

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL A-LEVEL CHEMISTRY (9620)

Unit 4: Organic 2 and Physical 2

Friday 5 June 2026

08:00 UK Time

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.

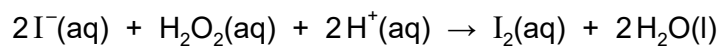
For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
TOTAL	



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

0 1

This question is about experiments to investigate the rate of a reaction. Iodide ions react with hydrogen peroxide solution in acidic conditions.

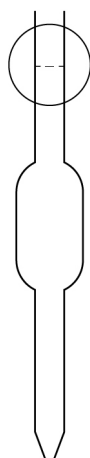


10.0 cm³ of hydrogen peroxide are added using a pipette in each experiment.

0 1 . 1

Figure 1 shows the 10.0 cm³ pipette used to measure the hydrogen peroxide solution. The area around the 10.0 cm³ line has been circled.

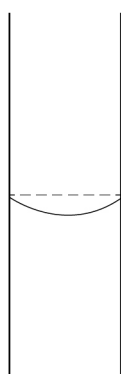
Figure 1



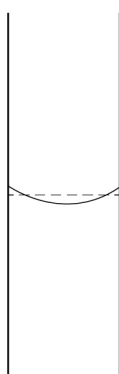
Which diagram shows the meniscus of the solution when the pipette is used to transfer 10.0 cm³ of solution?

Tick (✓) **one** box.

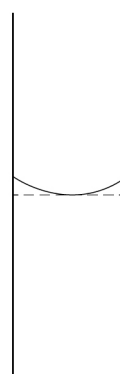
[1 mark]



A

☐


B

☐


C

☐


0 1 . 2

The initial concentration of potassium iodide is changed for each experiment. Different volumes of 0.10 mol dm^{-3} potassium iodide solution are diluted to give a total volume of 25.0 cm^3

In one experiment, 8.0 cm^3 of the potassium iodide solution are used.

Determine the concentration, in mol dm^{-3} , of potassium iodide in this solution.

Name another piece of equipment that should be used to make accurate solutions of diluted potassium iodide.

Do **not** include safety equipment.

[2 marks]

Concentration of potassium iodide _____ mol dm^{-3}

Equipment _____

0 1 . 3

The time taken, t , for a fixed amount of iodine to be produced is measured.

The initial rate of the reaction can be represented as $\frac{1}{t}$

Suggest how a graph can be used to find the order of the reaction with respect to the initial iodide ion concentration.

[2 marks]

Question 1 continues on the next page

Turn over ►



0 1 . 4 **Table 1** shows the initial rates of reaction in three experiments when the concentrations of H_2O_2 and H^+ are changed.

All other variables are kept constant.

Table 1

Initial $[\text{H}_2\text{O}_2]$ / mol dm^{-3}	Initial $[\text{H}^+]$ / mol dm^{-3}	Initial rate / $\text{mol dm}^{-3} \text{ s}^{-1}$
0.10	0.25	6.50×10^{-3}
0.06	0.25	3.90×10^{-3}
0.18	0.10	1.17×10^{-2}

The reaction is first order with respect to I^-

Use the data in **Table 1** to deduce the order of reaction with respect to H_2O_2 and the order of reaction with respect to H^+

Give the rate equation for the reaction.

[3 marks]

Order with respect to H_2O_2 _____

Order with respect to H^+ _____

Rate equation _____



0 1 . 5

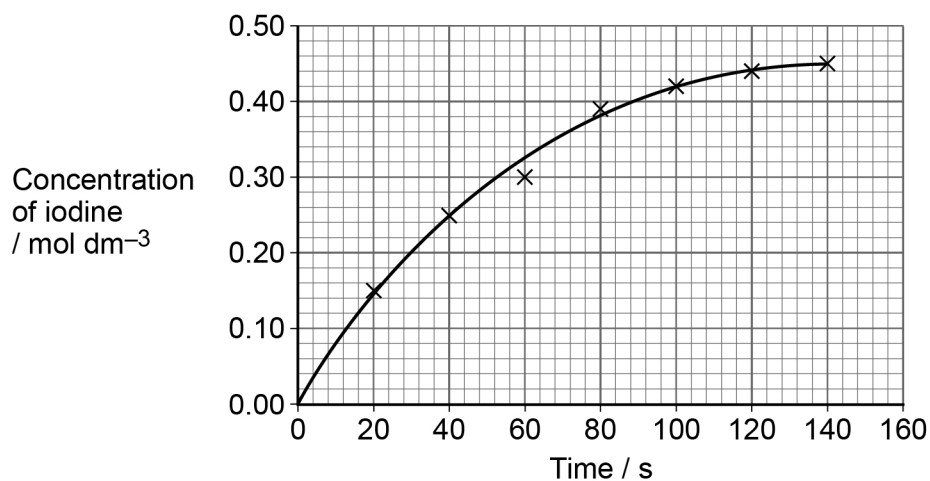
The rate of reaction can also be found by a continuous monitoring method.

