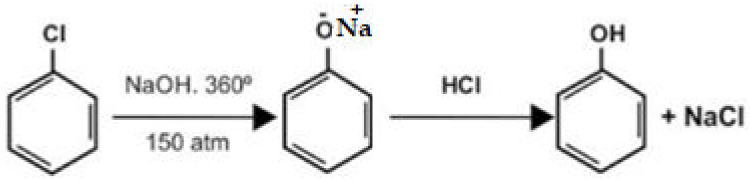


Q. How does phenol react with bromine water?

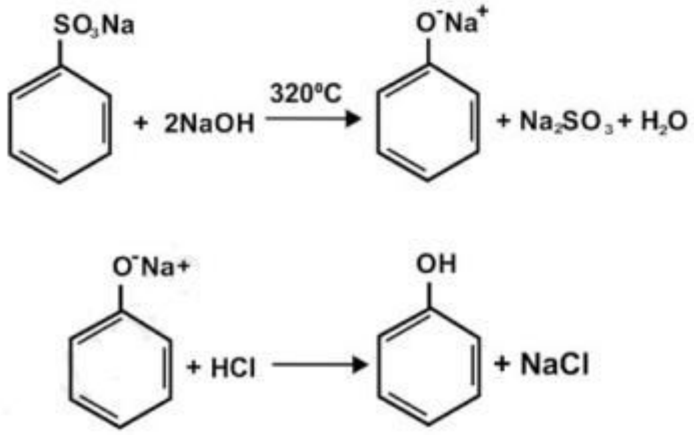


Q. Write two methods of preparation of Phenol. OR Prepare phenol from chlorobenzene by Dow's method.

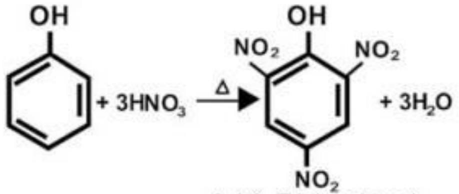
a.



b.



Q. Convert phenol to picric acid. OR Picric acid is a phenol which behaves like an acid. Justify.

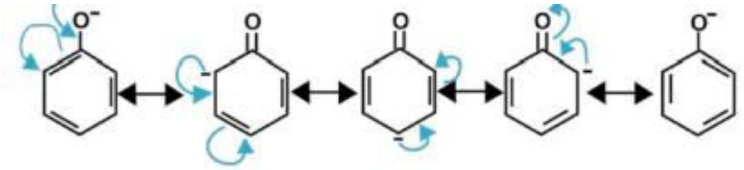


2,4,6- Trinitrophenol
(Picric acid)

Picric acid 2,4,6-Trinitrophenol has **3 nitro groups** present which have **electron withdrawing nature**. Nitro groups can engage the negative charge on benzene ring in delocalization, setting the proton free for longer time. So, picric acid acts as an acid.

Q. Why is phenol acidic in nature?

The reason why phenol is acidic lies in the nature of the phenoxide ion. **The negative charge on oxygen atom can become involved with the pi electron cloud on the benzene ring**. The **negative charge is thus delocalized in the ring** and the **phenoxide ion** becomes relatively **stable**.



Ethers

Q. What is Williamson's synthesis?

$2C_2H_5OH+2Na \longrightarrow 2C_2H5O^-Na^++H_2$

$C_2H_5O^-Na^++C_2H_5Br \longrightarrow C_2H_5OC_2H_5+ NaBr$

Q. Why ethers are referred to as inert compounds?

Ethers are comparatively inert substances. It is because the **oxygen atom is surrounded by bulky alkyl groups rendering them inert** towards majority of the reagents.

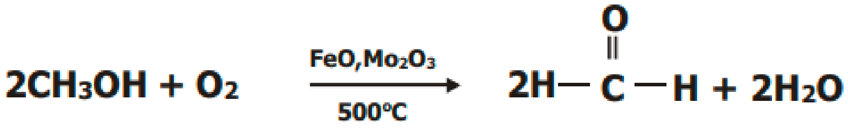
Chapter 12

Aldehydes and Ketones

Aldehydes

Q. How formalin (formaldehyde) is prepared on commercial (large) scale?

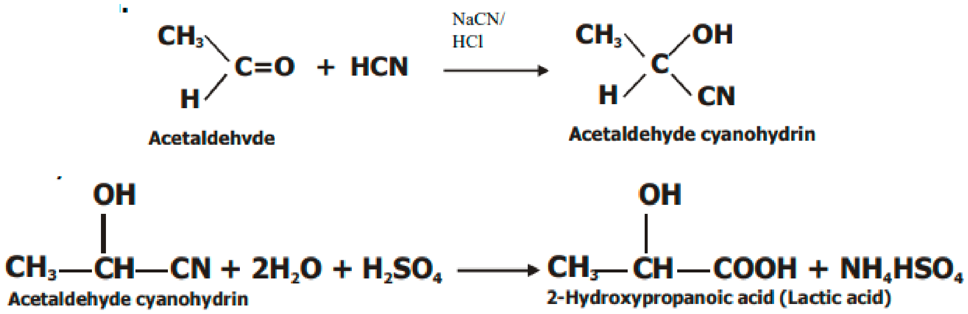
Formaldehyde (Formalin) is manufactured commercially by passing a mixture of methanol vapours and air over iron oxide-molybdenum oxide or silver catalyst at 500 °C.



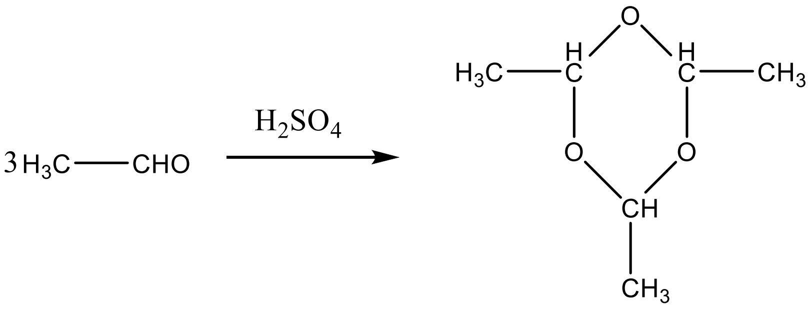
$$2CH_3OH + O_2 \xrightarrow[500^\circ C]{FeO,Mo_2O_3} 2H-\overset{\overset{O}{\|}}{C}-H + 2H_2O$$

Q. Prepare following compounds from carbonyl compounds: a. Lactic acid b. Paraldehyde c. Ethanal Oxime d. Crotonaldehyde e. Metaformaldehyde

a.

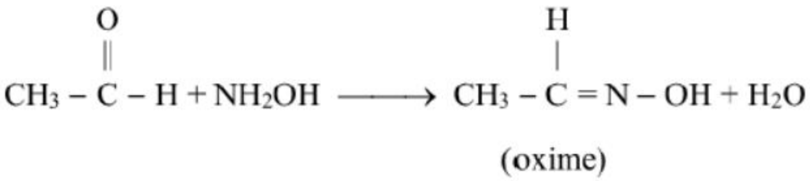


b.



Paraldehyde

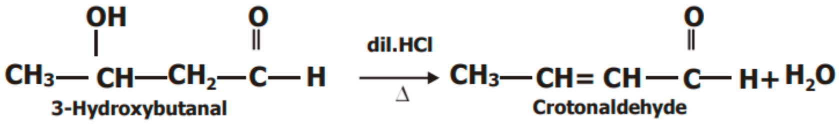
c.



$$CH_3-\overset{\overset{O}{\|}}{C}-H + NH_2OH \longrightarrow CH_3-\overset{\overset{H}{|}}{C}=N-OH + H_2O$$

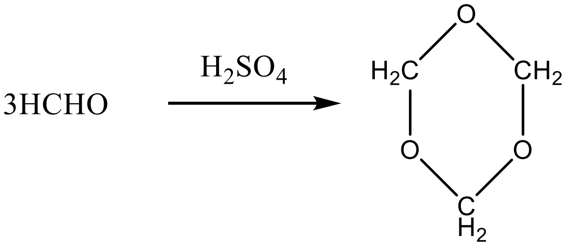
(oxime)

d.

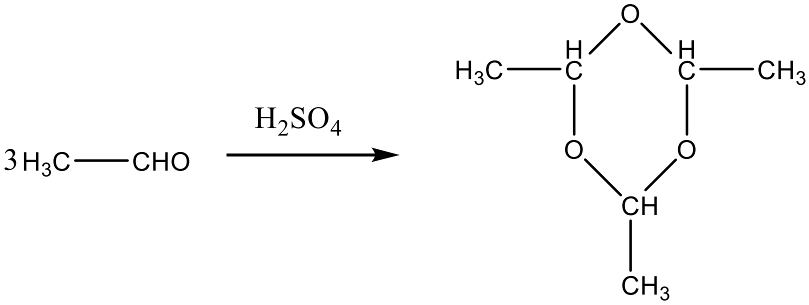


$$CH_3-CH(OH)-CH_2-CHO \xrightarrow[\Delta]{dil.HCl} CH_3-CH=CH-CHO + H_2O$$

b&e.

