

Candidate Name	Centre Number				Candidate Number			
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**GCE AS/A LEVEL CHEMISTRY****AS UNIT 2****SPECIMEN PAPER****Energy, Rate and Chemistry of Carbon Compounds****1 hour 30 minutes**

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
Section A Section B 1. to 6.	10	
7.	14	
8.	14	
9.	12	
10.	15	
11.	15	
Total	80	

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a data sheet and a calculator.

INSTRUCTIONS TO CANDIDATES

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

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

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

INFORMATION FOR CANDIDATES

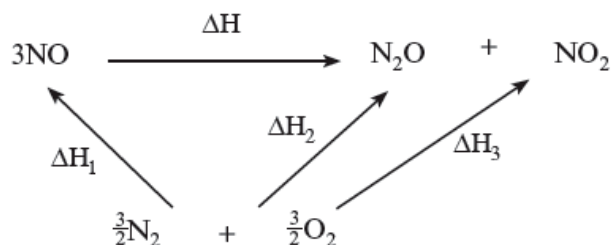
The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question 10.

SECTION A

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

1. The energy cycle for a decomposition of nitrogen(II) oxide is shown below.



- (a) Complete the equation to show ΔH in terms of ΔH_1 , ΔH_2 and ΔH_3 . [1]

$\Delta H =$

- (b) Write the chemical equation for the standard molar enthalpy change of formation of gaseous nitrogen(II) oxide, NO. [1]

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2. A compound of carbon, hydrogen and oxygen has a relative molecular mass of 180.

The percentage composition by mass is C 40.0%; H 6.70%; O 53.3%.

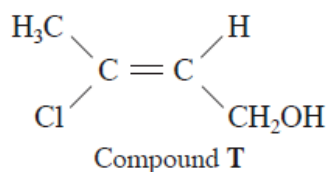
- (a) Calculate the empirical formula of this compound. [2]

Empirical formula

- (b) Determine the molecular formula of this compound. [1]

Molecular formula

3. (a) Explain why Compound **T** has *E*-*Z* isomers. [1]



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- (b) Explain why the enthalpy change to convert the *E*-isomer of compound **T** to the *Z*-isomer of compound **T** is 0 kJ mol^{-1} [1]

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4. Draw the **skeletal** formula of 4-chloro-2-methylpentane. [1]

5. Ethanol is present in many intoxicating drinks. Give **one** health problem associated with the consumption of excess ethanol. [1]

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6. 'Superglue' is a liquid containing methyl 2-cyanopropenoate. In the presence of moisture this alkene rapidly polymerises, in a similar way to ethene.

Complete the table showing the structure of the repeating unit. [1]

Monomer	Repeating unit

SECTION B

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

7. (a) The reaction of methane with chlorine gives a wide array of products including chloromethane, dichloromethane, trichloromethane, tetrachloromethane and ethane. This reaction only occurs in the presence of ultraviolet light.

- (i) Give a balanced equation for the formation of trichloromethane from dichloromethane and chlorine. [1]
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- (ii) Under similar conditions, pentane can be used to produce 1-chloropentane.

- I. Explain how decane, $C_{10}H_{22}$, could be produced as one of the products of this reaction. [2]
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- II. Warming 1-chloropentane with aqueous sodium hydroxide produces pentan-1-ol. Use the infrared absorption frequencies given in the data sheet to explain how you could check spectroscopically that this reaction had converted **all** the 1-chloropentane into pentan-1-ol. [2]
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- (iii) Gas **X** is another product of this reaction.

1.23 g of gas **X** occupies 1 dm^3 at a temperature of 308 K and pressure of 105000 Pa. Use this information to suggest its identity.

[3]

Gas **X**

- (b) It is possible to test for the presence of halogen atoms in a halogenoalkane by hydrolysing the molecule and testing for the halide ions released, using silver nitrate solution. This is a nucleophilic substitution reaction with the nucleophile attacking the $C^{\delta+}$ of the C–halogen bond. In each case, a precipitate is formed.

The carbon–halogen bond energies and the electronegativity differences for each bond are given below.

Bond	Average bond enthalpy /kJ mol ⁻¹	Electronegativity difference
C–Cl	338	0.61
C–Br	276	0.41
C–I	238	0.11

Using the information in the table, state how you would expect the rate of hydrolysis to vary as the halogenoalkane is changed. [2]

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- (c) The hydrolysis of three compounds was performed under identical conditions, and the time required for a precipitate of silver halide to form was measured.

