



A-Level Chemistry

Aldehydes and Ketones

Question Paper

Time available: 68 minutes

Marks available: 66 marks

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1.

Aqueous NaBH_4 reduces aldehydes but does not reduce alkenes.

- (a) Show the first step of the mechanism of the reaction between NaBH_4 and 2-methylbutanal. You should include two curly arrows.

Explain why NaBH_4 reduces 2-methylbutanal but has no reaction with 2-methylbut-1-ene.

First step of mechanism

Explanation _____

(5)

- (b) A student attempted to reduce a sample of 2-methylbutanal but added insufficient NaBH_4 . The student confirmed that the reduction was incomplete by using a chemical test.

Give the reagent and observation for the chemical test.

Reagent _____

Observation _____

(2)

(Total 7 marks)

2.

Butanone is reduced in a two-step reaction using NaBH_4 followed by dilute hydrochloric acid.

- (a) Write an overall equation for the reduction of butanone using $[\text{H}]$ to represent the reductant.

(1)

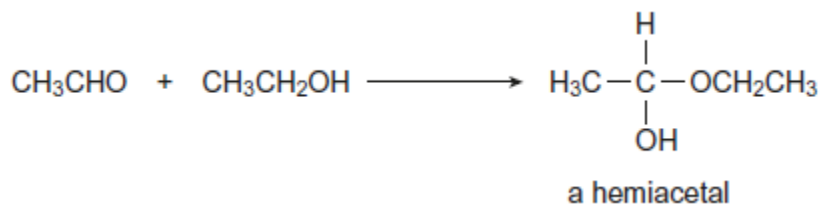
- (b) By considering the mechanism of the reaction, explain why the product has **no** effect on plane polarised light.

(6)

(Total 7 marks)

3.

Hemiacetals and acetals are compounds formed by the reaction of aldehydes with alcohols, such as the reaction of ethanal with ethanol.



- (a) (i) Use your knowledge of carbonyl mechanisms to suggest the name of the mechanism of this reaction.

(1)

- (ii) Outline how an ethanol molecule reacts with an ethanal molecule in the first step of this mechanism. Include two curly arrows to show the movement of electron pairs.

(2)

(b) The reaction produces a racemic mixture of chiral molecules.

(i) Explain the meaning of the term racemic mixture.

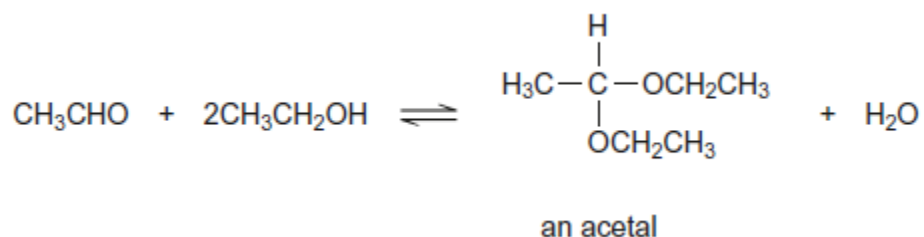
(1)

(ii) State the relationship between two chiral molecules with the same structural formula.

(1)

(c) In the presence of an acid catalyst such as dry hydrogen chloride, ethanal reacts with an excess of ethanol to form an acetal.

The overall reaction of ethanal with an excess of ethanol forms an equilibrium mixture as shown. All reactants and products are liquids.



A mixture of 0.75 mol of ethanal and 5.00 mol of ethanol was left to reach equilibrium in the presence of dry hydrogen chloride at a given temperature. The equilibrium mixture contained 0.42 mol of the acetal.

(i) Calculate the amount, in moles, of ethanal and of ethanol in this equilibrium mixture.

Amount of ethanal _____ mol

Amount of ethanol _____ mol

Space for working _____

(2)

- (ii) In a different experiment using the same reaction as in part (c), an equilibrium mixture was established at a given temperature. This mixture contained 0.58 mol of ethanal, 3.76 mol of ethanol, 0.37 mol of the acetal and 0.65 mol of water in a total volume of 310 cm³.

Write an expression for the equilibrium constant K_C for this reaction.

Calculate a value for K_C at this temperature. Give units with your answer.

K_C _____

Calculation _____

(4)

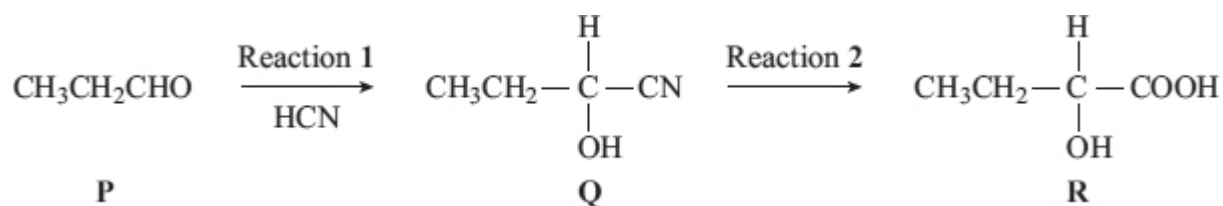
- (d) Draw the structure of the acetal (C₄H₈O₂) formed by the reaction of ethanal with ethane-1,2-diol.