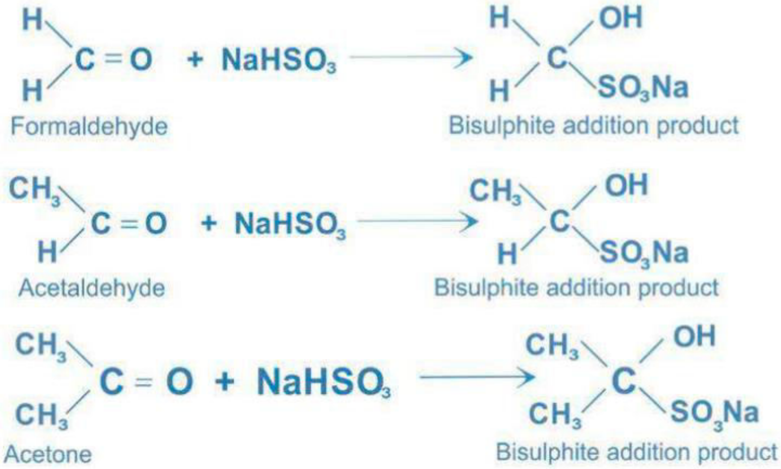


Metaformaldehyde

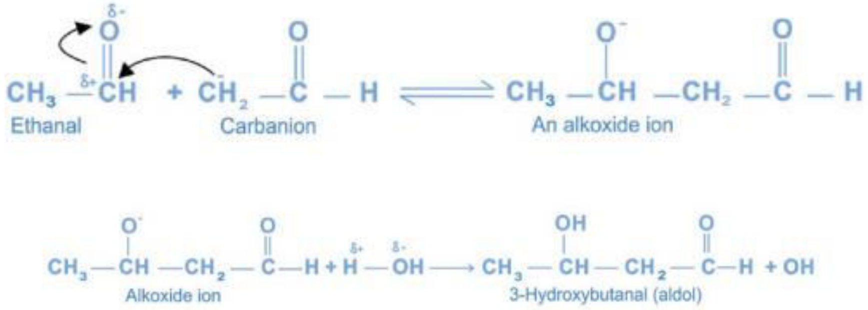


Paraldehyde

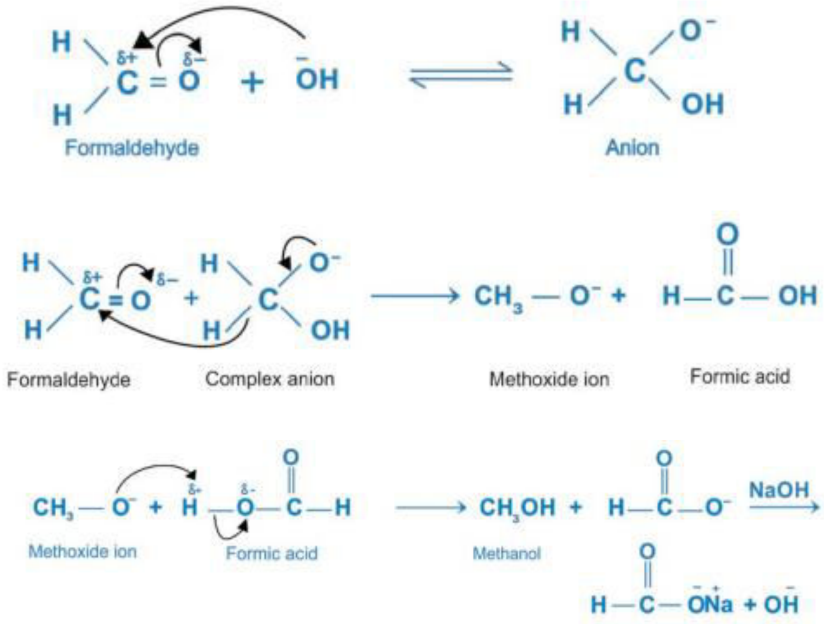
Q. How formaldehyde, acetaldehyde and acetone react with NaHSO₃?



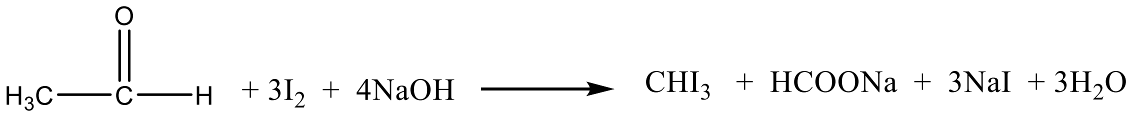
Q. Give mechanism of aldol condensation.



Q. Give mechanism of Cannizzaro's condensation.

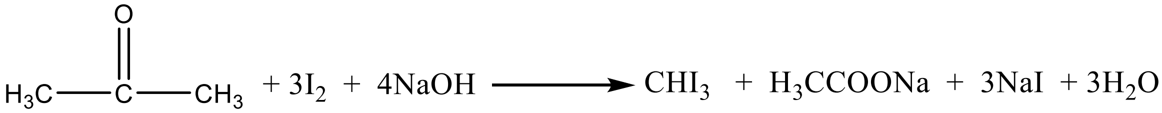


Q. Give haloform reaction of acetaldehyde, acetone and ethanal.



$$H_3C-\overset{\overset{O}{\|}}{C}-H + 3I_2 + 4NaOH \longrightarrow CHI_3 + HCOONa + 3NaI + 3H_2O$$

Acetaldehyde Iodine Iodoform (yellow ppt) Sod. formate



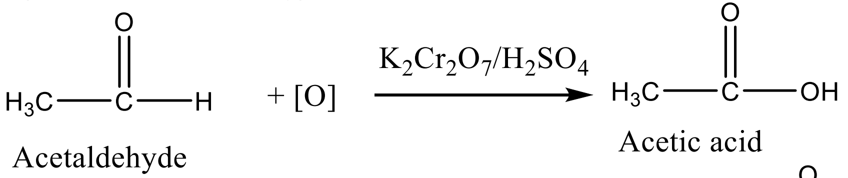
$$H_3C-\overset{\overset{O}{\|}}{C}-CH_3 + 3I_2 + 4NaOH \longrightarrow CHI_3 + H_3CCOONa + 3NaI + 3H_2O$$

Acetone Iodine Iodoform (yellow ppt) Sod. acetate

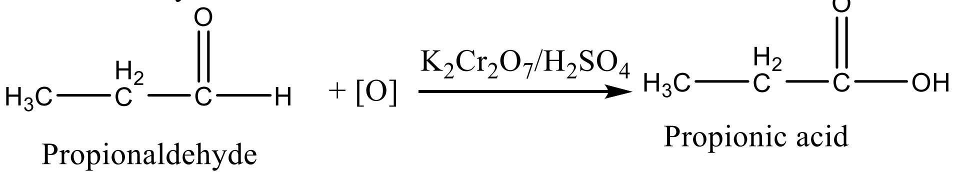
$$CH_3CH_2OH + 4I_2 + 6NaOH \longrightarrow CHI_3 + HCOONa + 5NaI + 5H_2O$$

Iodoform Sod. formate

Q. Tell about oxidation of aldehydes and ketones.

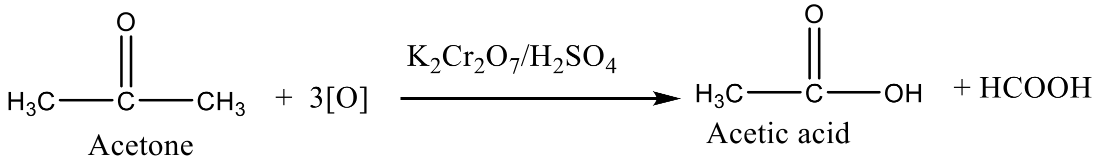


$$CH_3CHO + [O] \xrightarrow{K_2Cr_2O_7/H_2SO_4} CH_3COOH$$

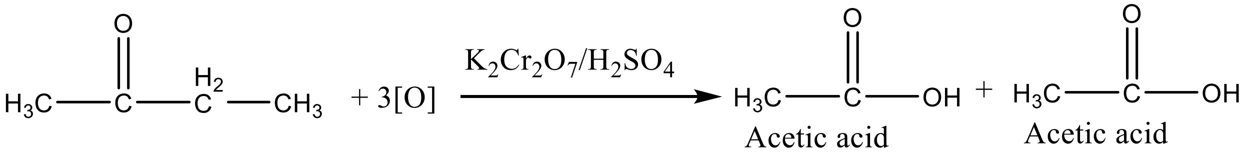


$$CH_3CH_2CHO + [O] \xrightarrow{K_2Cr_2O_7/H_2SO_4} CH_3CH_2COOH$$

Ketones do not undergo oxidation easily because they require breaking of strong carbon - carbon bond. They give no reaction with mild oxidising agents. They are only oxidised by strong oxidising agents such as $K_2Cr_2O_7$/ H_2SO_4, $KMnO_4$/ H_2SO_4, and conc. HNO_3.

