Chapter 19

Carbonyl Compounds 1: Aldehydes and Ketones

Major Concepts

19.1 Nomenclature
19.2 Physical Properties
19.3 Structure
19.4 Preparations of Aldehydes and Ketones
19.5 Reactivity
19.6 Reactions of Aldehydes and Ketones

Learning Outcomes:

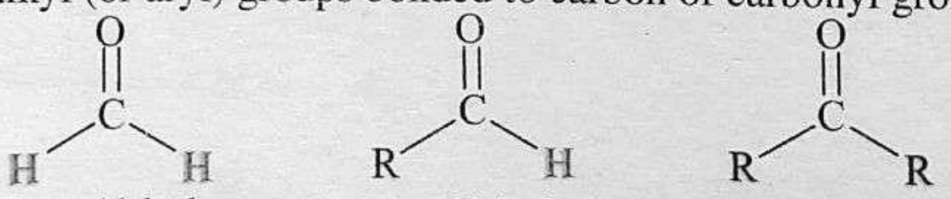
Students will be able to:

- Explain nomenclature and structure of aldehydes and ketones. **(Applying)**
- Discuss the preparation of aldehydes and ketones by ozonolysis of alkenes, hydration of alkynes, oxidation of alcohols and Friedal Craft's acylation of aromatics. **(Applying)**
- Describe reactivity of aldehydes and ketones and their comparison. **(Analyzing)**
- Describe acid and base catalysed nucleophilic addition reactions of aldehydes and ketones. **(Applying)**
- Discuss the chemistry of aldehydes and ketones by their reduction to hydrocarbons, alcohols, by using carbon nucleophiles, nitrogen nucleophiles and oxygen nucleophiles. **(Applying)**
- Describe oxidation reactions of aldehydes and ketones. **(Applying)**
- Describe isomerism in aldehydes and ketones. **(Understanding)**

Introduction

Aldehydes and ketones are carbonyl compounds. They play an important role in chemistry, biology and biochemistry. They are responsible for many flavours and odours. Vanillin, an aldehyde, gives vanilla flavour. Benzaldehyde, an aldehyde, gives almond flavour. R-Carvone, a ketone, gives spearmint flavour. The male and female sex hormones (testosterone and progesterone) also contain carbonyl groups.

An aldehyde has one alkyl (or aryl) group and one hydrogen atom bonded to the carbon of carbonyl group. Formaldehyde is the exception because it has two hydrogen atoms that are bonded to the carbon of carbonyl group. On the other hand, a ketone has two alkyl (or aryl) groups bonded to carbon of carbonyl group.



Formaldehyde   An aldehyde   A ketone

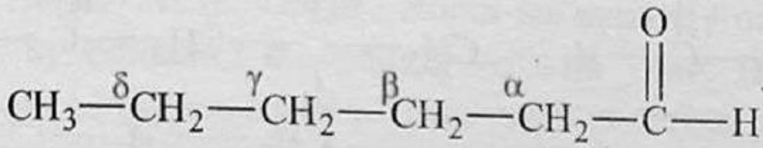
19.1 Nomenclature

Both common and IUPAC names are used for aldehydes and ketones.

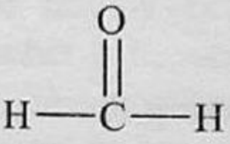
19.1.1 Nomenclature of Aldehydes

19.1.1.1 Common System

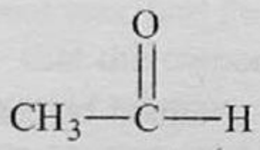
The common names of aldehydes are derived from the names of the corresponding carboxylic acids by replacing the ending *–ic acid* with the word *–aldehyde*. The position of substituents on the chain, if any, is indicated by Greek letters α, β, γ, δ, etc. The α-carbon atom is one which is directly bonded to the carbon of carbonyl group.



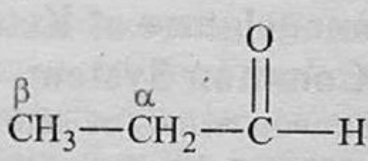
The common names of some aldehydes are given below:



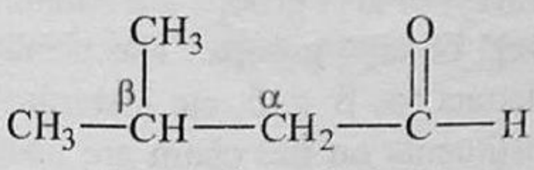
Formaldehyde



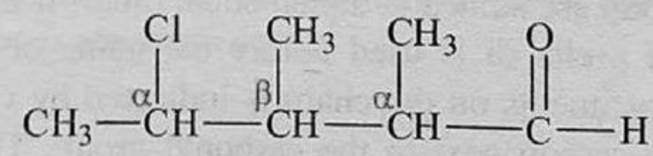
Acetaldehyde



Propionaldehyde



β-Methylbutyraldehyde

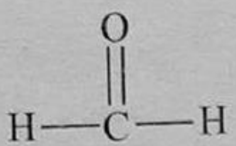


γ-Chloro-α,β-dimethylvaleraldehyde

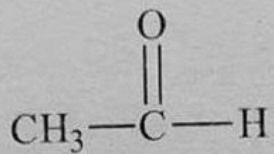
19.1.1.2 IUPAC System

The IUPAC names of aldehydes are derived from the names of the corresponding alkanes by replacing the ending *–e* with *–al*. Hence, the aldehydes are named as '***Alkanals.***' For example, if there are three carbon atoms in the chain of aldehyde, it is derivative of propane and its name is propanal. If there are four carbon atoms in the chain, then it is derivative of butane and its name is butanal and so on.

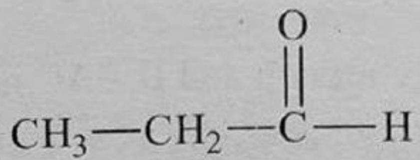
In case of higher aldehydes when substituents are present, find the longest chain containing aldehyde group and number it in such a way that the aldehyde group is assigned position number one. There is no need to indicate the position of aldehyde group because it must always lie at the end of the carbon chain and it is given position number one. The IUPAC names of some aldehydes are given below:



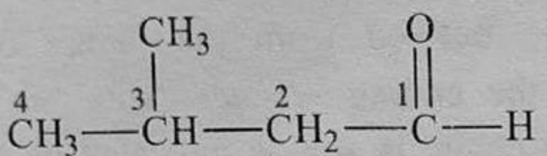
Methanal



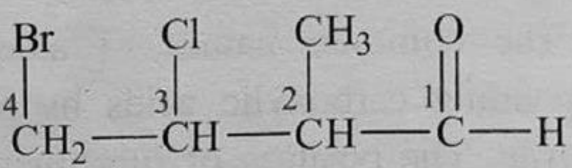
Ethanal



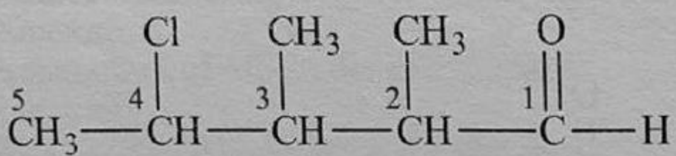
Propanal



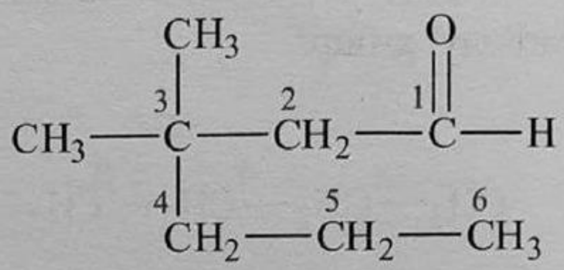
3-Methylbutanal



4-Bromo-3-Chloro-2-methylbutanal



4-Chloro-2,3-dimethylpentanal

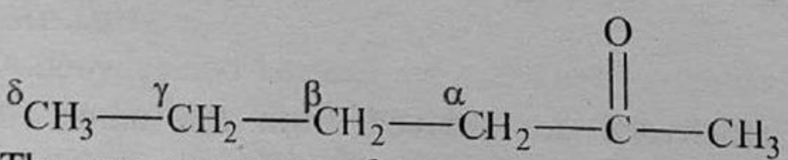


3,3-Dimethylhexanal

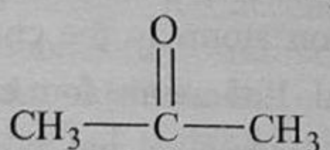
19.1.2 Nomenclature of Ketones

19.1.2.1 Common System

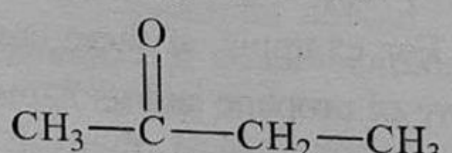
The common names of ketones are obtained by simply naming the two alkyl (or aryl) groups bonded to the carbon of carbonyl group and the word ketone is added as a separate word. The two alkyl (or aryl) groups bonded to the carbon of carbonyl group are named in alphabetical order. If the two alkyl or aryl groups are similar, than the prefix di is used before the name of the alkyl or aryl groups. The position of substituents on the chain is indicated by Greek letters (α, β, γ, δ, etc.), starting with the carbon next to the carbonyl group. The substituents on the chain are named in alphabetical order.