The concentration of iodine formed in the reaction can be determined using a colorimeter.

The reaction mixture is placed in the colorimeter and readings taken every 20 seconds.

Figure 2 shows the results.

Figure 2



Draw a tangent on the graph in **Figure 2** at 40 s

Determine the rate of reaction at 40 s

[2 marks]

Rate at 40 s _____ mol dm⁻³ s⁻¹

10

Turn over ►



0 2

This question is about a reaction at equilibrium in a closed system.

0 2 . 1

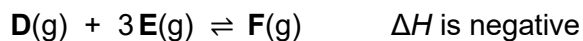
Give **two** features of a reaction at equilibrium.

[2 marks]

1 _____

2 _____

D and **E** react to form **F** in a reversible reaction.



0 2 . 2

An equilibrium mixture is formed in a closed flask at 600 K using a 1:3 mixture of **D** and **E**.

The total pressure in the flask is 0.20 MPa

The mole fraction of **F** in the equilibrium mixture is 0.68

Calculate the mole fraction of **D** and the mole fraction of **E** in the equilibrium mixture.

Calculate the partial pressure, in MPa, of **F** in the equilibrium mixture.

[3 marks]

Mole fraction of **D** _____

Mole fraction of **E** _____

Partial pressure of **F** _____ MPa



0 2 . 3

A second equilibrium mixture of **D**, **E** and **F** is formed at a different temperature and a total pressure of 2.05 MPa.

Table 2 shows the partial pressures of the gases in this second mixture.

Table 2

Gas	Partial pressure / MPa
D	0.18
E	0.22
F	1.65

The equilibrium constant for this reaction is shown.

$$K_p = \frac{p(\text{F})}{p(\text{D}) p(\text{E})^3}$$

Use the data in **Table 2** to calculate a value for K_p for this equilibrium at the different temperature.

Give the units of K_p

[3 marks]

Value of K_p _____

Units of K_p _____

0 2 . 4

A third equilibrium mixture of **D**, **E** and **F** is formed at an increased temperature and pressure and with the addition of a catalyst.

State the effect of each of these changes independently on the mole fraction of **F** and on the value of K_p

Write **increase**, **decrease** or **no change** in each box.

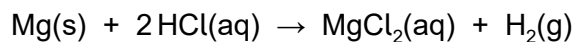
[3 marks]

Change	Effect on mole fraction of F	Effect on value of K_p
Increased temperature		
Increased pressure		
Addition of catalyst		



0 3

A student investigates the effect of changing temperature on the rate of a reaction using an initial rate method.



0 3 . 1

The initial rate can be used to calculate the rate constant, k , for the reaction at a given temperature.

Table 3 shows the calculated values of k for the reaction at four different temperatures.

Table 3

Experiment	Temperature / K	$\frac{1}{T} / \text{K}^{-1}$	k / s^{-1}	$\ln k$
1	296		235	5.46
2	303	3.30×10^{-3}	257	5.55
3	313	3.20×10^{-3}	326	
4	333	3.00×10^{-3}	624	6.44

Complete **Table 3**.

[1 mark]

0 3 . 2

The Arrhenius equation can be written in the form

$$\ln k = \ln A - \frac{E_a}{RT}$$

Use the data in **Table 3** for **Experiment 2** to calculate a value, in s^{-1} , for the Arrhenius constant, A .

The gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
 $E_a = 28.4 \text{ kJ mol}^{-1}$

[2 marks]

A _____ s^{-1}



0 3 . 3 Adding a catalyst lowers the activation energy for the reaction.

Explain why the value of k increases when a catalyst is added.

[1 mark]

0 3 . 4 The rate equation for this reaction is

$$\text{Rate} = k [\text{HCl}]$$

Suggest why adding a catalyst may lead to a different rate equation.

