Surname	Centre Number	Candidate Number
Other Names		2

GCE A LEVEL

1410U30–1

CHEMISTRY
Physical and Organic Chemistry

2 hours 45 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	14	
2.	8	
3.	6	
4.	8	
5.	11	
6.	11	
7.	4	
8.	5	
9.	19	
10.	10	
11.	5	
12.	20	
13.	1	
14.	3	
15.	13	
16.	8	
Total	146	

ADDITIONAL MATERIALS

- A calculator, pencil and ruler
- **Data Booklet** supplied by WJEC

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.
You may use a pencil for graphs and diagrams only.
Write your name, centre number and candidate number in the spaces at the top of this page.
Section A Answer all questions.
Section B Answer all questions.
Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.
The maximum mark for this paper is 146.
Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.
The assessment of the quality of extended response (QER) will take place in **Q5.2** and **Q9(b)(ii)**.

1 Benzene reacts with bromine and with ethanoyl chloride. Both reactions require a catalyst.

(a) (i) Complete the table below.

Reaction of benzene	Name of organic product	Name of catalyst
with bromine	bromobenzene	
with ethanoyl chloride		

[3]

(ii) Write an equation for the reaction of benzene with bromine to form bromobenzene.

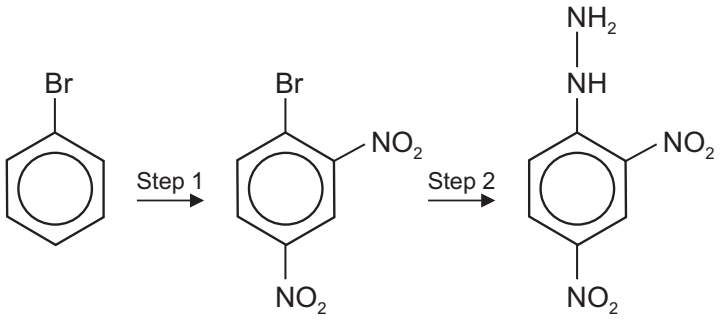
_____ [1]

(iii) Name the mechanism by which benzene reacts with bromine and with ethanoyl chloride.

_____ [1]

[Turn over

(b) 2,4-dinitrophenylhydrazine can be synthesised from bromobenzene as shown below. The mechanism for Step 1 involves the reaction of bromobenzene with nitronium ions formed in a nitrating mixture. The nitrated product, formed in Step 1, reacts with hydrazine in Step 2 to form 2,4-dinitrophenylhydrazine.



bromobenzene 2,4-dinitrophenylhydrazine

(i) In Step 1, name the two reagents in the nitrating mixture.

_____

_____ [2]

(ii) Write an equation for the formation of the nitronium ion in the nitrating mixture.

_____ [2]

(iii) Write an equation for Step 1.

_____ [1]

(e) Malonic acid reacts with excess lithium tetrahydridoaluminate(III) to form a diol.

(i) Write the formula of lithium tetrahydridoaluminate(III).

_____ [1]

(ii) Name the type of reaction which occurs between malonic acid and lithium tetrahydridoaluminate(III).

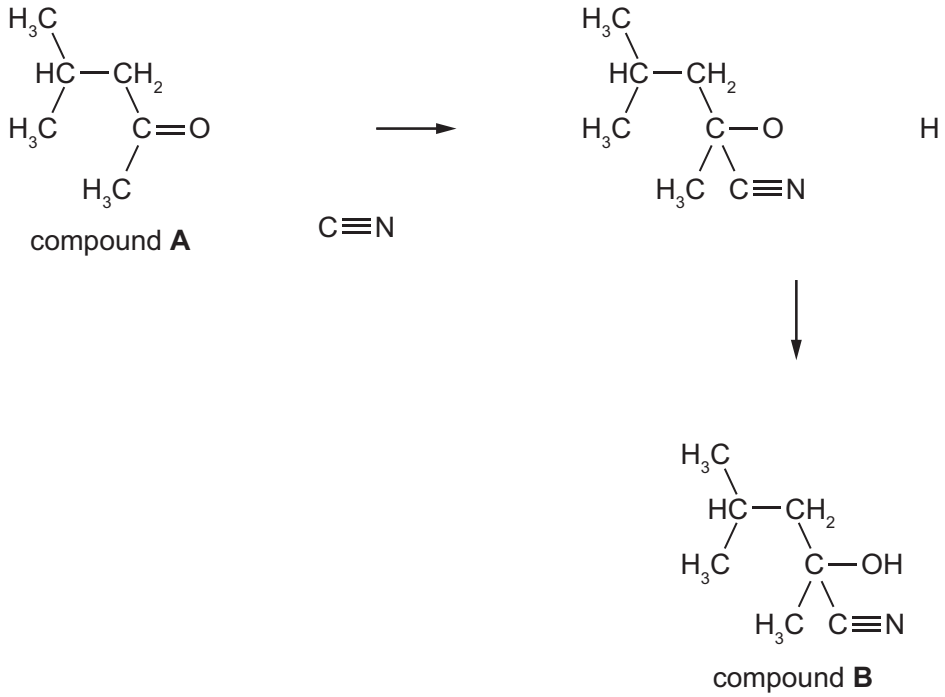
_____ [1]

(iii) Write an equation for the reaction of malonic acid with lithium tetrahydridoaluminate(III).

_____ [2]

2 Aldehydes and ketones react with hydrogen cyanide.

(a) (i) Complete the mechanism below for the reaction of compound **A** with hydrogen cyanide by adding relevant charges, lone pairs and curly arrows.



