Q1.

This question is about ketones.

(a) Solution **X** reacts with liquid ketones to form a crystalline solid.

This reaction can be used to identify a ketone if the crystalline solid is separated, purified by recrystallisation, and the melting point determined.

Describe how the crystalline solid is separated and purified.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(b) Propanone (CH_3COCH_3) reacts with the weak acid HCN to form a hydroxynitrile.

This hydroxynitrile is usually made by reaction of propanone with KCN followed by dilute acid, instead of with HCN

State the hazard associated with the use of KCN

Suggest a reason, other than safety, why KCN is used instead of HCN.

Hazard _____

Why KCN is used _____

_____

(2)

(c) Outline the mechanism for the reaction of propanone with KCN followed by dilute acid.

(4)

(Total 11 marks)

Q2.

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)

Q3.

Ethanal reacts with potassium cyanide, followed by dilute acid, to form 2-hydroxypropanenitrile.

(a) Name the mechanism for the reaction between potassium cyanide and ethanal.

_____

(1)

(b) The 2-hydroxypropanenitrile formed by the reaction in part **(a)** is a mixture of equal amounts of two isomers.

State the name of this type of mixture.

Explain how the structure of ethanal leads to the formation of two isomers.

Draw 3D representations of the two isomers to show the relationship between them.

Name

_____

Explanation

_____

_____

_____

_____

_____

_____

3D representations

(5)

(c) 2-Hydroxypropanenitrile can be used in the synthesis of the monomer, acrylonitrile, CH_2=CHCN

Suggest a suitable reagent and conditions for the conversion of 2-hydroxypropanenitrile into acrylonitrile.

Reagent

_____

Conditions

_____

(2)

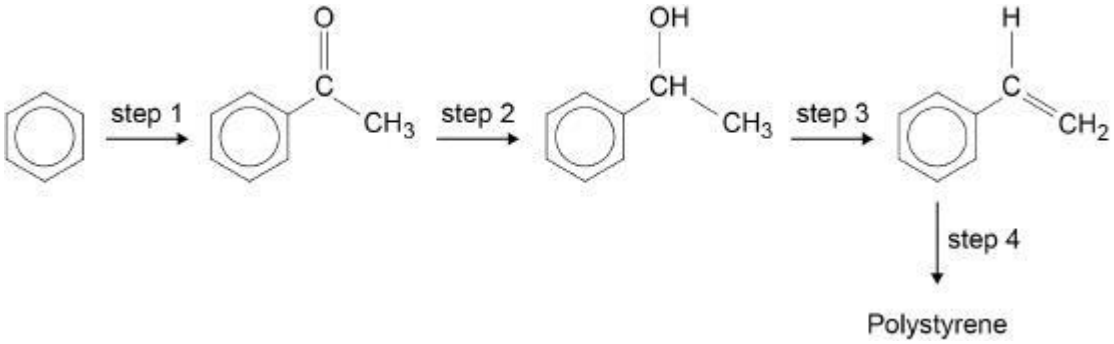
(d) Draw a section of the polymer polyacrylonitrile, showing three repeating units.

(1)

(Total 9 marks)

Q4.

Polystyrene can be made from benzene in the series of steps shown.



(a) State the type of reaction in step **1**.

Identify the reagent(s) and conditions needed for step **1**.

Type of reaction

_____

Reagent(s)

_____

Conditions

_____

(3)

(b) State the name of the mechanism for the reaction in step **2**.

Identify the inorganic reagent needed for step **2**.

Name the organic product of step **2**.

Name of mechanism _____

Inorganic reagent _____

Name of organic product _____

(3)

(c) The organic product of step **2** is reacted with concentrated sulfuric acid in step **3**.

Outline the mechanism for step **3**.

(3)

(d) Draw the repeating unit of polystyrene.

(1)
(Total 10 marks)

Q5.

Acyl chlorides are useful reagents in synthesis. They react with aromatic compounds and also with alcohols.

(a) CH_3CH_2COCl reacts with benzene in the presence of $AlCl_3$ in an electrophilic substitution reaction.

