OXFORD

INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

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Candidate signature _____

I declare this is my own work.

INTERNATIONAL A-LEVEL

CHEMISTRY (9620)

Unit 4: Organic 2 and Physical 2

Monday 16 January 2023 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.
- 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).
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- 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	
TOTAL	

Do not write outside the box

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

0 1 This question is about the equilibrium reaction to form ammonia.

$$N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$$

Nitrogen and hydrogen are mixed together in a container of volume 2.25×10^4 cm^3 and allowed to reach equilibrium at 150 kPa and 350 °C

0 1 . 1 Calculate the total amount, in moles, of gas in the equilibrium mixture.

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

[3 marks]

Amount _____ mol

0 1 . 2 A different equilibrium mixture, at the same temperature and pressure, contains a total of 0.800 mol of the same gases. The amount of nitrogen is 0.450 mol and the amount of hydrogen is 0.171 mol

Calculate the partial pressure, in kPa, of ammonia in the equilibrium mixture.
Give your answer to 3 significant figures.

[3 marks]

Partial pressure _____ kPa

Do not write outside the box

0 1 . 3 Write an expression for the equilibrium constant (K_p) for this equilibrium.

[1 mark]

K_p

0 1 . 4 What effect, if any, does adding a catalyst have on the value of K_p for this reaction?

Tick (✓) **one** box.

[1 mark]

K_p increases. ☐

K_p stays the same. ☐

K_p decreases. ☐

8

Turn over for the next question

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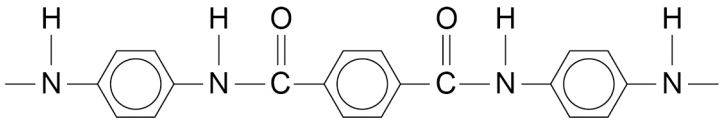
0 2 This question is about polymers.

Kevlar is a polyamide.

A section of this polymer is shown.



0 2 . 1 Draw the structures of the two monomers used to make Kevlar.

[2 marks]

monomer 1 monomer 2

0 2 . 2 State the strongest type of intermolecular force between the polymer chains in Kevlar.

[1 mark]

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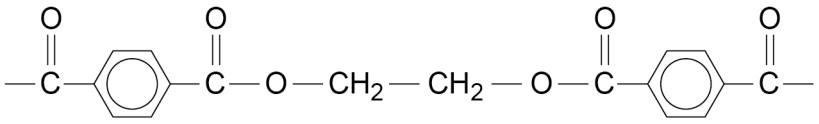
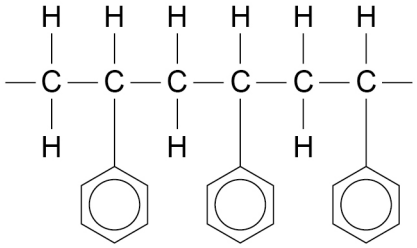
Polymers **A** and **B** also contain benzene rings.

Sections of these polymers are shown.

A



B



0 2 . 3 Name the type of polymerisation used to make polymer **A** from its monomers.

[1 mark]

0 2 . 4 Explain why **A** is biodegradable but **B** is not.

[3 marks]

7

Turn over for the next question

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0 3 Ammonia, methylamine and phenylamine are all bases.

0 3 . 1 Give the formula of the strongest base and the formula of the weakest base.

[1 mark]

strongest base weakest base

0 3 . 2 Explain the difference in base strength between phenylamine and ammonia.

[2 marks]

0 3 . 3 Write an equation for the reaction of methylamine with hydrochloric acid.

[1 mark]

Methylamine can also act as a nucleophile.

0 3 . 4 Write an equation for the reaction of an excess of methylamine with bromoethane to form a secondary amine.

[2 marks]

Do not write outside the box

Under different conditions a quaternary ammonium salt can be formed from the reaction of methylamine with an excess of bromoethane.

0 3 . 5 Give the structural formula of the quaternary ammonium salt formed.

[1 mark]

0 3 . 6 Give **one** use of a quaternary ammonium salt.

[1 mark]

8

Turn over for the next question

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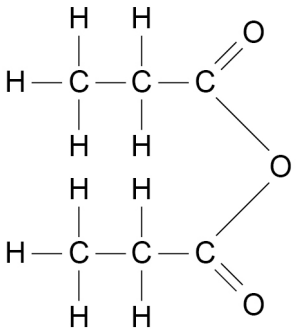
0 4 Esters can be formed in several ways.

