Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS/A LEVEL

S24-2410U20-1

2410U20-1

TUESDAY, 21 MAY 2024 – MORNING

CHEMISTRY – AS unit 2
Energy, Rate and Chemistry of Carbon Compounds

1 hour 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 7.**	**10**	
Section B	**8.**	**6**	
	9.	**10**	
	10.	**16**	
	11.	**12**	
	12.	**11**	
	13.	**15**	
	Total	**80**	

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ADDITIONAL MATERIALS

- A calculator, pencil and ruler
- **Data Booklet** supplied by WJEC

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions.
Section B Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in **Q8**.

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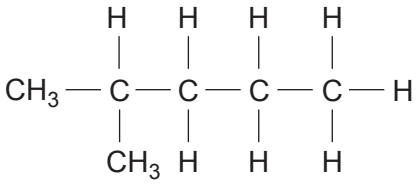
SECTION A

Answer **all** questions.

1. Give the name of the compound shown. [1]



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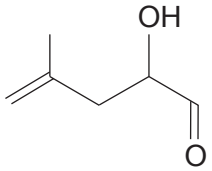
2. Draw the energy profile diagram for an endothermic reaction.

Label the activation energy, E_a, and the enthalpy change of the reaction, ΔH. [2]

3. Give the molecular and empirical formulae of the compound shown. [2]



Molecular formula .....

Empirical formula .....

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4. Chloroethene is polymerised to make PVC.

(a) State why the chloroethene monomer does not exhibit *E*–*Z* isomerism. [1]

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(b) Draw the repeating unit for PVC. [1]

5. Complete the equation to show the structure of the **main** product formed. [1]

$CH_3CH=CH_2 \quad + \quad HBr \longrightarrow$

6. Give the structure of a tertiary alcohol which contains 5 carbon atoms. [1]

7. Name the catalyst used in the hydrogenation of unsaturated oils to make saturated fats such as margarine. [1]

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SECTION B

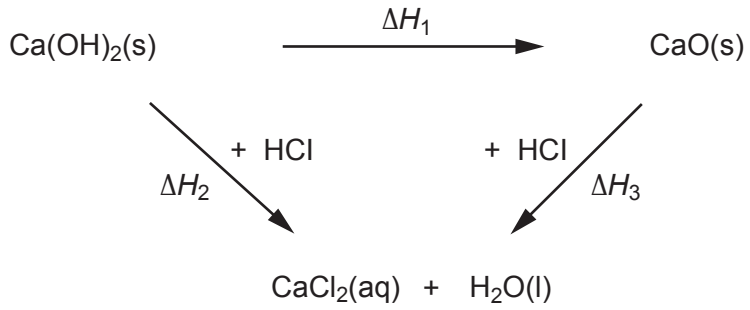
Answer **all** questions.

8. On heating, calcium hydroxide decomposes to produce calcium oxide and water.

$$Ca(OH)_2(s) \longrightarrow CaO(s) + H_2O(l) \qquad \Delta H_1$$

The enthalpy change of this reaction cannot be measured directly.

Both calcium hydroxide and calcium oxide react with dilute hydrochloric acid and enthalpy changes can be found for the reactions. Hess's law can then be used to determine ΔH_1.



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Describe the practical steps you would carry out and how you would use Hess's law to determine the enthalpy change for the decomposition of calcium hydroxide, ΔH_1.

You should state clearly what needs to be measured but you should **not** calculate any values.
[6 QER]