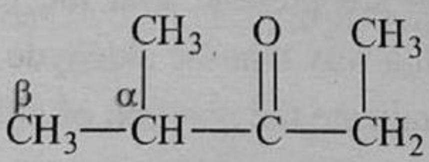
The common names of some ketones are given below:



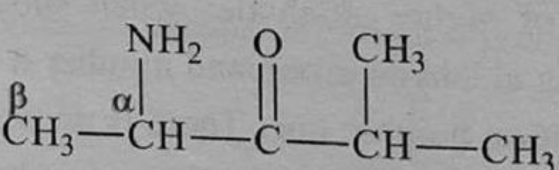
Dimethyl ketone



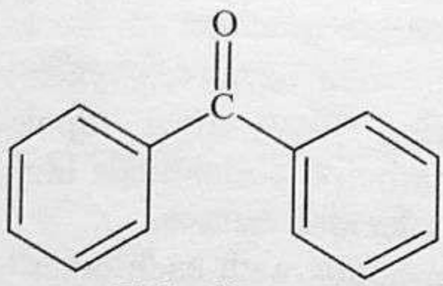
Ethyl methyl ketone



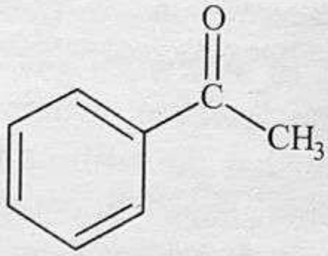
Ethyl isoporpyl ketone
(Ethyl-α-methylethyl ketone)



α-Aminoethyl isoporpyl ketone



Dipheyl ketone



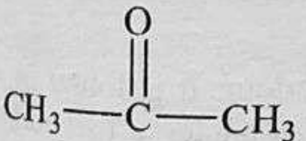
Methyl phenyl ketone

Some ketones are also known by their historical names. Dimethyl ketone is always named acetone, diphenyl ketone is called as benzophenone and methyl phenyl ketone is known as acetophenone.

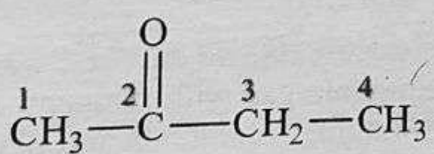
19.1.2.2 IUPAC System

The IUPAC names of ketones are derived from the names of the corresponding alkanes by replacing the ending **–e** with ***–one***. Hence, the ketones are named as '***Alkanones.***' For example, if there are four carbon atoms in the chain of ketone, it is derivative of butane and its name is butanone. If there are five carbon atoms in the chain, then it is derivative of pentane and its name is pentanone and so on.

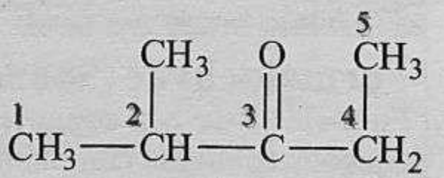
In case of open chain ketones, find the longest chain containing carbonyl group and number it in such a way that the carbonyl group is assigned the lowest possible number. The position of carbonyl carbon is indicated before the stem name of ketone. If two or more ketonic groups are present in the chain, then the prefixes di, tri, tetra are used for two, three, four ketonic groups respectively as dione, trione, tetraone. The position of substituents are indicated by the number of that carbon atom to which they are attached. The IUPAC names of some ketones are given as:



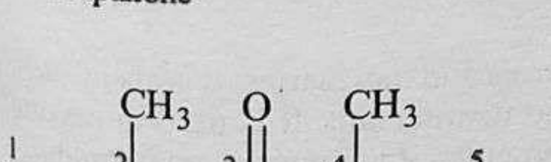
Propanone



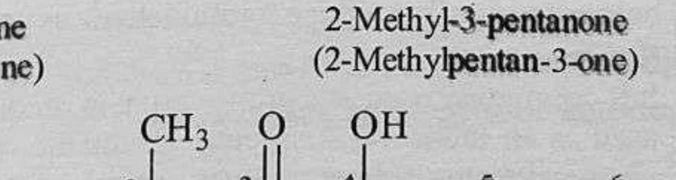
2-Butanone
(Butan-2-one)



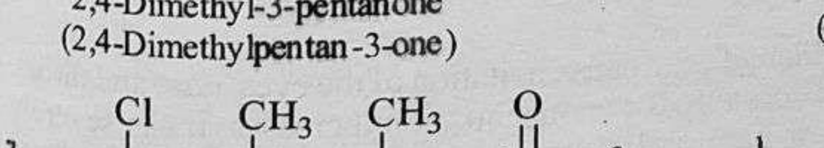
2-Methyl-3-pentanone
(2-Methylpentan-3-one)



2,4-Dimethyl-3-pentanone
(2,4-Dimethylpentan-3-one)



4-Hydroxy-2-methyl-3-hexanone
(4-Hydroxy-2-methylhexan-3-one)



6-Chloro-4,5-dimethyl-3-heptanone
(6-Chloro-4,5-dimethylheptan-3-one)

19.2 Physical Properties of Aldehydes and Ketones

i) The carbonyl group of aldehydes and ketones is polar because oxygen is more electronegative than carbon. Due to polarity, they show dipole-dipole interactions which makes the boiling point of carbonyl compounds higher than those of corresponding alkanes of comparable molecular masses.

ii) The carbonyl compounds cannot form hydrogen bonds with each other because they have no O—H bond which makes them less polar than alcohols and carboxylic acids. They, therefore, have low boiling points than alcohols and carboxylic acids.

iii) Aldehydes and ketones having five or less than five carbon atoms are soluble in water because they can form hydrogen bond with water molecules.

iv) Aldehydes and ketones having more than five carbon atoms are insoluble in water because the non-polar hydrocarbon portion is too large to dissolve in the polar water.

v) Methanal and ethanal are gases; the other lower aldehydes and ketones are colourless liquids at room temperature. The higher aldehydes having more than twenty carbon atoms and ketones having more than thirty carbon atoms are solids at room temperature.

vi) Lower aldehydes have pungent smells and higher aldehydes have pleasant smell. Vanillin, an aldehyde, has pungent smell while the camphor, a ketone, has sweet smell.

vii) Density of aldehydes and ketones is less than that of water.

Society, Technology and Science

Formaldehyde (Sources, Health Risks and Recommendations)

Formaldehyde is a colourless, flammable gas with pungent, irritating odour. It is found in aqueous solutions (formalin). All organisms (animals and plants) such as bacteria, fish and humans naturally produce formaldehyde as part of cell metabolism.

Sources

It is commonly used as a preservative in medical laboratories and mortuaries. It is also widely used as an industrial fungicide, germicide, fumigant and disinfectant. It is used in making chemical resins, rubber products, paper products and cosmetics. It is found in many products such as adhesives, glues, varnishes, paints, household products, plywood and fibreboard. It is also present in combustion products such as vehicle exhaust and tobacco smoke.

Health Risks

- **Short term exposure** of formaldehyde can cause irritation of the eyes, nose and throat. It can also cause coughing and sore throat as concentration increases. It can severely irritate the lungs, causing chest pain and shortness of breath when formaldehyde concentration is high.
- **Long term exposure** of formaldehyde makes all symptoms worse. It can cause allergic reactions of the skin (dermatitis), the eyes and the lungs (asthma). Prolonged and

repeated contact can also cause numbness and a hardening of skin. It can cause cancer in the nose, throat, or lungs when formaldehyde concentration is high.

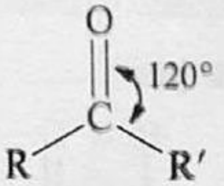
- **Formaldehyde solution (formalin)** is skin irritant. It can cause smarting, drying, cracking, and scaling.
- **Formaldehyde** can decrease fertility and increase the risk of spontaneous miscarriage in humans.

Recommendations

Students, teachers and workers who may be exposed to formaldehyde can inhale it as a gas or vapour or absorb it through the skin as a liquid. Wear safety googles, gloves, face shield and apron of appropriate materials to prevent the formaldehyde contacting the eyes, nose, mouth, hands, arms and trunk of the body before entering the workplace.

19.3 Structure of Aldehydes and Ketones

The carbonyl group of aldehydes and ketones is composed of one sigma bond and one pi bond. Both carbon and oxygen of the carbonyl group are sp^2 hybridized. The fourth p orbital of carbon remains unhybridized. The three sp^2 hybrid orbitals of carbon form three sigma bonds, one with oxygen and two with the other groups bonded to it.

