Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS

B410U20-1

S24-B410U20-1

TUESDAY, 21 MAY 2024 – MORNING

CHEMISTRY – AS component 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 6.**	**10**	
Section B	**7.**	**14**	
	8.	**14**	
	9.	**10**	
	10.	**16**	
	11.	**16**	
	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 **Q9**(a).

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SECTION A

Answer **all** questions.

1. Name the type of bond fission that leads to the formation of radicals. [1]

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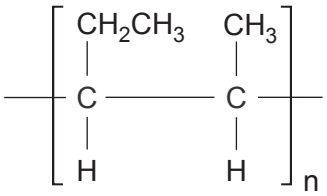
2. (a) Name the alkene monomer that can be polymerised to give [1]



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(b) New polymers are being made that are biodegradable.

Give an advantage of biodegradable polymers. [1]

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3. Draw the structure of 3-chloro-2-methylbutan-2-ol. [1]

4. State what is meant by a tertiary alcohol. [1]

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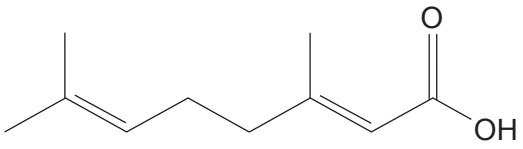
5. Geranic acid is a pheromone used by some organisms. Its skeletal structure is shown below.



(a) State the molecular formula of the compound. [1]

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(b) Describe a test to show that the compound is unsaturated.

Give the reagent(s) used and the expected observation. [2]

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6. Propanoic acid reacts with metals such as magnesium to produce hydrogen.

$$Mg + 2C_2H_5COOH \longrightarrow (C_2H_5COO)_2Mg + H_2$$

Calculate the minimum mass of magnesium needed to completely react with 0.02 mol of propanoic acid. Give your answer in **mg**. [2]

Mass = ... mg

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SECTION B

Answer **all** questions.

7. (a) Crude oil can be separated into fractions. Each fraction is a mixture of saturated hydrocarbons, some of which are structural isomers.

Some of these isomers can be cracked to form important chemicals such as ethene, while others are used as fuels.

Heptane, C_7H_{16}, and decane are two hydrocarbons obtained from crude oil.

(i) Write a balanced equation for the complete combustion of heptane. [1]

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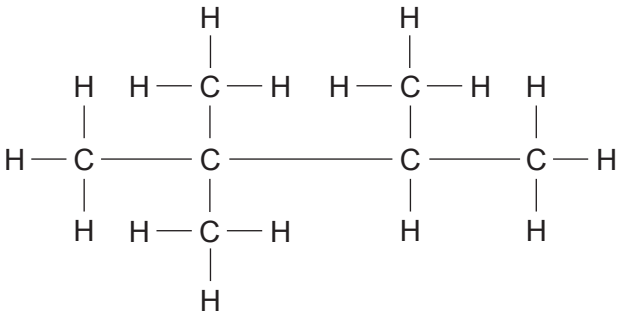
(ii) Triptane is one structural isomer with the molecular formula C_7H_{16}.



Give the systematic name of this isomer. [1]

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(iii) The boiling temperatures in °C for heptane, triptane and decane, which are **not given in any particular order**, are 81, 98 and 174.

Deduce the boiling temperature of **each** compound. Give reasons in support of your conclusions. [3]

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(iv) Decane can be cracked to form ethene and only one other molecule.

Write a balanced equation for this reaction. [1]

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(b) (i) Draw the mechanism for the reaction of propene with hydrogen bromide to show the formation of the **major** product. [3]

(ii) A student said that "the reaction between butene and hydrogen bromide also gives a major product and a minor product".