6

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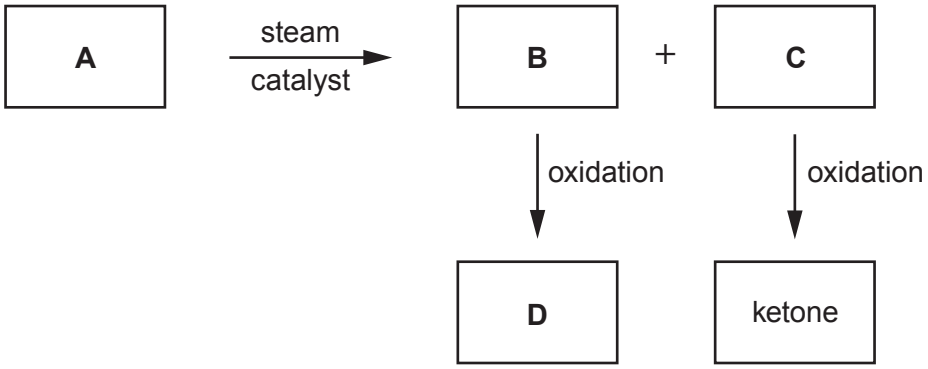
9. Look at the reaction scheme below and other information about compounds **A** to **D**.



A is a straight chain hydrocarbon. It contains 85.7 % carbon by mass.

B and **C** are structural isomers.

D is soluble in water. 0.93 g of **D** is dissolved in water to make 100 cm^3 of solution. 25.0 cm^3 of this solution is titrated against 0.100 mol dm^{-3} aqueous sodium hydroxide. 26.40 cm^3 of sodium hydroxide is needed for neutralisation. **D** reacts with sodium hydroxide in a ratio of 1:1.

(a) Calculate the empirical formula of **A**. [2]

Empirical formula .....

Examiner only

(b) Show that the relative molecular mass (M_r) of **D** is 88. [3]

(c) Give the names of compounds **A** to **D**. [4]

A .....

B .....

C .....

D .....

(d) Name a suitable reagent for the conversion of **B** to **D**. [1]

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Turn over.

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10. Thiosulfate ions react with acid according to the equation shown.

$$S_2O_3^{2-}(aq) + 2H^+(aq) \longrightarrow S(s) + SO_2(g) + H_2O(l)$$

A student investigates the effect of changing the concentration of thiosulfate ions on the rate of the reaction.

(a) Describe how the student could prepare 250 cm^3 of 0.10 mol dm^{-3} sodium thiosulfate solution to use in this experiment. The relative formula mass (M_r) of sodium thiosulfate, $Na_2S_2O_3.5H_2O$, is 248.3.

You should include the apparatus needed and any relevant masses and volumes. [4]

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(b) The student mixes known volumes of aqueous 0.10 mol dm^{-3} sodium thiosulfate and hydrochloric acid in a beaker. He places the beaker on a cross drawn on a piece of paper and measures the time taken for the cross to be obscured.

(i) State what causes the cross to become obscured. [1]

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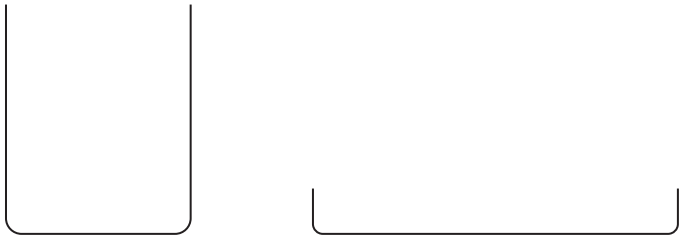
(ii) The diagram shows a beaker and a shallow dish.

If the student replaced the beaker with a shallow dish, state the effect this would have on the time taken to obscure the cross. Explain your answer.

Assume that the student used the same volumes and concentrations in each experiment. [1]



beaker shallow dish

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(c) The student plans to change the concentration of $S_2O_3^{2-}(aq)$ by reducing the volume of aqueous sodium thiosulfate and adding water to keep the total volume constant.

The data obtained by the student for one experiment is shown in the table.