[3]

(ii) Name the mechanism.

_____ [1]

(iii) State the IUPAC name for compound **A**.

_____ [1]

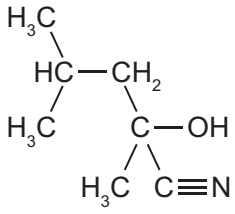
(b) Compound **B** formed in **(a)(i)** has an chiral center.

(i) Define the term **chiral center.**

_____

_____ [1]

(ii) Label the chiral center using an asterisk (*) on the structure of compound **B** below.



[1]

(iii) Explain why the mixture formed from the reaction of compound **A** with hydrogen cyanide does not show any optical activity.

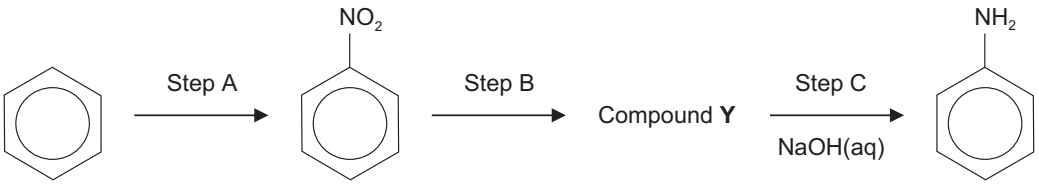
_____

_____

_____ [1]

[Turn over

3 **(b)** Phenylamine may be produced, in a three-step synthesis, from benzene.



(i) Name the organic product of Step A.

_____ [1]

(ii) Name the two reagents required for Step B.

1. _____

2. _____ [2]

(iii) Classify the type of reaction which occurs in Step B.

_____ [1]

(iv) Draw the structure and state the name of Compound **Y**.

Name: _____ [2]

[Turn over

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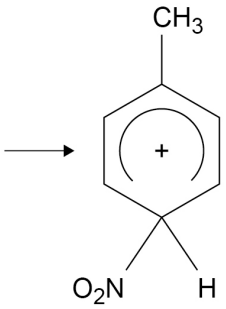
4 . 2 **Figure 4** shows an intermediate formed in the first step of a reaction mechanism of methylbenzene.

Figure 4



Complete **Figure 4** to show the reactant species and any curly arrows involved in the formation of the intermediate.

Draw a curly arrow on the intermediate to show how the product is formed.

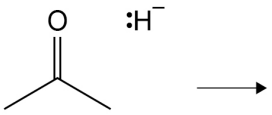
Give the name of the reaction mechanism.

[4 marks]

Name of mechanism _____

4 . 3 **Figure 5** shows the reactant species involved in the first step of a mechanism.

Figure 5



Complete **Figure 5** to show the structure of the intermediate formed with curly arrows involved in its formation.

Give the name of the reaction mechanism.

[4 marks]

Name of mechanism _____

12

Turn over ►

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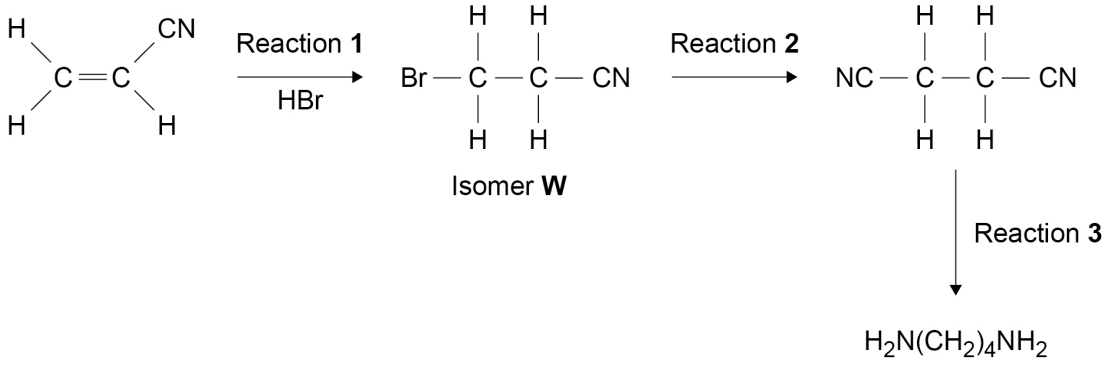
5 Acrylonitrile, $H_2C=CHCN$, can be used as a starting material for the synthesis of butane-1,4-diamine, as shown in this reaction scheme.



5 . 1 Use IUPAC rules to name isomer **W**.

[1 mark]

5 . 2 Reaction **1** produces a mixture of **W** and two other isomers.

Draw the structures of the two other isomers.

Explain, by considering the mechanism of this reaction, why all three isomers are formed.

