



Oxford Cambridge and RSA

Tuesday 20 May 2025 – Morning

AS Level Chemistry A

H032/02 Depth in chemistry

Time allowed: 1 hour 30 minutes



You must have:

- the Data Sheet for Chemistry A

You can use:

- a scientific or graphical calculator
- an HB pencil



Please write clearly in black ink. **Do not write in the barcodes.**

Centre number

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Candidate number

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First name(s)

Last name

INSTRUCTIONS

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION

- The total mark for this paper is **70**.
- The marks for each question are shown in brackets [].
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **24** pages.

ADVICE

- Read each question carefully before you start your answer.

2

- 1** A student is investigating the enthalpy change of neutralisation for a strong acid and a strong alkali.

(a) Explain what is meant by an **alkali**.

.....
..... **[1]**

(b) Write the ionic equation for the neutralisation reaction between an acid and an alkali.

..... **[1]**

(c) The student mixes 40.0 cm^3 of 1.40 mol dm^{-3} HCl and 40.0 cm^3 of 1.40 mol dm^{-3} NaOH .

The temperature rises by 9.40°C

(i) Calculate the enthalpy change of neutralisation, in kJ mol^{-1} .

Give your answer to **3** significant figures.

Assume that the density of all solutions and the specific heat capacity, c , of the reaction mixture is the same as for water.

Enthalpy change of neutralisation = kJ mol^{-1} **[4]**

- (ii) The student repeats the experiment using the same volume and concentration of NaOH but using 20.0 cm^3 of $2.80\text{ mol dm}^{-3}\text{ HCl}$ instead of 40.0 cm^3 of $1.40\text{ mol dm}^{-3}\text{ HCl}$.

The temperature rise is greater than 9.4°C .

Explain why.

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..... [2]

Group 2 element	1st Ionisation energy / kJ mol ⁻¹	2nd Ionisation energy / kJ mol ⁻¹
Mg	738	1451
Ca	590	1145

Include state symbols.

..... [1]

Give a balanced equation for the reaction of **calcium** with water and describe what would be observed. Explain why this is a redox reaction.

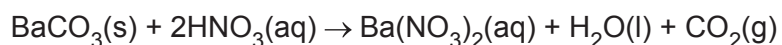
Explain the difference in reactivity of magnesium and calcium.

[6]

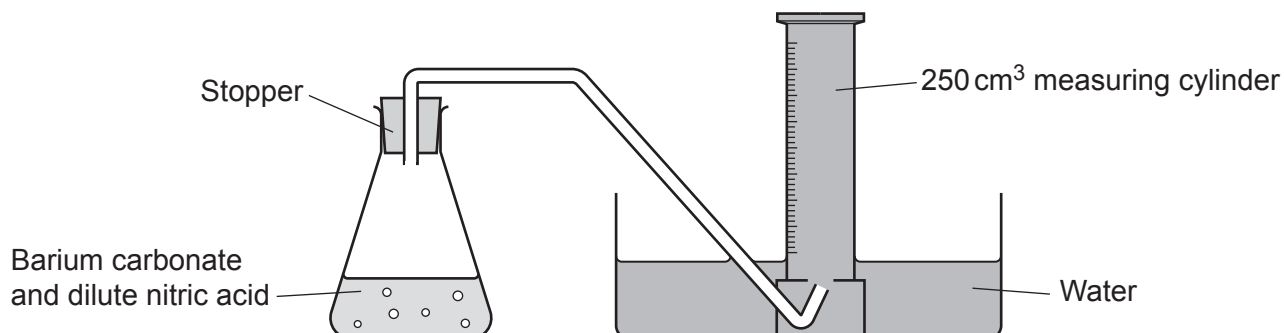
Extra answer space if required.

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- (b) A student adds 1.51 g of barium carbonate, BaCO_3 (molar mass 197.3 g mol^{-1}), to an excess of dilute nitric acid. The equation is shown below.



The student uses the following apparatus.



- (i) Calculate the volume, in cm^3 , of gas the student expects to be produced at room temperature and pressure (RTP).

Give your answer to **3** significant figures.

Volume of gas cm^3 [2]

- (ii) The volume of gas collected is less than the calculated volume.

Suggest **two** reasons for this difference.

1

.....

2

.....

[2]

- (iii) Suggest **one** way in which the student could modify the apparatus to produce a volume closer to the calculated volume.

.....

