Carbonyl Compounds Chemistry Questions with Solutions

Q1: Why is the Collins reagent better oxidising agent than acidified $K_2Cr_2O_7$ for the oxidation of the primary (1°) alcohol to form respective aldehydes?

Answer: Both the Collins reagent and the acidified $K_2Cr_2O_7$ oxidise the 1° alcohol to form respective aldehydes.

$$RCH_2\text{-}OH \xrightarrow[H_2SO_4]{K_2Cr_2O_7} R\text{-}CHO$$

$$RCH_2\text{-}OH \xrightarrow[reagent]{Collins} R\text{-}CHO$$

However, if the aldehyde thus formed upon the action of acidified $K_2Cr_2O_7$ is left within the same reaction mixture, the aldehyde further gets oxidised into the carboxylic acid.

$$R\text{-}CHO \xrightarrow[H_2SO_4]{K_2Cr_2O_7} R\text{-}COOH$$

This happens because acidified $K_2Cr_2O_7$ is a strong oxidising agent and leaving the thus formed aldehyde in the solution mixture may lead to its oxidation.
While Collins reagent being the mild oxidising agent does not further oxidise the aldehyde. Collins reagent also does not attack any of the C=C double bonds present in the compound.

Q2. Write the chemical reactions of the following transformations.

a. Butanol to Butanoic acid
b. Benzyl alcohol to phenylethanoic acid

Answer: The corresponding chemical reactions for each of the following transformations are as:

a. This is a simple oxidation of alcohol to form carboxylic acid.
Since oxidation with $KMnO_4$ in the acidic medium often results in some esters too. So, the reaction is carried by treating the alcohol with $KMnO_4$ in neutral or in alkaline medium and therefore, treating the thus produced K-salt of the acid with dil. H_2SO_4 gives the desired carboxylic acid.

$$CH_3CH_2CH_2CH_2OH \xrightarrow[(ii.)dil.\ H_2SO_4]{(i.)KMnO_4/\ KOH,\ \Delta} CH_3CH_2CH_2COOH$$

b. In this transformation, the alcohol functional group on the carbon attached to benzene is converted into cyanide functional group. The cyanide group under hydrolysis gives a carboxylic acid group.

$$C_6H_5CH_2OH \xrightarrow{PBr_3} C_6H_5CH_2Br \xrightarrow{KCN} C_6H_5CH_2CN \xrightarrow[Hydrolysis]{H_3O^+,\ \Delta} C_6H_5CH_2COOH$$

Q3. Give any one test to distinguish between carboxylic acids and phenols.

Answer: When carboxylic acids are treated with $NaHCO_3$, brisk effervescence of CO_2 gas are formed. For example:

$$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2$$

However, phenols do not react with $NaHCO_3$ and hence no brisk effervescences are formed. This is called the Sodium Bicarbonate test.

Q4. The reagent used for the conversion of acid chloride to its corresponding aldehyde is ____.

Answer: In this reaction, controlled/ partial reduction of an acid chloride is done to obtain an aldehyde. Such a reduction can be brought about by the addition of H_2 in the presence of Pd and some sulphur (in order to partially poison the reaction). This reaction is called Rosenmunds' reduction in the presence of some poison such as S.

$$RCOCl + H_2 \xrightarrow[S \ or \ Quinoline]{Pd/BaSO_4} RCHO + HCl$$

Q5. Why are the carboxylic acids called fatty acids?

Answer: This is because the higher acids first discovered were obtained by the saponification of oils and fats.

Q6. Draw a scheme to convert a 1° alcohol into a carboxylic acid containing one more C-atom.

Answer: This can be done by introducing one more carbon to the 1° alcohol before converting it into an acid. Hence, the alcoholic group is replaced with a halogen (-X) by a suitable halogenating reagent. The halogen group is again replaced by a -CN group which can be further hydrolysed to form an acid containing an extra carbon than the initial alcohol.