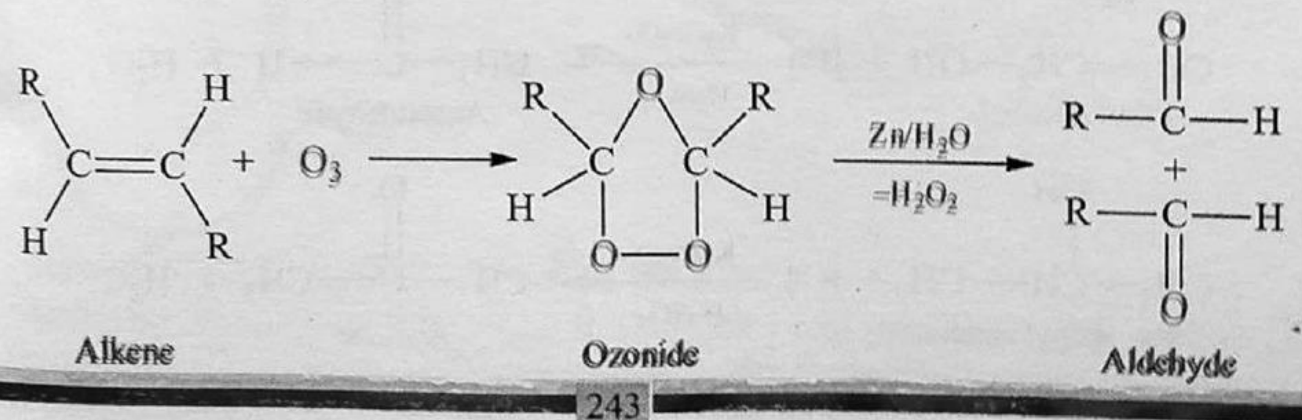


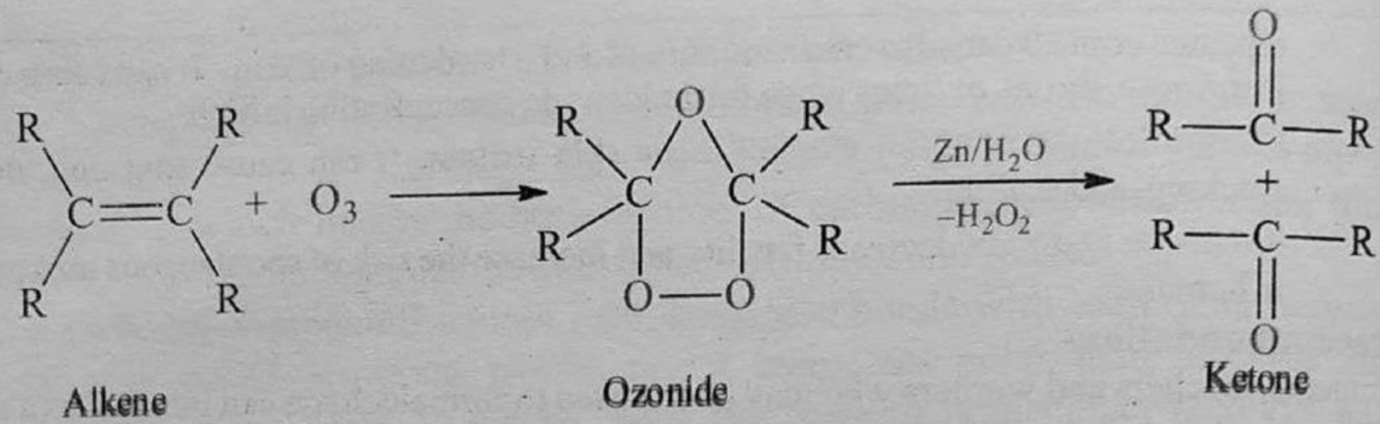
The fourth unhybridized p orbital of carbon forms pi bond with oxygen. The three atoms or groups attached to carbon of carbonyl group lie in the same plane. The bond angles between the bonded atoms or groups are around 120°.

19.4 Preparations of Aldehydes and Ketones

19.4.1 Ozonolysis of Alkenes

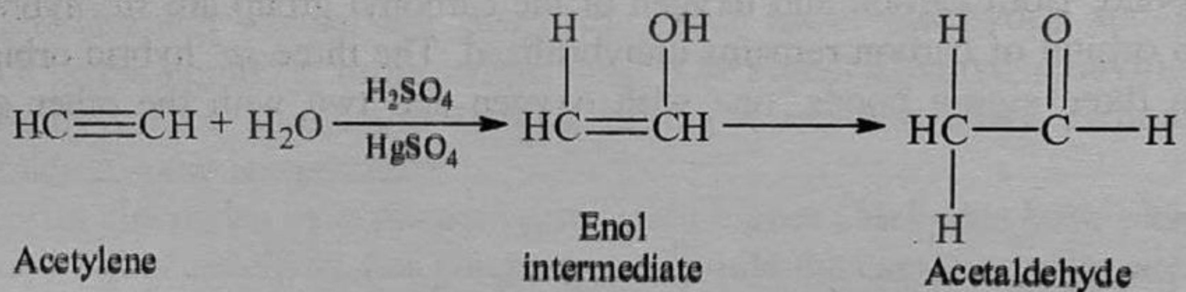
Alkenes reacts with ozone to from an explosive compound ozonide, which on subsequent reductive cleavage with zinc dust and water produce aldehydes or ketones or both depending on the structure of alkene.

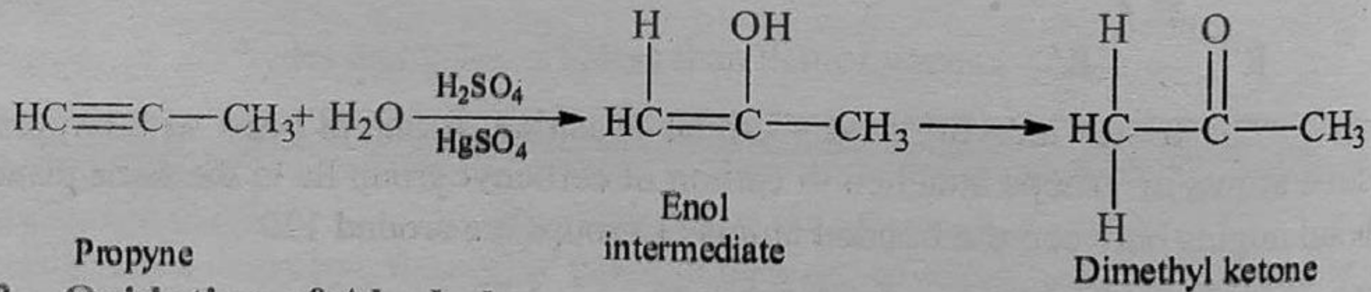




19.4.2 Hydration of Alkynes

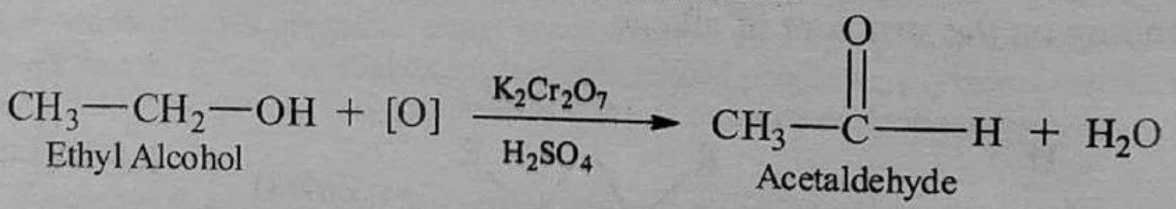
Alkyne undergo hydration according to Markovnikov's rule in the mercuric sulphate and sulphuric acid to form an unstable enol, which on rearrangement gives aldehydes or ketones or both depending on the structure of alkyne. The acetylene produces aldehyde and all other alkynes under same conditions produce corresponding ketones.

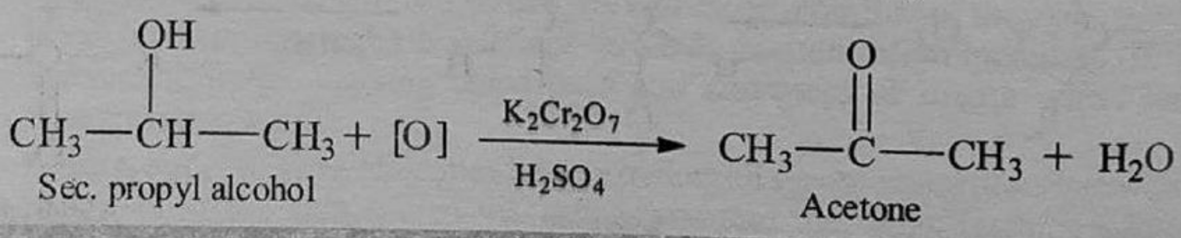




19.4.3 Oxidation of Alcohols

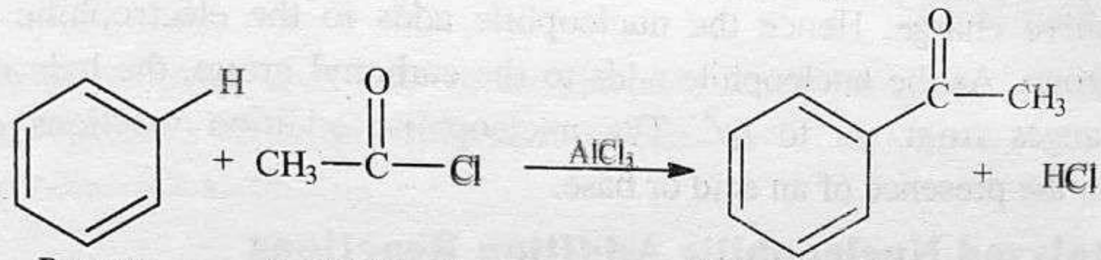
Controlled oxidation of primary alcohols in the presence of acidified solution of potassium dichromate or potassium permanganate produce aldehydes whereas secondary alcohols result in the formation of ketones.





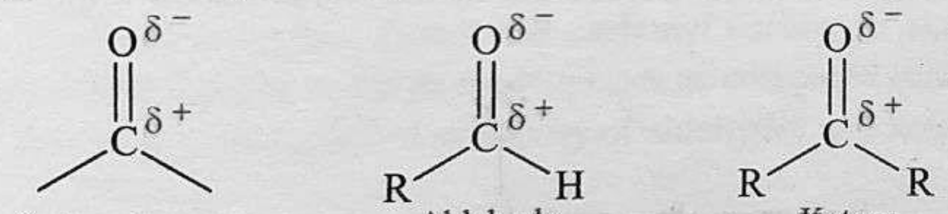
19.4.4 Friedel-Crafts Acylation of Aromatic Compounds

An aromatic compound (benzene) reacts with acyl halide in the presence of Lewis acid ($AlCl_3$) to produce an aryl ketone (methyl phenyl ketone).

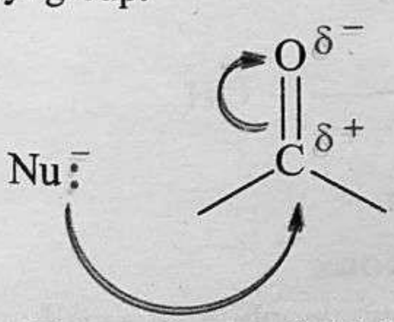


19.5 Reactivity of Carbonyl Compounds

Aldehydes and ketones both contain a carbon-oxygen double bond. Ketone has alkyl or aryl group on each side of the carbonyl and an aldehyde has a hydrogen on one side and an alkyl or aryl group on the other side of the carbonyl. Oxygen of the carbonyl is more electronegative than carbon. Therefore, the less tightly held pi (π) electrons are strongly attracted by oxygen atom. This attraction makes the carbonyl group highly polar in nature. So partial negative charge develops on oxygen and partial positive charge develops on carbon of carbonyl group.