..... [1]

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Turn over for the next question

3 Malic acid tablets are sold as a health supplement.

A student carries out a titration to determine the mass of malic acid, $\text{C}_4\text{H}_6\text{O}_5$, in **one** tablet.

The student follows the method below:

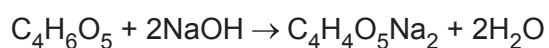
Step 1 Crush **three** tablets, transfer the powder into a beaker and dissolve in distilled water.

Step 2 Transfer the solution into a 250.0 cm^3 volumetric flask and make up to the mark with distilled water.

Step 3 Pipette 25.0 cm^3 of the solution from **Step 2** into a conical flask and add a few drops of indicator.

Step 4 Titrate this solution with $0.0800\text{ mol dm}^{-3}$ sodium hydroxide, NaOH, in the burette.

The equation for the neutralisation reaction is:



(a) The student takes burette readings to the nearest 0.05 cm^3 .

The student's readings are shown in the table.

The rough titre has been omitted.

(i) Complete the table below.

Titration	1	2	3
Final reading / cm^3	23.60	46.70	25.65
Initial reading / cm^3	0.30	23.65	2.50
Titre / cm^3			

[1]

(ii) Calculate the mean titre of NaOH that the student should use to analyse the results.

Mean titre = cm^3 [1]

(iii) Calculate the mass, in mg, of malic acid in **one** tablet.

Assume that malic acid (molar mass 134.0 g mol^{-1}) is the only acid in the tablets.

Give your answer to **3** significant figures.

Mass of malic acid mg **[5]**

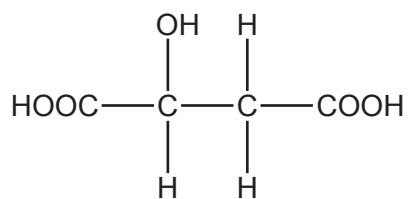
(b) Another student carries out the same experiment.

Instead of rinsing the burette used in **Step 4** with $0.0800 \text{ mol dm}^{-3}$ NaOH, the student rinses with water before filling it up with $0.0800 \text{ mol dm}^{-3}$ NaOH.

State and explain how this error would affect the titre.

.....
.....
.....
..... **[2]**

(c) The structure of malic acid is shown below.



When malic acid is heated with an acid catalyst, a mixture of *cis* and *trans* stereoisomers is produced.

Draw the structures of the *cis* and *trans* isomers.

<i>cis</i>	<i>trans</i>

[2]

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Table 4.1

Alkane	Molecular formula	Boiling point / °C	Enthalpy change of combustion / kJ mol ⁻¹
Propane	C ₃ H ₈	−42	−2219
Butane	C ₄ H ₁₀	0	To estimate in part (b)(iv)
Pentane	C ₅ H ₁₂	36	−3509
Hexane	C ₆ H ₁₄	69	−4163

(a) State and explain the trend in boiling points of the straight chain alkanes in **Table 4.1**.

[4]

(b) When alkanes undergo complete combustion carbon dioxide and water are produced.

(i) Write the balanced equation for the complete combustion of **one** mole of pentane.

..... [1]

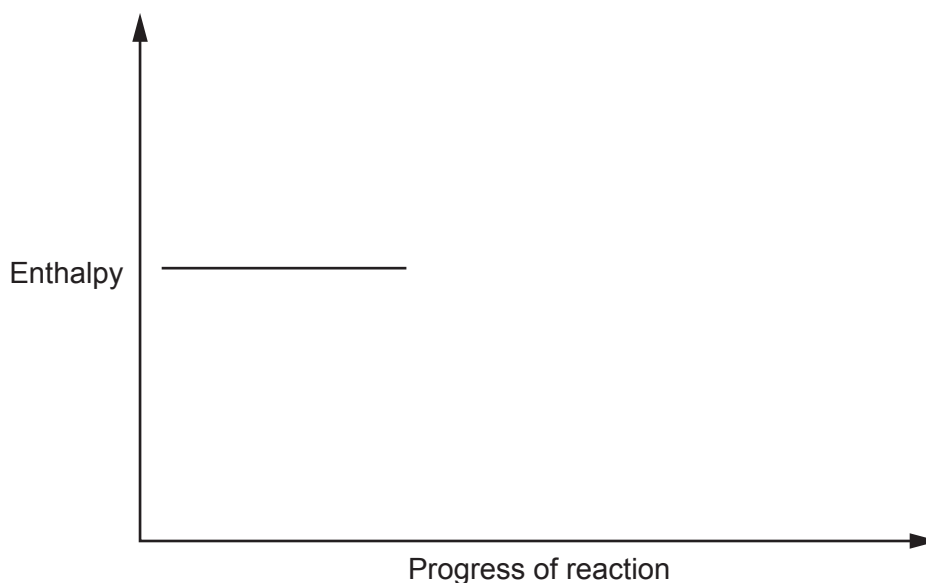
(ii) Use the information in **Table 4.1** to calculate the mass of carbon dioxide formed when 1.00 kJ of energy is released during the complete combustion of pentane.