(1)

(Total 12 marks)

4.

Consider the sequence of reactions below.



- (a) Name and outline a mechanism for Reaction 1.

Name of mechanism _____

Mechanism

(5)

- (b) (i) Name compound **Q**

- (ii) The molecular formula of **Q** is $\text{C}_4\text{H}_7\text{NO}$. Draw the structure of the isomer of **Q** which shows geometrical isomerism and is formed by the reaction of ammonia with an acyl chloride.

(3)

- (c) Draw the structure of the main organic product formed in each case when **R** reacts separately with the following substances:

- (i) methanol in the presence of a few drops of concentrated sulphuric acid;

(ii) acidified potassium dichromate(VI);

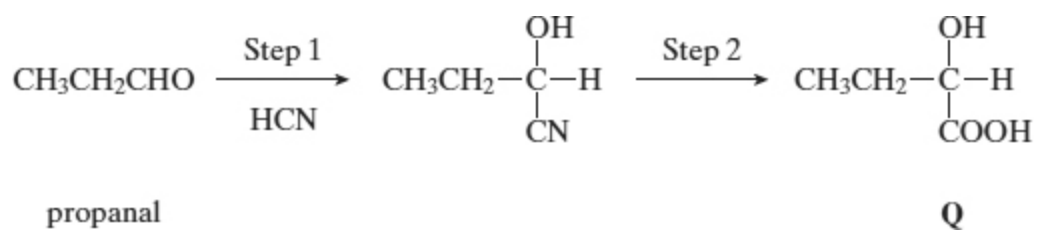
(iii) concentrated sulphuric acid in an elimination reaction.

(3)

(Total 11 marks)

5.

Consider the reaction sequence shown below.



(a) Name and outline a mechanism for the reaction in Step 1.

Name of mechanism _____

Mechanism

(5)

- (b) (i) Name compound **Q** formed in Step 2.

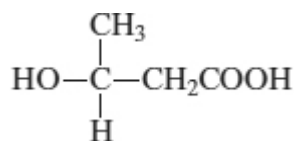
- (ii) Two stereoisomers are formed by the dehydration of **Q**. Give the structures of these two isomers and name the type of stereoisomerism shown.

Structures of isomers

Type of stereoisomerism _____

(4)

- (c) An isomer of **Q** which has the structure shown below is polymerised to form the biodegradable polymer known as PHB.

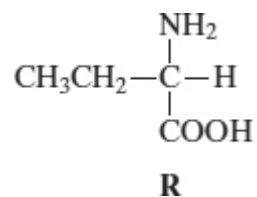


- (i) Draw the repeating unit of the polymer PHB.

- (ii) Suggest a reason why the polymer is biodegradable.

(2)

(d) The amino acid **R** is shown below.



(i) Draw the structure of the zwitterion formed by **R**.

(ii) Draw the structure of the major organic product formed when an excess of **R** is reacted with bromomethane.

(iii) Name the mechanism of the reaction which results in the formation of the product given in part (ii).

(3)

(Total 14 marks)

6.

(a) Describe how propanal, $\text{CH}_3\text{CH}_2\text{CHO}$, and propanone, CH_3COCH_3 , can be distinguished using

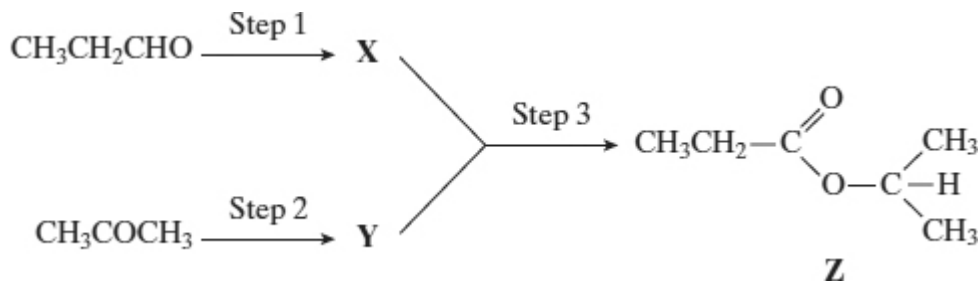
(i) a chemical test and

(3)

(ii) the number of peaks in their proton n.m.r. spectra.

(2)

(b) Compound **Z** can be produced by the reaction of compound **X** with compound **Y** as shown in the synthesis outlined below.



Identify compounds **X** and **Y**.

For each of the three steps in the synthesis, name the type of reaction involved and give reagents and conditions. Equations are **not** required.

(10)
(Total 15 marks)