[6 marks]

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Question 4 continues on the next page

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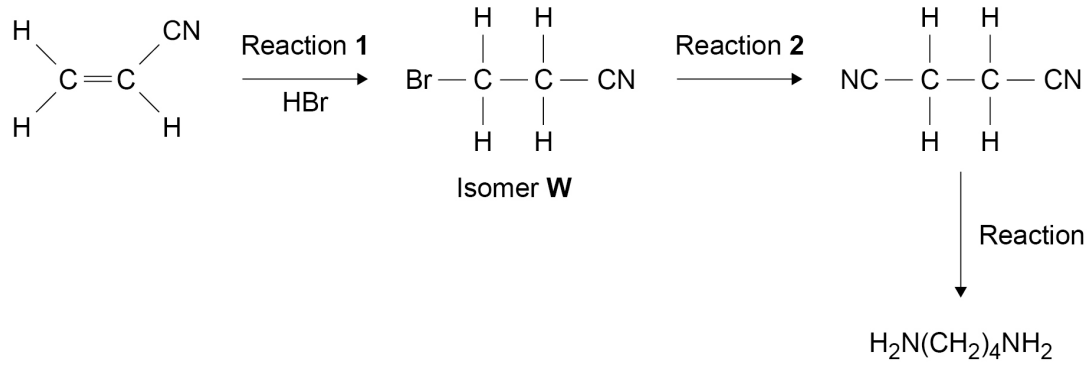
The reaction scheme is repeated here.



5 . 3 Identify the reagent that is warmed with isomer **W** in reaction **2**.

State the other reaction condition needed.

[2 marks]

Reagent _____

Condition _____

5 . 4 State the reagent and reaction conditions needed for reaction **3**.

Give an equation for reaction **3**.

[2 marks]

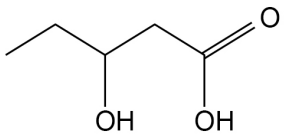
Reagent and conditions _____

Equation

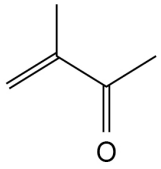
_____

Do not write outside the box

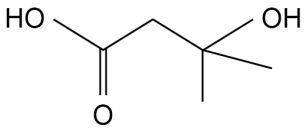
0 6 A student plans a series of chemical tests to confirm the identities of four organic liquids.



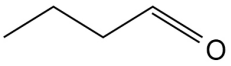
Liquid **J**



Liquid **K**



Liquid **L**



Liquid **M**

This is the student's method.

To separate test tubes containing samples of each liquid:

Test 1 add potassium dichromate(VI) solution and warm gently

Test 2 add Fehling's solution and cool in iced water

Test 3 add sodium hydrogencarbonate solution and test any gas produced with a lighted splint

Test 4 add bromine water and shake at room temperature.

0 6 . 1 Identify the missing reagent needed in **Test 1**.

[1 mark]

Do not write outside the box

0 6 . 2 In addition to the missing reagent in **Test 1**, there is a mistake in the method for **two** of the other tests.

State the **two** mistakes.

Suggest how each of the mistakes should be corrected.

[2 marks]

Mistake 1 _____

Suggestion _____

_____

Mistake 2 _____

Suggestion _____

_____

0 6 . 3 The missing reagent is added and the mistakes are corrected.

Identify the liquid(s), **J**, **K**, **L** and **M**, that would react in each test.

State the expected observation for each reaction.

[8 marks]

Liquid(s) that react in **Test 1** _____

Expected observation _____

_____

Liquid(s) that react in **Test 2** _____

Expected observation _____

_____

Liquid(s) that react in **Test 3** _____

Expected observation _____

_____

Liquid(s) that react in **Test 4** _____

Expected observation _____

_____

Turn over ►

Do not write outside the box

7] This question is about ethanoic anhydride.

In the gas phase, ethanoic anhydride $(CH_3CO)_2O$ decomposes to form ethenone.

The equation is

$$(CH_3CO)_2O \rightarrow H_2C{=}C{=}O + CH_3COOH$$
Ethenone

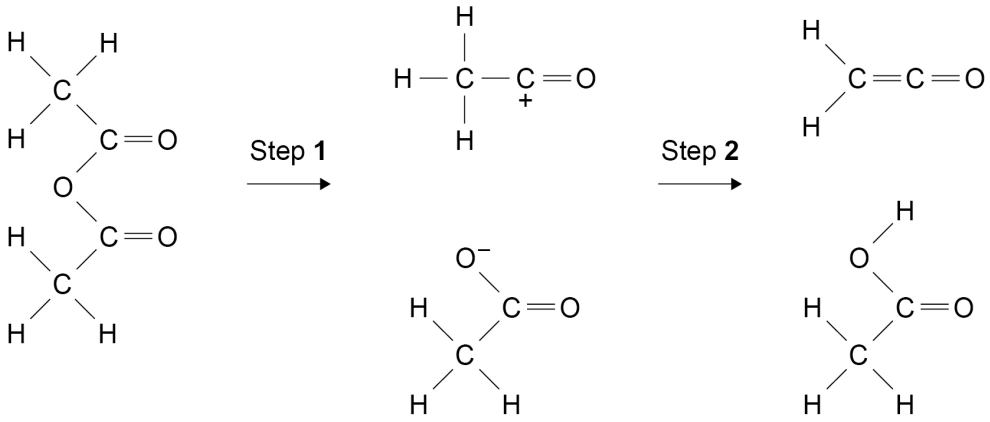
7].1 Ethenone is the simplest member of the ketene homologous series.
Ketenes all contain one C=C double bond and one C=O double bond.

Deduce the general formula for the ketene homologous series.

[1 mark]

7].2 **Figure 11** shows an incomplete suggested mechanism for the decomposition of ethanoic anhydride.