A student prepares an ester by reacting ethanol with compound **C**.

C



0 4 . 1 Name **C**.

[1 mark]

---

0 4 . 2 Draw the structures of the ester and the other product formed in the reaction between ethanol and **C**.

[2 marks]

Ester

Other product

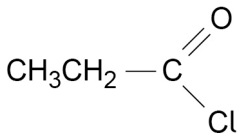
Do not write outside the box

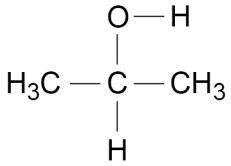
0 4 . 3 The student produces a different ester by reacting propan-2-ol with CH_3CH_2COCl

Name and outline the mechanism for this reaction.

[4 marks]

Name of mechanism _____





0 4 . 4 Give **one** reason why the reaction shown in Question **04.3** is **not** often used in industry.

[1 mark]

_____

_____

8

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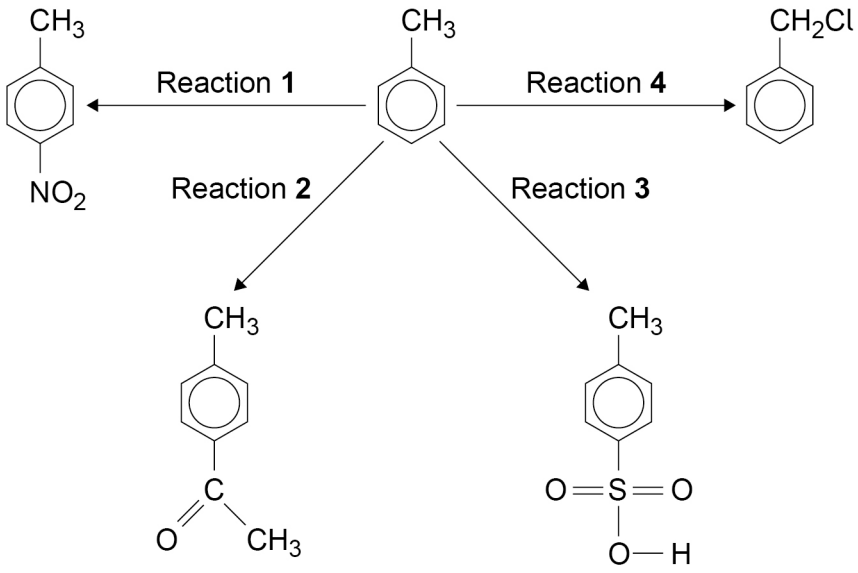
0 5 This question is about methylbenzene.

Figure 1 shows some reactions of methylbenzene.

Figure 1



0 5 . 1 Reactions **1**, **2** and **3** occur by the same mechanism.

Name this mechanism.

[1 mark]

In Reactions **1**, **2** and **3** the reagent(s) form reactive species in initial reactions. The different reactive species then react with the benzene ring in methylbenzene to form the products shown.

0 5 . 2 Identify the reagent(s) used for Reaction **1**.

[1 mark]

0 5 . 3 Write an equation for the reaction of CH_3COCl with $AlCl_3$ to form the reactive species in Reaction **2**.

[1 mark]

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0 5 . 4 Reaction **3** uses concentrated sulfuric acid as the reagent.

Write an equation to show the formation of the reactive species used in Reaction **3**.

[1 mark]

0 5 . 5 Outline a mechanism for Reaction **3**.

[3 marks]

0 5 . 6 Reaction **4** occurs by a different mechanism from Reactions **1**, **2** and **3**.

Name this mechanism.

[1 mark]

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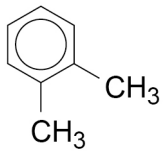
Methylbenzene can react with chloromethane and aluminium chloride to form different isomers.

One isomer, **D**, is shown

D



0 5 . 7 Carbon-13 NMR can be used to distinguish between methylbenzene and compound **D**.

State the number of peaks in the

- ^{13}C NMR spectrum of methylbenzene
- ^{13}C NMR spectrum of **D**.

[2 marks]

Number of peaks for methylbenzene _____

Number of peaks for **D** _____

0 5 . 8 Draw the structure of the isomer of **D** that has only two peaks in its ^{1}H NMR spectrum.

[1 mark]

11

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0 6 Propanone reacts with iodine in the presence of hydrochloric acid as shown

$$CH_3COCH_3 + I_2 \rightarrow CH_3COCH_2I + HI$$

The rate equation for this reaction can be written as

$$\text{Rate} = k[H^+]^a[CH_3COCH_3]^b$$

where *a* and *b* are whole numbers.