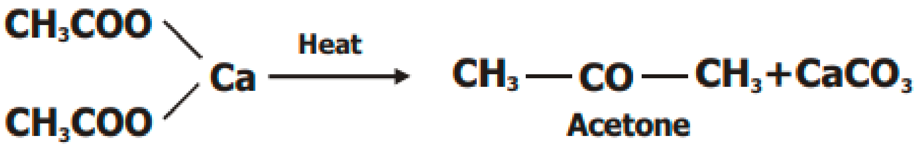


$$CH_3COCH_3 + 3[O] \xrightarrow{K_2Cr_2O_7/H_2SO_4} CH_3COOH + HCOOH$$



$$CH_3COCH_2CH_3 + 3[O] \xrightarrow{K_2Cr_2O_7/H_2SO_4} CH_3COOH + CH_3COOH$$

Q. Prepare acetone from calcium acetate?



$$(CH_3COO)_2Ca \xrightarrow{Heat} CH_3-CO-CH_3 + CaCO_3$$

Tests to Distinguish Carbonyl Compounds

2,4 DNPH Test

Aldehydes and ketones form a yellow or red precipitate with 2,4 dinitrophenylhdrazine solution.

Sodium Bisulphite Test

Aldehydes and small methyl ketones form a crystalline white precipitate with saturated sodium bisulphite solution.

Tollen's Test [Silver Mirror Test]

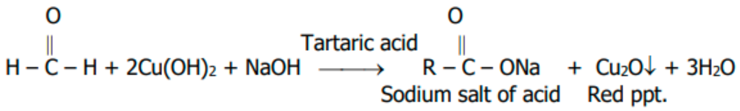
Aldehydes form silver mirror with Tollen's reagent (ammoniacal silver nitrate solution). Add Tollen's reagent to an aldehyde solution in a test tube and warm. A silver mirror is formed on the inside of the test tube. High quality mirrors are manufactured by using this principle. Ketones do not give this test.

$$AgNO_3 + 3NH_4OH \longrightarrow [Ag(NH_3)_2]OH + NH_4NO_3 + 2H_2O$$

$$R\text{-}CHO + 2[Ag(NH_3)_2]OH \longrightarrow R\text{-}COONH_4 + \underset{\text{Silver mirror}}{2Ag} + 2NH_3 + H_2O$$

Fehling's test

Fehling's solution is a mixture of $Cu(OH)_2$, NaOH and tartaric acid. It reduces **aldehyde and produces brick red ppt of Cu_2O on heating**.



$$H-\overset{\overset{\displaystyle O}{\|}}{C}-H + 2Cu(OH)_2 + NaOH \xrightarrow{\text{Tartaric acid}} \underset{\text{Sodium salt of acid}}{R-\overset{\overset{\displaystyle O}{\|}}{C}-ONa} + \underset{\text{Red ppt.}}{Cu_2O\downarrow} + 3H_2O$$

Benedict's solution

Aliphatic aldehydes form a brick-red precipitate with Benedicts's solution. To an aldehyde solution, add Benedict's solution and boil. A brick-red precipitate of cuprous oxide is formed. **Ketones do not give this test.**

$$RCHO + 2Cu(OH)_2 + NaOH \rightarrow RCOONa + Cu_2O + 3H_2O$$

Sodium Nitroprusside Test

Ketones produce a wine red or orange red colour on adding alkaline sodium nitroprusside solution dropwise. **Aldehydes do not give this test.**

Q. Give uses of formaldehyde and acetaldehyde.

Uses of formaldehyde

(i) It is used in the manufacture of resins like urea-formaldehyde and plastics such as bakelite.

(ii) It is used in the manufacture of dyes such as indigo, para-rosaniline, etc.

(iii) Its 40% aqueous solution called formalin is used as an antiseptic, a disinfectant, a germicide, a fungicide and for preserving animal specimens and sterlising surgical instruments.

(iv) It is used as a decolourising agent in vat dyeing.

Uses of acetaldehyde

1. It is used in the production of acetic acid, acetic anhydride, n-butanol, ethanol, 2-ethyl-1- hexanol, vinyl acetate, paraldehyde, ethylacetate, etc.

2. It is used to make acetaldehyde ammonia used as a rubber-accelerator.

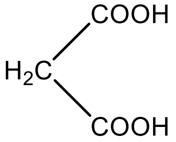
3. It is used to make chloral hydrate, ethanol trimer and tetramer. Chloral hydrate and ethanol trimer are both used as hypnotic drugs whereas ethanol tetramer is used as a slug poison.

4. It is used as an antiseptic inhalant in nasal infections.

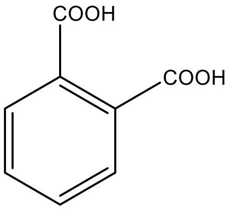
Chapter 13

Carboxylic Acids

Q. Write structural formulae of Phthalic acid and Malonic acid.



Propanedioic acid
(malonic acid)



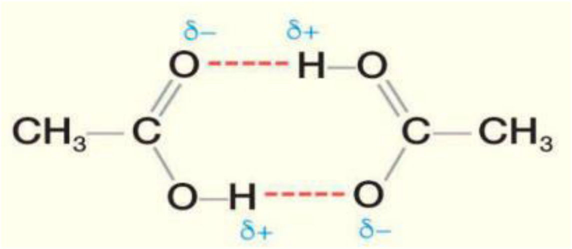
1,2-Benzenedicarboxylic acid
or Phthalic acid

Q. Why first four members of aliphatic carboxylic acids are soluble into water?

The first four members of aliphatic carboxylic acids are soluble into water due to hydrogen bonding.

Q. Why do mostly carboxylic acids exist as dimers?

In pure carboxylic acids Hydrogen bonding can occur between two molecules of acid to produce a dimer. This immediately doubles the size of the molecule and so increases Vander Waals dispersion forces between one of these dimmers and its neighbours, resulting in a high boiling point.



What is meant by Glacial acetic acid?

The pure, anhydrous acetic acid, forming ice-like crystals at temperatures below 16.7°C, is called glacial acetic acid.

Q. How carboxylic acid can be obtained from alkene?

$$\underset{\text{Symmetrical alkene}}{\text{R-CH=CH-R}} + 4[\text{O}] \xrightarrow[\triangle]{\text{KMnO}_4/\text{OH}^-} \underset{\text{Carboxylic acid}}{2\text{RCOOH}}$$

$$\underset{\text{2-Butene}}{\text{CH}_3\text{-CH=CH-CH}_3} + 4[\text{O}] \xrightarrow{\text{KMnO}_4/\text{OH}^-} \underset{\text{Ethanoic acid}}{2\text{CH}_3\text{COOH}}$$

Q. Write two reactions of carboxylic acids in which hydrogen atom of carboxyl group is involved.

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

$$2CH_3COOH + 2Na \rightarrow 2CH_3COO^-Na^+ + CO_2 + H_2$$

Acetic Acid

Q. How acetic acid is prepared from methyl nitrile?

$$CH_3\text{-}C{\equiv}N + 2H_2O + HCl \longrightarrow CH_3COOH + NH_4Cl$$

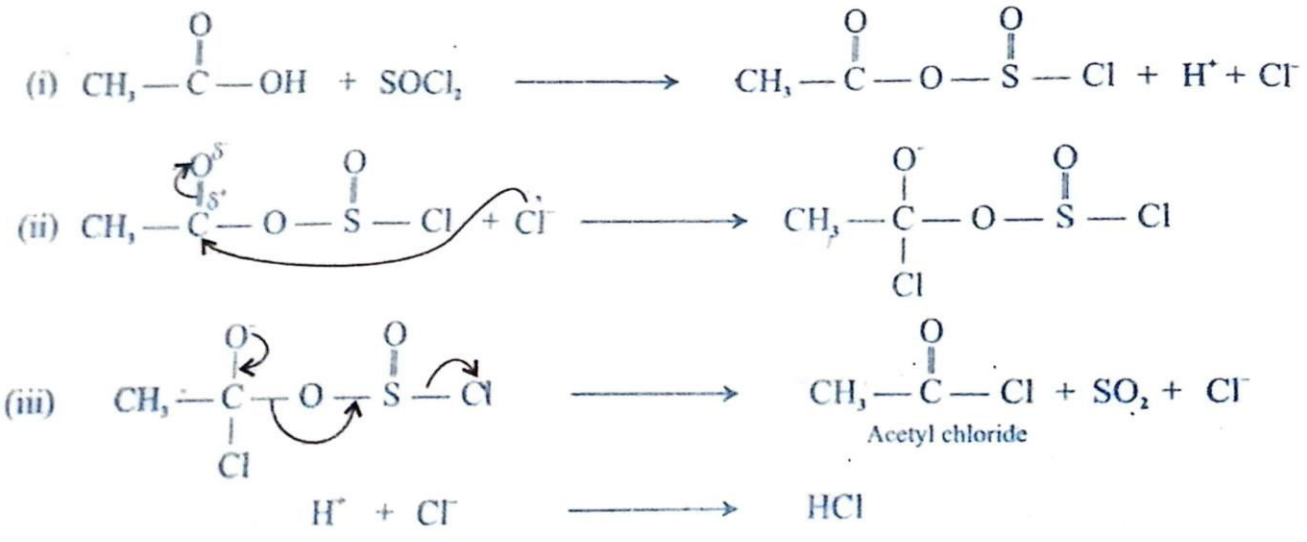
Q. How acetic acid reacts with a. PCl_5 b. $SOCl_2$ c. Na_2CO_3

a.