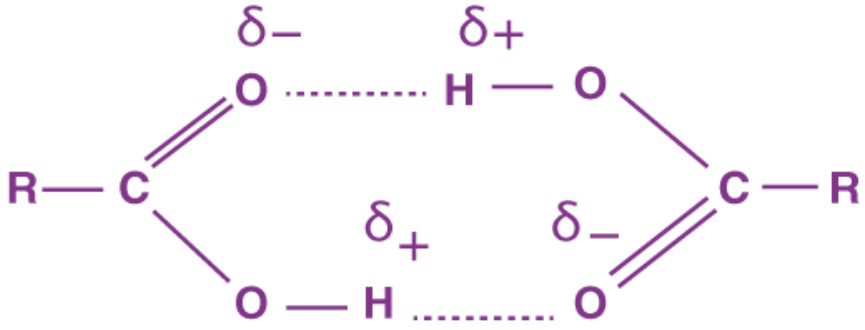
$$RCH_2OH \xrightarrow[-SO_2, -HCl]{SOCl_2} RCH_2Cl \xrightarrow[-KCl]{KCN} RCH_2CN \xrightarrow[Hydrolysis]{H^+/H_2O} RCH_2COOH$$

Q7. Name a reagent used to convert carboxylic acid into an alcohol.

Answer: $LiAlH_4$

Q8. Why do carboxylic acids exist as cyclic dimers?

Answer: Due to the polarity in the terminal O-H bonds of the carboxylic acid group, the negatively polarised Oxygen atom forms a Hydrogen bond with the positively polarised hydrogen atom of another molecule of the carboxylic acid. Due to this strong H-bonding, carboxylic acids exist as dimer in vapour phase as well as in aprotic solvents.



Dimerization in vapour state or in aprotic solvents

Q9. How can an acid be converted into an ester without using any alcohol?

Answer: This can be done by using diazomethane (CH_2N_2).

$$RCOOH + CH_2N_2 \xrightarrow[ether]{Dry} RCOOCH_3 + N_2$$

Q10. Schiff's reagent is a

a. Magenta solution decolourised with Cl_2
b. Magenta solution decolourised with sulphurous acid
c. Ammoniacal manganese sulphate solution
d. Ammoniacal cobalt chloride solution

Answer: (b.)

Explanation: Schiff's reagent is an acidic solution of fuchsin that is decolourised by sulphurous acid.

Q11. Ethanol is used for the preparation of:

a. Tincture iodine solution
b. CCl_4
c. D.D.T.
d. Toluene

Answer: (a.)

Explanation: Tincture Iodine is a solution containing 2-7% of the elemental iodine and Na/K-iodide dissolved in an ethanol-water mixture.

Q12. Which of the following enzymes will convert glucose into ethyl alcohol?

a. Diastase

b. Maltase
c. Zymase
d. Invertase

Answer: (c.)

Explanation: Zymase catalyses the fermentation of sugars into ethanol and CO_2.

Q13. The boiling point of C_2H_5OH is higher than C_2H_5SH on an account of
a. Association
b. Dissociation
c. Low mol. Mass
d. None of the above

Answer: (a.)

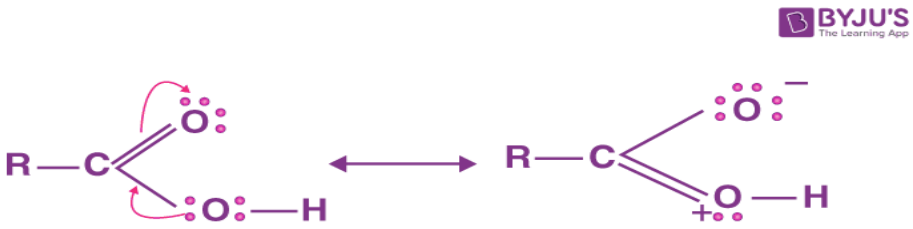
Explanation: The C_2H_5OH remains in the associated form due to strong inter-molecular H-bonding which are not there in C_2H_5SH. Hence, C_2H_5OH has a higher boiling point than C_2H_5SH.

Q14. The aliphatic saturated ethers are often regarded as the _____ of water.

Answer: Alkyl derivatives

Q15. Why is the C-O bond in RCOOH shorter than that in the RC-OH?