Figure 11



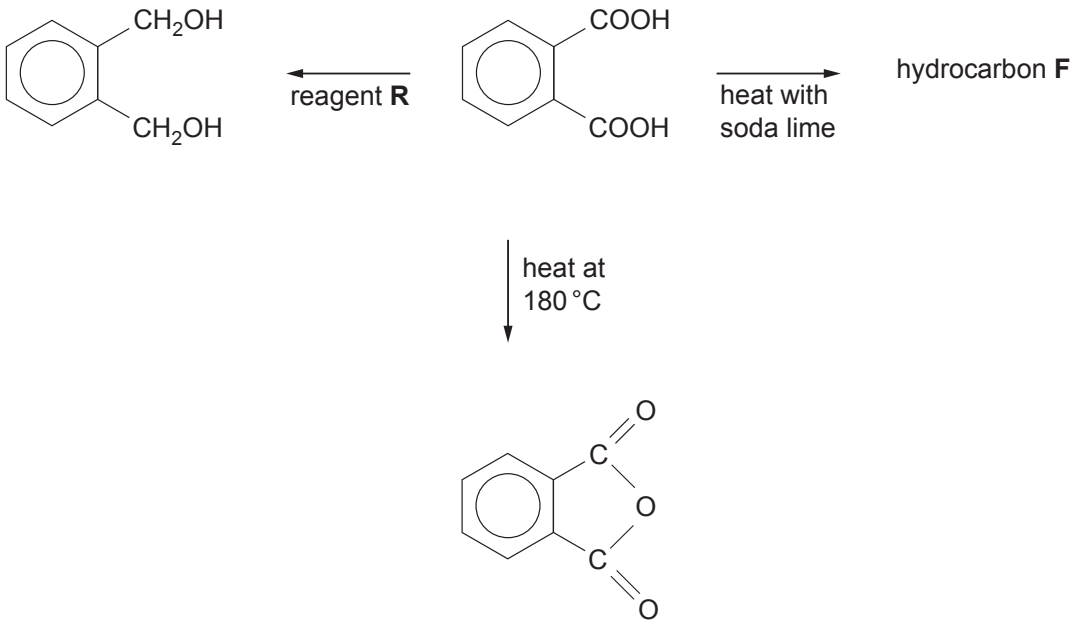
Complete the mechanism in **Figure 11** by adding three curly arrows and any relevant lone pairs of electrons.

[3 marks]

Examiner only

8 (c) Some of the reactions of benzene-1,2-dicarboxylic acid are shown below.

Use this flow chart to answer the questions that follow.



(i) Give the **formula** of reagent **R**. [1]

.....

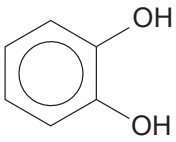
(ii) Give the structure of hydrocarbon **F**. [1]

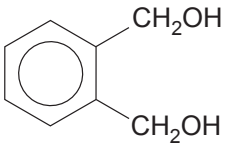
(iii) State the type of reaction that occurs when benzene-1,2-dicarboxylic acid is heated at 180 °C. [1]

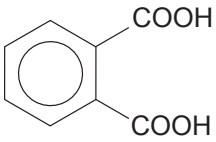
.....

Examiner only

(d) Describe a chemical test that will identify which of these three compounds, present in separate unlabelled aqueous solutions, is the most acidic. [2]







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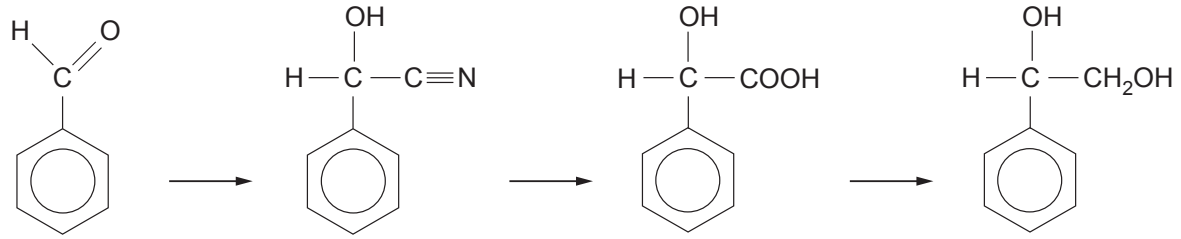
Examiner only

9 (a) The scheme below shows a sequence of reactions starting from benzaldehyde.



(i) One way of increasing the length of a carbon chain is by reacting an aldehyde with hydrogen cyanide.

I. Show the mechanism for the reaction of benzaldehyde with hydrogen cyanide to produce 2-hydroxy-2-phenylethanenitrile.

Include appropriate charges and curly arrows. [3]

II. State the name of the reaction mechanism that you have described in part I. above. [1]

.....

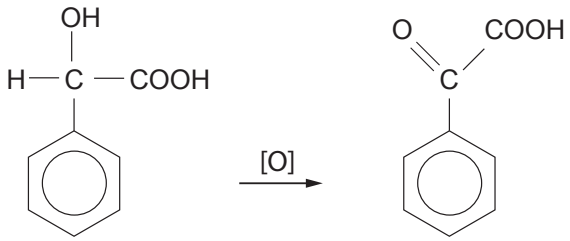
Examiner only

(iii) Suggest why a solution of 2-hydroxy-2-phenylethanoic acid, produced in part (ii), does not show any optical activity when placed in a polarimeter. [1]

.....

.....

(iv) 2-Hydroxy-2-phenylethanoic acid can be oxidised to the corresponding keto-acid, compound **W**.



compound **W**

Suggest why compound **W** does not show any optical activity when a solution is placed in a polarimeter. [1]

.....

.....

Examiner only

(v) I. Explain why 2-hydroxy-2-phenylethanoic acid will react with methanol, in the presence of a catalyst.

Give the formula of the organic compound formed. [2]

.....

.....

