OXFORD AQA

INTERNATIONAL QUALIFICATIONS

Please write clearly in block capitals.

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I declare this is my own work.

INTERNATIONAL A-LEVEL

CHEMISTRY (9620)

Unit 4: Organic 2 and Physical 2

Wednesday 14 January 2026 07:00 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.

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

Information

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

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

Do not write outside the box

0 1 This question is about aldehydes and ketones.

0 1 . 1 Aldehydes and ketones contain the carbonyl functional group.

Explain why the carbonyl group reacts with nucleophiles.

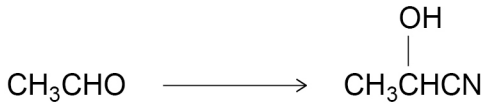
[2 marks]

0 1 . 2 **Compound A** reacts with aqueous ethanolic KCN and dilute acid to make **Compound B**.

Outline the mechanism for this reaction.

Use IUPAC rules to name **B**.

[3 marks]



A **B**

Mechanism

Name of **B** _____

Do not write outside the box

Compound B can be converted into **Compound C**.

B **C**

0 1 . 3 State the type of reaction.

Identify a reagent or combination of reagents for the reaction of **B** to make **C**.

[2 marks]

Type of reaction _____

Reagent(s) _____

0 1 . 4 **C** exists as a pair of stereoisomers.

Draw 3D representations of the stereoisomers of **C** to show how their structures are related.

[1 mark]

8

Turn over for the next question

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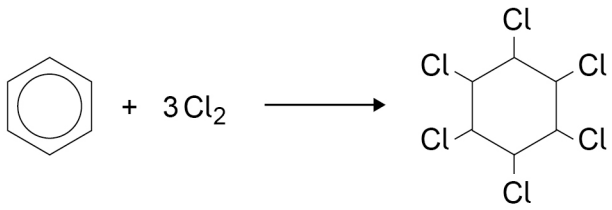
0 2 This question is about aromatic compounds.

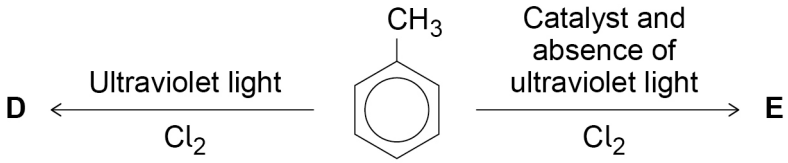
0 2 . 1 Benzene reacts with chlorine.



Name this type of reaction.

[1 mark]

0 2 . 2 Methylbenzene also reacts with chlorine.
Compound D is made in the presence of ultraviolet light.
Compound E is made when electrophilic substitution takes place with chlorine at room temperature in the presence of a catalyst.



Name the mechanism of the reaction to make **D**.

Suggest the catalyst used in the reaction to make **E**.

Draw a structure for **D**.

Draw a structure for **E**.

[4 marks]

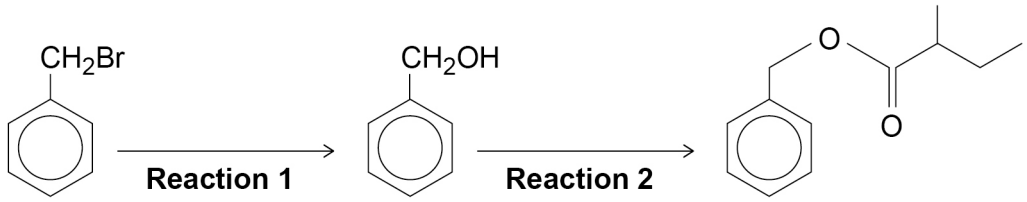
Name of mechanism _____

Catalyst _____

Structure for D	Structure for E

Do not write outside the box

A reaction sequence is shown.



Compound **F**

0 2 . 3 Give the reagent and the conditions for **Reaction 1**.

[2 marks]

Reagent _____

Conditions _____

0 2 . 4 A carboxylic acid is used as the reagent for **Reaction 2**.

Draw the displayed formula of the carboxylic acid.

Give the conditions for **Reaction 2**.

[2 marks]

Displayed formula

Conditions _____

_____

0 2 . 5 Give the empirical formula of **F**.