The results were as follows:

Compound	Time for precipitate to form / minutes
1-chloropentane	17
1-bromopentane	4
1-iodopentane	Less than 1

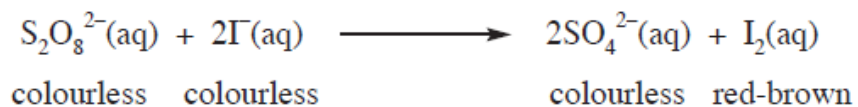
- (i) Use the tables to explain which of the factors does affect the rate of reaction. [2]

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- (ii) Briefly describe how you could gain further evidence to support the conclusion in part (b). [2]

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8. (a) Iodine is slowly produced, as a red-brown solution, by the reaction of aqueous peroxodisulfate ions, $S_2O_8^{2-}$, with a large excess of aqueous iodide ions,

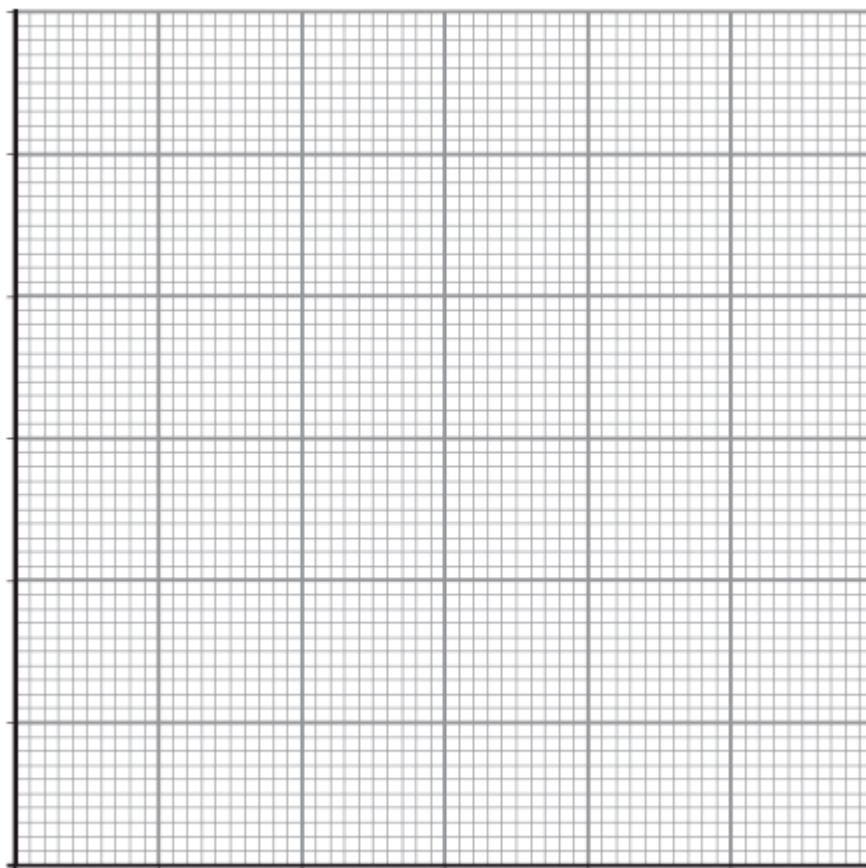


The following results were collected by a student.

Reaction time / min	0	1	2	3	4	5	6
Concentration of $I_2(aq)$ / $mol\ dm^{-3}$	0	0.0043	0.0070	0.0088	0.0097	0.0102	0.0102

- (i) Plot these results on the grid below. Label the axes, select a suitable scale and draw the line of best fit.

[3]



- (ii) Describe the key features of the method that would have been used to measure the rate of this reaction. [3]

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- (iii) Explain, using particle theory, the effect of increasing temperature on the rate of this reaction. [2]

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- (iv) State the concentration of the peroxodisulfate ions at the start of the reaction, explaining your answer. [2]

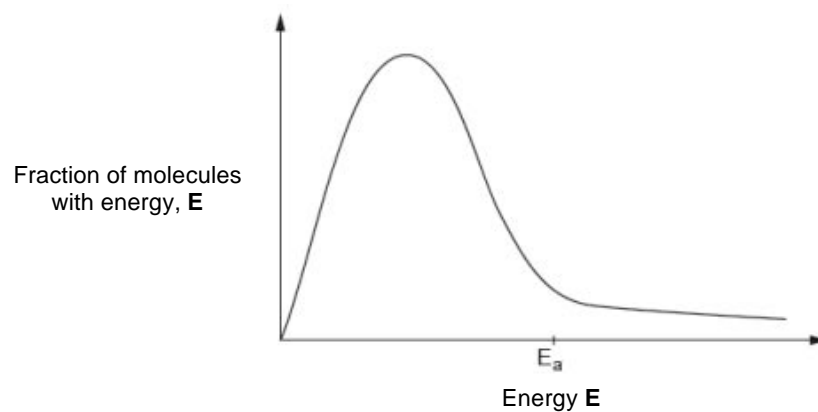
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- (v) Use the graph to calculate the initial rate of the reaction, stating the units. [2]