II. Explain why 2-hydroxy-2-phenylethanoic acid can also react with ethanoic acid, in the presence of a catalyst. [1]

.....

.....

Examiner only

(b) Pentan-2-one can be made by the oxidation of pentan-2-ol using acidified potassium dichromate.

(i) State the colour change that is seen in the reaction flask as acidified dichromate is added to pentan-2-ol. [1]

.....

(ii) After the reaction the mixture is distilled and the fraction boiling between 100 and 120 °C is collected. This distillate is largely pentan-2-one. It also contains a little unreacted pentan-2-ol and water.

Describe how you would obtain a dry sample of pentan-2-one from this distillate.

It is not necessary to redistil your dry sample of pentan-2-one.

You are given the following information to help you in your answer.

- You should use a separating funnel
- Pentan-2-ol is more soluble than pentan-2-one in water
- Pentan-2-one is very soluble in ethoxyethane
- Ethoxyethane boils at 35 °C and is very flammable
- The density of ethoxyethane is 0.71 g cm^{-3}
- Solid anhydrous magnesium sulfate is a suitable drying agent for pentan-2-one [6 QER]

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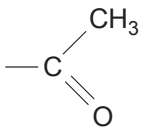
Examiner only

(iii) Describe how infrared spectroscopy could confirm that there is no longer pentan-2-ol present. [1]

.....

.....

(iv) Give the reagent(s) and an observation to show that pentan-2-one contains the following group. [2]



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10 (a) (i) Lactose, found in milk, is classed as a reducing sugar because it reacts with Fehling's solution.

Describe what is seen when lactose reacts with Fehling's solution. [2]

.....

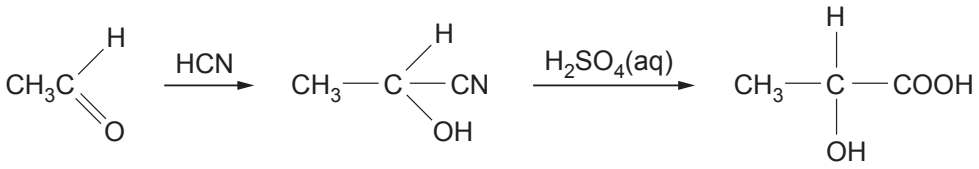
.....

(ii) Give another compound that will reduce Fehling's solution in this way. [1]

.....

(b) In industry, 2-hydroxypropanoic acid (lactic acid) is still largely made by the fermentation of dairy products.

A laboratory method of producing 2-hydroxypropanoic acid is from ethanal.



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(i) State the name of the mechanism in the reaction between ethanal and hydrogen cyanide. [1]

.....

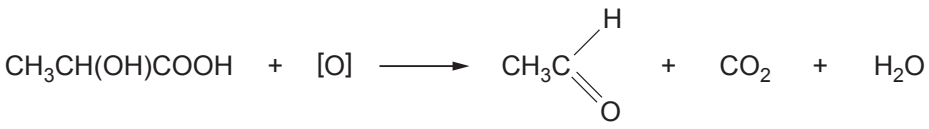
(ii) The second stage of this reaction involves hydrolysis of the intermediate compound 2-hydroxypropanenitrile.

State what is meant by the term hydrolysis. [1]

.....

Examiner only

(c) 2-Hydroxypropanoic acid can be converted back to ethanal by using a suitable oxidising agent.



2-Hydroxypropanoic acid was oxidised and produced a 45% yield of ethanal. The boiling temperature of ethanal is 293 K.

Suggest **two** reasons for this low yield. [2]

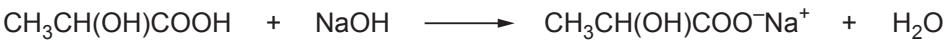
1. .....

.....

2. .....

.....

(d) A 75 cm^3 sample of yoghurt was titrated against 0.200 mol dm^{-3} aqueous sodium hydroxide. 40.0 cm^3 was needed to just neutralise the lactic acid present in the yoghurt.



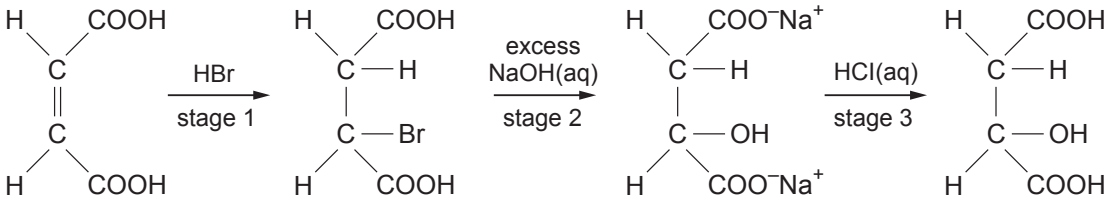
Calculate the percentage by volume of lactic acid (density 1.2 g cm^{-3}) in the yoghurt.

You should assume that lactic acid is the only acid present in the yoghurt. [3]

Percentage = ... %

Examiner only

11 (iii) One method to prepare malic acid from maleic acid is shown in the reaction sequence below.



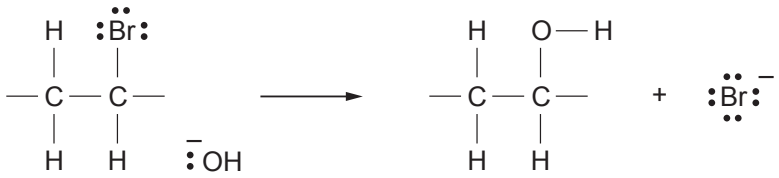
maleic acid malic acid

I. Stage 1 is described as an electrophilic addition reaction.

Give the formula of the electrophile used in this stage. [1]

.....