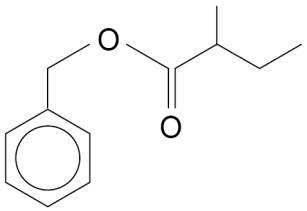
[1 mark]

_____

Turn over ►

Do not write outside the box

0 2 . 6 Compound **F** is repeated here.



F

Which is the IUPAC name for **F**?

Tick (✓) **one** box.

[1 mark]

Phenyl 2-methylbutanoate ☐

Phenyl 3-methylbutanoate ☐

Phenylmethyl 2-methylbutanoate ☐

Phenylmethyl 3-methylbutanoate ☐

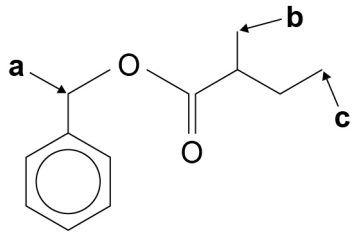
0 2 . 7 **F** is analysed using spectroscopy.

State the number of peaks in the ^{13}C NMR spectrum of **F**.

[1 mark]

Do not write outside the box

0 2 . 8 The peaks in the ^{1}H NMR spectrum of **F** caused by the parts of the molecule labelled **a**, **b** and **c** are studied.



Complete **Table 1** to show the integration value and the splitting pattern for these peaks.

[2 marks]

Table 1

Section	Integration value	Splitting pattern
a		
b		
c		

14

Turn over for the next question

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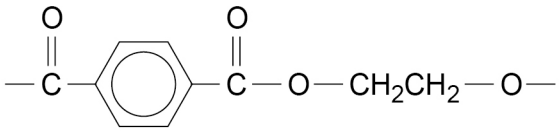
0 3 This question is about polymers.

0 3 . 1 **Figure 1** shows the repeating unit of a condensation polymer.

Figure 1



Name the monomers used to make this condensation polymer.

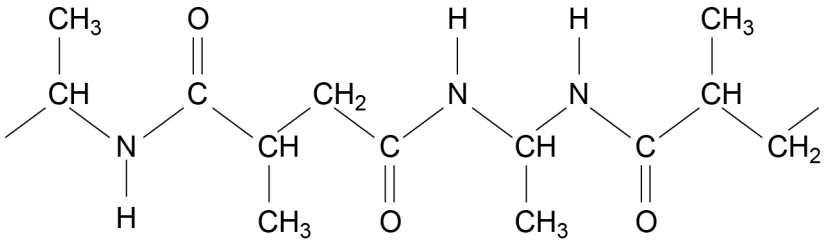
[1 mark]

Monomer 1 _____

Monomer 2 _____

0 3 . 2 **Figure 2** shows a section of a different polymer.

Figure 2



Draw brackets [ ] on **Figure 2** to identify the repeating unit of the polymer.

[1 mark]

0 3 . 3 Explain why the polymers in **Figure 1** and **Figure 2** are biodegradable.

[1 mark]

_____

_____

3

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Turn over for the next question

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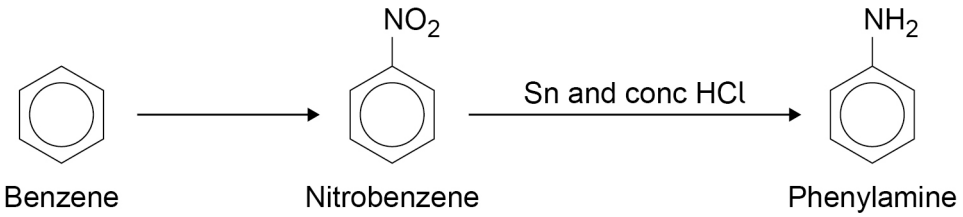
0 4 This question is about amines.

Phenylamine can be synthesised as shown.



0 4 . 1 In the first step of this synthesis, benzene reacts with a reactive species.

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

[1 mark]

0 4 . 2 At the end of the synthesis, the solution formed is evaporated.
An organic product that is **not** phenylamine is isolated as a white solid.

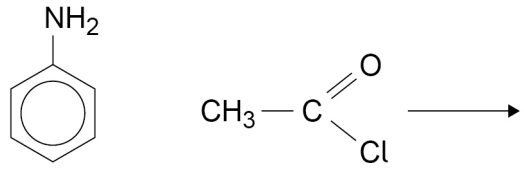
Suggest the identity of this white solid.