Volume $S_2O_3^{2-}(aq)$ / cm^3	Volume H_2O / cm^3	Volume HCl(aq) / cm^3	Time / s
40	0	10	50

(i) **Complete the table** to show suitable volumes of thiosulfate, water and acid that the student could use to investigate the effect of changing concentration of $S_2O_3^{2-}(aq)$ on the rate of the reaction. [2]

(ii) The rate of reaction can be calculated using rate = $\frac{1000}{\text{time}}$

State the unit of rate in this reaction. [1]

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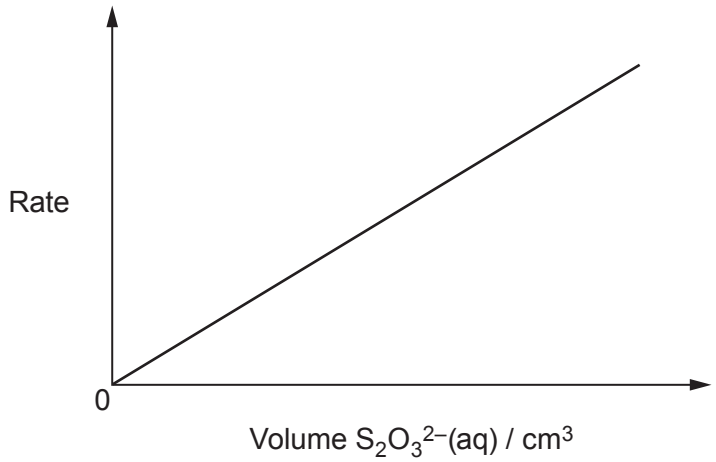
(iii) The student calculates the rate of reaction using different volumes of $S_2O_3^{2-}(aq)$ and plots a graph. The graph is shown.



State what can be deduced from the shape of this graph. [1]

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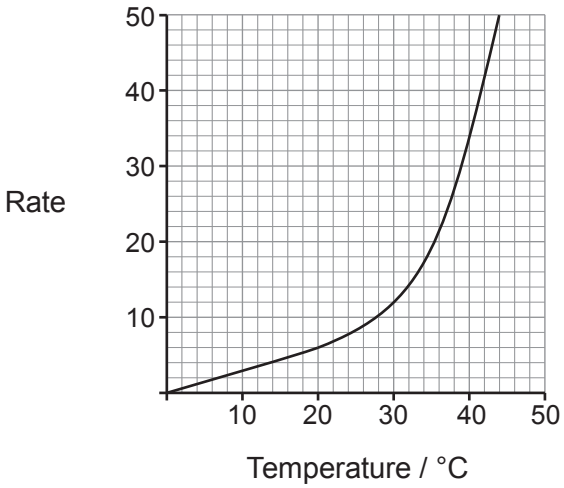
(d) Another student uses a similar experiment to investigate the effect of changing the temperature on the rate of this reaction. He draws a graph of his data.



(i) Use the graph to determine the time taken for the cross to be obscured at a temperature of 30 °C. Show clearly how you obtained your answer. [2]

$$\text{rate} = \frac{1000}{\text{time}}$$

Time = ... s

(ii) Some textbooks state that a 10 °C temperature rise approximately doubles the rate of many reactions. Use the graph to find to what extent this is true for this reaction. [2]

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(iii) Explain why the rate of the reaction is affected by an increase in temperature. [2]

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11. Compound **X** is thought to be a halogenoalkane containing only one halogen atom.

(a) Describe a chemical test by which you could identify which halogen is present in **X**. [4]