Thus negatively charged oxygen atom acts as a nucleophile and positively charged carbon atom acts as an electrophile. The most characteristic reaction of aldehydes and ketones is nucleophilic addition to the carbon–oxygen double bond. During addition of a reagent to the carbonyl, the negative part of reagent adds to the carbon of carbonyl group and the positive part of the reagent adds to the oxygen of carbonyl group.



19.6 Reactions of Aldehydes and Ketones

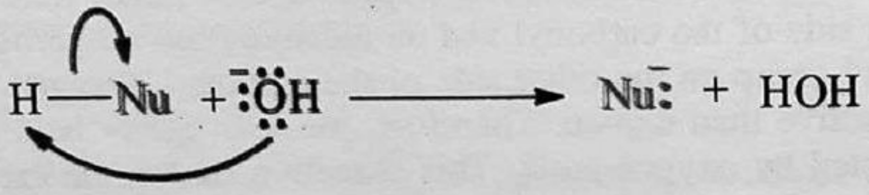
Aldehydes and ketones react with nucleophiles and produce a wide variety of useful derivatives. Their most common reaction is the nucleophilic addition reaction, in which a nucleophile adds to the carbon of the carbonyl group.

19.6.1 Nucleophilic Addition Reactions

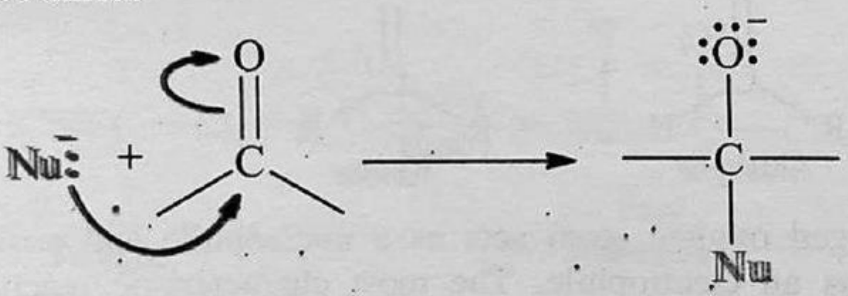
Aldehydes and ketones undergo addition of hydrogen, carbon, nitrogen and oxygen nucleophiles. The carbon of carbonyl group is highly electrophilic due to a partial positive charge. Hence the nucleophile adds to the electrophilic carbon of carbonyl group. As the nucleophile adds to the carbonyl group, the hybridization of carbon changes from sp^2 to sp^3. The nucleophilic addition reactions can either catalyzed in the presence of an acid or base.

Base Catalyzed Nucleophilic Addition Reactions

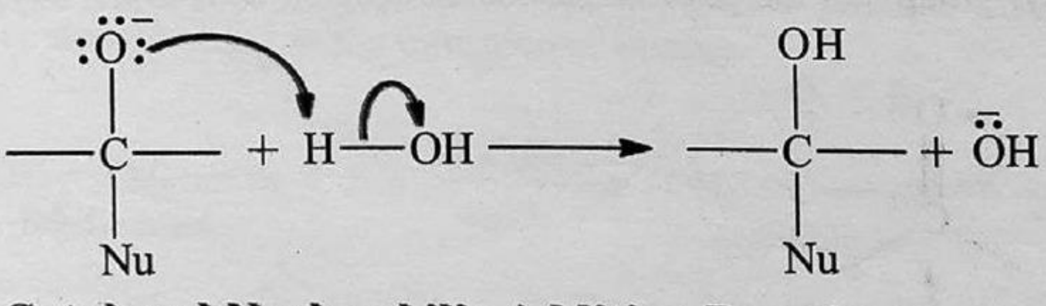
These reactions occur in the presence of a strong nucleophile. A strong nucleophile is produced by the reaction of the base with the reagent.



The nucleophile uses its pair of electrons to make a bond to the carbonyl carbon, the electrons of the π-bond are forced out to the oxygen atom to produce an alkoxide anion.

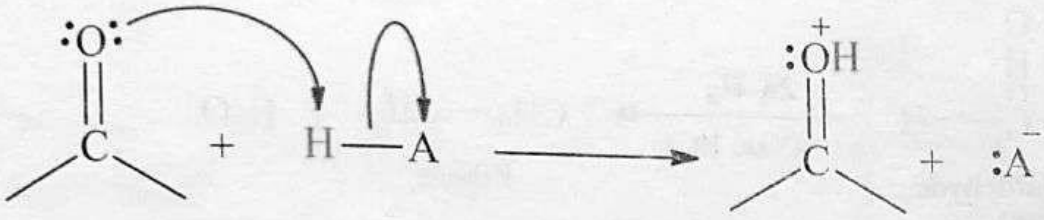


The alkoxide intermediate is protonated upon treatment with water. Here the base is regenerated.

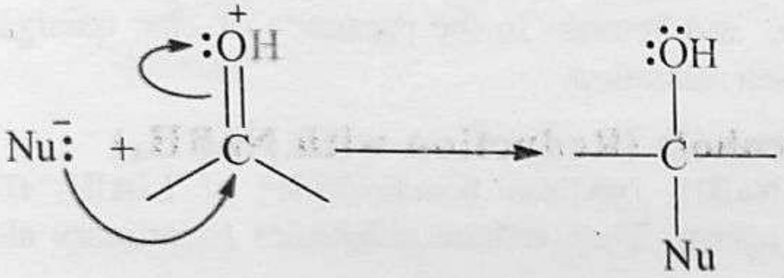


Acid Catalyzed Nucleophilic Addition Reactions

These reactions occur in the presence of a weak nucleophile. A small amount of acid is used to initiate the reaction. The proton of acid attacks the carbonyl oxygen atom to produce protonated carbonyl group. Protonation increases the electrophilic character of the carbonyl carbon and makes it more reactive towards nucleophile.

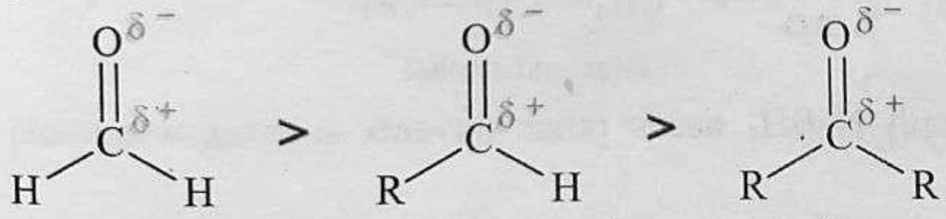


The nucleophile uses pair of its electrons to make a bond to the carbonyl carbon, the electrons of the pi (π) bond is forced out to the oxygen atom to form the addition product (an alcohol).



19.6.2 Relative Reactivity of Aldehydes and Ketones

The aldehydes are more reactive than ketones toward nucleophilic addition reactions because an alkyl group is electron donating group so it makes the carbonyl carbon less electrophilic. Hence the carbonyl carbon of ketones that has two alkyl groups is less reactive towards nucleophiles as compared to aldehydes which has only one alkyl group. The order of reactivity of aldehydes and ketones is as:



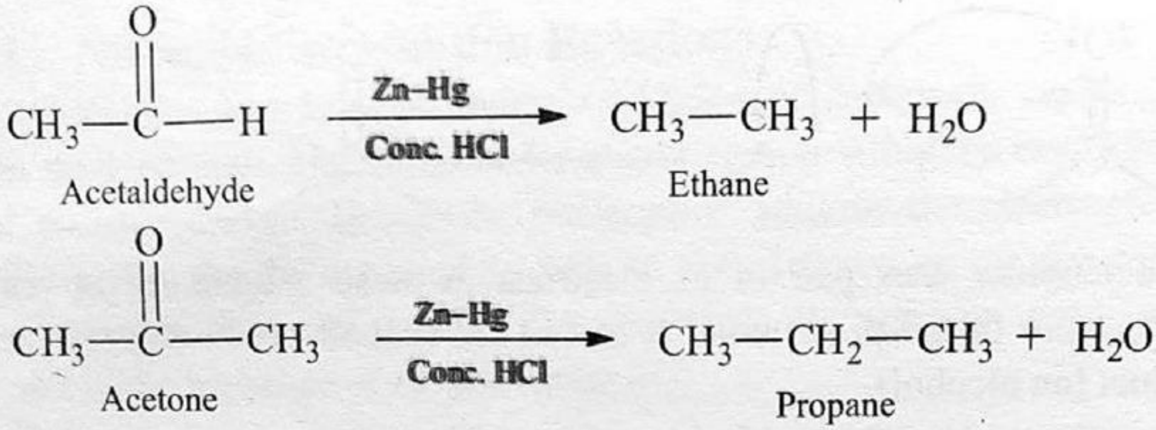
Steric effects are also important in the transition state. The aldehyde has only one alkyl (or aryl) group, so the transition state is less crowded while ketone has two alkyl (or aryl) groups, so the transition state is more crowded. As a result of the greater steric crowding in the transition states, ketones are less reactive toward nucleophilic attack as compared to aldehydes.

19.6.3 Reduction of Aldehydes and Ketones

Aldehydes and ketones undergo reduction in the presence of different reducing agents to produce hydrocarbons, alcohols or glycols.