Answer: This is because the RCOOH exhibits resonance effects.

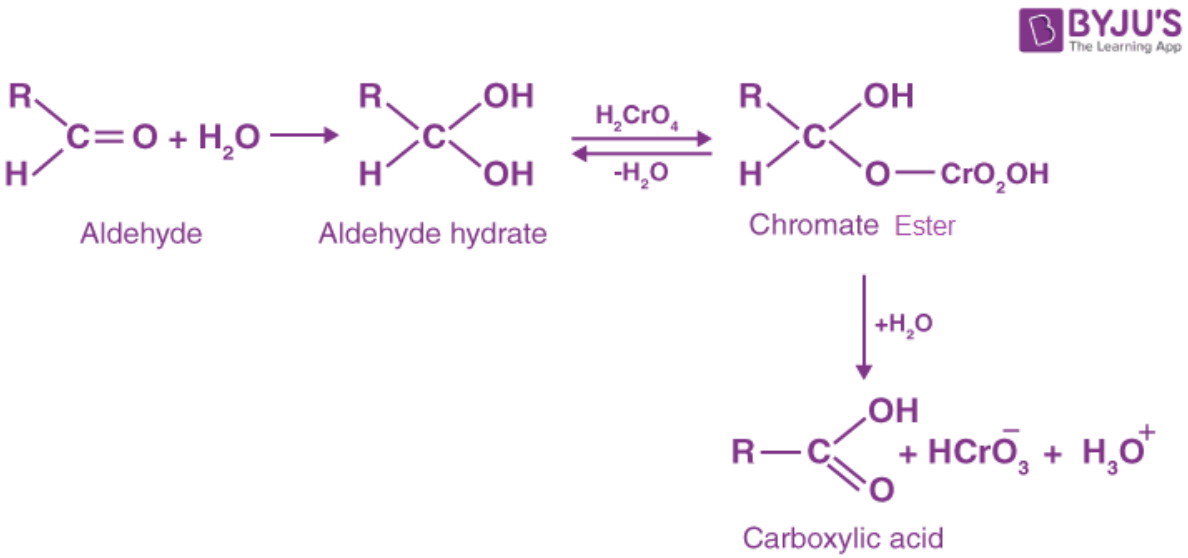


Due to the resonance effect, the C-O bond possesses some double bond character and hence have shorter bond lengths than in alcohols.

Practise Questions on Carbonyl Compounds

Q1. Unlike acidified $K_2Cr_2O_7$, why does the Collins reagent not further oxidise the aldehyde?

Answer: This difference arises because of the mediums used in acidified $K_2Cr_2O_7$ and the Collins reagent. The acidified $K_2Cr_2O_7$ reacts in aqueous medium; while the Collins reagent reacts in anhydrous medium.
In the presence of water, the aldehyde forms the aldehyde hydrate. The aldehyde hydrate reacts with H_2CrO_4 to form the chromate ester which upon further hydrolysis forms the carboxylic acid.



Since the Collins reagent reacts in the absence of water, the aldehyde hydrate does not form. Hence, further oxidation of aldehyde to carboxylic acid does not take place.

Q2. Give the names of the reagents used to bring about the following transformations for the formation of aldehydes.