Explain, with reference to the reaction mechanism, why the student is only partially correct. [2]

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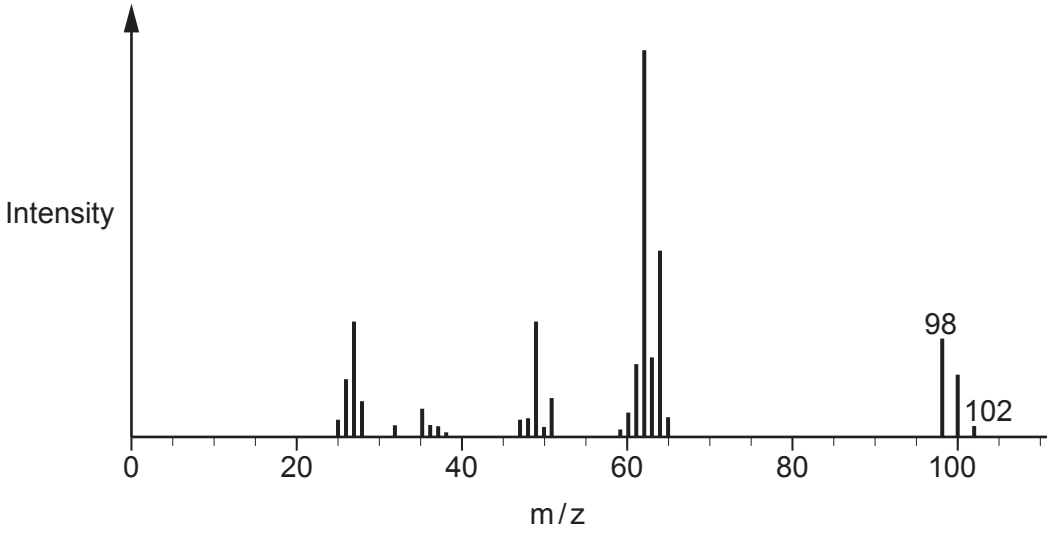
(c) A compound contains 24.1% carbon, 4.10% hydrogen and 71.8% chlorine by mass.

Its mass spectrum is shown below.



Calculate both the empirical and molecular formulae of the compound.

You **must** show your working. [3]

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Empirical formula .....

Molecular formula .....

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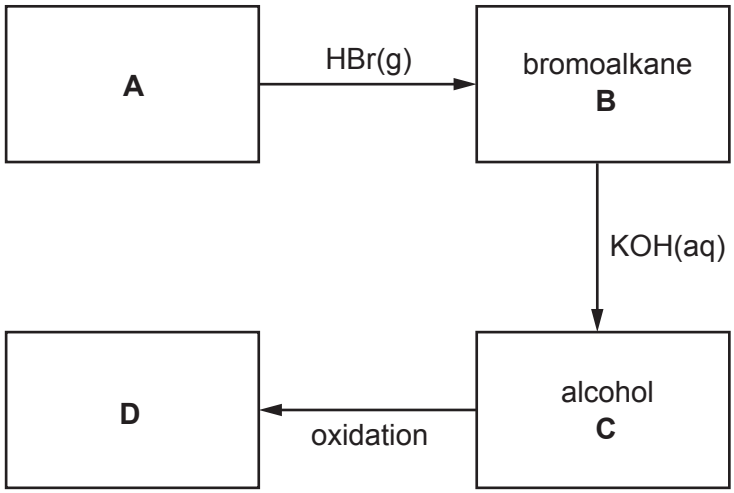
8. (a) Study the reaction scheme shown below for the hydrocarbon **A**.



(i) Classify the type of reaction mechanism taking place when compound **B** is converted to compound **C**. [1]

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(ii) Give the reagent(s) required to convert compound **C** to compound **D**. [1]

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(iii) Give **one** chemical test, apart from use of an indicator, which could be used to confirm that compound **D** is a carboxylic acid.

Your answer should include reagent(s) and the expected observation. [2]

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(iv) A mass of 0.564 g of compound **B** reacts in a 1:1 ratio with hot aqueous potassium hydroxide. The residual solution is treated with dilute nitric acid followed by aqueous silver nitrate solution. 0.973 g of silver bromide is precipitated.

Calculate the relative molecular mass of compound **B** and so deduce the identity of compound **A**. [3]

M_r of **B** = ...

Compound **A** is .....