19.6.3.1 Reduction to Hydrocarbon (Clemmensen Reduction)

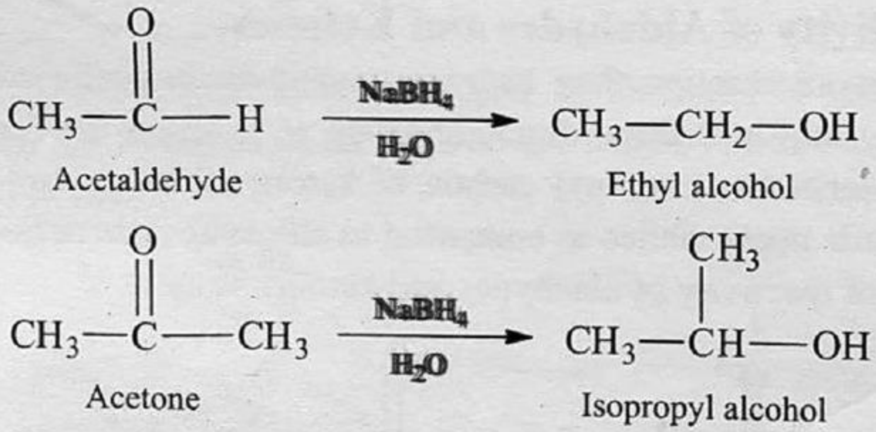
Aldehydes and ketones produce hydrocarbons on reduction with zinc amalgam and conc. HCl.



The reduction of aldehydes and ketones in the presence of zinc amalgam and conc. HCl is known as Clemmensen reduction.

19.6.3.2 Reduction to Alcohols (Reduction with $NaBH_4$)

Metal hydrides such as $NaBH_4$ (sodium borohydride) or $LiAlH_4$ (lithium aluminiumhydride) are reducing agents. They reduce aldehydes to primary alcohols and ketones to secondary alcohols.



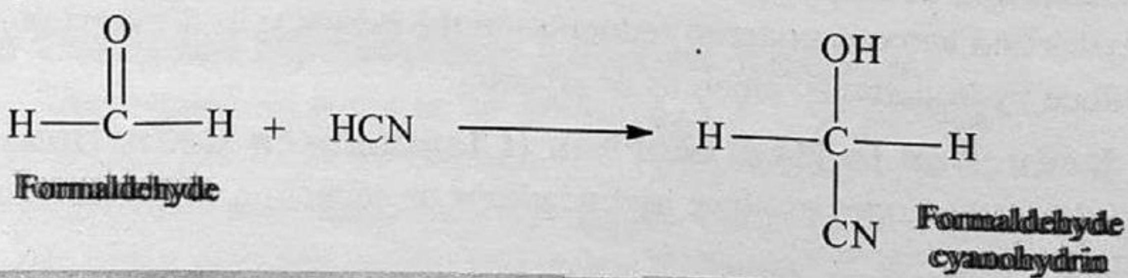
The reduction with $NaBH_4$ needs polar solvents such as water and ethyl alcohol.

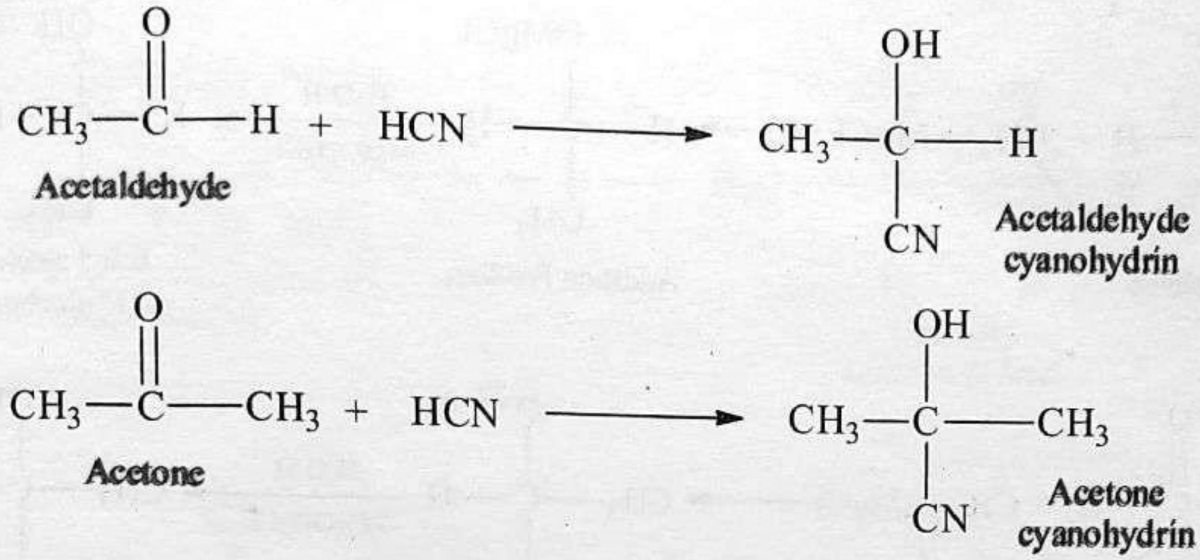
19.6.3.3 Reduction with Carbon Nucleophiles

The carbon in HCN, organometallic compounds such as RLi, terminal alkynes and Grignard's reagent acts as a nucleophile and can reduce aldehydes and ketones into various compounds.

Reduction with HCN

Hydrogen cyanide is a weak acid that adds to aldehydes and ketones to form cyanohydrin.

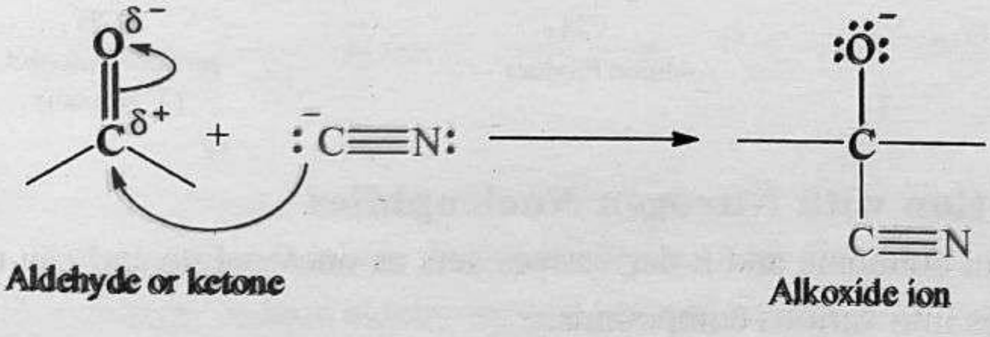




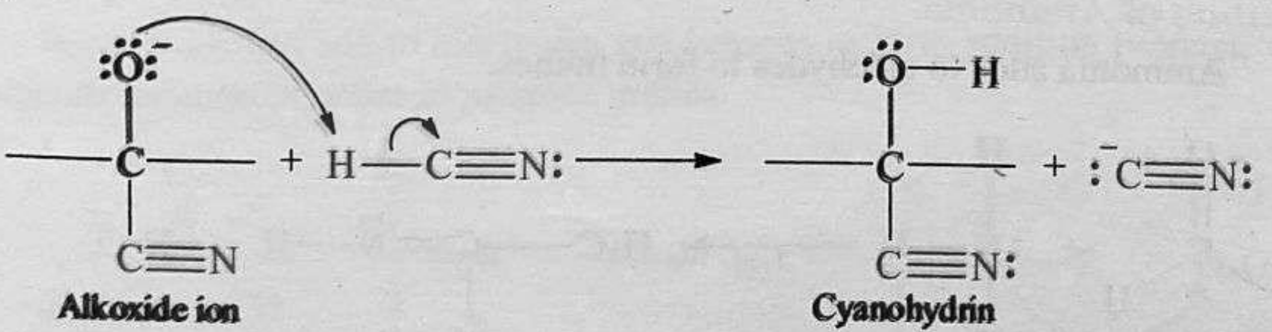
Mechanism

The conjugate base of HCN is the cyanide ion ($^{-}$:C≡N:) which acts as strong nucleophile and strong base. Cyanide ion adds to the carbonyl carbon, giving an alkoxide ion that protonates to produce the cyanohydrin.

Step 1:

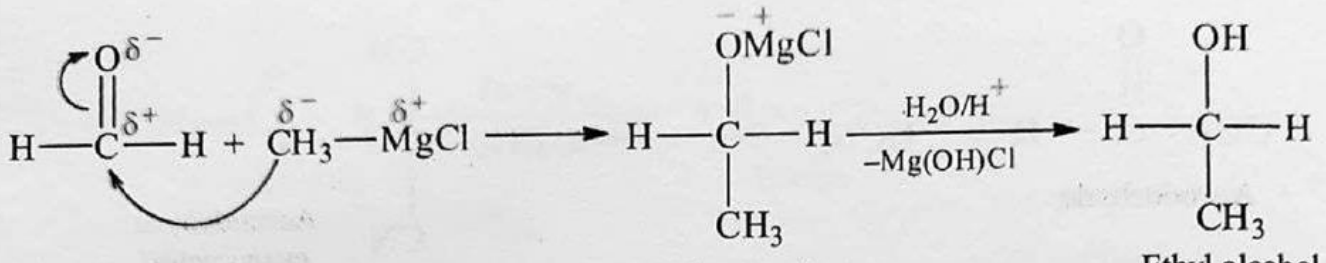


Step 2:

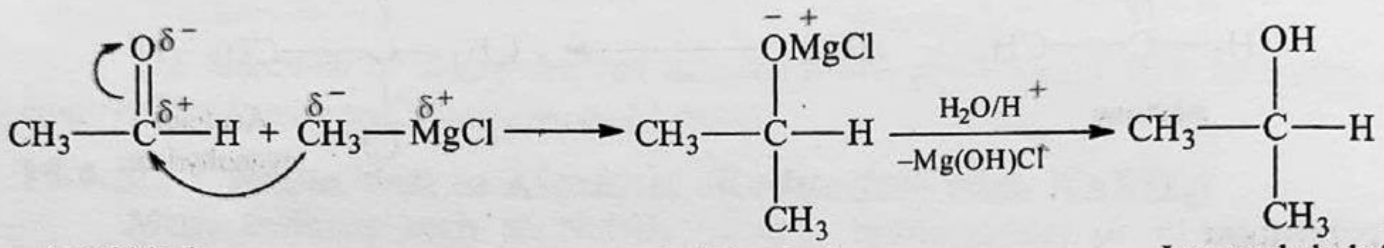


Reduction with RMgX

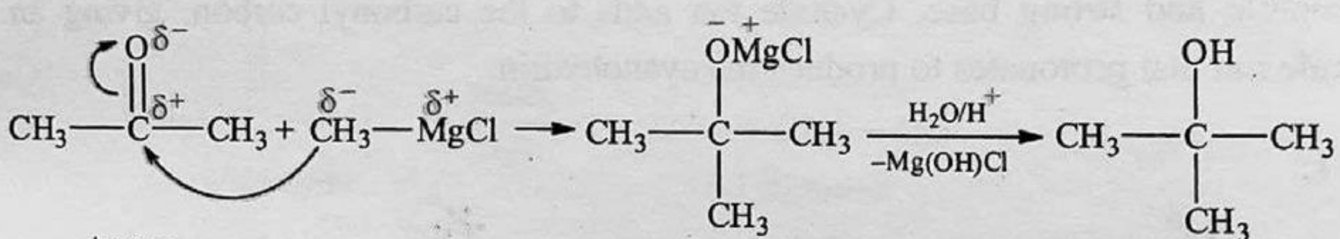
The reaction of aldehyde or ketone with Grignard's reagent (RMgX) followed by protonation in aqueous acid forms a primary, secondary or tertiary alcohol containing a new carbon-carbon bond.