II. A bromine atom is substituted by an —OH group in stage 2. Complete the mechanism for the reaction by using curly arrows and appropriate partial charges. [2]



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III. Explain why it is necessary to use an **excess** of aqueous sodium hydroxide in stage 2. [1]

.....

.....

IV. Discuss why the C — Br bond is broken via heterolytic fission in stage 2. [1]

.....

.....

.....

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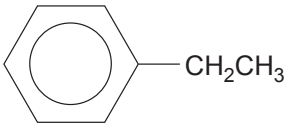
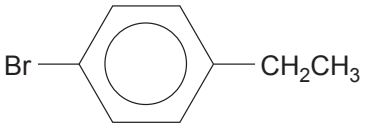
Turn over.

Examiner only

12 (a) A student was asked for a method to produce 4-bromo-1-ethylbenzene, starting from ethylbenzene.



ethylbenzene



4-bromo-1-ethylbenzene

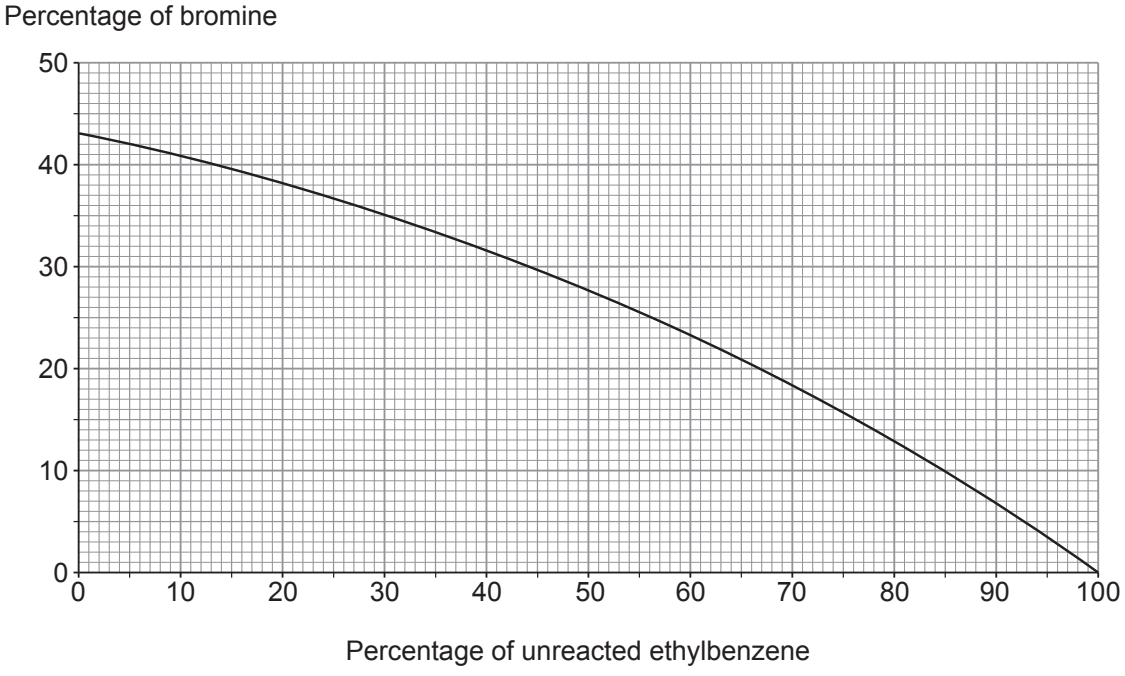
(i) State the reagent(s) needed for this reaction. [1]

.....

(ii) The organic products of the reaction contained some unreacted ethylbenzene as well as bromine-containing reaction products.

The percentage of bromine in these products was 39.

Use the graph to find the percentage of unreacted ethylbenzene. [1]



Percentage = ... %

Examiner only

(iii) An HPLC chromatogram was taken of the organic products of the reaction.

Apart from unreacted ethylbenzene there were four other signals.

I. Three signals resulted from products with a relative molecular mass of 185. One of these is 4-bromo-1-ethylbenzene.

Suggest structures for the other two compounds with this relative molecular mass. Give a reason for your answer. [2]

.....

II. The fourth compound had the molecular formula $C_8H_8Br_2$.

Suggest a structure for this compound. [1]

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(b) Give reagent(s) that can be used to convert (1-bromoethyl)benzene, $C_6H_5CHBrCH_3$, into phenylethene, $C_6H_5CH=CH_2$. State why this is classed as an elimination reaction. [2]

.....

.....

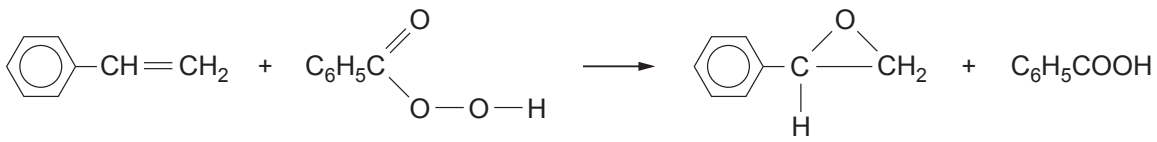
(c) A sample of ethylbenzene is contaminated with phenylethene.