[1 mark]

5

Turn over for the next question

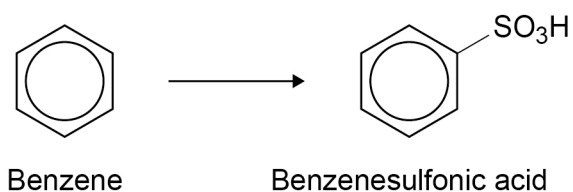
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0 4

This question is about aromatic compounds.

Benzenesulfonic acid can be formed from benzene.

**0 4 . 1**

Concentrated sulfuric acid is used to form the reactive species (SO_3) that reacts with the benzene ring.

Write the equation to show the formation of the reactive species.

[1 mark]

0 4 . 2

Name and outline a mechanism for the formation of benzenesulfonic acid from benzene.

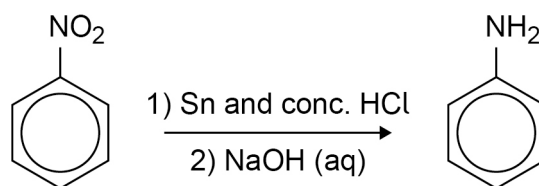
[4 marks]

Name of mechanism _____

Mechanism



Nitrobenzene can be reduced to phenylamine using Sn and concentrated HCl



0	4	.	3
---	---	---	---

Suggest why sodium hydroxide is added after the reduction of nitrobenzene has taken place.

[1 mark]

0	4	.	4
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Explain why phenylamine is a weaker base than ammonia.

[2 marks]

8

Turn over for the next question

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0 5

This question is about isomers.

0 5 . 1

State what is meant by optical isomers.

[1 mark]

0 5 . 2

Organic optical isomers contain a common structural feature.

Name and describe this structural feature.

[2 marks]

Name _____

Description _____

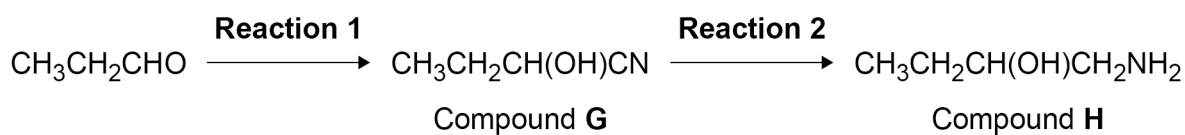
0 5 . 3

Describe how a pair of optical isomers can be distinguished from each other.

[2 marks]

Question 5 continues on the next page**Turn over ►**

A synthesis of **Compound H** is shown.



0 5 . 4 Use IUPAC rules to name **G**.

[1 mark]

0 5 . 5 Give the reactant(s) used in **Reaction 1**.

[1 mark]

0 5 . 6 Name and outline the mechanism that takes place in **Reaction 1**.

[3 marks]

Name of mechanism _____

Mechanism



0 5 . 7

Explain why the sample of **G** made in **Reaction 1** is **not** optically active.

[3 marks]

0 5 . 8

Give the reactant(s) and condition(s) used in **Reaction 2**.

[1 mark]

0 5 . 9

H reacts with concentrated sulfuric acid in an elimination reaction to form a mixture of products that show stereoisomerism.Give the structure of an *E*-isomer that is formed.

[1 mark]

Turn over for the next question



0 6

This question is about benzene.

0 6 . 1

Benzene is less reactive than other unsaturated compounds.

Table 4 shows the enthalpy of hydrogenation of benzene and cyclohexene.**Table 4**

	Enthalpy of hydrogenation / kJ mol^{-1}
Benzene	– 208
Cyclohexene	–120

Use data in **Table 4** to calculate the enthalpy of hydrogenation of the theoretical molecule cyclohexa-1,3,5-triene.

Deduce the difference between your calculated value and the enthalpy of hydrogenation of benzene in **Table 4**.

Explain this difference.

[3 marks]

0 6 . 2

Give a reagent that can be used to show that benzene does **not** contain reactive C=C bonds.

State the observation.

[2 marks]

Reagent _____

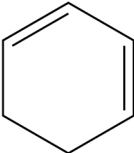
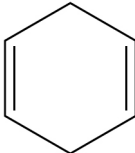
Observation _____



0 6 . 3 Which compound has the least exothermic enthalpy of hydrogenation?

Tick (✓) **one** box.