Mass of carbon dioxideg [2]

(iii) Complete the enthalpy profile diagram for the complete combustion of pentane.

On your diagram:

- Label the enthalpy change as ΔH .
- Include the formulae of the reactants and products.
- Label the activation energy as E_a .



[2]

(iv) Use the data in **Table 4.1** to estimate a value for the enthalpy change of combustion of butane.

Give your answer to **2** significant figures.

Estimated enthalpy change of combustion of butanekJ mol⁻¹ [1]

- (c) Besides pentane, there are two other structural isomers of C_5H_{12} .

Draw the **skeletal** formulae of these two other structural isomers and state the systematic name of each.

	Isomer 1	Isomer 2
Skeletal formula		
Systematic name		

[2]

- (d) In the presence of ultraviolet radiation, propane reacts with bromine to form a mixture of products.

Two of these products are structural isomers of C_3H_7Br .

- (i) Write an equation, using molecular formulae, for the formation of C_3H_7Br from propane.

..... [1]

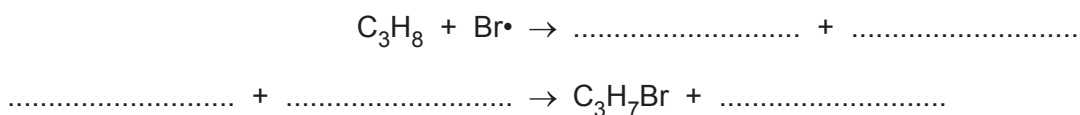
- (ii) The first step in the mechanism of the reaction is the homolytic fission of a Br–Br bond.

Explain what is meant by **homolytic fission**.

.....
 [1]

- (iii) Complete the equations for the propagation steps in the mechanism.

Use molecular formulae for organic species and dots (•) for unpaired electrons on radicals.



[2]

- (iv) Explain why two structural isomers of C_3H_7Br are formed.

.....

 [1]

5 This question is about haloalkanes.

(a) Chloromethane, CH_3Cl is a covalent molecule.

(i) Draw a 'dot-and-cross' diagram for CH_3Cl .

Show outer electrons only.

Use a different symbol for the electrons of each element.

[1]

(ii) Name the shape of the chloromethane molecule and predict the value of the $\text{H}-\text{C}-\text{Cl}$ bond angle.

Name of shape.....

Bond angle.....

[2]

(b) Chloroethene, $\text{H}_2\text{C}=\text{CHCl}$, is a covalent molecule with a double bond.

The bond angles in $\text{H}_2\text{C}=\text{CHCl}$ are different from those in CH_3Cl .

Predict the $\text{H}-\text{C}-\text{Cl}$ bond angle in $\text{H}_2\text{C}=\text{CHCl}$ and explain why it is different from the $\text{H}-\text{C}-\text{Cl}$ bond angle in CH_3Cl .

Bond angle

Explanation

.....

.....

.....

.....

[3]

$$\text{CH}_3\text{CH}_2\text{CHOHCH}_3 + \text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{CH}_3\text{CH}_2\text{CHClCH}_3 + \text{NaHSO}_4 + \text{H}_2\text{O}$$

- Add 9.25g $\text{CH}_3\text{CH}_2\text{CHOHCH}_3$ to an excess of NaCl(aq) in a pear-shaped flask.
- Add an excess of concentrated sulfuric acid.
- Heat the flask under reflux for about 45 minutes.

After purification, the percentage yield of $\text{CH}_3\text{CH}_2\text{CHClCH}_3$ is 65.0 %.

Calculate the mass of pure $\text{CH}_3\text{CH}_2\text{CHClCH}_3$ that would be expected from this preparation.