$$CH_3COOH + PCl_5 \rightarrow CH_3COCl + POCl_3 + HCl$$

b. $CH_3COOH + SOCl_2 \longrightarrow CH_3COCl + SO_2 + Cl^-$

Mechanism



c.

$$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COO^-Na^+ + CO_2 + H_2O$$

Prepare ethane from acetic acid by reduction.

$$CH_3COOH + 6HI \xrightarrow{P} CH_3\text{—}CH_3 + 2H_2O + 3I_2$$

Write reactions of acetic acid with: i. HI/Red Phosphorus ii. NH_3/Heat (Formation of acetamide)

i.

$$CH_3COOH + 6HI \xrightarrow{P} CH_3\text{—}CH_3 + 2H_2O + 3I_2$$

ii.

$$CH_3COOH + NH_3 \rightarrow CH_3COONH_4$$

$$CH_3COO^-N^+H_4 \xrightarrow{\text{Heat}} CH_3CONH_2 + H_2O$$

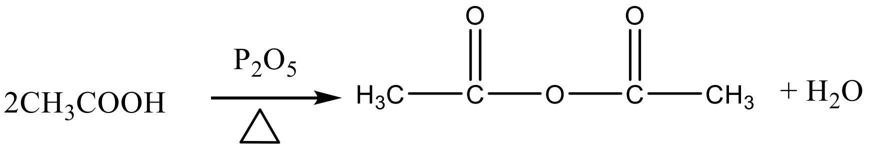
Q. How will you convert acetic acid into methane and acetic anhydride?

Acetic acid to methane

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Sodium hydroxide}}{NaOH} \longrightarrow \underset{\text{Sodium ethanoate}}{CH_3COONa} + \underset{\text{Water}}{H_2O}$$

$$\underset{\text{Sodium ethanoate}}{CH_3COONa} + \underset{\text{Sodium hydroxide}}{NaOH} \longrightarrow \underset{\text{Methane}}{CH_4} + \underset{\text{Sodium carbonate}}{Na_2CO_3}$$

Acetic acid to acetic anhydride

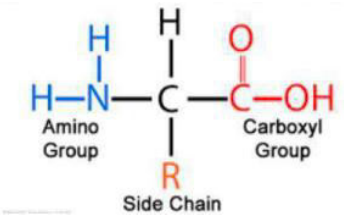


$$2CH_3COOH \xrightarrow[\triangle]{P_2O_5} H_3C-\overset{\overset{O}{\|}}{C}-O-\overset{\overset{O}{\|}}{C}-CH_3 + H_2O$$

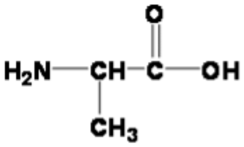
Amino acids

Q. Define amino acid.

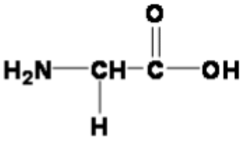
Amino acids are organic compounds containing both amino and carboxyl groups. They are represented by the general formula:



Q. Write formulae of Glycine and Alanine.



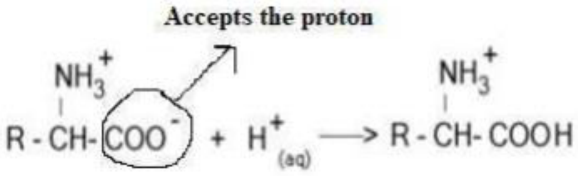
alanine



glycine

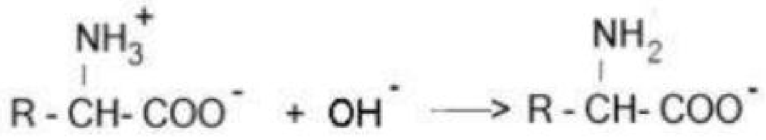
Q. Tell about acidic and basic nature of amino acids.

1. When an acid is added to an amino acid the carboxylate ion accepts the proton and, therefore, the basic character is due to this group.



$$R-\overset{NH_3^+}{\overset{|}{C}H}-COO^- + H^+_{(aq)} \longrightarrow R-\overset{NH_3^+}{\overset{|}{C}H}-COOH$$

2. When an alkali is added to an amino acid, NH3 group releases the proton and therefore the acidic character is due to this group.



$$R-\overset{NH_3^+}{\overset{|}{C}H}-COO^- + OH^- \longrightarrow R-\overset{NH_2}{\overset{|}{C}H}-COO^-$$

Q. Differentiate between acidic and basic amino acids.

Acidic amino acid	Basic amino acid
1. The amino acids which contain two carboxyl groups are called acidic amino acids.	1. The amino acids which contain two amino groups are called basic amino acids.
2. For example, Glutamic acid and Aspartic acid.	2. For example, Lysine and Histidine.

Q. Define neutral amino acids with example.

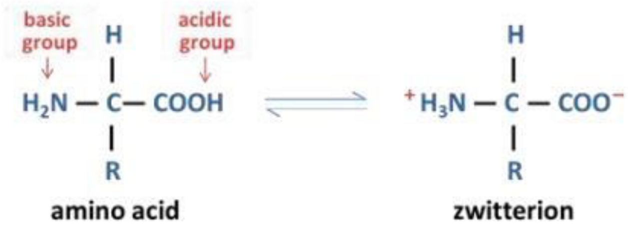
Since an amino acid has both an amine and acid group which have been neutralized **in the zwitter ion the amino acid is neutral unless there is an extra acid or base on the side chain**. If neither is present then the whole amino acid is neutral. eg. glycine, alanine, valine etc.

Q. What is difference between essential and non-essential amino acids?

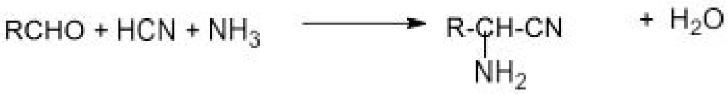
Essential amino acid	**Non-essential amino acids**
1. The amino acids which our body can't prepare are called essential amino acids.	1. The amino acids which our body can prepare are called non-essential amino acids.
2. These we have to take in to our diet for proper health and growth.	2. These are not required in diet.

Q. Define Zwitter ion or internal salt?

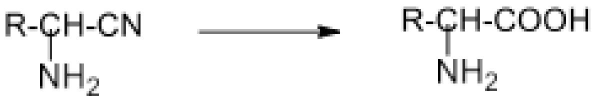
The amino acids exist as dipolar ion called Zwitter ion. It has **positive as well as negative ends within the same molecule. In the formation of Zwitter ion, the proton goes from the carboxyl group to amino group**. The Zwitter ionic structure of an amino acid may be written as:



Q. How amino acid is prepared by Strecker's synthesis?



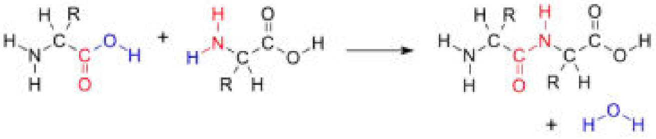
$$\mathrm{RCHO + HCN + NH_3 \longrightarrow R\text{-}\underset{NH_2}{\underset{|}{C}}H\text{-}CN + H_2O}$$



$$\mathrm{R\text{-}\underset{NH_2}{\underset{|}{C}}H\text{-}CN \longrightarrow R\text{-}\underset{NH_2}{\underset{|}{C}}H\text{-}COOH}$$

Q. What is peptide bond? Write formula of a dipeptide.

Peptides are the compounds formed by the **condensation of two or more same or different α-amino acids**.