(v) Compound **A** can be converted directly to compound **C** under suitable conditions.

$$\mathbf{A}(g) + H_2O(g) \rightleftharpoons \mathbf{C}(g) \qquad \Delta H^{\theta} = -46\ kJ\,mol^{-1}$$

I. Name the catalyst used in this reaction. [1]

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II. State and explain what happens to the equilibrium yield of compound **C** if the reaction is carried out at a higher pressure. [2]

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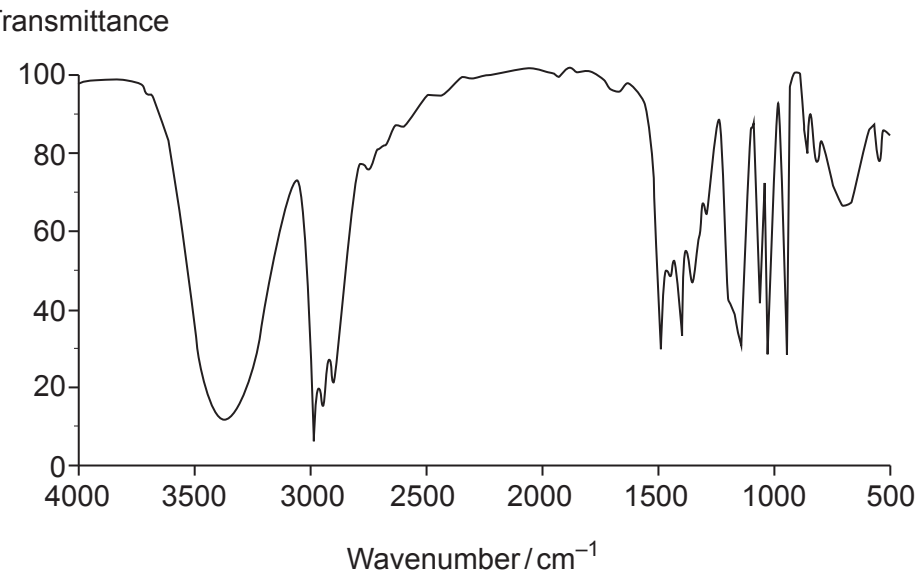
(b) **E** and **F** are both straight-chained compounds.

The infrared spectrum of compound **E** is shown below.



When compound **E** undergoes a dehydration reaction, it forms compound **F** only.

0.25 mol of compound **F** has a mass of 17.5 g and compound **F** shows *E-Z* isomerism.

Identify compounds **E** and **F**. Give your reasoning. [4]

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9. (a) Sodium thiosulfate solution reacts with hydrochloric acid to produce a precipitate of sulfur. The equation for the reaction is shown below.

$$Na_2S_2O_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + SO_2(g) + S(s) + H_2O(l)$$

The rate of the reaction can be measured by finding the time taken for a fixed amount of sulfur to be produced.

Outline a suitable method to investigate the effect of changing the concentration of sodium thiosulfate on the rate of this reaction.

Your answer should include a

- method for the experiment
- description of how you would calculate rate values and use them to draw an appropriate graph
- sketch of the graph that you would expect [6 QER]

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(b) Use collision theory to explain why a change in concentration affects the rate of a reaction. [2]

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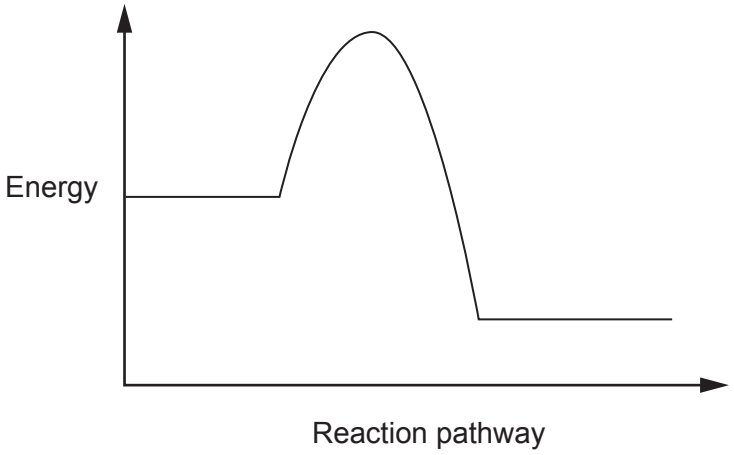
(c) The energy profile for a reversible reaction with an exothermic forward reaction is shown below.