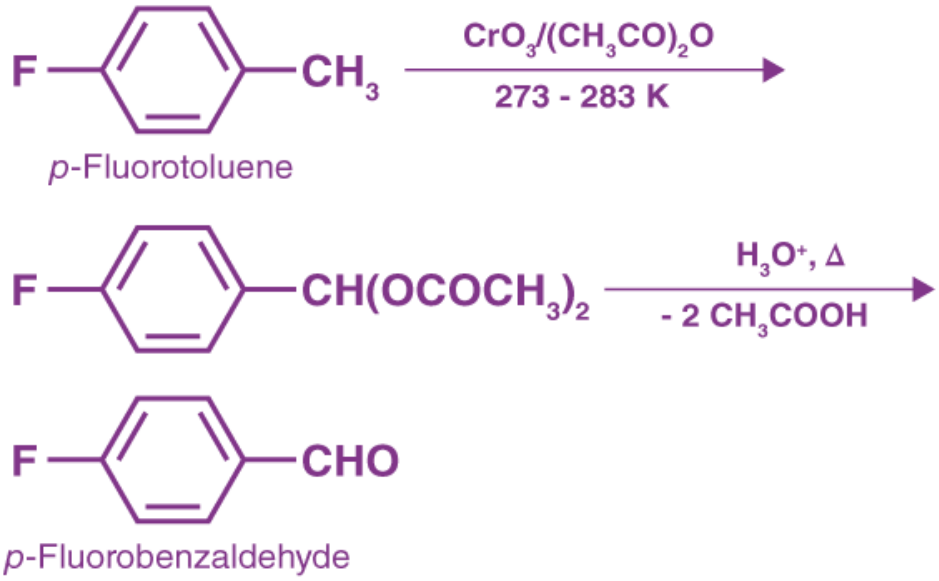
a. Hexanol to Hexanal
b. p-Fluorotoluene to p-Fluorobenzaldehyde
c. But-2-ene to Ethanal

Answer: The names of the reagents used are given hereunder.

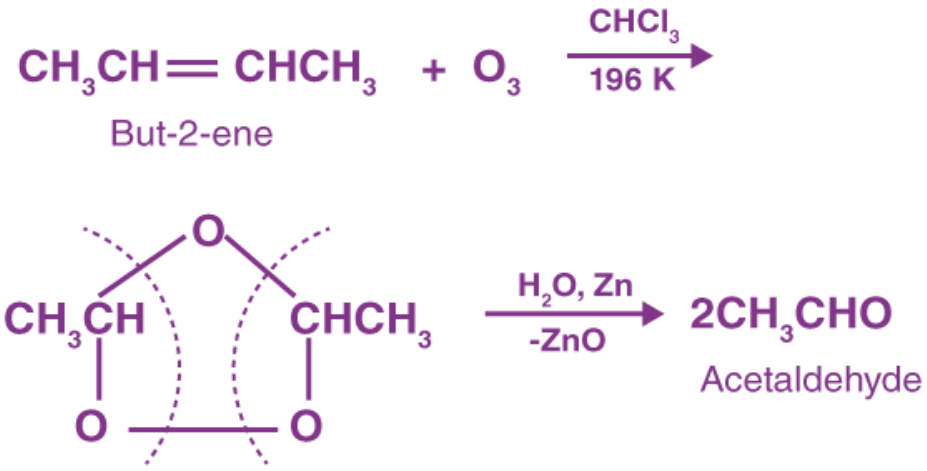
a. This is a controlled oxidation of an alcohol to an aldehyde. Hence, the reagent used must be either the Collins reagent or PCC.

$$CH_3(CH_2)_4CH_2OH \xrightarrow[or\ PCC,\ CH_2Cl_2]{Collins\ Reagent,\ CH_2Cl_2} CH_3(CH_2)_4CHO$$

b. This reaction involves the conversion of a methyl benzene into benzaldehyde. This conversion takes place by the use of chromic trioxide in the presence of acetic anhydride.
In this reaction, the p-Fluorotoluene reacts with chromic trioxide in the presence of acetic anhydride to form a Benzylidene gem-diacetate. The gem-diacetate formed is isolated and hydrolysed either by an alkali or a dil. acid to form p-Fluorobenzaldehyde.



c. The conversion of alkenes to aldehydes takes place via reductive ozonolysis. In this, the alkenes react with O_3 forming a ozonide which on reductive cleavage with Zn-dust gives the aldehyde. In this, only symmetrically disubstituted alkenes give aldehydes.