0 6 . 1 Iodine is **not** in the rate equation.

State what this shows about the mechanism of this reaction.

[1 mark]

A student does a series of experiments to determine the order of reaction with respect to H^+

In these experiments the student uses a large excess of propanone and a large excess of iodine. Under these conditions the rate equation for the reaction is

$$\text{Rate} = k_1[H^+]^a$$

0 6 . 2 Deduce why propanone is now **not** included in the rate equation.

[2 marks]

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The student determines the order of reaction with respect to propanone in a series of experiments.

Table 1 shows the volumes of solution in each experiment.

Table 1

Experiment	Volume of 0.400 mol dm^{-3} propanone / cm^3	Volume of 0.400 mol dm^{-3} aqueous iodine / cm^3	Volume of 0.500 mol dm^{-3} hydrochloric acid / cm^3	Volume of distilled water / cm^3
1	20.0	20.0	15.0	0.0
2	16.0	20.0	15.0	4.0
3	12.0	20.0	15.0	8.0
4	8.0	20.0	15.0	12.0
5	4.0	20.0	15.0	16.0

0 6 . 3 Suggest why the student adds distilled water to experiments **2**, **3**, **4** and **5**.

[1 mark]

0 6 . 4 The student deduces that the reaction is first order with respect to propanone.

Sketch, on the axes below, the graph the student obtains.

[1 mark]

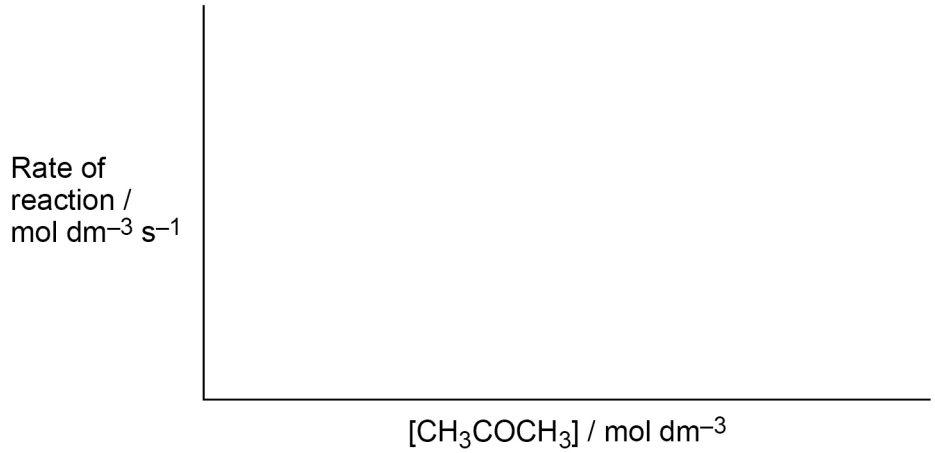

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Table 1 is repeated here.

Table 1

Experiment	Volume of 0.400 mol dm^{-3} propanone / cm^3	Volume of 0.400 mol dm^{-3} aqueous iodine / cm^3	Volume of 0.500 mol dm^{-3} hydrochloric acid / cm^3	Volume of distilled water / cm^3
1	20.0	20.0	15.0	0.0
2	16.0	20.0	15.0	4.0
3	12.0	20.0	15.0	8.0
4	8.0	20.0	15.0	12.0
5	4.0	20.0	15.0	16.0

From the results of all five experiments, the student deduces that the reaction is first order with respect to H^+ and also first order with respect to propanone.

The overall rate equation is

$$\text{Rate} = k[H^+][CH_3COCH_3]$$

0 6 . 5 Use data from **Table 1** to calculate the concentration of H^+ ions and the concentration of propanone in the mixture for experiment **3**.

[3 marks]

Concentration of H^+ ions _____ mol dm^{-3}

Concentration of propanone _____ mol dm^{-3}

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0 6 . 6 The rate of reaction for experiment **3** is 0.0650 mol dm^{-3} s^{-1}

Use your answers to Question **06.5** and the value for the rate constant, *k*, for this reaction.

Give the units of *k*

(If you could not answer Question **06.5** you should use concentration of H^+ = 0.112 mol dm^{-3} and concentration of propanone = 0.071 mol dm^{-3} These are **not** the correct values.)