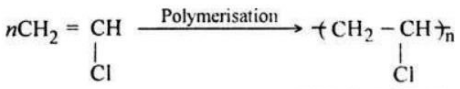


Chapter 14

Macromolecules

Q. Define polymerization. Explain the term degree of polymerization.

Polymerization is a process of reacting **monomer molecules** together in a chemical reaction to **form polymer chains or three-dimensional networks**.



$$nCH_2=\underset{\displaystyle Cl}{\underset{|}{CH}} \xrightarrow{\text{Polymerisation}} -\!\!\left(CH_2-\underset{\displaystyle Cl}{\underset{|}{CH}}\right)\!\!-_n$$

Polyvinyl chloride

The length of the polymer chain is specialized by the **number of repeating units in the chain known as the degree of polymerization (DP)**, for example, in linear polythene

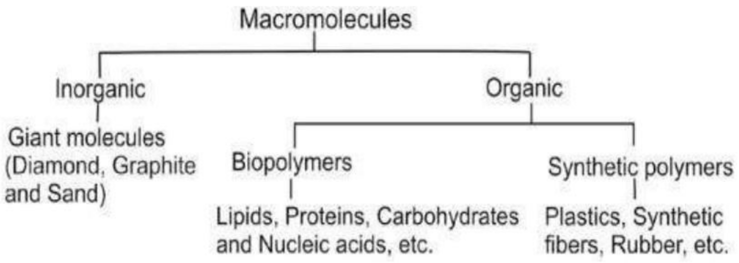
$$-CH_2-CH_2-CH_2-CH_2-CH_2-$$

The repeating unit is

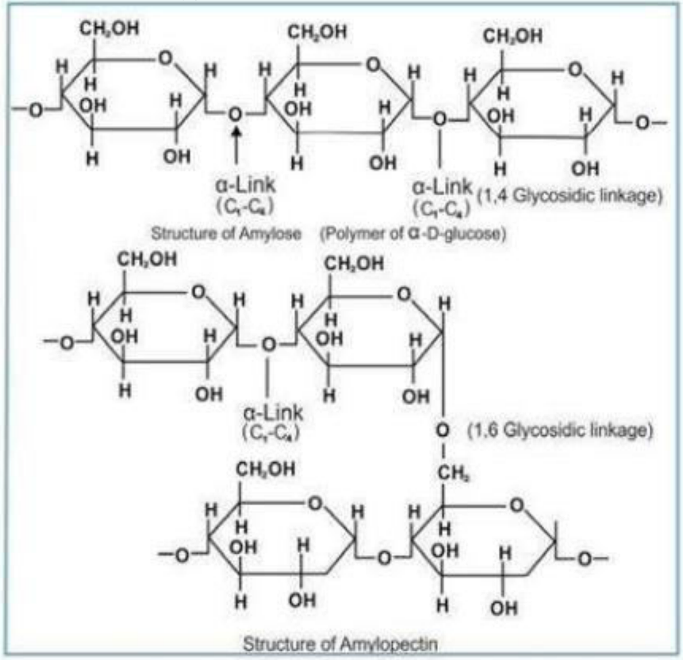
$$-\!\!\left(CH_2-CH_2\right)\!\!-_n$$

Where, **n is called degree of polymerization** and it is usually a large number.

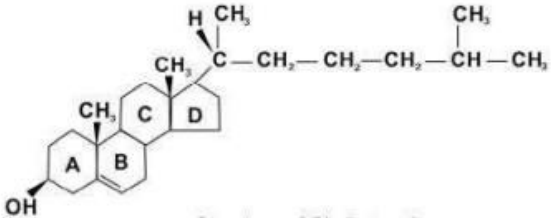
Q. How are macromolecules classified?



Q. What is the structure of starch and cholesterol?



Structure of Starch

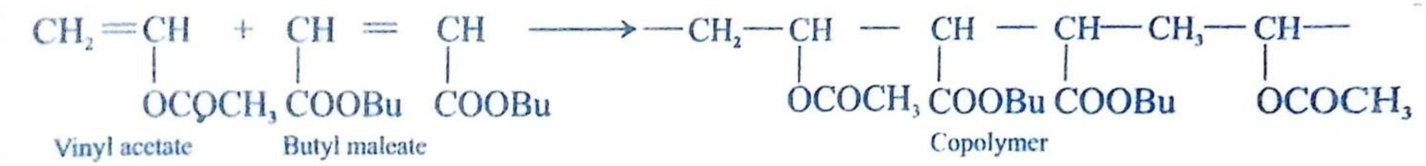


Structure of Cholesterol

Types of Polymers

Q. Define copolymer. Give example.

A copolymer is formed by the **polymerization of two monomers together**, e.g; vinyl acetate reacts with butyl maleate to give a copolymer.



Q. How Polyvinyl chloride (PVC) is prepared and give its uses?

It is an **addition polymer** obtained by **polymerizing vinyl chloride at 52 °C and 9 atmospheric pressure**.

$$n\,CH_2{=}\underset{Cl}{\underset{|}{CH}} \longrightarrow -CH_2-(\underset{Cl}{\underset{|}{CH}}-CH_2)_{n-1}-\underset{Cl}{\underset{|}{CH}}-$$

Vinyl chloride   Polyvinyl chloride (PVC)

It is widely used in **floor coverings, in pipes, in gramophone recorders**, etc.

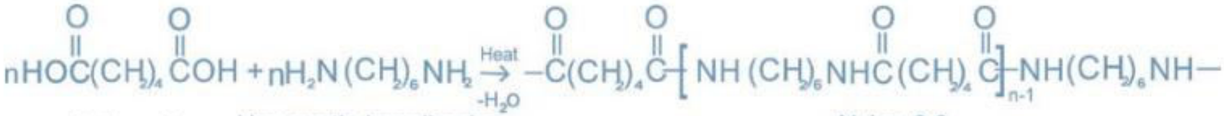
Q. What are thermoplastic and thermosetting polymers?

A **thermoplastic polymer** is one which **can be softened repeatedly when heated and hardened when cooled** with a little change in properties. Examples: **PVC pipes, plastic toys,** etc.

The polymers which **become hard on heating and cannot be softened again** are called **thermosetting polymers**. A thermosetting polymer, **on heating, decomposes instead of melting**. Examples: **synthetic varnish, epoxy resins,** etc.

Q. How is Nylon-6,6 prepared?

It is obtained by **heating adipic acid (hexanedioic acid) with hexamethylene diamine**.



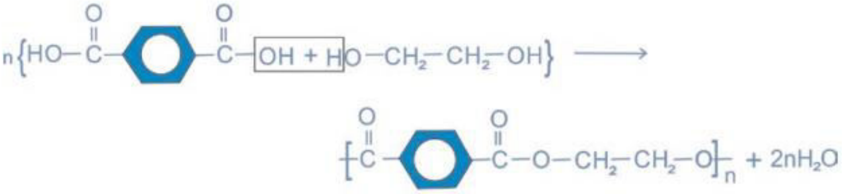
$$n\,HO\overset{O}{\overset{\|}{C}}(CH_2)_4\overset{O}{\overset{\|}{C}}OH + n\,H_2N(CH_2)_6NH_2 \xrightarrow[-H_2O]{Heat} -\overset{O}{\overset{\|}{C}}(CH_2)_4\overset{O}{\overset{\|}{C}}-[NH(CH_2)_6NH\overset{O}{\overset{\|}{C}}(CH_2)_4\overset{O}{\overset{\|}{C}}]_{n-1}-NH(CH_2)_6NH-$$

Adipic acid   Hexamethylenediamine   Nylon-6,6

Q. Write a note on condensation polymer.

This type of polymerization results from the **mutual reaction of two functional groups**. The reaction usually involves the **removal of a water molecule or a methanol molecule**.

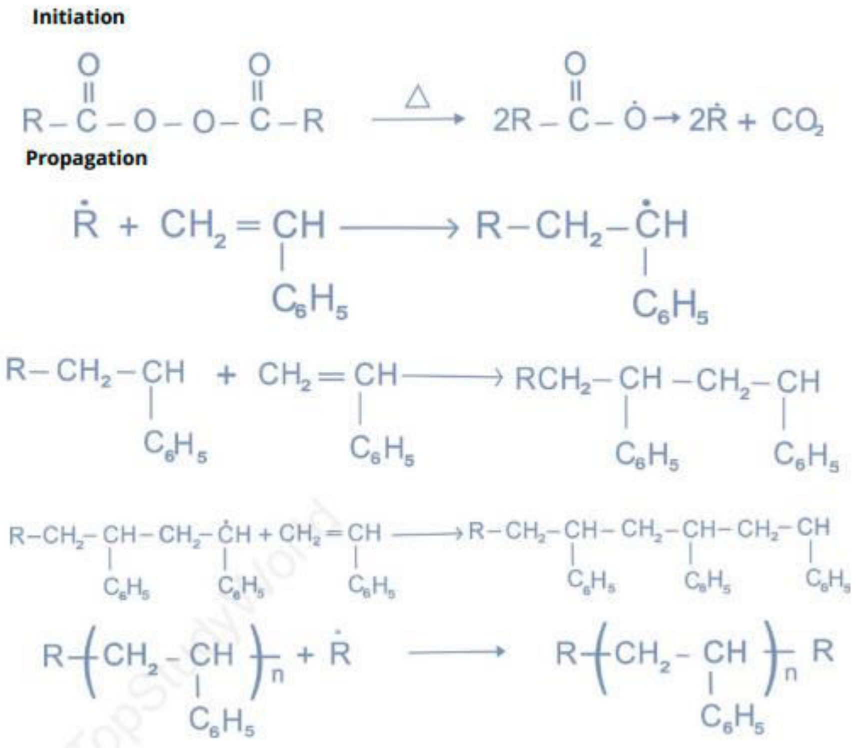
For example, **dicarboxylic acids or esters combine with diols to get the desired polymer like nylon and polyester fibre**. Such polymerizations are generally ionic in nature.