Formaldehyde — Addition Product — Ethyl alcohol (1° alcohol)



Acetaldehyde — Addition Product — Isopropyl alcohol (2° alcohol)



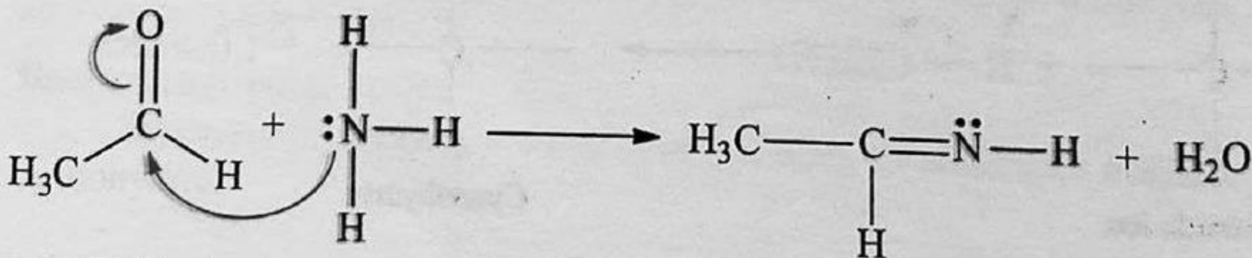
Acetone — Addition Product — *tert.*butyl alcohol (3° alcohol)

19.6.3.4 Reduction with Nitrogen Nucleophiles

The nitrogen in ammonia and it derivatives acts as nucleophile and can reduce aldehydes and ketones into various compounds.

Addition of Ammonia

Ammonia adds to aldehydes to form imines.

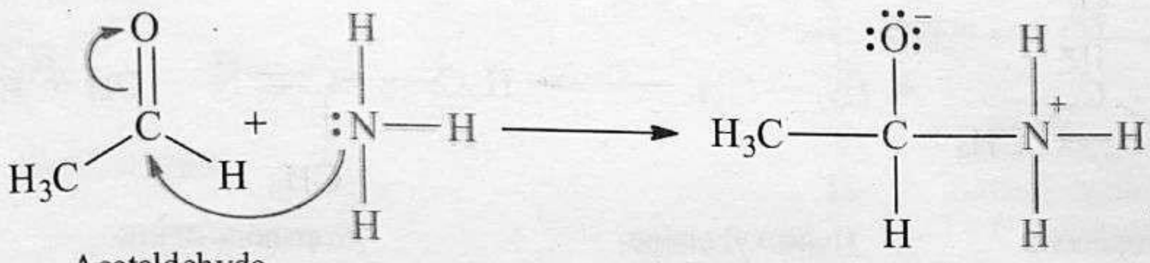


Acetaldehyde — Imine

Mechanism

Ammonia adds to aldehydes to form addition product, which go through elimination of water to produce imines.

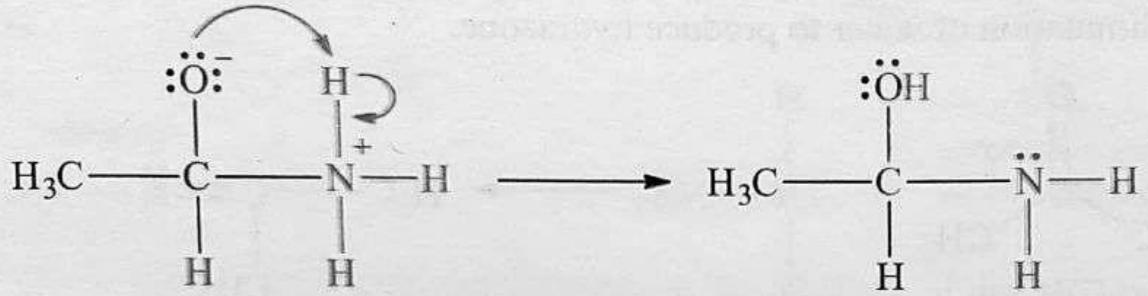
Step 1:



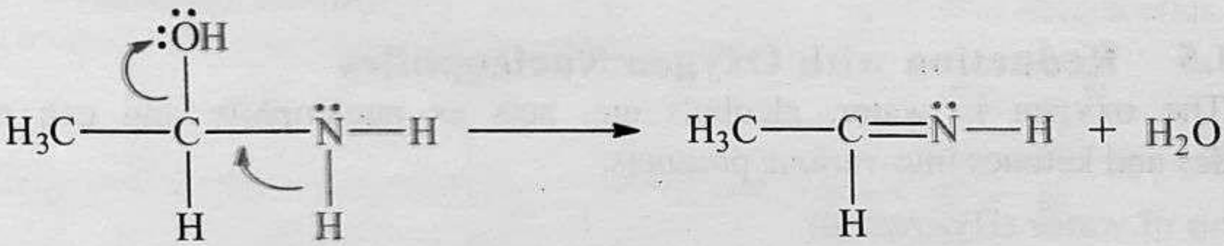
Acetaldehyde

Unstable addition protuct

Step 2:



Step 3

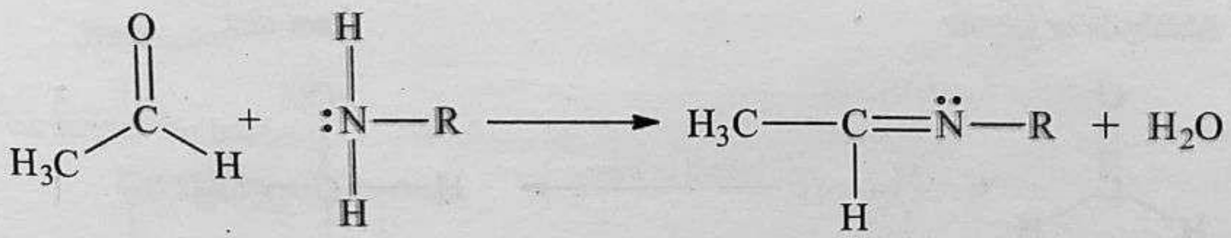


Addition of Ammonia Derivatives

Ammonia derivatives such as alkyl amines, hydroxyl amine, hydrazine and phenyl hydrazine reduce aldehydes and ketones to produce a variety of products.

Addition of Alkyl Amines

Primary amines add to aldehydes and ketones to form addition product, which undergo elimination of water to produce imines.

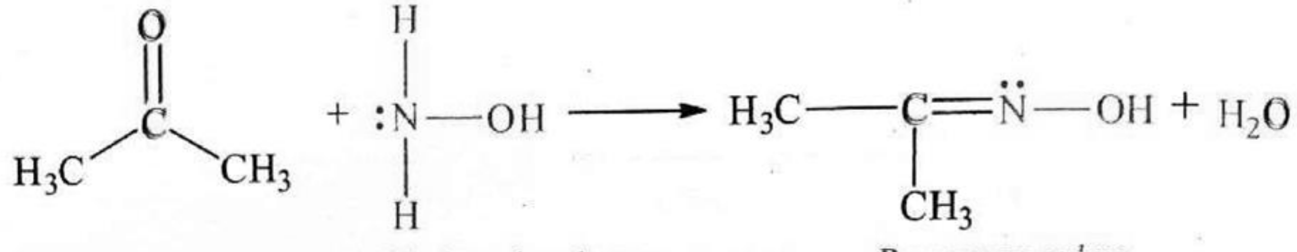


Acetaldehyde

Imine

Addition of Hydroxyl Amine

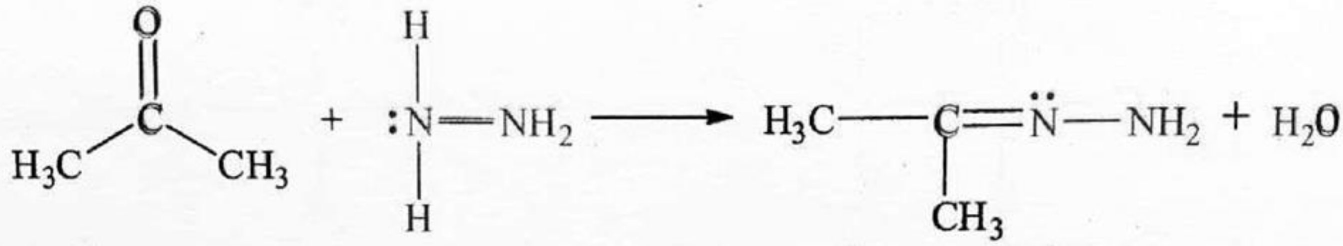
Hydroxyl amine adds to aldehydes and ketones to form addition product, which undergo elimination of water to produce oxime.