Give a test that would confirm the presence of phenylethene in this sample. State the reagent used and the expected observation. [2]

.....

Examiner only

(d) Phenylethene reacts with peroxybenzoic acid, C_6H_5COOOH, to give phenyloxirane.



M_r 104 M_r 120

phenyloxirane

In a preparation, 3.00 g of phenylethene is added slowly to a solution of a slight excess of peroxybenzoic acid dissolved in 500 cm^3 of trichloromethane. The mixture is kept at 0 °C and stirred for 24 hours.

The products are then placed in a separating funnel and shaken with an excess of aqueous sodium hydroxide. The layers are allowed to separate and the trichloromethane layer removed. This layer is washed with water to remove traces of sodium hydroxide and then dried. The trichloromethane is removed by distillation, leaving phenyloxirane, which is collected by distillation at 188-192 °C. The yield of phenyloxirane is 2.50 g.

(i) Suggest why aqueous sodium hydroxide is added to the products. [2]

.....

.....

(ii) Two layers are formed in the separating funnel. The trichloromethane layer is the lower layer.

State why trichloromethane forms the lower layer. [1]

.....

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(iii) Calculate the percentage yield of phenyloxirane. [3]

Percentage yield = ... %

(e) A sample of phenylethane-1,2-diol is contaminated with a small quantity of phenylethanal.

Explain how the infrared absorption spectrum of this impure sample would indicate the presence of phenylethanal. [2]

.....

.....

(f) Complete the table below. Give the observations made, if any, when phenylethanal and phenylethanone are tested with the reagents shown. [3]

Test	phenylethanal $C_6H_5CH_2CHO$	phenylethanone $C_6H_5C(O)CH_3$
alkaline iodine	.....	.....
Tollens' reagent	.....	.....
warming with acidified potassium dichromate	.....	.....

20

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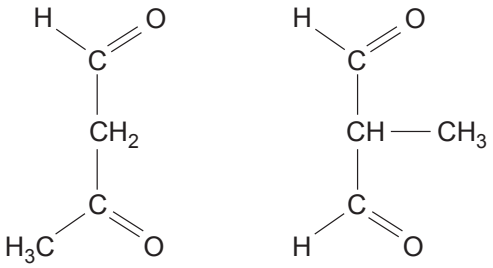
13 The formulae of compounds **Q** and **R** are shown below. Both are aldehydes.



compound **Q** compound **R**

(f) Draw the structure of the compound produced when compound **Q** reacts with excess sodium tetrahydridoborate, $NaBH_4$. [1]

18

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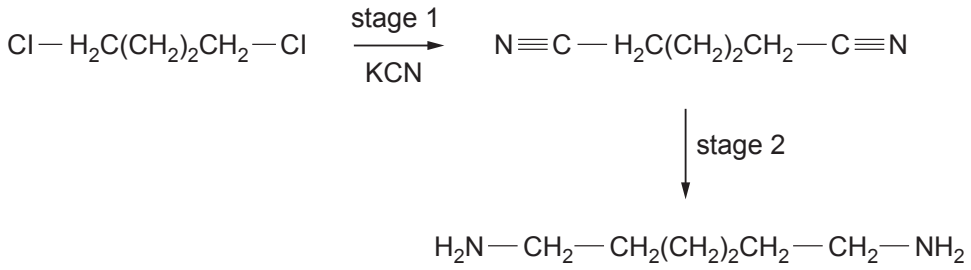
14 (b) Nylon 6,10 can be made by reacting 1,6-diaminohexane, $H_2N(CH_2)_6NH_2$, with decanedioyl dichloride, $ClOC(CH_2)_8COCl$.

(i) The flow chart shows a method for producing 1,6-diaminohexane from 1,4-dichlorobutane.



I. Give the equation for the reaction of potassium cyanide with 1,4-dichlorobutane in stage 1. [1]

.....

II. The mechanism in stage 1 is described as nucleophilic substitution.

Give the formula of the nucleophile used in this stage. [1]

.....

III. State a reducing agent that can be used in stage 2. [1]

.....

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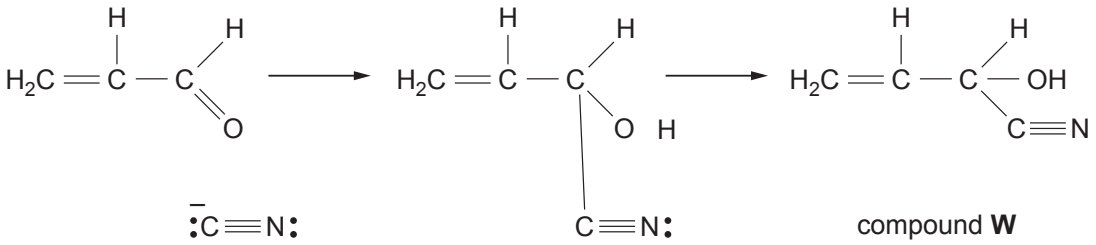
15 (v) Prop-2-enal reacts with hydrogen cyanide to give compound **W**.

The mechanism for this reaction is similar to the reaction of ethanal and hydrogen cyanide.

I. Complete the mechanism for the reaction. [2]



II. Explain why this mechanism is described as nucleophilic addition. [2]

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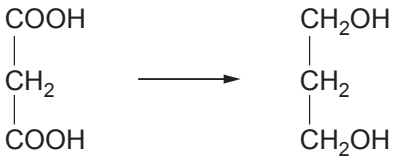
(b) Propanedioic acid can be used as a starting material in the preparation of certain polyesters.