(i) Draw an arrow on the energy profile to show the activation energy for the **backward** reaction. [1]

(ii) State the effect of increasing the temperature on the rate of the backward reaction. Give a reason for your answer. [1]

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10. (a) A student is asked to prepare a sample of ethanoic acid by oxidising ethanol.

(i) Write a balanced equation for this reaction.

Use [O] to represent the oxidising agent. [1]

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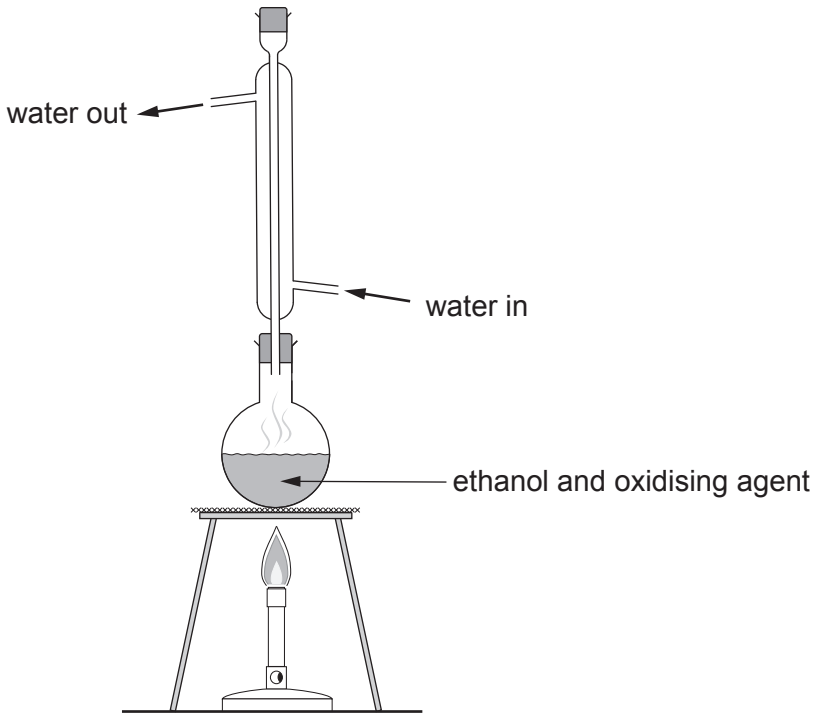
(ii) The student sets up the apparatus as shown in the diagram.

You may assume that all the equipment is safely clamped.



I. Name the method being used. [1]

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II. State **two** changes that must be made to the apparatus for safe and effective use.

Give your reasoning in each case. [4]

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(b) In another preparation of ethanoic acid from ethanol, 8.23 g of ethanoic acid was obtained. The percentage yield of ethanoic acid was 80%.

Calculate the volume of ethanol used in this preparation. [4]

density of ethanol = 0.789 g cm^{-3}

Volume = ... cm^3

(c) Give the equation for the reaction between ethanoic acid and sodium hydroxide. [1]

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(d) (i) State the meaning of the term standard molar enthalpy change of formation of ethanol. [2]

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(ii) Give a reason why it is not possible to measure the standard enthalpy change of formation of ethanol directly. [1]

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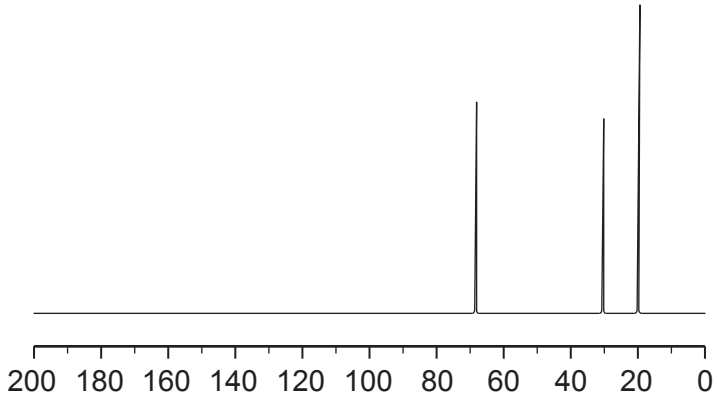
(e) Four isomers with the molecular formula $C_4H_{10}O$ are alcohols.

The ^{13}C NMR spectrum of one of these isomers is shown below.