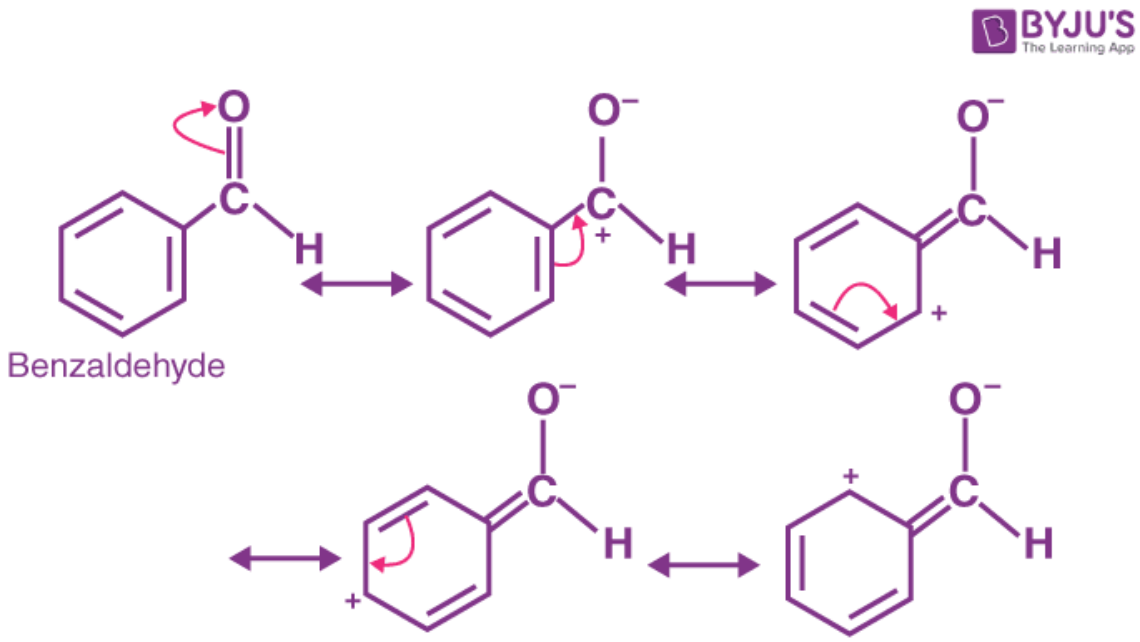
Q3. Arrange the boiling points of the given compounds in increasing order.
$CH_3CH_2CH_2CHO$, $CH_3CH_2CH_2CH_2OH$, $C_2H_5OC_2H_5$, $CH_3CH_2CH_2CH_2CH_3$

Answer: The given compounds have almost similar molecular masses.
Among the given compounds, butanol has the highest boiling point owing to its extensive inter-molecular H-bonding.
Since Butanal is more polar than ethoxy ethane, it has stronger dipole-dipole interactions sthan in ethoxyethane. Hence, butanal has a higher boiling point than ethoxyethane.
Furthermore, n-pentane has no polarity and the only inter-molecular forces are the weak van der waals forces. Hence, n-pentane has the lowest boiling point among the given compounds.
The increasing order of boiling point goes as:
$CH_3CH_2CH_2CH_2CH_3 < C_2H_5OC_2H_5 < CH_3CH_2CH_2CHO < CH_3CH_2CH_2CH_2OH$

Q4. Why is benzaldehyde less reactive than propanal in Nucleophilic addition reactions?

Answer: This is due to the fact that the positive charge on the carbon atom of the carbonyl group of propanal gets reduced to a very small extent due to the +I effect of the ethyl group.

While in benzaldehyde, the positive charge is reduced to a greater extent due to the +R effect of the benzene ring.



Hence, the carbon atom of the carbonyl group in benzaldehyde is much less electrophilic than the carbon atom of the carbonyl group in the propanal. Hence, benzaldehyde is less reactive in Nucleophilic substitution reactions than propanal.

Q5. Complete the following reaction.

$$CH_3CHO + SeO_2 \xrightarrow[temperature]{Room}$$

Answer: On going oxidation with SeO_2 at room temperature, the aldehydes and ketones with a methyl or methylene group adjacent to the C=O carbon form α-dicarbonyl compounds. Hence, the products of the given reaction would be:

$$CH_3CHO + SeO_2 \xrightarrow[temperature]{Room} O{=}CH{-}CH{=}O + Se + H_2O$$

The new α-dicarbonyl compound formed in this reaction is called as Glyoxal.