Polyester

Q. Give mechanism of addition polymerization.

It is a **free-radical addition reaction** which involves initiation, propagation and termination steps. For example, **polymerization of styrene**. Addition of polymerization is **catalyzed by thermal or photochemical decomposition of organic peroxides to give free radicals.**



Lipids

Q. In what way fats and oils are different?

The **glycerides in which long chain saturated acid components predominate** tend to be solid or semi-solid and are termed as **fats**. On the other hand, **oils are glycerol esters which contain higher proportion of unsaturated fatty acid components** and are in liquid form at room temperature.

Q. What are lipids? Give two physical properties.

Lipids are **naturally occurring organic compounds of animals and plant origin** which are soluble in organic solvents and belong to a very heterogeneous group of substances. Examples: Fats & Oils

1. They are **insoluble in water** and **soluble in non-polar solvents** e.g. ether, chloroform and benzene, etc.

2. Their primary **building blocks are fatty acids, glycerol and sterols**.

Q. Discuss Saponification number and give example.

It is defined as the **number of milligrams of potassium hydroxide or sodium hydroxide required to saponify one gram of the fat or oil.** For example, one mole of glycerol tripalmitate (mol. wt = 807) requires 168,000 mg of KOH for saponification. Therefore, one gram of fat will require 168000/807 mg of KOH. Hence the **saponification number of glycerol tripalmitate is 208.**

Q. Define iodine number and acid number.

Iodine number is defined as the **number of grams of iodine which will add to 100 grams of a fat or an oil**. The value of iodine number **depends on the number of double bonds** present in the acid component of the glycerides. The **glycerides with no double bonds have zero iodine number.**

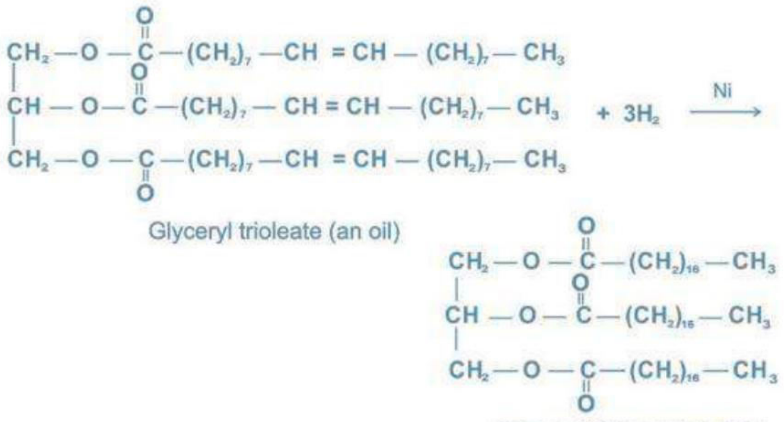
Acid number tells the **amount of free fatty acids present in it**. It is expressed as **the number of milligrams of potassium hydroxide required to neutralize one gram of fat**.

Q. What is rancidity of fats and oils?

Fats or oils are liable to spoilage and **give off an odour known as rancidity**. It is mainly caused by the **hydrolytic or oxidative reactions** which **release foul smelling aldehydes and fatty acids**.

Q. What is meant by hardening of oil?

Unsaturated glycerides react with hydrogen in the presence of a metal catalyst to give **saturated glycerides**. The result is the conversion of a **liquid glyceride (an oil) into a semi-solid glyceride (a fat)**.



Glyceryl trioleate (an oil)

Glyceryl tristearate (a fat)

Proteins

Q. What is denaturation of proteins?

The **structure of proteins** can be **disrupted** easily by **heat, change in pH and under strong oxidizing and reducing conditions**. This is **denaturation of proteins**. The most familiar example of denaturation is the **change that takes place in albumin**, the principle component of egg white, **when it is cooked**.

Carbohydrates

Q. What are carbohydrates? Why are they called so?

The name carbohydrate (hydrate of carbon) is derived from the fact that the first compound of this group which was studied had an **empirical formula $C_x(H_2O)_y$** . **They are commonly called 'sugars' and are 'polyhydroxy compounds' of aldehydes and ketones.**

DNA and RNA

Q. What are differences between DNA and RNA?

DNA	**RNA**
1. DNA is Deoxyribonucleic acid .	1. RNA is ribonucleic acid.
2. It carries genetic information.	2. It puts this information to work in cell
3. Sugar in DNA is 2-deoxyribose	3. Sugar in RNA is ribose.
4. It is double stranded .	4. It is single stranded.
5.Four bases are found in DNA. Cytosine, Thymine, Adenine & Guanine.	5. In RNA thymine is replaced by Uracil

Q. What is function of DNA and RNA?

The function of DNA and RNA is to **carry genetic information** which is used in cells to make proteins necessary for cell function.

Enzymes

Q. Give four properties of enzymes.

1. Enzymes are **specific in their action** which means that an enzyme will act on only one substrate or a group of closely related substrates.

2. Enzymes with few exceptions are **protein in nature**.

3. Most enzymatic **reactions are reversible**.

4. The **enzymes from the same organisms which catalyze the same reaction but are chemically and physically distinct from each other are called isoenzymes**.

Chapter 15

Common Chemical Industries in Pakistan

Fertilizers

Q. What are fertilizers?

Fertilizers are the **substances added to the soil to make up the deficiency of essential elements** like nitrogen, phosphorus and potassium (NPK) required for the proper growth of plants. Fertilizers enhance the natural fertility of the soil or replenish the chemical elements taken up from soil by the previous crops.

Q. What are micronutrients?

Elements required in very small amount for the growth of plants are considered as micro- nutrients. These include Boron, Copper, Iron, Manganese, Zinc, Molybdenum and Chloride. These are required in **range from 6grams to 200grams per acre**.

Q. What are macronutrients?

Elements required in large amount are considered as macro-nutrients. These include Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulphur, Carbon, Hydrogen and Oxygen. These are required in **range from 5kg to 200kg per acre**.

Q. Mention any four essential qualities of a good fertilizer.

The essential requisites of a good fertilizer are:

1. The nutrient elements present in it must be **readily available to the plant**.

2. It must be fairly soluble in water so that it **thoroughly mixes with the soil**.

3. It should **not be injurious to plant**.

4. It should be **cheap**.

Manufacturing of Urea is Long Question

Q. Mention the steps involved in the manufacturing of urea.

Following steps are involved in the manufacture of urea.

i) Preparation of Hydrogen and Carbon dioxide

ii) Preparation of Ammonia

iii) Preparation of Ammonium Carbamate

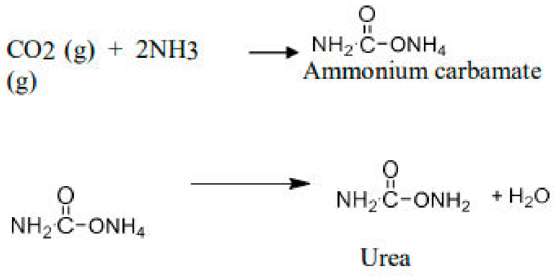
iv) Preparation of Urea

v) Concentration of Urea

vi) Prilling

Q. Which reactions are involved in the manufacture of urea?

Following reactions are involved in the manufacturing of urea:



$$\text{CO2 (g)} + \text{2NH3 (g)} \longrightarrow NH_2\overset{O}{\overset{\|}{C}}-ONH_4$$

Ammonium carbamate

$$NH_2\overset{O}{\overset{\|}{C}}-ONH_4 \longrightarrow NH_2\overset{O}{\overset{\|}{C}}-ONH_2 + H_2O$$

Urea

Q. What is meant by prilling of urea?

The **molten urea** is sprayed at the prilling tower by means of prilling bucket where it is cooled by the air rising upward. Molten droplets **solidify into the form of prills**.

Q. What is the role of phosphorus in plant growth?

Phosphorus is required to **stimulate early growth to accelerate the seed and fruit formation** during the later stages of growth. It also **increases resistance to diseases**.

Q. What is the role of potassium in plant growth?

Potassium is required for **the formation of starch, sugar and the fibrous material** of the plant. They increase **resistance to diseases** and make the plants strong by helping in **healthy root development**. They also help in **ripening of seeds, fruits and cereals**. Potassium fertilizers are especially **useful for tobacco, coffee, potato and corn**.

Q. What is the role of nitrogen in plant growth?

Nitrogen is required during the **early stage of plant growth for the development of stems and leaves**. It is the **main constituent of protein, imparts green colour to the leaves and enhances the yield and quality** of the plants.