[1 mark]

0 4 . 3 Phenylamine can react with carboxylic acid derivatives.

Outline the mechanism for the reaction of phenylamine with ethanoyl chloride.

[3 marks]



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0 4 . 4 Dimethylamine $(CH_3)_2NH$ is a secondary amine.

Write an equation for the reaction of an **excess** of dimethylamine with 2-bromopropane.

[1 mark]

Equation

---

0 4 . 5 Draw the product formed when an **excess** of 2-bromopropane reacts with dimethylamine.

[1 mark]

7

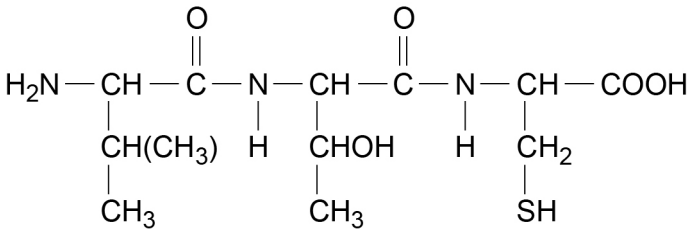
Turn over for the next question

Do not write outside the box

0 5 This question is about amino acids and proteins.

Figure 3 shows a tripeptide.

Figure 3



0 5 . 1 Suggest a reagent that can be used to hydrolyse this tripeptide.

[1 mark]

0 5 . 2 After hydrolysis, the amino acid mixture is purified and then analysed using time of flight (TOF) mass spectrometry.

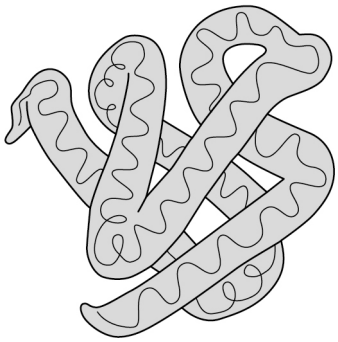
Identify the amino acid from the tripeptide in **Figure 3** that would be detected first when analysed using TOF mass spectrometry.

[1 mark]

Do not write outside the box

0 5 . 3 **Figure 4** shows the structure that long chains of amino acids can form.

Figure 4



Ionic and hydrogen bonding hold the structure together.
The structure is maintained by one other interaction.

Name the type of structure.

Identify this other interaction.

[2 marks]

Type of structure _____

Interaction _____

0 5 . 4 Give the structure of cisplatin.

Explain how cisplatin acts as an anticancer drug.

State why this treatment can have adverse side effects.

[4 marks]

Structure of cisplatin

_____

Explanation _____

_____

_____

_____

Reason for side effects _____

_____

8

Turn over ►

Do not write outside the box

0 6 This question is about purifying and identifying organic solids.

0 6 . 1 Benzenecarboxylic acid can be purified by recrystallisation using water as the solvent.

Explain the property of benzenecarboxylic acid that allows water to be used as the solvent for recrystallisation.

[1 mark]

0 6 . 2 When crystals of benzenecarboxylic acid have formed, they are separated from the water.

Draw and label the equipment used to separate the crystals by filtration under reduced pressure.

[2 marks]

0 6 . 3 One advantage of filtration under reduced pressure is that it is faster than simple filtration.

State **one** other advantage of filtration under reduced pressure.

[1 mark]

Do not write outside the box

0 6 . 4 A student completed this process and obtained a yield over 100%.

Suggest a reason why the mass was higher than expected.

[1 mark]

0 6 . 5 Ethanol can also be used instead of water as the solvent in this recrystallisation.

Give **one** safety reason why the student did **not** use ethanol as the solvent.

[1 mark]

0 6 . 6 The student took a melting point to confirm they had obtained a pure sample of benzenecarboxylic acid.

State **two** ways that the melting point value shows that the sample is pure.