Identify the isomer. Give a reason for your answer. [2]

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11. A student was asked to find the molar enthalpy change for the reaction between zinc and copper(II) sulfate solution.

$$Zn(s) + CuSO_4(aq) \longrightarrow ZnSO_4(aq) + Cu(s)$$

She was told to use the following method.

- Measure 25.0 cm^3 of copper(II) sulfate solution of concentration 1.00 mol dm^{-3} into a polystyrene cup.
- Roughly weigh out a sample of zinc powder in a weighing bottle. Ensure that the zinc contains at least 20% more mass than is needed to react with all the copper(II) sulfate solution.
- Place a thermometer in the solution, stir and record the temperature every minute for 3 minutes.
- At exactly 3½ minutes add the zinc powder to the copper(II) sulfate solution.
- Continue to stir the solution and read the temperature each minute from 4 to 10 minutes.

Her results are shown below.

Time / minutes	0	1	2	3	4	5	6	7	8	9	10
Temperature / °C	22.0	22.2	22.2	22.2	61.0	64.5	60.0	56.0	52.5	48.8	45.7

(a) Give a reason why she did not accurately measure the mass of zinc. [1]

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(b) Give a reason why the temperature of the solution was measured for 3 minutes before adding zinc. [1]

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(c) Give a reason why the temperature of the solution was measured for a period of time after all the copper(II) sulfate had reacted. [1]

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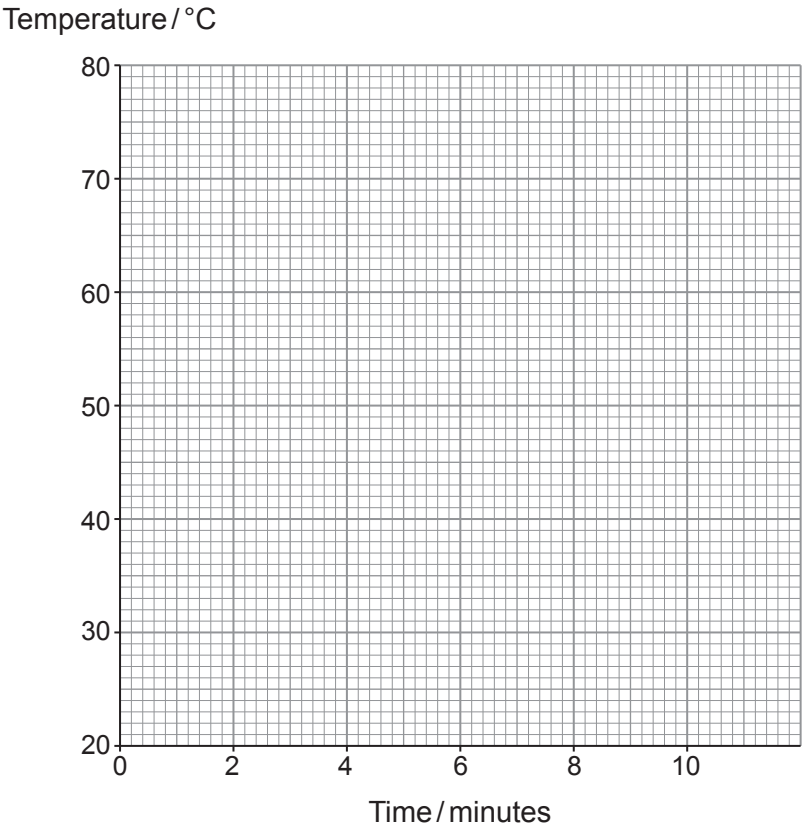
(d) Plot the student's results on the grid below. [2]



(e) Determine the maximum temperature change by drawing appropriate lines of best fit. [3]

Maximum temperature change = ... °C

(f) State whether the lines of best fit on the graph are good enough to be extrapolated with confidence. Explain your answer. [2]

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(g) Calculate the actual mass of zinc needed to react with the copper(II) sulfate solution. [2]

Mass = ... g

(h) Calculate the molar enthalpy change for this reaction, in $kJ\,mol^{-1}$.

Give your answer to the appropriate number of significant figures. [4]

ΔH = ... $kJ\,mol^{-1}$

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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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