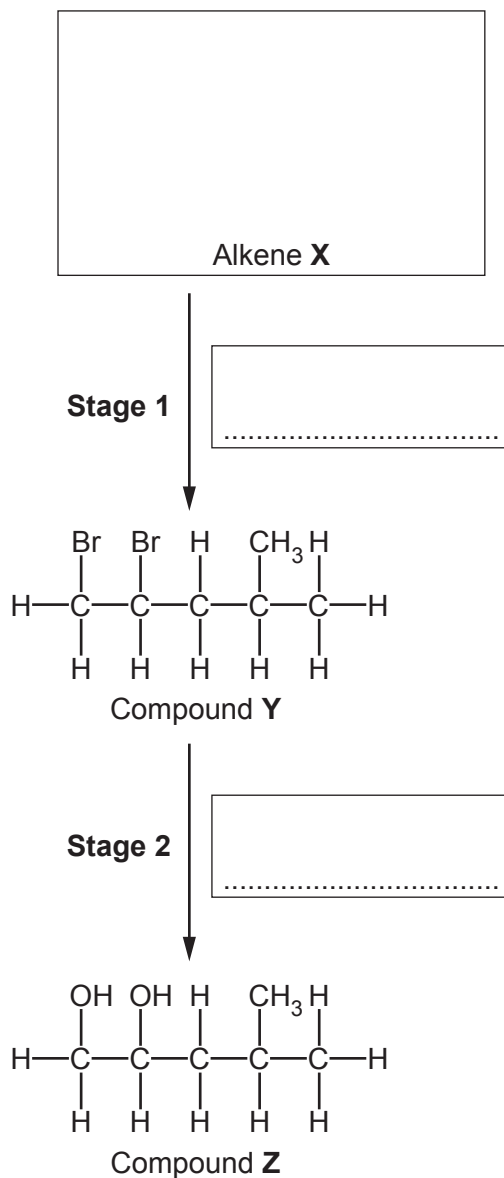
..... [6

[illegible]

(d) Haloalkanes are important intermediates in organic synthesis.

A student plans a two-stage synthesis to prepare compound **Z** from a hydrocarbon alkene **X**.

(i) Draw the structure of the hydrocarbon alkene **X** in the box and write down the reagents for each stage on the dotted lines.



[3]

(ii) State the name of the mechanism of the reaction in **Stage 2**.

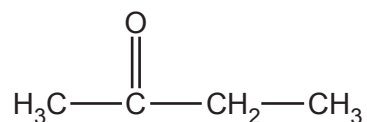
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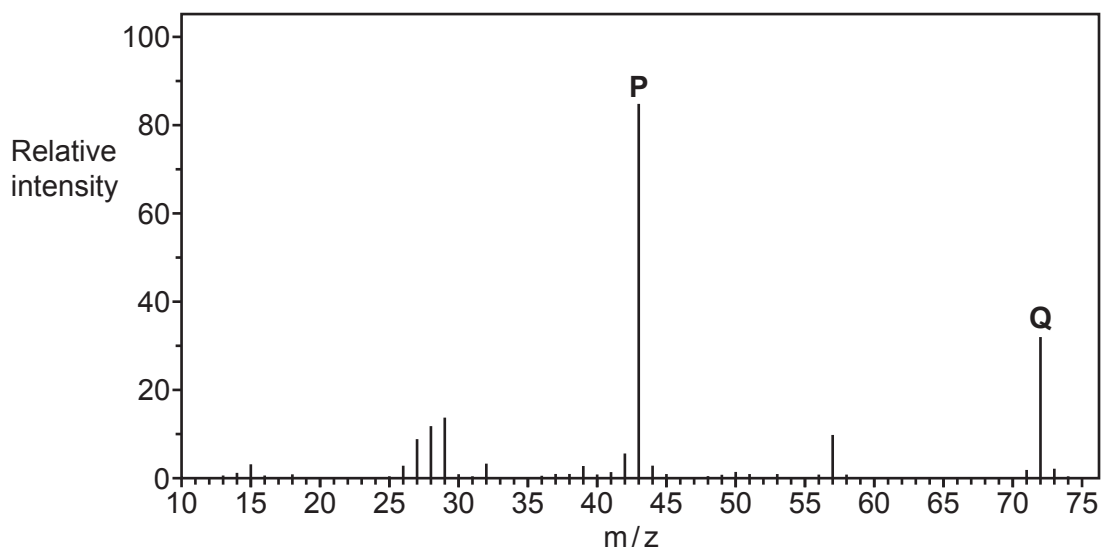
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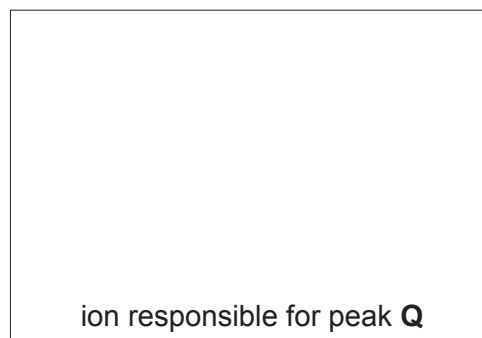
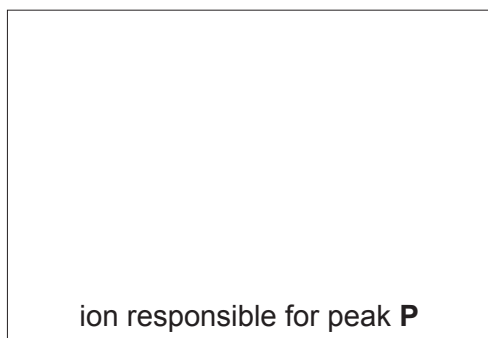
- 6 Compound **A** is a ketone. It has the following structure.