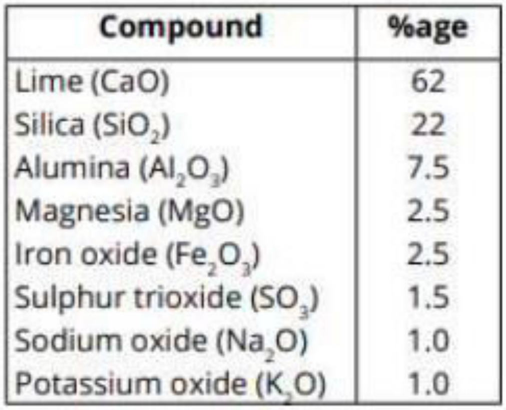
Cement Industry

(Long Question)

Q. Define cement.

Cement is the material obtained by burning an **intimate mixture of calcarious and argillaceous materials** at sufficiently high temperature to produce clinkers. These clinkers are then ground to a fine powder. The **essential constituents are lime (obtained from limestone) silica and alumina (present in clay)**.

Q. Give percentage composition of cement.



Compound	%age
Lime (CaO)	62
Silica (SiO_2)	22
Alumina (Al_2O_3)	7.5
Magnesia (MgO)	2.5
Iron oxide (Fe_2O_3)	2.5
Sulphur trioxide (SO_3)	1.5
Sodium oxide (Na_2O)	1.0
Potassium oxide (K_2O)	1.0

Q. What are the steps of the wet process for the manufacturing of cement?

1. Crushing and grinding of the raw material.

2. Mixing the material in correct proportion.

3. Heating the prepared mixture in a rotary kiln.

4. Grinding the heated product known as clinker.

5. Mixing and grinding of cement clinker with gypsum.

Q. Give different zones in the rotary kiln and their temperature ranges.

There four different zones:

(a) Drying or Pre-heating Zone (Minimum temperature zone): In this zone the temperature is kept at **500°C**, whereby the moisture is removed and the clay is broken into Al_2O_3, SiO_2, and Fe_2O_3.

(b) Decomposition Zone (Moderate temperature zone): Here the temperature **goes up to 900°C** In this zone the limestone ($CaCO_3$) decomposes into lime (CaO) and CO_2

$$CaCO_3(s) \xrightarrow[900°C]{} CaO(s) + CO_2(g)$$

(c) Burning Zone (Maximum temperature zone): In this zone, the temperature **goes up to 1500°C** and the oxides, e.g. CaO, SiO_2, Al_2O_3 and Fe_2O_3 combine together and form calcium silicate, calcium aluminate and calcium ferrite.

(d) Cooling Zone: This is the last stage in the kiln where the charge is cooled up to **150- 200°C**.

Q. What is clinker formation?

The **resulting product obtained from the kiln** is known as cement clinker. This has the appearance of **greenish black or grey colored balls varying in size from small nuts to peas**.

Q. What is meant by setting of cement? Mention the reactions involved in setting of cement.

When **cement is mixed with water it sets to a hard mass when allowed to stand for some time**. This is called setting of cement. The reactions involved in the setting of cement are described as follows:

Q. Mention the reactions taking place in first 24 hours in setting of cement.

Reactions Taking Place in First 24 Hours

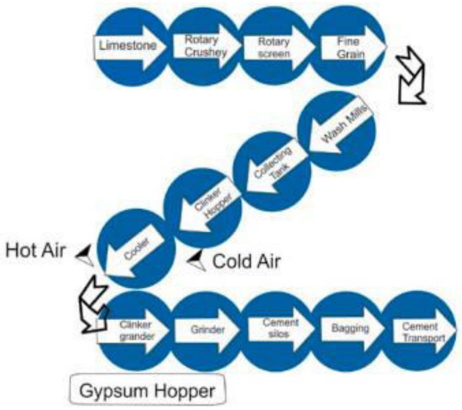
A short time after the cement is mixed with water, **tri-calcium aluminate absorbs water** (hydration) and forms a colloidal gel of the composition, **3 CaO. $Al_2O_3.6H_2O$, (hydrated tricalcium aluminate)**. This gel starts crystallizing slowly, **reacts with gypsum ($CaSO_4$. $2H_2O$)** to form the crystals of **calcium sulpho-aluminate ($3CaO.Al_2O_3.3CaSO_4.2H_2O$)**.

Q. Mention the reactions taking place between 1 to 7 days in setting of cement.

Reactions Taking Place Between 1 to 7 Days

Tricalcium silicate ($3CaO.SiO_2$) and tri-calcium aluminate (3CaO. Al_2O_3) get hydrolyzed to produce **calcium hydroxide and aluminium hydroxide**. The **calcium hydroxide**, thus formed, starts changing into **needle-shaped crystals**, which get **studded in the colloidal gel** and impart strength to it. **Aluminium hydroxide**, on the other hand, **fills the interstices resulting in hardening the mass**. **The gel** formed starts losing water partly by evaporation and **sets to a hard mass**.

Q. Give flow sheet diagram for the manufacturing of cement.



Paper Industry

(Long Question)

Q. Mention three non-woody and three woody raw materials used in paper industry.

Names of the three non-woody materials are: i. Wheat straw ii. Cotton stalk iii. Rice straw

Names of the woody materials are: (i) Poplar (hard wood) (ii) Eucalyptus (hard wood) (iii) Douglas fir (soft wood)

Q. What is meant by NSSC? Why it is commonly used in Pakistan?

The term **NSSC** stands for **neutral sulphite semi chemical** process. The neutral sulphite semi chemical process has come to occupy the dominant position because of the **advantages in chemical recovery and pulp strength**.

Q. Briefly describe the process of neutral sulphite semi chemical process.

The process utilizes **sodium sulphite cooking liquor** which is **buffered with sodium carbonate or NaOH** to **neutralize the organic acid liberated** from the raw materials.

Q. Mention the parts of paper making machine.

Following are the parts of paper making machine:

(a) Flow Spreader

(b) Head Box

(c) Fourdrinier Table

(d) Press Section

(e) Dryer Section

(f) Calendar Stock

(g) Reel

Long Questions

(Only main points are given to be remembered for long question so you may get some credit)

Add information from the short questions already given

Q. Explain neutral sulphite semi-chemical process for paper making.

The essential steps in the process are as follows:

i. Cutting of the raw materials

Precut state or big logs are cut into small chips.

ii. Dry cleaning

Air is blown into the raw material, which removes unwanted particles.

iii. Wet cleaning

It removes the remaining dust particles and the soluble materials also get dissolved in water.

iv. Screening

Magnetic separator remove iron pieces. Stones and other oversized pieces are removed by centricleaners. The major types of chest screens are vibratory, gravity, and centrifugal.

v. Digestion

As the raw material enters into the digester, steam is introduced at the bottom and a liquor containing sodium sulphite is injected to cover the raw material. Sodium sulphite used is buffered with sodium carbonate to maintain its pH 7-9. The digester is closed and revolved at 2.5 RPM and a temperature of 160-180°C is maintained. After 45 minutes the digester is switched off automatically and pressure is released.

vi. Blow tank

The cooked material from the digester is blown into a blow tank and then pumped to a centrifugal screen for the separation of cooked from uncooked materials.

vii. Pulp washing

The cooked material is washed with water using 80-mesh sieve to remove the black liquor. The pulp is washed with required amount of water to remove soluble lignin and coloured compounds.

viii. Bleaching

Bleaching is done with chlorine or sodium hypochlorite and hydrogen peroxide.

ix. Stock preparation plant

ix. Paper making machine

(a) Flow Spreader

(b) Head Box

(c) Fourdrinier Table

(d) Press Section

(e) Dryer Section

(f) Calendar Stock

(g) Reel

Chapter 16

Environmental Chemistry

Components of the Environment

Q. Define Environmental chemistry. Name components of the environment.

Environmental chemistry deals with the **chemicals and other pollutants in the environment**.

Environment consists of following four components:-

i. Atmosphere

ii. Hydrosphere

iii. Lithosphere

iv. Biosphere/Ecosphere

Q. What is biosphere?

Biosphere is the **region of earth capable of supporting life**. It includes lower atmosphere, the oceans, rivers, lakes, soils and solid sediments that actively interchange materials with all types of living organisms i.e., human beings, animals and plants.

Q. What is hydrosphere?

The hydrosphere includes all water bodies, mainly oceans, rivers, streams, lakes, polar ice caps, glaciers and ground water reservoirs (water below earth surface).

Q. Define atmosphere. What is the composition of atmosphere?

The **layer of gases surrounding the earth** is called atmosphere. It consists of various gases in different proportions i.e., N_2 (78%), O_2 (21%), Ar (0.9%), CO_2 (0.03 %) and trace amounts of H_2, O_3, CH_4, CO, He, Ne, Kr and Xe. It also contains varying amounts of water vapours.

Q. What is lithosphere?

It consists of **rigid rocky crust of earth and extends to the depth of 100 km**. The mantle and core are the heavy interior of the earth, making up most of the earth's mass.

Types of Pollution

Q. What are primary and secondary air pollutants?

The **waste products given out from chimneys of industrial units and exhaust of automobiles** are called **primary pollutants**. For example, sulphur dioxide, sulphur trioxide, nitrogen oxides, radioactive materials etc.

The **primary pollutants in the atmosphere through various reactions produce secondary pollutants**. For example, sulphuric acid, carbonic acid, hydrofluoric acid etc.