[1 mark]

6

Turn over for the next question

Turn over ►

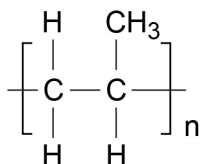
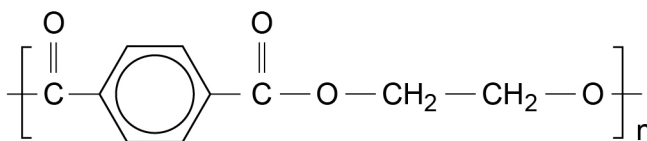


0 7

This question is about polymers.

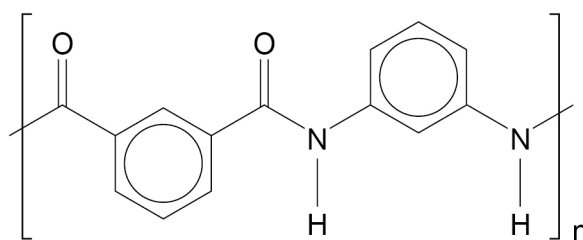
0 7 . 1

Two polymers are shown.

Polymer **S**Polymer **T**State the type of polymer shown as **S** and state the type of polymer shown as **T**.**[1 mark]****S** _____**T** _____**0 7 . 2**Explain, in terms of bonding in each polymer, why Polymer **S** is **not** biodegradable, but Polymer **T** **is** biodegradable.**[2 marks]**



0 7 . 3 Give the **two** monomers that form this polymer.



[1 mark]

4

Turn over for the next question

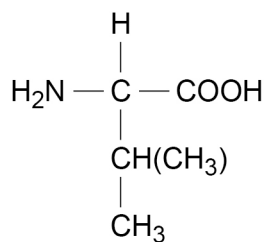
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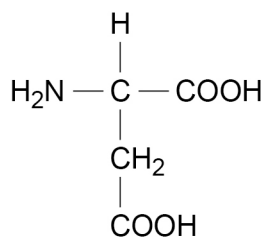
0 8

This question is about amino acids and chromatography.

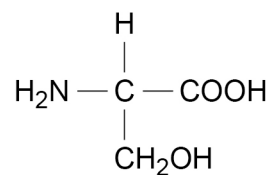
Valine, aspartic acid and serine are amino acids.



Valine



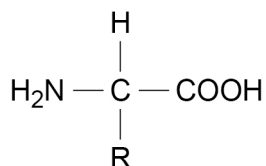
Aspartic acid



Serine

0 8**1**

Name and outline a mechanism for the reaction between valine and ethanoyl chloride. You should represent valine as

**[4 marks]**

Name of mechanism _____

Mechanism



0 8 . 2

Give the structure of the organic species present in a solution of aspartic acid at pH = 12

[1 mark]

0 8 . 3

Draw the structure of the organic product formed when serine reacts with an excess of ethanol in acidic conditions.

[1 mark]

0 8 . 4

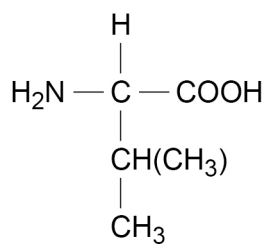
Draw the structure of the organic compound formed when 1 mol of serine reacts with 1 mol of 2-chloropropane.

[1 mark]

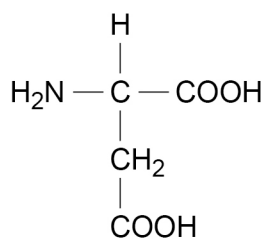
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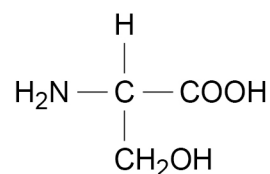
0 8 . 5 The structures of the three amino acids are repeated here.