One stage in this process is the reduction of the acid to propane-1,3-diol.

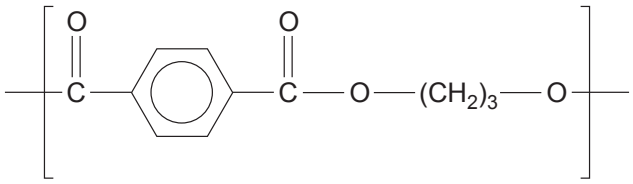


(i) State a reagent that can be used for this reaction. Explain why this process is described as reduction. [2]

.....

.....

(ii) The formula for the repeating unit of the polyester PTT is shown below.



State the name of the compound that reacts with propane-1,3-diol to give PTT. [1]

.....

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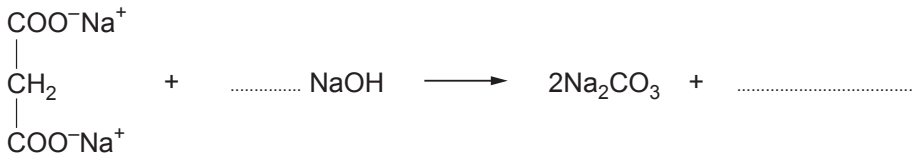
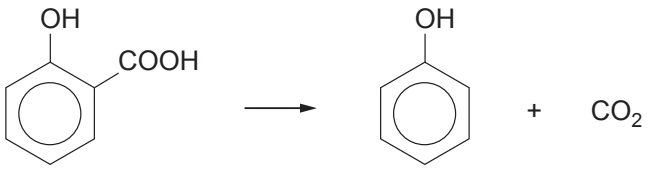
(c) (i) The process of decarboxylation can be used to reduce the number of carbon atoms in a chain, usually producing an alkane. One method is to heat the sodium salt of the acid with soda lime (shown as NaOH in the equation).

Complete the equation below that shows the decarboxylation of the sodium salt of propanedioic acid. [2]



(ii) If solid 2-hydroxybenzoic acid is slowly heated, decarboxylation occurs, giving phenol.



At intervals during this reaction, samples were removed and dissolved in water.

State a reagent that you could add to the solution to show when decarboxylation was complete. Give the observation and explain your answer. [3]

.....

.....

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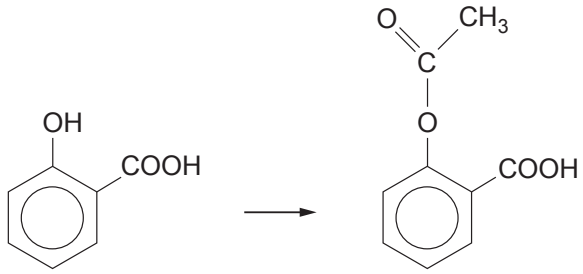
(iii) Aspirin is produced from 2-hydroxybenzoic acid by ethanoylation.



At intervals during the reaction, a few drops of the reaction mixture were added to aqueous iron(III) chloride solution.

State how you would know when the reaction was complete. [1]

.....

.....

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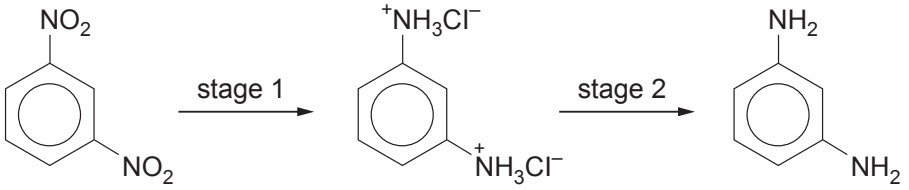
16 (b) When benzene is nitrated to form nitrobenzene, some dinitration to form 1,3-dinitrobenzene can occur if the temperature of the reaction rises too high.

(i) Starting from nitrobenzene, complete the mechanism for the formation of 1,3-dinitrobenzene. [2]

(ii) Benzene-1,3-diamine can be obtained by the reduction of 1,3-dinitrobenzene.



I. State the reagent(s) used in stage 1. [1]

.....

II. State the reagent(s) used in stage 2. [1]

.....

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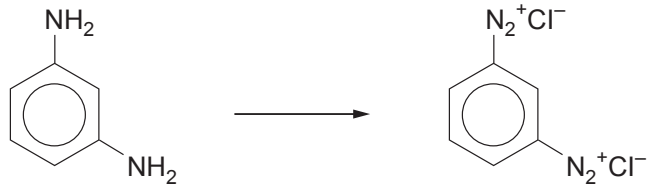
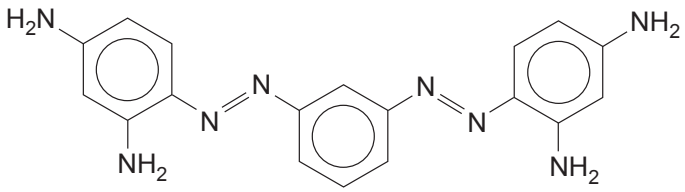
(iii) State the reagent(s) and conditions for the formation of a diazonium compound from benzene-1,3-diamine. [2]



Reagent(s) .....

Conditions .....

(iv) The diazonium compound formed in part (iii) can react with more unreacted benzene-1,3-diamine to give the azo dye Bismarck brown Y.



This dye is used as a biological stain and is sold for this purpose as a salt, produced from the dye and hydrochloric acid.

Explain how this salt is formed. [1]

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