- (a) The mass spectrum of compound **A** is shown below.



- (i) Draw structures for the ions responsible for peak **P** and peak **Q**.



[2]

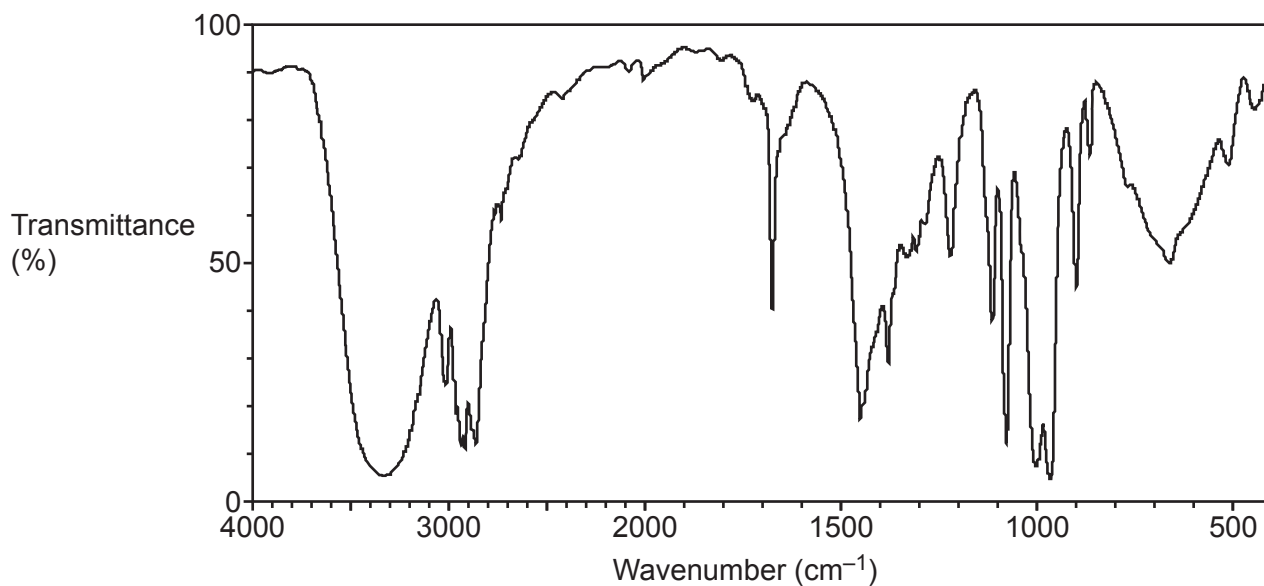
- (ii) Explain why there is a small peak at $m/z = 73$

.....

..... [1]

(b) Compound **B** is a non-cyclic structural isomer of Compound **A**.

The infrared spectrum of Compound **B** is shown below.



(i) State the effect infrared radiation has on covalent bonds.

.....
 [1]

(ii) Identify **two** functional groups which are likely to be present in Compound **B** but are not present in Compound **A**.

Explain your answers.

Functional group

Explanation

[2]

END OF QUESTION PAPER

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