[2 marks]

1

2

8

Turn over for the next question

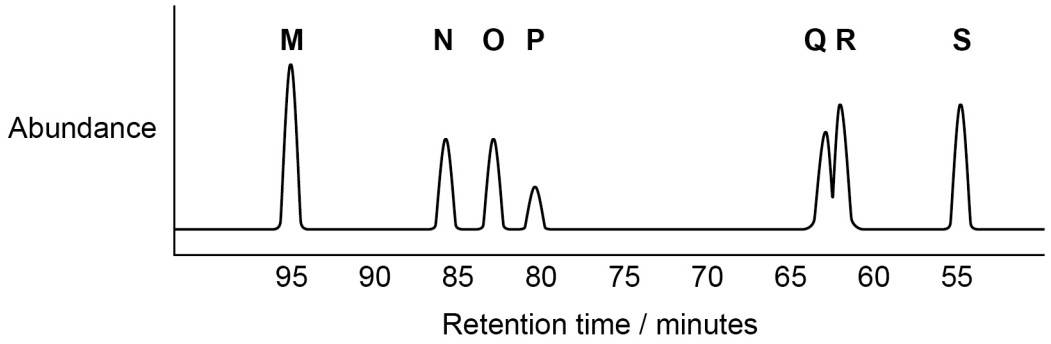
Do not write outside the box

0 7 This question is about gas chromatography.

Figure 5 shows the chromatogram of a mixture of hydrocarbons separated from crude oil.

The mixture contains hydrocarbon molecules **M** to **S** all with M_r = 114.0

Figure 5



0 7 . 1 State the type of material used as the stationary phase in the chromatography column.

[1 mark]

0 7 . 2 Retention time depends on the balance in the attraction between the molecules and the mobile phase and the stationary phase.

Which is the strongest attraction between the molecules **M** to **S** and the mobile phase and the stationary phase?

Tick (✓) **one** box.

[1 mark]

Hydrogen bonding ☐

Induced dipole-dipole forces ☐

Ionic bonding ☐

Permanent dipole-dipole forces ☐

Do not write outside the box

0 7 . 3 The molecules that cause peak **S** are branched hydrocarbons with a chain length of 4 carbon atoms.

Identify the molecules that cause peak **S**.

[2 marks]

0 7 . 4 Another sample of the mixture of hydrocarbons from crude oil was thermally cracked. The products of this thermally-cracked sample are analysed using gas chromatography.

Suggest how this gas chromatogram differs from **Figure 5**.

[1 mark]

5

Turn over for the next question

Do not write outside the box

0 8 This question is about the equilibrium reactions of some nitrogen compounds.

Ammonia decomposes according to the equation

$$2\,NH_3(g) \rightleftharpoons N_2(g) + 3\,H_2(g) \qquad \Delta H = +\,92.0\ kJ\ mol^{-1}$$

0 8 . 1 When equilibrium is reached, the mole fraction of $NH_3(g)$ in the mixture is 0.480

Calculate the mole fraction of N_2 **and** the mole fraction of H_2 in the equilibrium mixture.

[2 marks]

Mol fraction N_2 _____

Mol fraction H_2 _____

0 8 . 2 A second sample of ammonia is placed in a closed container in the presence of a catalyst at a given temperature.

When equilibrium is reached, the total pressure in the flask is 200 kPa and the mole fractions of the gases are given in **Table 2**.

Table 2

Gas	Mole fraction	Partial pressure / kPa
NH_3	0.250	
N_2	0.1875	
H_2	0.5625	

Calculate the partial pressure of each gas **and** complete **Table 2**.

Use the following expression to calculate the value of K_p for the reaction at this temperature.

$$K_p = \frac{p(N_2)\,p(H_2)^3}{p(NH_3)^2}$$

[2 marks]

Value of K_p _____

Do not write outside the box

0 8 . 3 The experiment is repeated at a higher temperature.

State how the value of K_p changes at this higher temperature.

Explain your answer.

[3 marks]

How K_p changes _____

Explanation _____

_____

_____

_____

_____

0 8 . 4 Nitrogen dioxide decomposes according to the equation

$$NO_2(g) \rightleftharpoons NO(g) + \frac{1}{2}O_2(g) \qquad \Delta H = +56.6 \text{ kJ mol}^{-1}$$

Give an expression for K_p

Give the units of K_p for this reaction when the total pressure is measured in kPa.

[2 marks]

K_p

Units _____

Question 8 continues on the next page

Do not write outside the box

0 8 . 5 0.108 mol of nitrogen dioxide decomposes at 250 K in a closed container of volume 1.50 dm^3
0.054 mol of nitrogen dioxide is present in the equilibrium mixture.

Calculate the total amount of gas, in mol, in the equilibrium mixture.

Calculate the total pressure, in kPa, of the equilibrium mixture.