Initial rate =

Units

- (b) Use the diagram below to explain the effect of adding a catalyst on the rate of a chemical reaction. [2]



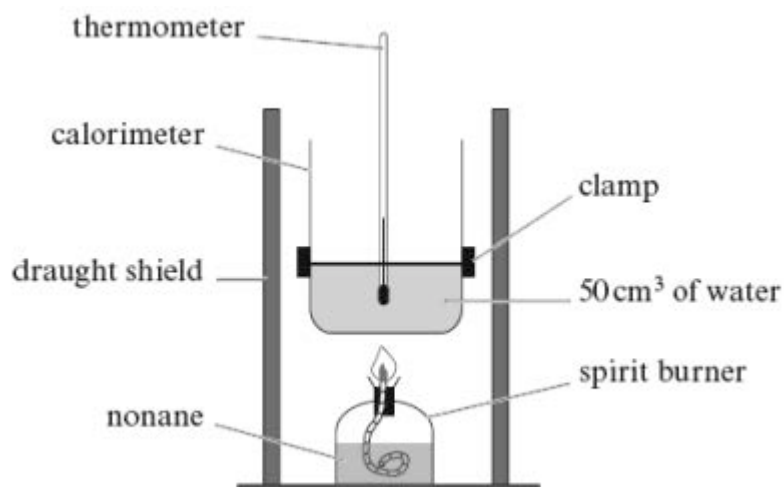
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9. (a) Iwan used the apparatus below to find the enthalpy change of combustion of nonane, C_9H_{20} .



- (i) Iwan measured the mass of the spirit burner at the start and end of the experiment and found that 0.20 g of nonane had been burned.

Calculate the number of moles of nonane present in 0.20 g. [2]

Number of moles = mol

- (ii) The initial temperature of the water was 22.5°C and the maximum temperature recorded during the experiment was 53.2°C. Calculate the enthalpy change of combustion of nonane, in kJ mol^{-1} . Show your working. [3]

[c is the specific heat capacity of water which is $4.18 \text{ J } ^\circ\text{C}^{-1} \text{ g}^{-1}$]

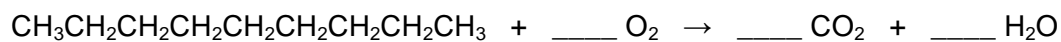
$\Delta_c H = \dots\dots\dots \text{ kJ mol}^{-1}$

- (iii) Give the main reason why the experimental value that Iwan obtained differs from the literature value. Suggest any improvements to the experiment that would give a more accurate value. [2]

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(b) In the complete combustion of nonane, carbon dioxide and water are formed.

- (i) Balance the equation below which represents the combustion of nonane. [1]



- (ii) The theoretical value for the enthalpy change of combustion of nonane ($\Delta_c H$) is $-4666 \text{ kJ mol}^{-1}$.

Use this value and the average bond enthalpy values in the table to calculate the average bond enthalpy of an O—H bond.

[3]

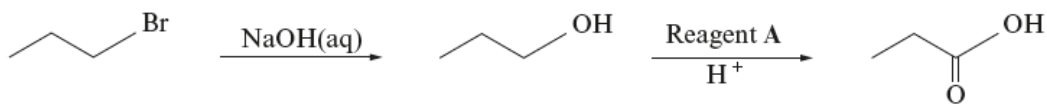
Bond	Average bond enthalpy / kJ mol^{-1}
C—H	412
C—C	348
O=O	496
C=O	743

Average bond enthalpy of an O—H bond = kJ mol^{-1}

- (iii) Suggest why the value calculated above does not agree exactly with the literature value for an O—H bond in a water molecule. [1]

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10. (a) 1-Bromopropane can be used to prepare propanoic acid in a two-stage process shown below.



- (i) The first stage uses aqueous sodium hydroxide. Under alternative conditions 1-bromopropane produces a different product when it reacts with sodium hydroxide.

Give the alternative conditions required, and the product that would be formed from 1-bromopropane under these conditions. [2]

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- (ii) For the second stage, state the **full name** of reagent **A** and classify the reaction occurring. [2]

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- (b) Compound **B** is an isomer of formula $C_6H_{12}O_2$ which exists as a sweet-smelling liquid at room temperature. It can be made from two of the organic compounds found in part (a).
- (i) Elemental analysis of compound **B** shows that it has a composition of 62.1 % carbon, 10.3% hydrogen and 27.6 % oxygen, by mass. Show that this composition is consistent with the formula above. [2]
- (ii) Compound **B** shows five resonances in its 1H nuclear magnetic resonance (NMR) spectrum. Apart from containing two CH_3- groups there are three $-CH_2-$ groups. The peaks on the NMR spectrum due to these $-CH_2-$ groups are found at 1.3 ppm, 2.1 ppm and 4.0 ppm.

