OXFORD
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INTERNATIONAL A-LEVEL
CHEMISTRY (9620)

Unit 4: Organic 2 and Physical 2

Tuesday 22 January 2019 07:00 GMT Time allowed: 1 hour 30 minutes

Materials
For this paper you must have:
- the Periodic Table/Data Sheet, provided as an Insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
TOTAL	

Do not write outside the box

Answer **all** questions in the spaces provided.

0 1 The rate of reaction between solutions of **A** and **B** is investigated.

$$\mathbf{A} + \mathbf{B} \rightarrow \text{products}$$

Three experiments are completed at a given temperature. The results of these experiments are shown in **Table 1**.

Table 1

	Initial concentration of A / mol dm^{-3}	**Initial concentration of B / mol dm^{-3}**	**Initial rate / mol dm^{-3} s^{-1}**
Experiment 1	2.40×10^{-3}	2.80×10^{-3}	1.60×10^{-4}
Experiment 2	3.60×10^{-3}	4.20×10^{-3}	3.60×10^{-4}
Experiment 3	5.40×10^{-3}	4.20×10^{-3}	8.10×10^{-4}

0 1 . 1 Use the data in **Table 1** to deduce the order of reaction with respect to **A** and the order of reaction with respect to **B**.

Place **one** tick (✓) in the box which shows the order with respect to **A** and the order with respect to **B**.

[2 marks]

Order with respect to **A**

Zero ☐

First ☐

Second ☐

Order with respect to **B**

Zero ☐

First ☐

Second ☐

Do not write outside the box

0 1 . 2 The reaction between compounds **C** and **D** is studied at a given temperature.
The rate equation for the reaction is found to be

$$rate = k\,[\mathbf{C}]^2[\mathbf{D}]$$

When the initial concentration of **C** is 8.55×10^{-2} mol dm^{-3} and the initial concentration of **D** is 2.80×10^{-2} mol dm^{-3}, the initial rate of reaction is 9.43×10^{-4} mol dm^{-3} s^{-1}

Calculate the value of the rate constant at this temperature and deduce its units.

[3 marks]

Rate constant _____ Units _____

5

Turn over for the next question

Do not write outside the box

0 2 Iodide ions react with hydrogen peroxide to form iodine as shown.

$$H_2O_2 + 2H^+ + 2I^- \rightarrow I_2 + 2H_2O$$

A student reacted iodide ions with hydrogen peroxide at different temperatures to determine the activation energy (E_a) for this reaction.

The student measured the time taken for a set amount of iodine to be formed at different temperatures. The results from the experiment are shown in **Table 2**.

An equation that relates activation energy (E_a) to the time taken (*time*) and temperature (T), where C is a constant, is shown.

$$\ln\left(\frac{1}{time}\right) = -\frac{E_a}{RT} + \ln C$$

Table 2

Experiment	Temperature / K	Time / s	$\frac{1}{time}$ / s^{-1}	$\ln\left(\frac{1}{time}\right)$	$\frac{1}{T}$ / K^{-1}
1	306	350	2.86×10^{-3}	–5.86	3.27×10^{-3}
2	316	102	9.80×10^{-3}	–4.62	3.16×10^{-3}
3	326	35	2.86×10^{-2}	–3.56	3.07×10^{-3}
4	336	12	8.33×10^{-2}	–2.48	2.98×10^{-3}

0 2 . 1 On **Figure 1**, plot a graph of $\ln\left(\frac{1}{time}\right)$ against $\frac{1}{T}$

You should plot $\ln\left(\frac{1}{time}\right)$ on the *y*-axis and $\frac{1}{T}$ on the *x*-axis.

Draw a line of best fit through your points.

Use the gradient of your line to calculate the activation energy, in kJ mol^{-1}, for this reaction.