Valine



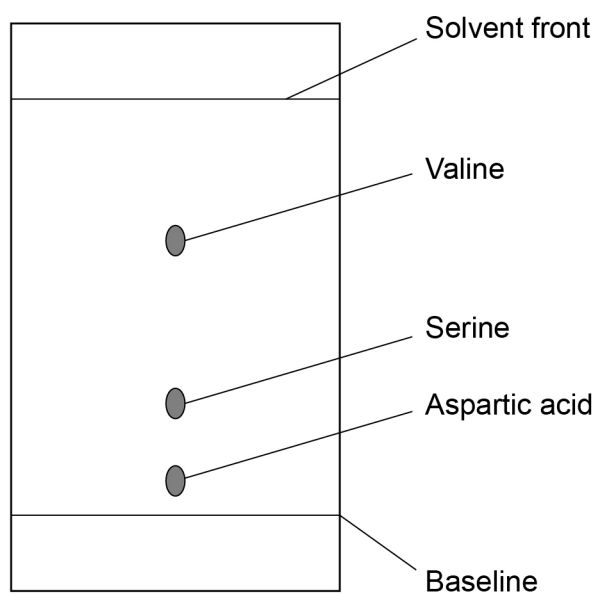
Aspartic acid



Serine

A mixture of the three amino acid molecules is separated using thin layer chromatography. The stationary phase used is polar and the mobile phase is non-polar.

Figure 3 shows the thin layer chromatography plate produced.

Figure 3

State how the positions of the amino acids can be shown on the thin layer chromatography plate.

Explain, in terms of structure, why the amino acid molecules appear in these positions on the plate.

Calculate the R_f value for **valine**.

[4 marks]

How the positions of the amino acids are shown _____

Explanation _____

R_f value for **valine** _____

11

Turn over for the next question

Turn over ►



0 9

This question is about the reactions of alcohols and spectroscopy.

0 9 . 1

Hexan-1-ol ($\text{CH}_3(\text{CH}_2)_5\text{OH}$) is heated under reflux with an excess of acidified potassium dichromate(VI) until no further oxidation occurs.

Write an equation for this reaction.

Use [O] to represent the oxidising agent.

State the colour change observed during this oxidation reaction.

[2 marks]

Equation

Colour change _____

0 9 . 2

Which isomer of hexan-1-ol will **not** undergo oxidation using the reagents and conditions in Question **09.1**?

Tick (✓) **one** box.

[1 mark]

$(\text{CH}_3)_2\text{CHCH}(\text{CH}_3)\text{CH}_2\text{OH}$

☐

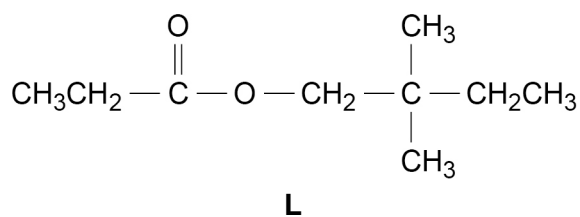
$(\text{CH}_3)_3\text{CCH}(\text{OH})\text{CH}_3$

☐

$(\text{CH}_3)_2\text{CHC}(\text{CH}_3)_2\text{OH}$

☐

Compound **K** is an isomer of hexan-1-ol and reacts with propanoic acid to make ester **L**.



0 9 . 3 Draw the skeletal formula of **K**.

[1 mark]

0 9 . 4 Deduce the number of peaks in the ^{13}C NMR spectrum of **L**.

[1 mark]

Question 9 continues on the next page

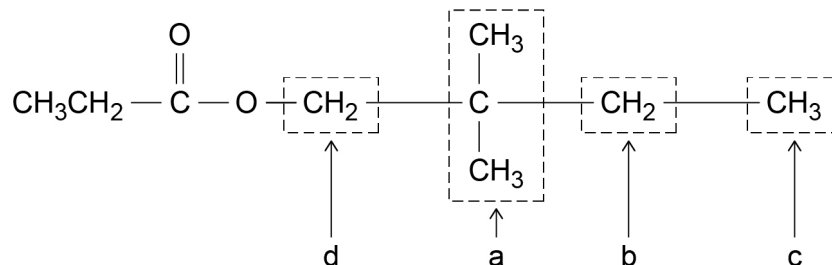
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The ^1H NMR spectrum of **L** was taken.

Figure 4 shows **L** with some sections labelled.

Figure 4



0 9 . 5

Complete **Table 5** to give the integration value and the splitting pattern for the three peaks caused by the hydrogen atoms in the sections labelled **a**, **b** and **c** in **Figure 4**.

[3 marks]

Table 5

Section	Integration value	Splitting pattern
a		
b		
c		

0 9 . 6

Use **Table B** on the Chemistry Data Sheet and the structure of **L** in **Figure 4** to predict the chemical shift for the peak caused by the hydrogen atoms in the section labelled **d**.

Explain why this peak is a singlet.

[2 marks]

Chemical shift _____

Explanation _____

10

END OF QUESTIONS



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