The infrared spectrum of compound **B** shows absorptions at 2981 cm^{-1} and 1750 cm^{-1} .

These are the only significant absorptions above 1500 cm^{-1} .

Using **all** the information supplied, deduce the structure of compound **B**. Give **reasons** in support of your answer. [6 QER]

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- (iii) State how this product, compound **B**, could be separated from the starting materials from part (a). Use your knowledge of intermolecular forces to explain why this method of separation would be suitable in this case. [3]

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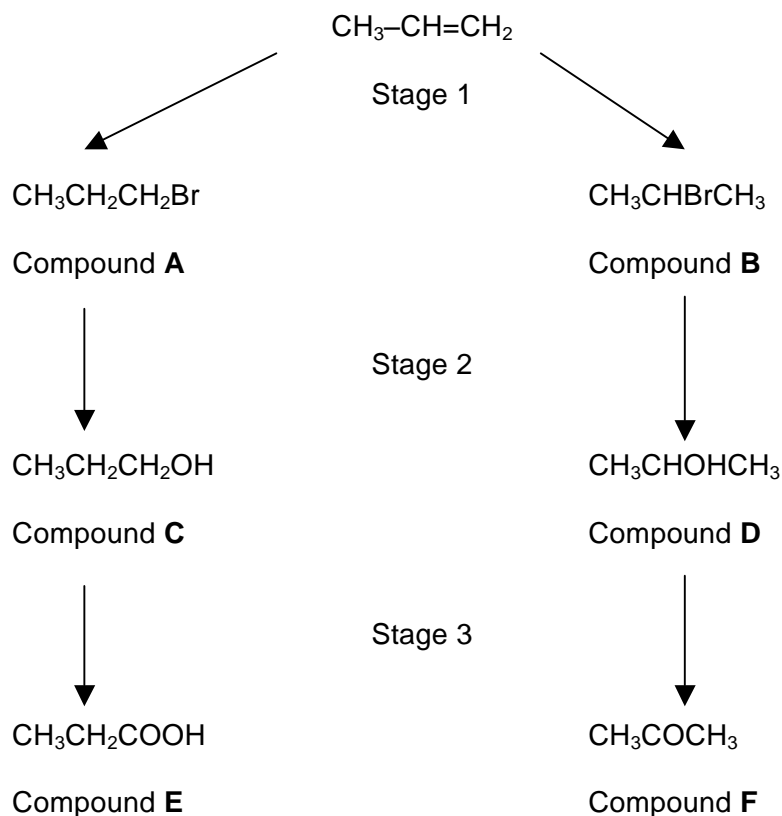
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11. Alkenes can be the precursors to many organic compounds as shown below.



- (a) (i) Draw the mechanism for the production of the major product in stage 1. In your answer you should classify the type of mechanism occurring. [4]

Type of mechanism

- (ii) Explain why two products are formed in stage 1 and why one of the products is favoured. [2]

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- (b) In stage 3 a third product was also formed which is not shown above. This compound also has three carbon atoms and its NMR spectrum includes a peak at chemical shift, $\delta = 9.8$ ppm. An absorption occurs in its infrared spectrum at 1715 cm^{-1} .

Use the information above to deduce whether this compound is a result of the reaction of compound **C** or compound **D**. In your answer you should also include the type of reaction occurring in stage 3. [4]

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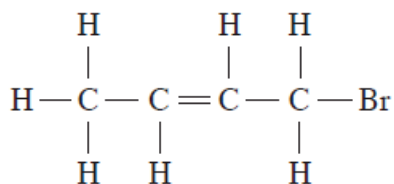
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- (c) As part of a project, two students were asked to report on tests for functional groups present in the compound below.



Nia reported that in testing for the C=C group:

- aqueous bromine should be added to the compound and if the test is positive, the colour of the mixture changes from purple to colourless;
- the name of the compound formed in this test is 2,3,4-tribromobutane.

- (i) Correct the **two** mistakes in her report. [2]

I.

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II.

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David reported that in testing for bromine:

- dilute hydrochloric acid should be added to the compound;
- aqueous silver nitrate should then be added;
- you should see a cream precipitate.

(ii) I. State and explain the observations David would have made if he had carried out his test. [1]

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II. Outline the correct method for carrying out a test for bromine in the compound. Include any reagents used in your answer. [2]

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