The gas constant, R = 8.31 J K^{-1} mol^{-1}

[5 marks]

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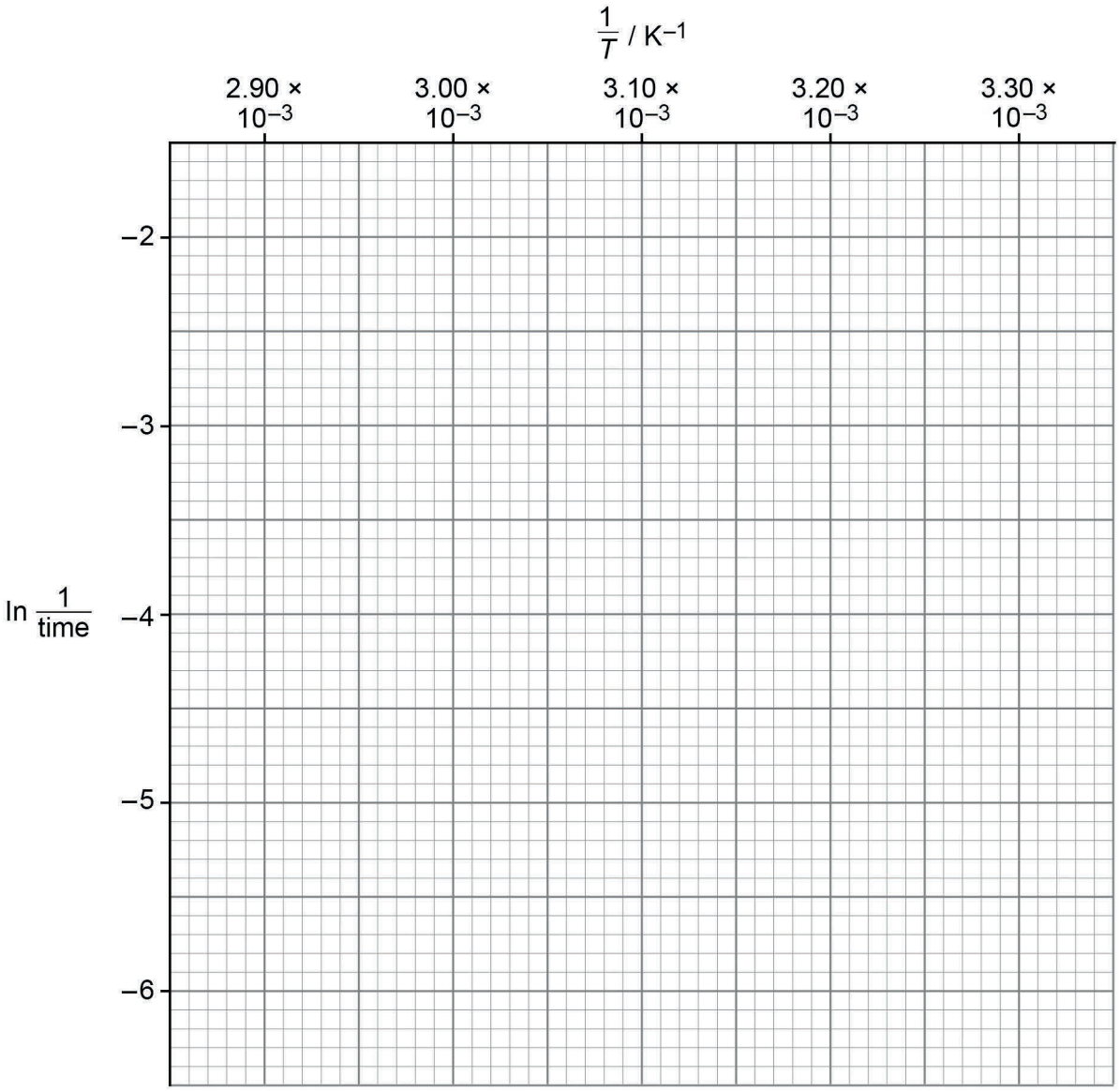
Figure 1



Activation Energy _____ kJ mol^{-1}

0 2 . 2 Suggest why the student did not repeat the experiment at temperatures higher than 336 K

[1 mark]

_____

_____

6

Turn over ►

Do not write outside the box

0 3 This question is about carboxylic acids and esters.