Q. CO is primary air pollutant. Write its poisoning effect on humans.

Carbon monoxide is highly poisonous gas and **causes suffocation** if inhaled. It binds blood haemoglobin more strongly than oxygen thus excluding oxygen from normal respiration. Exposure to **high concentration of CO** results in **headache, fatigue, unconsciousness and eventually death**.

Q. How is water purified by aeration?

The quality of raw water is improved by aeration. Air is passed through water to **remove the dissolved gases such as foul smelling H_2S, organosulphur compounds and volatile organic compounds**. Some of the **organic materials produce CO_2** in the aeration process. The **remaining portions of organic material are removed by passing water over activated carbon**. Aeration process also **oxidizes water soluble Fe^{2+} to Fe^{3+} which then forms insoluble $Fe(OH)_3$ and can be removed as solid**. Aeration also **improves the oxygen level of raw water**.

Q. How is oil spillage affecting the marine life?

Many petroleum products in oil spillage pose serious health problems. **Hydrocarbons particularly polycyclic aromatics are carcinogenic** even at very low concentrations. The marine organisms are severely **affected by soluble aromatic fractions of oil** (C-10 or less). **The light transmission through surface of water is affected by oily layer** on it thus **photosynthesis** of the plants and **dissolved oxygen** in water is **decreased**.

Q. How detergents are threat to aquatic life?

The waste water containing detergents when discharged in rivers or sea, greatly affects the aquatic life. **Detergent contents** of waste water **mobilize the bound toxic ions** of heavy metals such as Pb, Cd and Hg **from sediments into water**.

Q. What is acid rain?

The precipitation which is more acidic than natural rain is considered acid rain or acid deposition. The **rain water** which has **pH less than 5 is considered truly acidic**.

Q. Write four harmful effects of acid rain.

Acidification of the soil and rocks can **leach metals** like aluminium, mercury, lead and calcium and **discharges them into water bodies**.

The **heavy metals are accumulated in the fishes** and are health hazards for humans and birds as they eat these fishes. The elevated concentration of aluminium is harmful for fish as it **clogs the gills thus causing suffocation**.

Acidification of the soil can also **leach nutrients** thus **damaging leaves and plants and growth of forest**.

It also **damages building materials** such as steel, paint, plastic, cement, masonry work and sculptural materials **especially of marble and limestone**.

Q. What are leachates?

The **ground water which seeps in the landfill** and **liquid from the waste itself all percholate through the refuse producing leachate**. The **leachate contains dissolved, suspended and microbial contaminants**. The **gases** which are produced in landfills from the waste are **methane, ammonia, hydrogen sulphide and nitrogen**. The leachate contains **volatile organic acids** such as acetic acid and various fatty acids, bacteria, **heavy metals** and salts of common **inorganic ions such as Ca^{2+}**.

Q. What is smog?

The word smog is a combination of smoke and fog.

Q. What is meant by dissolved oxygen or D.O to check the quality of water?

In water the most important oxidizing agent is dissolved molecular oxygen (O_2) the concentration of which ranges from **4 - 8 ppm**. The **organic matter is oxidized with the help of this dissolved oxygen in water**. The dissolved oxygen value **less than 4 ppm** indicates that **water** is **polluted**.

Q. What do you know about chemical oxygen demand (C.O.D)?

The **organic content of water which consumes oxygen during chemical oxidation** is evaluated by its chemical oxygen demand.

Q. What is the role of chlorofluorocarbons in destroying ozone?

Chlorofluorocarbons (CFCs) play an effective role in removing O_3 in the stratosphere due to following reactions.

$$CFCl_3 \longrightarrow {}^{\cdot}CFCl_2 + Cl^{\cdot}$$
$$Cl^{\cdot} + O_3 \longrightarrow ClO^{\cdot} + O_2$$
$$ClO^{\cdot} + O \longrightarrow Cl^{\cdot} + O_2$$

A **single chloride free radical** can **destroy up to 100,000 ozone molecules**.

Q. What is B.O.D?

It is the **capacity of organic matter in natural water to consume oxygen within a period of five days**. The value of BOD is the amount of oxygen consumed as a result of biological oxidation of dissolved organic matter in the sample.

Solid Waste Management

Q. What are Landfills?

The **municipal solid waste** is mainly **disposed off** by dumping it **in a landfill**. The **landfill is a large hole in the ground or even a bare piece of land**. When the landfill becomes full with waste it is covered by soil or clay.

Q. What is depolymerization of plastic? Where it is used?

The recycling of plastics is done by reprocessing, depolymerization or transformation. In reprocessing the used plastics are re-melted and used for manufacturing of different products e.g., **the original use of polystyrene is for the manufacturing of foam, packaging, cutlery, furniture, etc,** but **after its reprocessing it is used mostly for the manufacturing of toys, trays, etc**.

Q. Define incineration and mention its harmful effects.

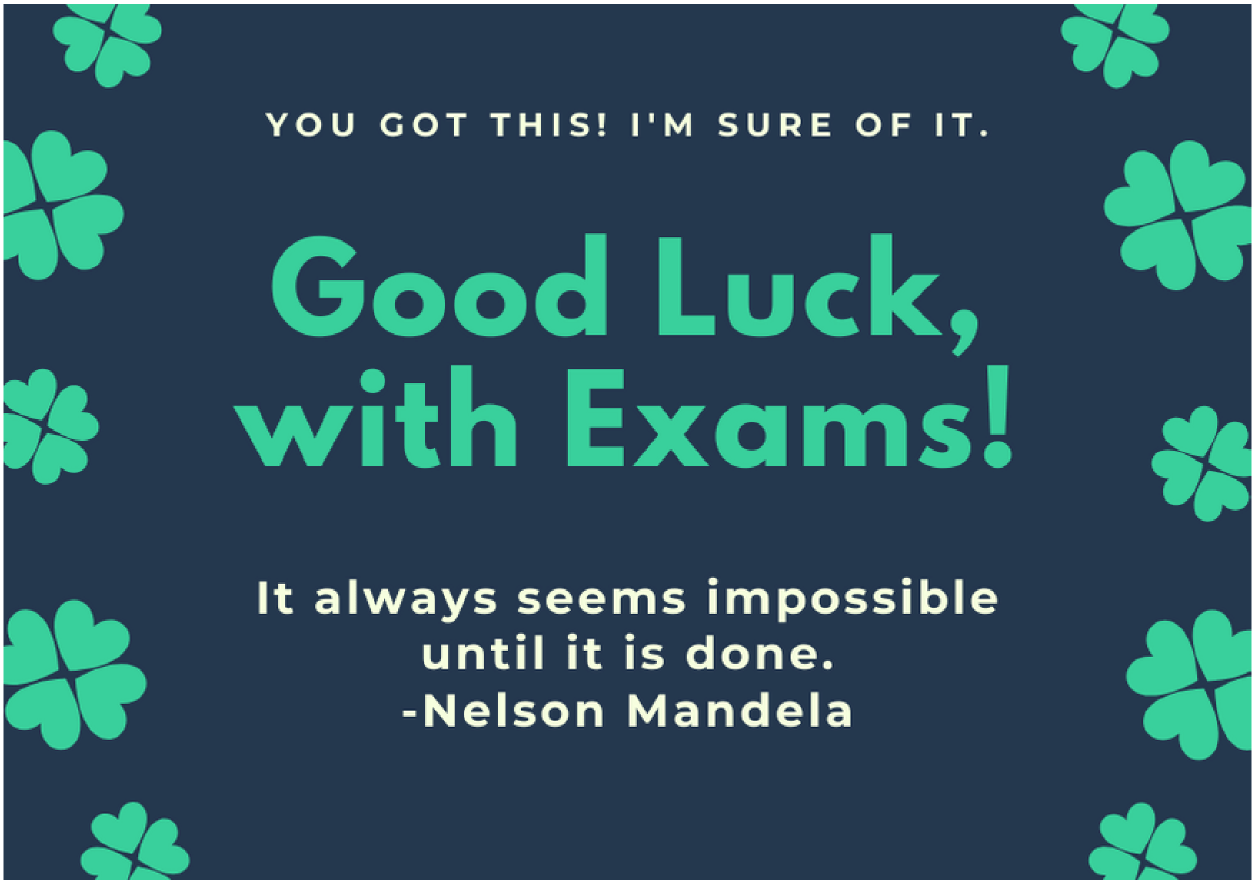
Incineration is a **waste treatment process** in which solid waste is burned at high temperatures ranging from **900 to 1000 °C**.

It is **not a clean process** of the disposal of solid wastes, as it produces **air pollution** and also **toxic ash**.

A significant **source of dioxins** which is a **class of carcinogen compounds**.

Smoke stacks from incineration may **emit oxides of nitrogen and sulphur** which lead to acid rain.

Heavy metals such as **lead, cadmium, mercury,** etc., may also be present **in the leachate of the incinerators**.



YOU GOT THIS! I'M SURE OF IT.

Good Luck, with Exams!

It always seems impossible
until it is done.
-Nelson Mandela