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

[3 marks]

Total amount of gas in the equilibrium mixture _____ mol

Total pressure _____ kPa

0 8 . 6 The industrial decomposition of nitrogen dioxide uses a catalyst.

Suggest the effect of a catalyst on the value of K_p **and** on the rate of reaction.

[2 marks]

Effect on value of K_p _____

Effect on the rate of reaction _____

14

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0 9 This question is about the rate of hydrolysis of esters.

0 9 . 1 Ester **Q** is hydrolysed in alkaline conditions at a given temperature for a range of concentrations.

Table 3 shows rate of reaction data from this experiment.

Table 3

[Q] / mol dm^{-3}	[NaOH] / mol dm^{-3}	Rate / mol dm^{-3} s^{-1}
0.060	0.100	4.50×10^{-5}
0.060	0.300	1.35×10^{-4}
0.180	0.200	2.70×10^{-4}

Deduce the order with respect to **Q** and the order with respect to NaOH.

Write the rate equation for this reaction.

Calculate the value of the rate constant, *k*, at this temperature.

[4 marks]

Order with respect to **Q** _____

Order with respect to NaOH _____

Rate equation _____

k _____

Do not write outside the box

0 9 . 2 The hydrolysis of a different ester is completed at a range of temperatures. The value of the rate constant, k, is calculated for each temperature.

Table 4 shows some data.

Table 4

Temperature / K	$\frac{1}{T}$ / K^{-1}	k	ln k
308	3.25×10^{-3}	0.0150	–4.20
	3.19×10^{-3}	0.0229	–3.78
318	3.14×10^{-3}	0.0324	–3.43
323	3.10×10^{-3}		–3.16
328	3.05×10^{-3}	0.0608	–2.80

Complete **Table 4**.

[1 mark]

Do not write outside the box

0 9 . 3 The Arrhenius equation can be written in the form

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

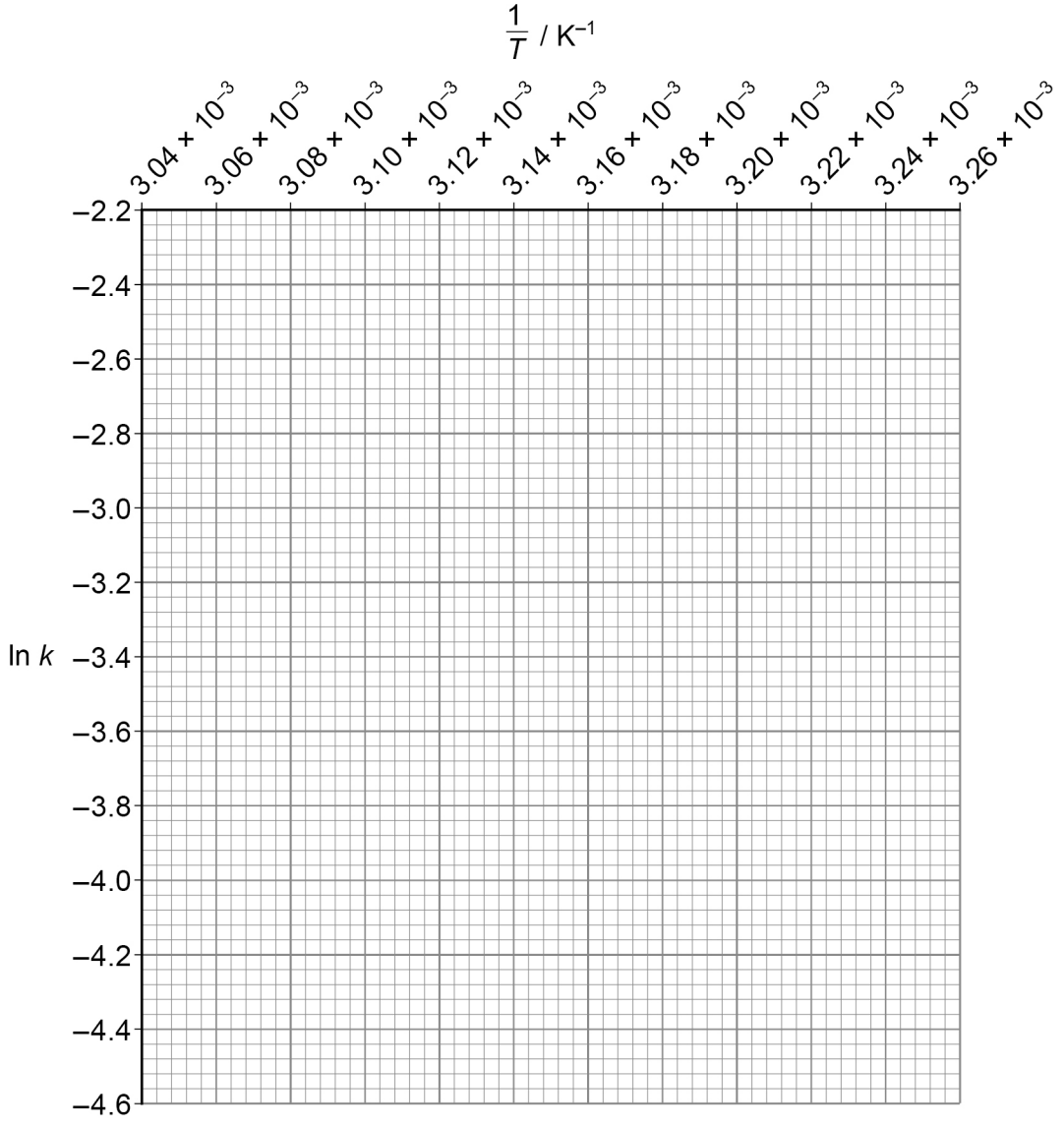
Use data from **Table 4** to plot a graph of ln k against $\frac{1}{T}$ on **Figure 6**.