0 3 . 1 Butanoic acid is a weak acid.

Write an expression for the acid dissociation constant (K_a) for butanoic acid.

[1 mark]

K_a

0 3 . 2 At 298 K for butanoic acid, $K_a = 1.51 \times 10^{-5}$ mol dm^{-3}

Calculate the pH of a 0.150 mol dm^{-3} solution of butanoic acid at 298 K

Give your answer to **two** decimal places.

[3 marks]

pH _____

0 3 . 3 Write an equation to show the reaction of butanoic acid with propan-1-ol.

Identify a catalyst for this reaction.

[2 marks]

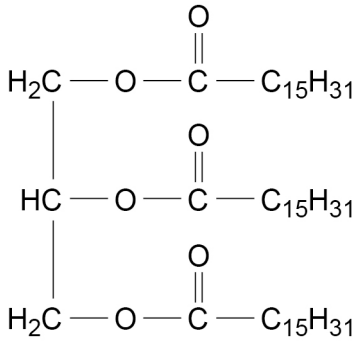
Equation

_____

Catalyst _____

Do not write outside the box

0 3 . 4 The structure of a tri-ester is shown.



Give the formula of each of the products formed when this tri-ester is hydrolysed in acid conditions.

[2 marks]

Product 1

Product 2

8

Turn over for the next question

Do not write outside the box

0 4 Propylamine can be formed in different reactions either from propanenitrile or from 1-bromopropane.

0 4 . 1 State the reagent and condition, other than temperature, for the formation of propylamine from each of these starting materials.

[3 marks]

From propanenitrile

Reagent _____

Condition _____

From 1-bromopropane

Reagent _____

Condition _____

0 4 . 2 N-methylethylamine is a secondary amine and an isomer of propylamine.

Suggest why the secondary amine is a stronger base than propylamine.

[2 marks]

_____

_____

_____

_____

5

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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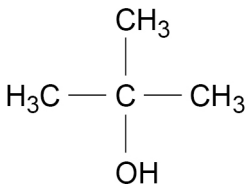
0 5 Simple test-tube reactions can be used to distinguish the following pairs of isomers.

Give a reagent, or combination of reagents, that can be added to the compounds in each pair to distinguish between them.

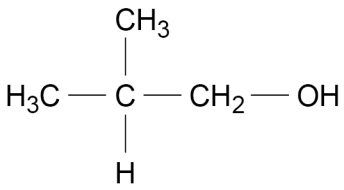
State what is observed in each case.

0 5 . 1

R



S



[3 marks]

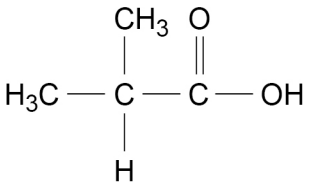
Reagent _____

Observation with **R** _____

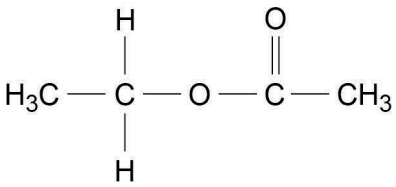
Observation with **S** _____

0 5 . 2

T



U



[3 marks]

Reagent _____

Observation with **T** _____

Observation with **U** _____

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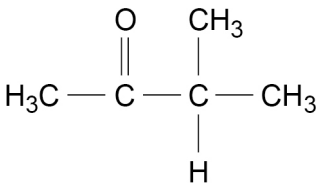
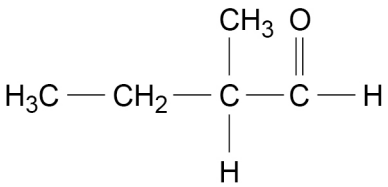
0 5 . 3