Propanone Hydroxyl amine Propanone oxime

Addition of Hydrazine

Hydrazine adds to aldehydes and ketones to form addition product, which undergo elimination of water to produce hydrazone.



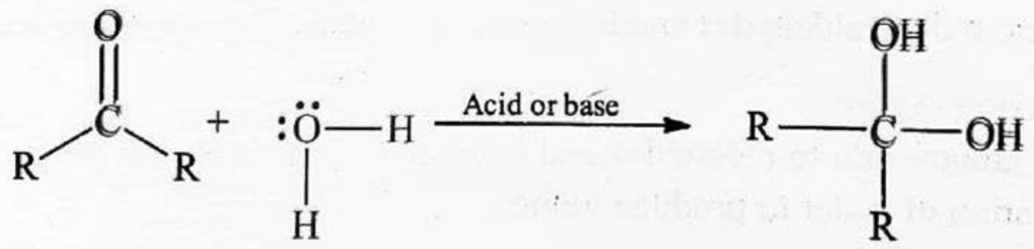
Propanone Propanone hydrazone (Acetone hydrazone)

19.6.3.5 Reduction with Oxygen Nucleophiles

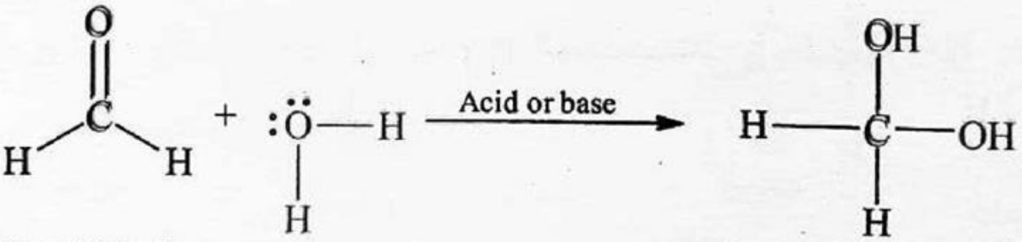
The oxygen in water, alcohols etc. acts as nucleophile and can reduce aldehydes and ketones into various products.

Addition of water (Hydration)

Water adds to aldehydes or ketones to produce germinal diol. The reaction is catalyzed by an acid or a base.

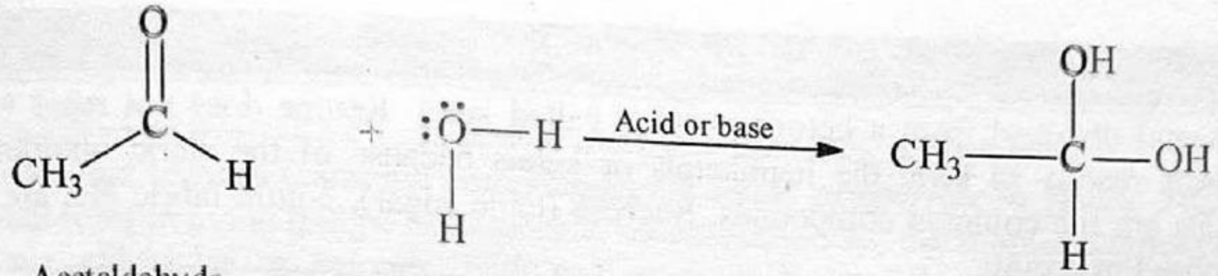


Aldehyde or ketone gem-diol



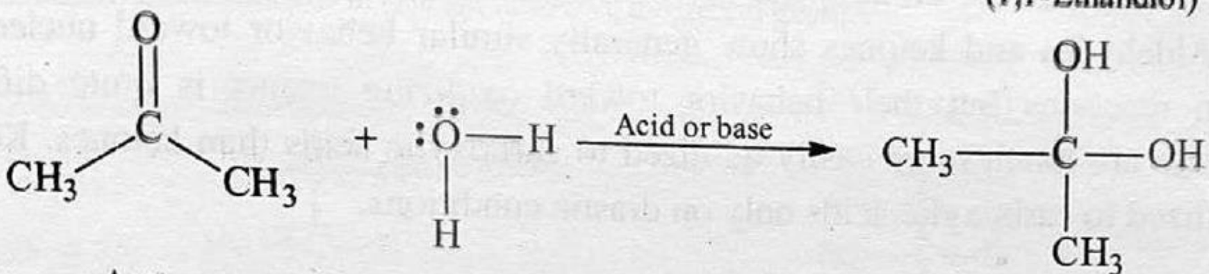
Formaldehyde Formaldehyde hydrate

A 37% solution of formaldehyde in water is known as formalin and is used to preserve biological specimens.



Acetaldehyde

Acetaldehyde hydrate
(1,1-Ethandiol)

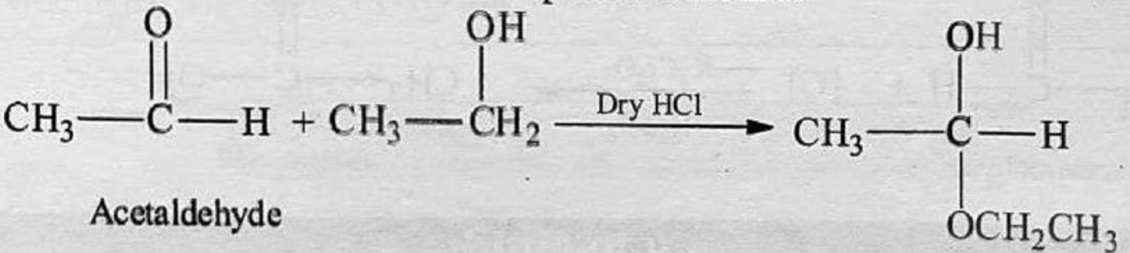


Acetone

Acetone hydrate
(2,2-Propandiol)

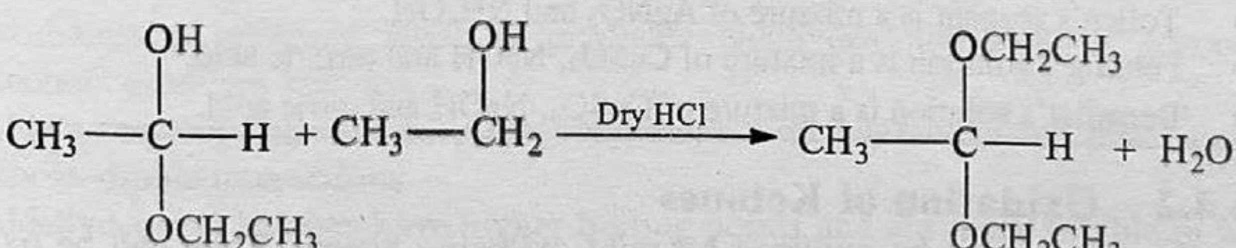
Addition of Alcohols

Alcohols adds to aldehydes (or ketones) in the presence of dry HCl to produce acetals. This reaction occurs in two steps. Addition of alcohols to aldehydes (or ketones) first produce hemiacetals, which are unstable. Therefore, hemiacetals react with the second molecule of alcohol to produce acetals.



Acetaldehyde

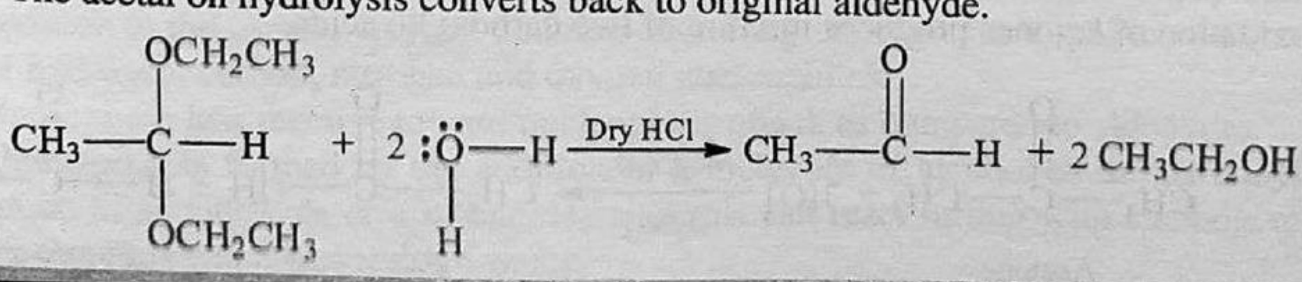
Hemiacetal



Hemiacetal

An acetal
(1,1-Diethoxyethane)

The acetal on hydrolysis converts back to original aldehyde.



Keep in Mind

An acetal obtained from a ketone is often called ketal. Ketone does not react with alcohols readily to form the hemiketals or ketals because of the steric hindrance. Acetals are the common compounds. Sucrose (table sugar), cotton fabric etc. are all composed of acetals.

9.6.4 Oxidation Reactions of Aldehydes and Ketones

Aldehydes and ketones show generally similar behavior toward nucleophilic ddition reactions but their behavior toward oxidizing agents is quite different. ldehydes are much more easily oxidized to carboxylic acids than ketones. Ketones re oxidized to carboxylic acids only on drastic conditions.

19.6.4.1 Oxidation of Aldehydes

Aldehydes can be oxidized by mild oxidizing agents such as silver oxide, Ag_2O (Tollen's reagent), and cupric oxide, CuO (Fehling' solution or Benedict's solution). Aldehydes can also be oxidized by strong oxidizing agents such as potassium permanganate or potassium dichromate in acidic medium.

$$\underset{\text{Acetaldehyde}}{CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-H} + [O] \xrightarrow[H_2SO_4]{K_2Cr_2O_7} \underset{\text{Acetic acid}}{CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-OH}$$

Keep in Mind

- Tollen's reagent is a mixture of $AgNO_3$ and NH_4OH.
- Fehling's solution is a mixture of $CuSO_4$, NaOH and tartaric acid.
- Benedict's solution is a mixture of $CuSO_4$, NaOH and citric acid.