Calculate the activation energy, E_a, in kJ mol^{-1}

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

[4 marks]

Figure 6



E_a _____ kJ mol^{-1}

Turn over ►

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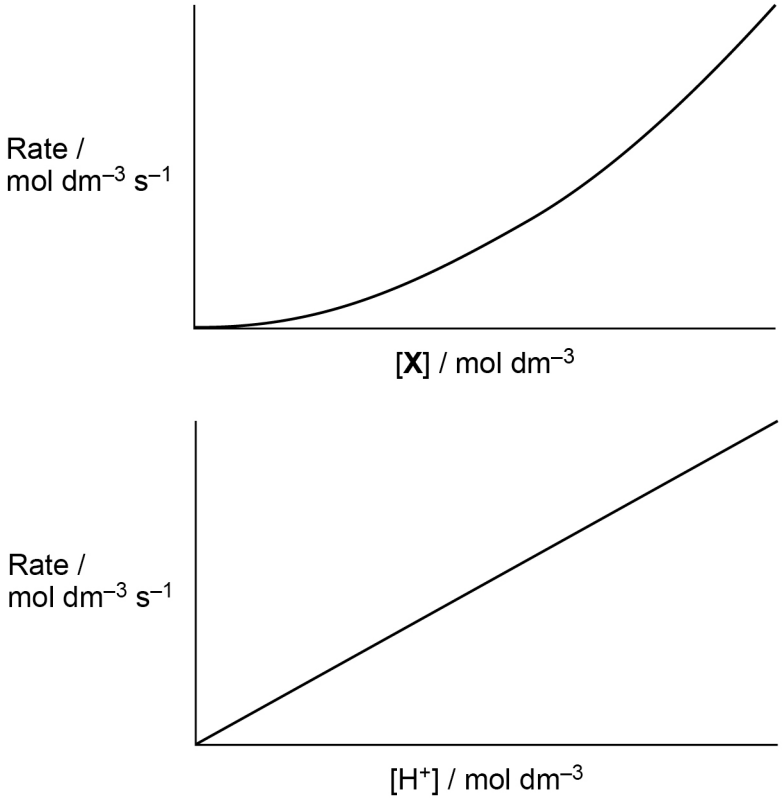
0 9 . 4 A third ester, **X**, is hydrolysed in acidic conditions according to the equation

$$\mathbf{X} \rightarrow \mathbf{Y} + 2\mathbf{Z}$$

The hydrolysis is studied using a series of experiments.
Figure 7 shows the results of the experiments.

Figure 7



Use **Figure 7** to deduce the order of reaction with respect to **X**.

State the role of H^+ in the reaction.

Justify your answers.

[4 marks]

Order with respect to **X** _____

Justification _____

_____

Role of H^+ _____

Justification _____

_____

13

END OF QUESTIONS

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