V



W



[3 marks]

Reagent _____

Observation with **V** _____

Observation with **W** _____

9

Turn over for the next question

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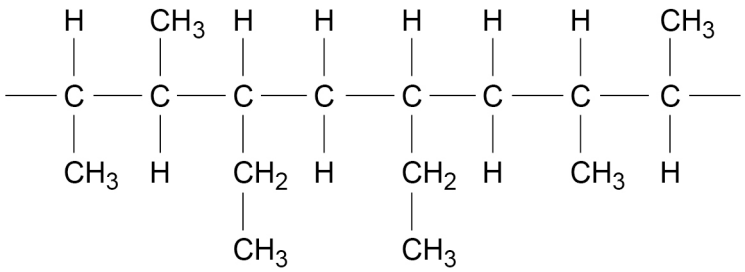
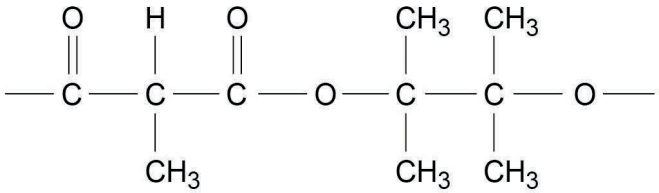
0 6 Sections of two polymers, **E** and **F**, are shown.

E



F



0 6 . 1 Polymer **E** is made from two different alkene monomers.

Draw the skeletal formula of each alkene monomer.

[2 marks]

Alkene monomer 1 **Alkene monomer 2**

Do not write outside the box

0 6 . 2 Polymer **F** is a polyester. This polyester is produced by reacting a diol with a dicarboxylic acid.

Give the structure of the diol and the structure of the dicarboxylic acid used to produce this polyester.

[2 marks]

Diol

Dicarboxylic acid

0 6 . 3 Suggest an environmental advantage of polymer **F** compared with polymer **E**.

Explain your answer.

[3 marks]

Advantage _____

Explanation _____

_____

_____

_____

7

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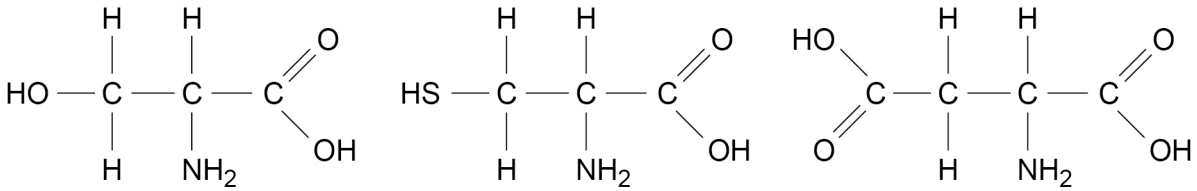
0 7 The structures of three amino acids are shown.



Serine **Cysteine** **Aspartic acid**

0 7 . 1 Use IUPAC rules to deduce the name for serine.

[1 mark]

_____

0 7 . 2 Draw the structure of the zwitterion formed by cysteine.

[1 mark]

0 7 . 3 Draw the structure of the species formed by aspartic acid at high pH.

[1 mark]

Do not write outside the box

0 7 . 4 Draw the structure of each of the two dipeptides formed when cysteine and serine react together.

[2 marks]

Dipeptide 1

Dipeptide 2

0 7 . 5 Draw the structure of the species formed when cysteine reacts with an excess of bromomethane.

[1 mark]

Do not write outside the box

0 7 . 6 Draw the structure of the species formed when serine reacts with an excess of ethanoyl chloride.

[2 marks]

0 7 . 7 A mixture of amino acids can be separated using thin-layer chromatography.

Describe how amino acids can be made visible on the chromatogram.

Explain why different amino acids have different R_f values.

[3 marks]

How amino acids are made visible _____

_____

Explanation _____

_____

_____

_____

_____

_____

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0 7 . 8 **Table 3** shows different types of bonding in proteins.

