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CHEMISTRY

INORGANIC CHEMISTRY II

Level & Board	AQA (A-LEVEL)
TOPIC:	ALDEHYDES AND KETONES
PAPER TYPE:	SOLUTION - 2
TOTAL QUESTIONS	10
TOTAL MARKS	30

Aldehydes and Ketones - 2

1.

(a)

Overall equation for the reduction

$CH_3CH_2COCH_3 + 2[H] \rightarrow CH_3CH_2CH(OH)CH_3$

(1)

(b)

Formation of product

Nucleophilic attack:

In the first step, a hydride ion (H^-) from $NaBH_4$ attacks the electrophilic carbon atom of the planar carbonyl group in butanone.

Planar carbonyl group:

The carbonyl group of butanone is planar, allowing the nucleophilic attack to occur.

Nature of product

Product of step 1:

The product formed after the nucleophilic attack is butanol.

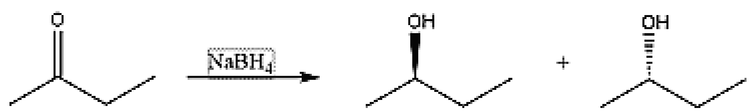
This exists in two chiral forms:

Butanol has a chiral center at the carbon that used to be the carbonyl carbon in butanone.

This results in two enantiomeric forms of butanol.

Racemic mixture formed:

Since the nucleophilic attack can occur from either side of the carbonyl group, equal amounts of each enantiomer are formed, resulting in a racemic mixture.



Optical activity

Optical isomers:

Enantiomers are optical isomers that rotate the plane of polarized light in opposite directions by equal amounts.

In a racemic mixture, there are equal amounts of both enantiomers present. Since each enantiomer rotates the plane of polarized light in opposite directions by the same amount, the effects cancel out, resulting in no net rotation of the plane of polarized light.

Therefore, the racemic mixture of butanol has no optical activity.

(6)

2. C

(1)

3.

(a)

When a reaction mixture is refluxed, it's being continuously heated and cooled in a closed system.

In this case, for the oxidation of ethanol to ethanoic acid, refluxing is essential for several reasons:

Preventing Loss of Volatile Components:

Ethanol, being volatile, tends to evaporate easily. Refluxing ensures that any evaporated ethanol is condensed and returned to the reaction mixture. This prevents the loss of ethanol.

Maintaining Reaction Conditions:

Refluxing helps maintain a constant temperature throughout the reaction.

This constant temperature provides optimal conditions for the oxidation reaction to occur efficiently.

Promoting Complete Reaction:

The oxidation of ethanol to ethanoic acid may be slow and reversible. Refluxing ensures that the reaction continues for an extended period, allowing more ethanol molecules to react and converting them into ethanoic acid.

This promotes a higher yield of the desired product.

In short, refluxing ensures that the oxidation reaction proceeds efficiently by preventing the loss of volatile reactants, maintaining optimal reaction conditions, and promoting complete conversion of ethanol to ethanoic acid.

(3)

(b)

Half-equation for the overall oxidation of ethanol into ethanoic acid:

$CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-$

(1)

4. D

(1)

5.

To confirm the presence of ethanal and absence of ethanoic acid in a liquid, the student can perform specific chemical tests used to detect each compound.

Tollens' Test (Silver Mirror Test) for Ethanal:

- Add a small amount of the liquid sample to a test tube.
- Add a few drops of Tollens' reagent to the test tube and gently heat the mixture in a water bath.
- If ethanal is present, it will undergo oxidation to form a silver mirror on the inner surface of the test tube. This occurs due to the reduction of silver ions (Ag^+) in Tollens' reagent by the aldehyde functional group of ethanal.

To confirm the **absence of ethanoic acid** in the liquid sample, the student can add sodium hydrogencarbonate ($NaHCO_3$) or sodium carbonate (Na_2CO_3) to the solution.

Addition of Sodium Hydrogencarbonate or Sodium Carbonate:

- Take a small amount of the liquid sample in a test tube.
- Add a small amount of solid sodium hydrogencarbonate ($NaHCO_3$) or sodium carbonate (Na_2CO_3) to the test tube containing the liquid sample.

Observation for Effervescence:

- If ethanoic acid is present in the liquid sample, it will react with sodium hydrogencarbonate or sodium carbonate to produce carbon dioxide gas.
- Effervescence (bubbling) would be observed as a result of the release of carbon dioxide gas.

- If no effervescence is observed after adding sodium hydrogencarbonate or sodium carbonate to the liquid sample, it indicates that there is **no acid present in the solution**, including ethanoic acid.

(5)

6. A

(1)

7.

(a)

IUPAC name of $CH_3CH_2CH_2CH_2CH(OH)CN$:

2-hydroxyhexanenitrile

(1)

(b)

To distinguish between separate samples of the two stereoisomers of $CH_3CH_2CH_2CH_2CH(OH)CN$ plane polarized light can be used.

When (plane) polarized light passes through a solution of enantiomers, each enantiomer will rotate the plane of polarization, but in opposite directions.

Enantiomers rotate plane-polarized light in opposite directions: one clockwise (+), the other counterclockwise (-).

This property is known as optical activity and is a key characteristic of chiral compounds like enantiomers.

Therefore, measuring the direction and magnitude of this rotation can help distinguish between the two stereoisomers.

(2)

(c)

The reaction produces a racemic mixture due to the planar nature of the carbonyl group.

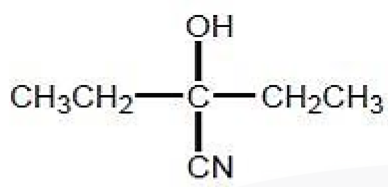
Since the carbonyl group is planar, the attacking nucleophile can approach it from either side with equal probability.

As a result, both enantiomers are formed in equal amounts because there's no preference for the nucleophile to attack from one specific side over the other.

This lack of selectivity leads to the production of a racemic mixture.

(3)

(d)



The compound formed does not contain a chiral center.

None of its carbon atoms are bonded to four different groups. Instead, it contains two identical ethyl groups, resulting in a symmetrical structure. Therefore, it does not exhibit stereoisomerism.

(2)

8. B

(1)

9.

Tollens' reagent is preferred over dichromate(VI) for aldehyde tests because dichromate(VI) also oxidizes alcohols, yielding false positives.

Additionally, dichromate(VI) can oxidize various organic molecules, complicating result interpretation.

Tollens' reagent offers selective oxidation of aldehydes without interfering with other functional groups.

(1)

10. C

(1)

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