[3 marks]

k = _____

Units _____

11

Turn over for the next question

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0 7 This question is about isomers of C_4H_8O

Butanone and compounds **E** and **F** are the three isomers of C_4H_8O that contain the carbonyl group.

0 7 . 1 Draw the displayed formulas of **E** and **F**.

Describe how Fehling's solution can be used to distinguish isomers **E** and **F** from butanone.

[3 marks]

Displayed formula of **E**

Displayed formula of **F**

Use of Fehling's solution _____

_____

_____

Butanone can be prepared in a two-step synthesis from 2-bromobutane.

2-bromobutane $\xrightarrow[\text{NaOH}]{\textbf{Step 1}}$ **G** $\xrightarrow{\textbf{Step 2}}$ butanone

0 7 . 2 Identify compound **G** and give **two** conditions needed in **Step 1**.

[2 marks]

G _____

Two conditions _____

Do not write outside the box

0 7 . 3 Give the reagent(s) needed for **Step 2**.

[1 mark]

Table 2 shows some data for the ^{1}H NMR spectrum of butanone.

Table 2

Chemical shift / ppm	1.1	2.1	2.4
Spin-spin splitting pattern		singlet	
Integration value			

0 7 . 4 Complete **Table 2** to show the spin-spin splitting patterns and integration values for the three peaks.

Use **Table B** in the Chemistry Data Sheet.

[3 marks]

0 7 . 5 State a suitable solvent for use in ^{1}H NMR spectroscopy.

[1 mark]

Question 7 continues on the next page

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0 7 . 6 Butanone can react with KCN followed by dilute acid to form a product with a chiral carbon.

Outline the mechanism for this reaction.

[4 marks]

0 7 . 7 Explain why the product formed in Question **07.6** is optically inactive.

[2 marks]

0 7 . 8 The infrared spectrum of an unbranched isomer of C_4H_8O shows

- an absorption at 1650 cm^{-1}
- a broad absorption in the region 3230–3550 cm^{-1}
- no absorption in the region 1680–1750 cm^{-1}

Use **Table A** in the Chemistry Data Sheet to deduce a possible structure of this isomer.

[1 mark]

17

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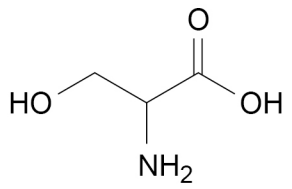
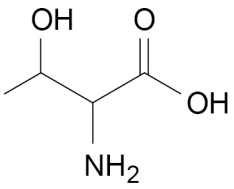
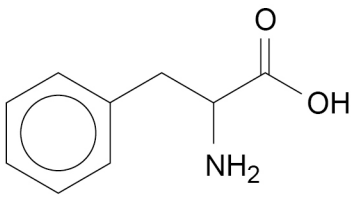
0 8 The structures of three amino acids are shown.



serine



threonine



phenylalanine

0 8 . 1 Draw a circle around any chiral centre(s) in **serine**.

[1 mark]

0 8 . 2 Use IUPAC rules to name **threonine**.

[1 mark]

0 8 . 3 Draw the structure of the species formed by **threonine** at high pH.

[1 mark]

0 8 . 4 A mixture of serine, threonine and phenylalanine is separated using thin-layer chromatography.

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

[1 mark]

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0 8 . 5 The stationary phase in the chromatography is polar and the moving phase is non-polar.

Deduce which of the three amino acids has the highest R_f value.

Explain your answer.

[3 marks]

Amino acid _____

Explanation _____

_____

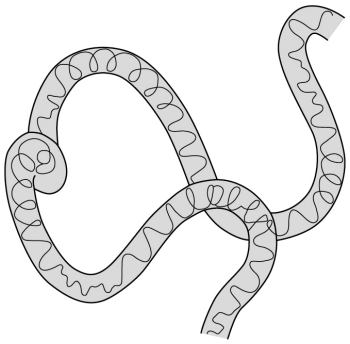
_____

_____

Proteins are chains of amino acids linked together. Proteins have different levels of structure known as primary, secondary or tertiary.

Figure 2 shows a protein structure.

Figure 2



0 8 . 6 Identify the highest level of structure shown in **Figure 2**.

[1 mark]

_____

0 8 . 7 The structure in **Figure 2** is held together by different interactions, including van der Waals forces and dipole-dipole interactions.

Name **two** other interactions that can hold this structure together.

[2 marks]

1 _____

2 _____

10

END OF QUESTIONS

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