Complete **Table 3** by placing a tick (✓) in the correct column to show which level of protein structure (primary, secondary or tertiary) contains each type of bonding.

[2 marks]

Table 3

Type of bonding	**Primary**	**Secondary**	**Tertiary**
Hydrogen bonds in an α-helix			
Peptide links between amino acids			
Hydrogen bonds between $–CH_2OH$ groups in serine amino acids			
Disulfide bonds between cysteine amino acids			

13

Turn over for the next question

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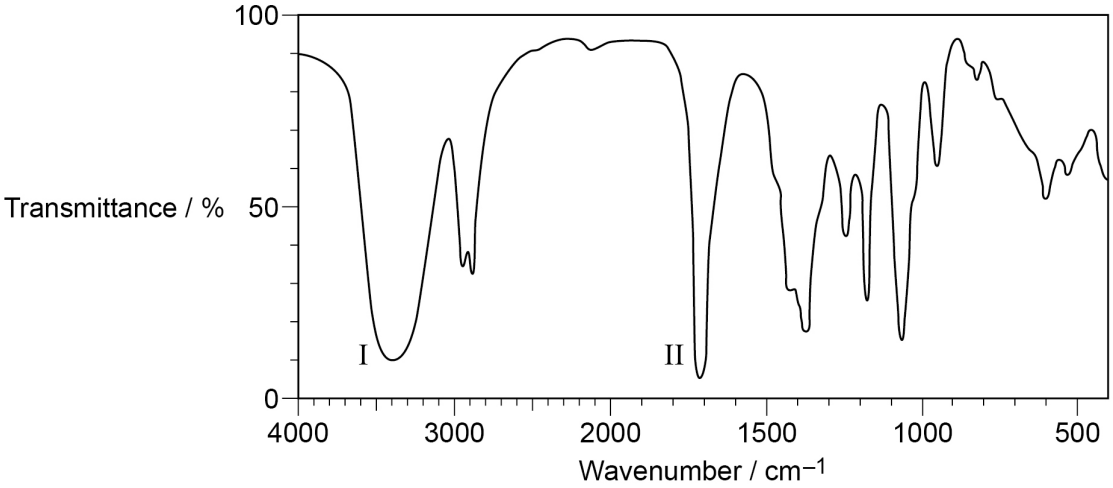
0 8 Compound **G** has the molecular formula $C_4H_8O_2$

The infrared spectrum of **G** is shown in **Figure 2**.

Figure 2



0 8 . 1 Use **Table A** on the Data Sheet to identify the bond causing the absorption labelled **I** and the bond causing the absorption labelled **II**.

[2 marks]

Bond **I** _____

Bond **II** _____

0 8 . 2 Proton (^1H) NMR spectra are recorded using solutions that contain the non-toxic and inert standard tetramethylsilane (TMS).

Give **two** other reasons why TMS is a suitable standard.

[2 marks]

Reason 1 _____

_____

Reason 2 _____

_____

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Question 8 continues on the next page

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0 8 . 3 Identify a suitable solvent to use when recording a ^{1}H NMR spectrum.

Give a reason for your choice.

[2 marks]

Solvent _____

Reason _____

The ^{1}H NMR spectrum of **G** shows four peaks. **Table 4** gives chemical shift (δ) values for the four peaks, their splitting patterns and integration values.

Table 4

δ / ppm	2.20	2.60	3.40	3.84
Splitting pattern	singlet	triplet	singlet	triplet
Integration value	0.75	0.50	0.25	0.50

Use **Figure 2**, **Table 4** and **Table B** of your Data Sheet to help you answer questions **08.4**, **08.5** and **08.6**.