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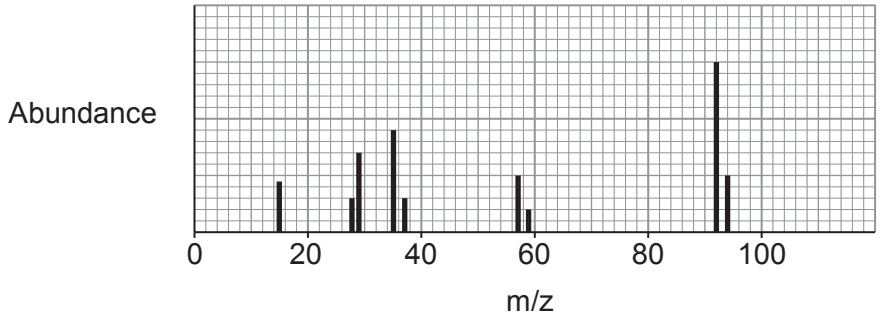
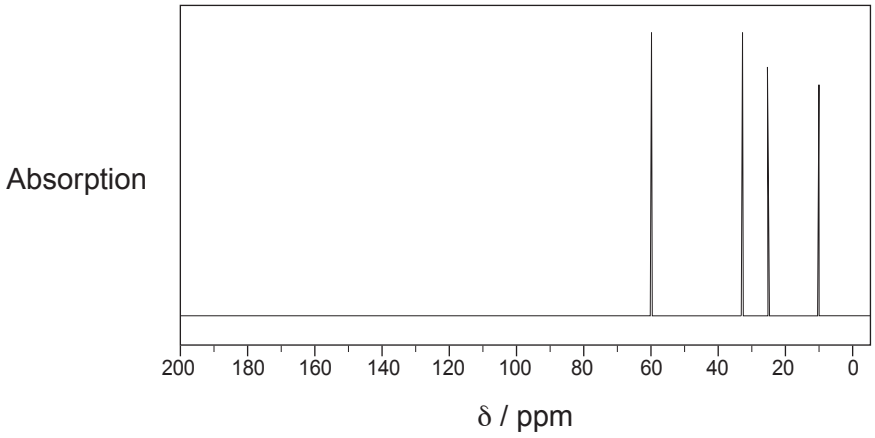
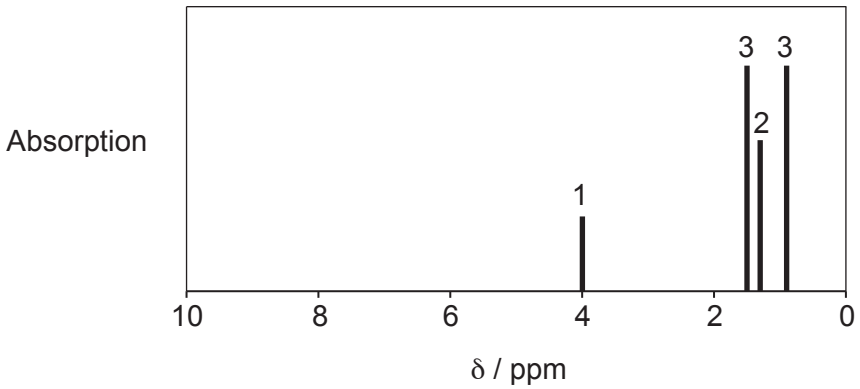
(b) A simplified form of the mass spectrum, the ^{13}C NMR spectrum and the low resolution ^{1}H NMR spectrum of halogenoalkane **X** are shown.



Mass spectrum



^{13}C NMR spectrum



^{1}H NMR spectrum

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Use this information to find the structure of halogenoalkane **X**. Show your reasoning.

You must use information from **all** the spectra. [8]

Structure of **X**

12

Examiner only

12. (a) State what is meant by the enthalpy change of combustion. [2]

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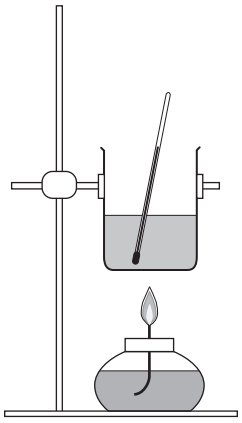
(b) (i) The equation that corresponds to the enthalpy change of combustion of propan-1-ol is shown.

$$C_3H_7OH(l) + 4\tfrac{1}{2}O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$$

The apparatus below can be used to determine the enthalpy change for this reaction.



A student used this apparatus and obtained the following results.

Initial mass of spirit burner with propan-1-ol = 126.16 g

Final mass of spirit burner with propan-1-ol = 126.02 g

Initial temperature of water = 21.0 °C

Final temperature of water = 33.5 °C

Volume of water in beaker = 100 cm^3

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Use these results in parts I and II.