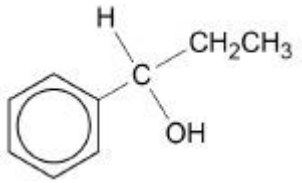
Give an equation for the reaction of CH_3CH_2COCl with $AlCl_3$ to form the electrophile.
Outline a mechanism for the reaction of this electrophile with benzene.

Equation

Mechanism

(4)

(b) The organic product in **part (a)** can be converted into the alcohol shown.



Give the IUPAC name of the alcohol.
Give the reagent needed for this reaction and name the mechanism.

IUPAC name

_____

Reagent

_____

Name of mechanism

_____

(3)

(c) The alcohol shown in **part (b)** reacts with ethanoyl chloride to form an ester.

Describe what would be observed when the alcohol reacts with ethanoyl chloride.
Name the mechanism for the reaction to form the ester.
Draw the structure of the ester.

Observation

_____

_____

Name of mechanism

_____

Structure of ester

(3)

(Total 10 marks)

Q6.

How many structural isomers with the molecular formula $C_5H_{10}O$ react with Tollens' reagent?

A 3 ⬭

B 4 ⬭

C 5 ⬭

D 6 ⬭

(Total 1 mark)

Q7.

The aldehyde $CH_3CH_2CH_2CH_2CHO$ reacts with KCN followed by dilute acid to form a racemic mixture of the two stereoisomers of $CH_3CH_2CH_2CH_2CH(OH)CN$

(a) Give the IUPAC name of $CH_3CH_2CH_2CH_2CH(OH)CN$

_____

(1)

(b) Describe how you would distinguish between separate samples of the two stereoisomers of $CH_3CH_2CH_2CH_2CH(OH)CN$

_____

_____

_____

_____

_____

(2)

(c) Explain why the reaction produces a racemic mixture.

_____

_____

_____

_____

_____

_____

(3)

(d) An isomer of $CH_3CH_2CH_2CH_2CHO$ reacts with KCN followed by dilute acid to form a compound that does not show stereoisomerism.

Draw the structure of the compound formed and justify why it does not show stereoisomerism.

Structure

Justification

_____

_____

(2)

(Total 8 marks)

Q8.

Which alcohol could **not** be produced by the reduction of an aldehyde or a ketone?

A 2,2-dimethylpropan-1-ol ⬭

B 2-methylbutan-2-ol ⬭

C 3-methylbutan-2-ol ⬭

D pentan-3-ol ⬭

(Total 1 mark)

Q9.

Which compound forms a racemic mixture when reacted with KCN followed by dilute acid?

A HCHO ⬭

B CH_3CHO ⬭

C CH_3COCH_3 ⬭

D $(CH_3CH_2)_2CO$ ⬭

(Total 1 mark)

Q10.

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 [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)

Q11.

Ethanol can be oxidised by acidified potassium dichromate(VI) to ethanoic acid in a two-step process.

ethanol ⟶ ethanal ⟶ ethanoic acid

(a) In order to ensure that the oxidation to ethanoic acid is complete, the reaction is carried out under reflux.

Describe what happens when a reaction mixture is refluxed and why it is necessary, in this case, for complete oxidation to ethanoic acid.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(b) Write a half-equation for the overall oxidation of ethanol into ethanoic acid.

_____

(1)

(c) The boiling points of the organic compounds in a reaction mixture are shown in the following table.

Compound	ethanol	ethanal	ethanoic acid
Boiling point / °C	78	21	118

Use these data to describe how you would obtain a sample of ethanal from a mixture of these three compounds. Include in your answer a description of the apparatus you would use and how you would minimise the loss of ethanal. Your description of the apparatus can be either a description in words or a labelled sketch.

_____

_____

_____

(5)

(d) Use your knowledge of structure and bonding to explain why it is possible to separate ethanal in this way.

(2)

(e) A student obtained a sample of a liquid using the apparatus in part **(c)**.

Describe how the student could use chemical tests to confirm that the liquid contained ethanal and did **not** contain ethanoic acid.

(5)

(Total 16 marks)

Q12.

Which alcohol could **not** be produced by the reduction of an aldehyde or a ketone?

A 2-methylbutan-1-ol ⬭

B 2-methylbutan-2-ol ⬭

C 3-methylbutan-1-ol ⬭

D 3-methylbutan-2-ol ⬭

(Total 1 mark)