0 8 . 4 Draw the part of the structure of **G** that can be deduced from the peak at δ = 2.20 ppm

[1 mark]

0 8 . 5 Draw the part of the structure of **G** that can be deduced from the peak at δ = 3.40 ppm

[1 mark]

Do not write outside the box

0 8 . 6 Draw the part of the structure of **G** that can be deduced from the peaks at δ = 2.60 ppm and δ = 3.84 ppm

[2 marks]

0 8 . 7 Deduce the structure of **G**.

[1 mark]

11

Turn over for the next question

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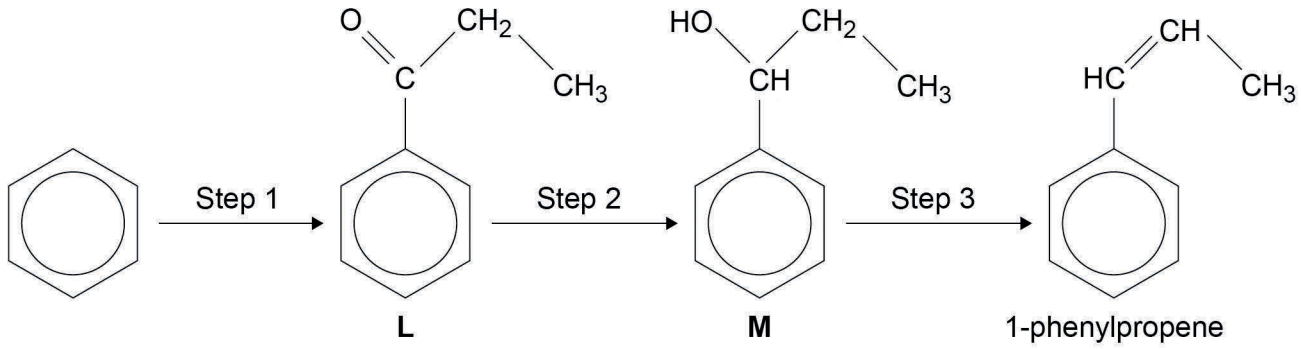
0 9 1-Phenylpropene can be prepared as shown in **Figure 3**.

Figure 3



0 9 . 1 **Step 1** involves an attack on benzene by the electrophile $[CH_3CH_2CO]^+$

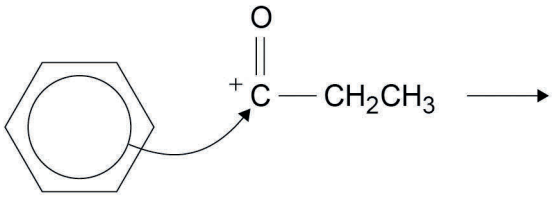
Write an equation for a reaction that forms this electrophile.

Complete the mechanism for the reaction of this electrophile with benzene.

[3 marks]

Equation _____

Mechanism



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0 9 . 2 **Step 2** involves the reaction of **L** with $NaBH_4$

Name and outline the mechanism for this reaction.

[5 marks]

Name of mechanism _____

Mechanism

Question 9 continues on page 25

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ANSWER IN THE SPACES PROVIDED