I. Calculate the number of moles of propan-1-ol used up in the reaction. [1]

Number of moles = ... mol

II. Calculate the enthalpy change of combustion of propan-1-ol, $\Delta_c H$, under these conditions of temperature and pressure. [3]

$\Delta_c H$ = ... kJ mol^{-1}
sign *value*

(ii) Another student suggested that leaving the spirit burner to burn for longer would increase the accuracy of the experiment.

State whether you agree with this student. Explain your answer. [1]

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(c) Enthalpy changes of combustion can be used to determine average bond enthalpies.

Some average bond enthalpies are given in the table.

Bond	Average bond enthalpy / kJ mol^{-1}
O = O	496
C — H	412
C — C	348
C = O	805
O — H	463

The equation that corresponds to the enthalpy change of combustion of butan-1-ol is shown below.

$$C_4H_9OH(l) + 6O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l) \qquad \Delta_c H = -2\,676 \text{ kJ mol}^{-1}$$

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Use the enthalpy change of combustion of butan-1-ol and the average bond enthalpies in the table to calculate the average bond enthalpy of a C—O bond. [4]

Average bond enthalpy [C—O] = ... kJ mol^{-1}

11

Examiner only

13. (a) Two students were discussing how to prepare chloroethane. One student suggested reacting chlorine with ethane but the other student said that the yield from this reaction was poor and that it was better to react hydrogen chloride with ethene.

(i) State the **type** of reaction involved in each case. [2]

ethane and chlorine

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ethene and hydrogen chloride

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(ii) Suggest why the reaction between ethene and hydrogen chloride gives the better yield. [1]

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(iii) Give the mechanism for the reaction between ethene and hydrogen chloride. [4]

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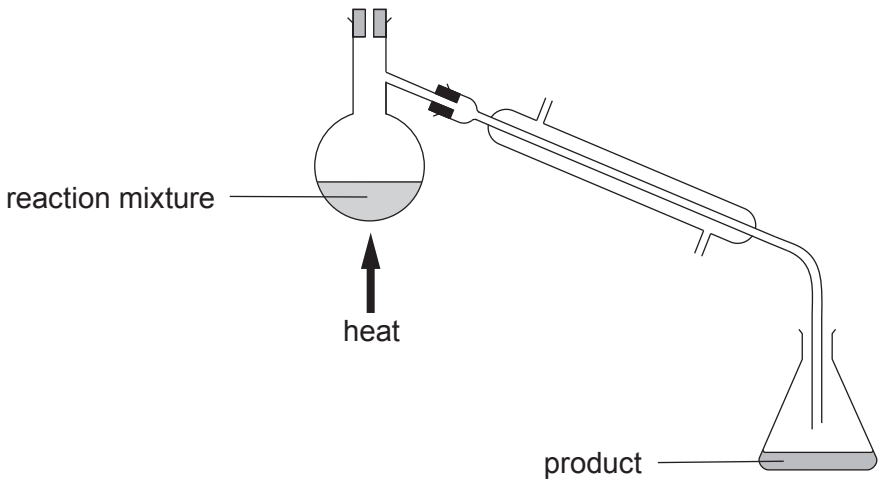
(b) The equation for the reaction between ethanoic acid and methanol to form an ester is shown.

$$CH_3COOH + CH_3OH \rightleftharpoons CH_3COOCH_3 + H_2O$$

(i) In the preparation of this ester, 25 g of ethanoic acid reacted with excess methanol. If the percentage yield of the reaction was 34 %, calculate the mass of ester formed. [3]

Mass = ... g

(ii) The diagram shows the method used to separate the ester from the reaction mixture.



Draw on the diagram

- the position of the thermometer
- the direction of water flowing through the condenser [2]

Examiner only

(iii) Addition of concentrated sulfuric acid increases the yield of ester. Explain this observation. [2]

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(c) Draw the structure of the ester formed when propan-2-ol reacts with methanoic acid. [1]

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END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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