19.6.4.2 Oxidation of Ketones

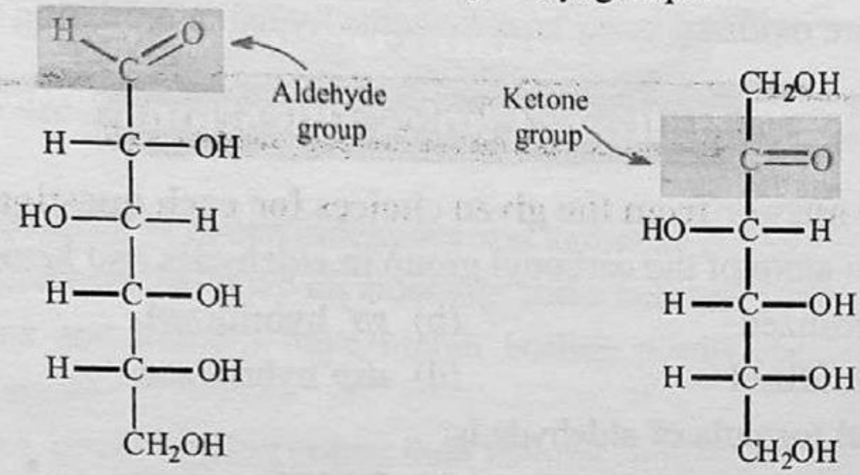
Ketones cannot be oxidized by mild oxidizing agents. They can be oxidized only by strong oxidizing agents such as potassium permanganate and potassium dichromate at higher temperatures and higher concentrations of acid or base. The oxidation of ketones produces mixture of two carboxylic acids.

$$\underset{\text{Acetone}}{CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-CH_3} + 3[O] \xrightarrow[H_2SO_4]{K_2Cr_2O_7} \underset{\text{Acetic acid}}{CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-OH} + \underset{\text{Formic acid}}{H-\overset{\overset{\displaystyle O}{\|}}{C}-OH}$$

Society, Technology and Science

Glucose and Fructose as Examples of Aldehydes and Ketones

Aldehydes and ketones (carbonyl compounds) are found extensively in nature. They play important roles in living things. For example, monosaccharides, the simplest carbohydrates, are either aldehydes or ketones, with one or more hydroxyl groups. The glucose, a monosaccharide, is a six carbon aldehyde with five hydroxyl groups and fructose, a monosaccharide, is a six carbon ketone with five hydroxyl groups.



Glucsoe

Fructose

The monosaccharide is an **aldose** when it has an aldehyde (RCOH) group, but is **a ketose** when it has a ketone (RCO) group.

Summary of Facts and Concepts

- Aldehydes and ketones are organic compounds containing carbonyl group as a functional group.
- Oxidation of primary alcohols produces aldehydes and that of secondary alcohols produces ketones.
- Aldehydes and ketones are polar compounds and interact in the pure state by dipole–dipole interactions.
- Aldehydes and ketones have higher boiling points and are more soluble in water than nonpolar compounds of similar molecular masses.
- They are very reactive compounds due to presence of polar carbonyl group.
- The most characteristic reaction of aldehydes and ketones is nucleophilic addition to the carbon–oxygen double bond. They undergo nucleophilic addition of hydrogen, carbon, nitrogen and oxygen nucleophiles.
- Ketones are less reactive toward nucleophilic attack as compared to aldehydes.
- Hemiacetal is formed by the addition of a molecule of alcohol to the carbonyl group of an aldehyde or a ketone. Hemiacetals can react further with alcohols to give acetals and a molecule of water.

- Ammonia and amines (primary aliphatic and aromatic amines) react with the carbonyl group of aldehydes and ketones in the presence of an acid catalyst to produce imines. Imines have carbon-nitrogen double bonds.
- Aldehydes and ketones are reduced to alcohols with reducing agents such as sodium borohydride or lithium aluminium hydride.
- Aldehydes and ketones undergo acid-catalyzed addition of water to give a hydrate.
- Aldehydes are oxidized to carboxylic acids by using oxidizing agents.

Multiple Choice Questions

Q. Select one answer from the given choices for each question:

i) The carbon atom of the carbonyl group in aldehydes and ketones is:
(a) *sp* hybridized (b) sp^2 hybridized
(c) sp^3 hybridized (d) dsp^2 hybridized

ii) The general formula of aldehyde is:
(a) RCHO (b) RCOH
(c) RCOR (d) RCOOH

iii) Which one of the following is the example of mild oxidizing agents?
(a) Potassium permanganate (b) Potassium dichromate
(c) Silver oxide (d) Nitric acid

iv) Which one of the following has an aldehyde group?
(a) Vanillin (b) R-carvone
(c) Testosterone (d) Progesterone

v) Which one of the following compounds show acidic properties?
(a) Aldehyde (b) Ketone
(c) Alcohol (d) Alkene

vi) Aldehydes are reduced to:
(a) Primary alcohols (b) Secondary alcohols
(c) Tertiary alcohols (d) Dihydric alcohols

vii) Ketones are reduced to:
(a) Primary alcohols (b) Secondary alcohols
(c) Tertiary alcohols (d) Dihydric alcohols

viii) Aldehydes are obtained by the oxidation of:
(a) Primary alcohols (b) Secondary alcohols
(c) Tertiary alcohols (d) Dihydric alcohols

ix) Indentify that reagent which reacts with both aldehydes and ketones.
(a) Water
(b) Grignard's reagent
(c) Hydrogen cyanide
(d) Tollen's reagent

x) Which one of the following reagents can oxidize ketones?
(a) Tollen's reagent
(b) Potassium dichromate
(c) Fehling' solution
(d) Benedict's solution

Short Answer Questions

Q.1. Why ketones are less reactive toward nucleophilic attack as compared to aldehydes?

Q.2. What is the similarity between aldehydes and ketones?

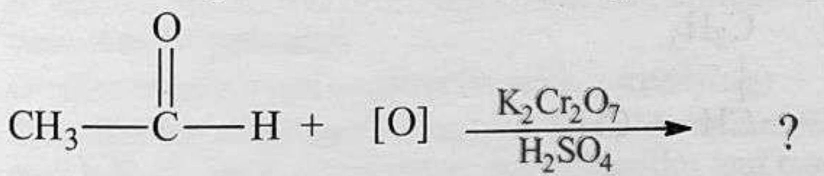
Q.3. What is the difference between an aldehyde and a ketone?

Q.4. Why aldehydes and ketones have higher boiling points than those of ethers and alkanes?

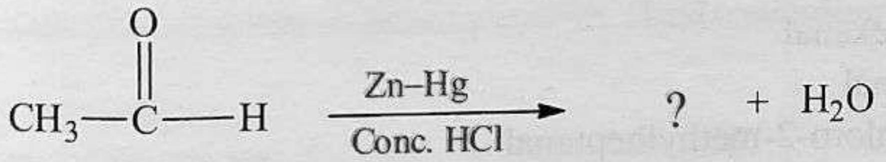
Q.5. Aldehydes have lower boiling points than ketones, why?

Q.6. Which compound has hydrogen bonding, an aldehyde or ketone?

Q.7. What is the product of the following reaction?



Q.8. What is the major product of the reaction given below? What type of reaction is this?



Acetaldehyde

Long Answer Questions

Q.1. What are aldehydes and ketones? Explain nomenclature of aldehydes and ketones.

Q.2. Discuss the structure and reactivity of aldehydes and ketones.

Q.3. What are the physical properties of aldehydes and ketones?

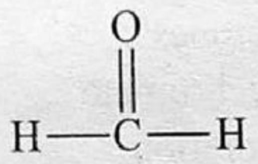
Q.4. Write down three methods for the preparation of aldehydes and ketones?

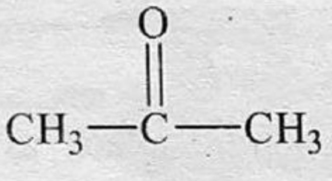
Q.5. Discuss base and acid catalysed nucleophilic addition reactions.

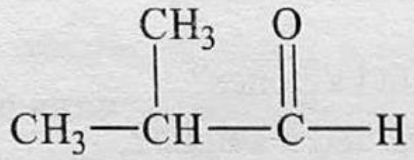
Q.6. How can aldehyde reacts with the following reagents?
(i) Hydrogen cyanide
(ii) Grignard's reagent

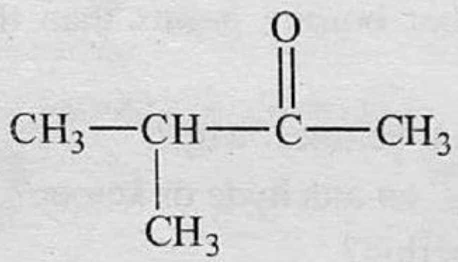
(iii) Ammonia
(iv) Primary amines

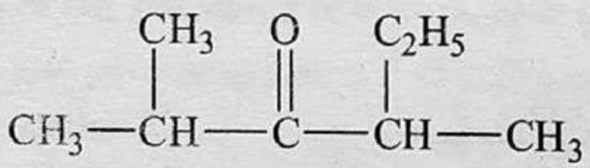
Q.7. What are the IUPAC names of the following compounds?

i) 

ii) 

iii) 

iv) 

v) 

Q.8. Write structural formulas for the following compounds:
i) Butanal
ii) 2-Methyl-2-hexanal
iii) 2-Chlorobutanal
iv) 2-Bromo-3-chloro-2-methylheptanal
v) Butanone
vi) 2,3-Pentadione
vii) 2-Phenyl-3-pentanone
viii) 4-nitroacetophenone
ix) 3-Hydroxybutanal
x) 3-methyl-3-phenylpentanal