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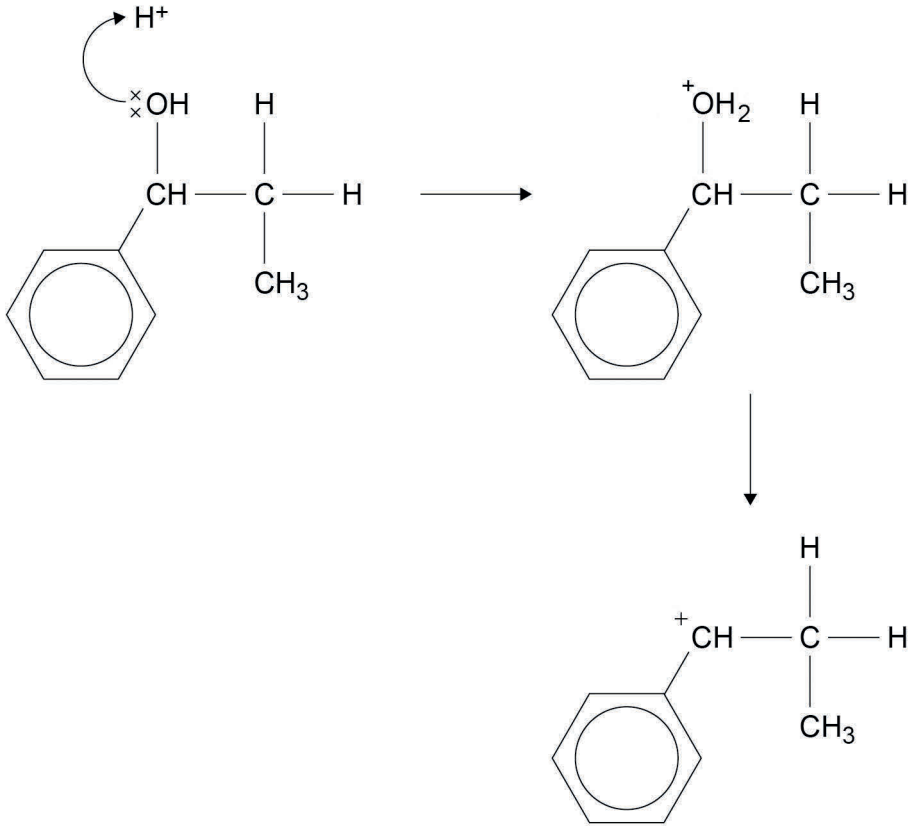
0 9 . 3 1-Phenylpropene can be formed by reacting **M** with concentrated sulfuric acid. Part of the mechanism is shown in **Figure 4**.

Draw **two** curly arrows on **Figure 4** to complete the mechanism.
You do **not** need to draw the final products.

[2 marks]

Figure 4



Question 9 continues on the next page

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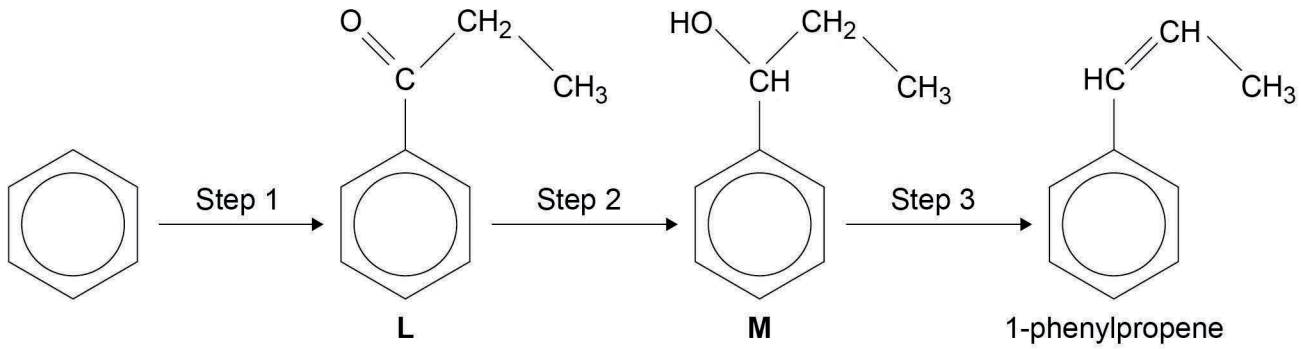
Figure 3 is repeated here.

Figure 3



0 9 . 4 **M** exists as two enantiomers.

State the meaning of the term enantiomers.

[1 mark]

_____

_____

0 9 . 5 Describe how the two enantiomers could be distinguished.

[2 marks]

_____

_____

_____

_____

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0 9 . 6 The overall percentage yield in the preparation of 1-phenylpropene from benzene is 68.0%

Calculate the minimum mass of benzene needed to produce 1.68 g of 1-phenylpropene.

[3 marks]

Mass of benzene _____ g

16

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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