Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS/A LEVEL

S23-2410U20-1

2410U20-1

THURSDAY, 25 MAY 2023 – 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.	**6**	
	10.	**18**	
	11.	**10**	
	12.	**13**	
	13.	**17**	
	Total	**80**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- **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 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 **Q.8**.

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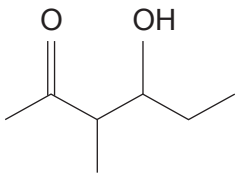
SECTION A

Answer **all** questions.

1. Give the molecular formula of the compound shown. [1]



Molecular formula .....

2. When fuels are burned with insufficient oxygen, incomplete combustion occurs and carbon monoxide is formed instead of carbon dioxide.

Write the equation for the incomplete combustion of propane, C_3H_8. Assume that carbon monoxide is the only carbon-containing product. [1]

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3. Name the reagent that is needed to change unsaturated oils into saturated fats. [1]

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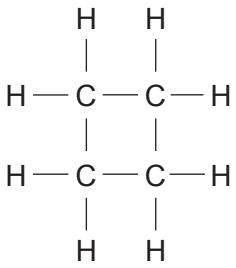
4. Cyclobutane is a cyclic hydrocarbon whose structure is shown.



Draw the structures of **two** structural isomers of this compound. [2]

5. Propene reacts with hydrogen bromide.

$$C_3H_6 + HBr \longrightarrow C_3H_7Br$$

Draw the structures of the **two** isomers formed and give the name of the major product. [2]

Major product .....

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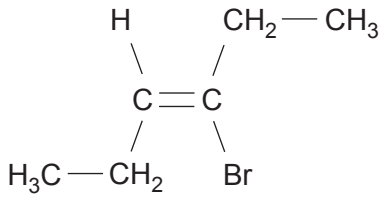
6. In the forward direction, the enthalpy change of reaction, ΔH, for a reversible endothermic reaction, has the numerical value of 60 kJ mol^{-1}.

If the activation energy, E_a, of the forward reaction is 100 kJ mol^{-1}, calculate the activation energy of the backward reaction. [1]

E_a = ... kJ mol^{-1}

7. Name the following *E*-*Z* isomer. [2]



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SECTION B

Answer **all** questions.

8. The use of biofuels has been proposed as the way to ensure the sustainability of energy production in the future.

Discuss the extent to which you agree with this proposal, giving both advantages and disadvantages of the use of biofuels. Include relevant examples in your answer. [6 QER]

6

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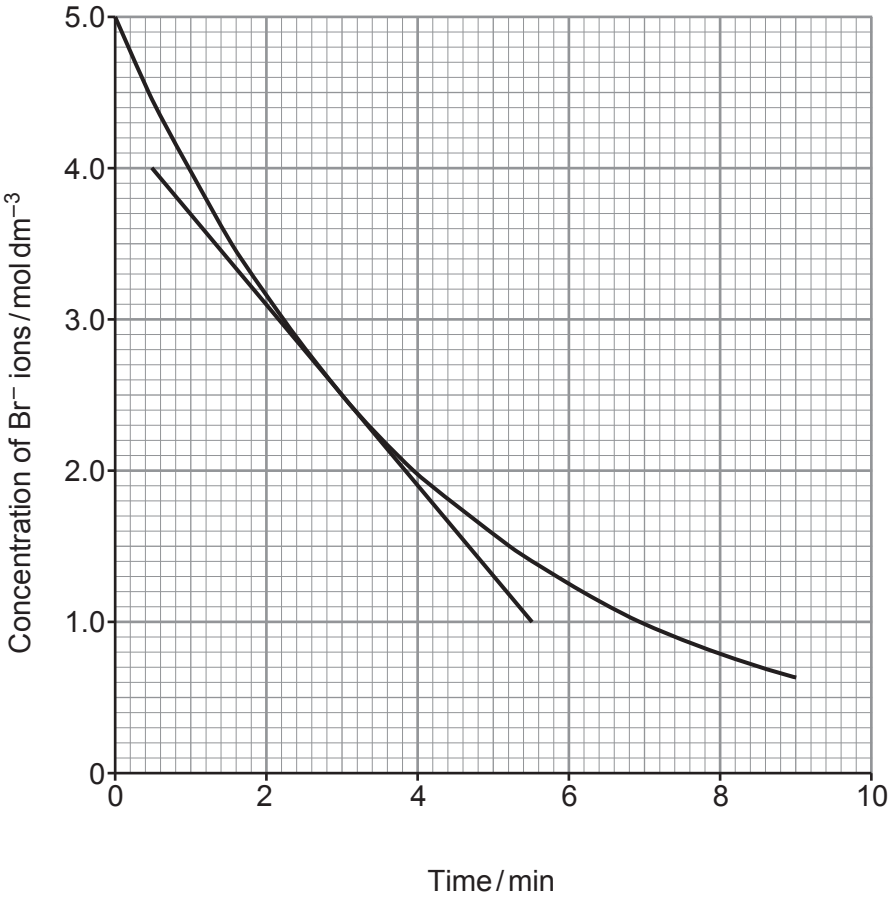
9. Bromide ions react with bromate(V) ions, BrO_3^-, as shown in the equation.

$$5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \longrightarrow 3Br_2(aq) + 3H_2O(l)$$

Some students investigated the rate of this reaction by following the concentration of bromide ions over time. They plotted their results as shown.



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(a) (i) The students calculated that the initial rate of the reaction was $1.20\,mol\,dm^{-3}\,min^{-1}$.

Use the tangent to the curve to calculate the rate of the reaction when the concentration of bromide ions had fallen to $2.50\,mol\,dm^{-3}$.

You **must** show your working. [2]

Rate = ... $mol\,dm^{-3}\,min^{-1}$

(ii) Use your answer to part (i) to suggest the relationship between the rate of this reaction and the concentration of bromide ions. [1]

.....

.....

(b) Suggest how the students could follow the rate of this reaction. Explain your answer. [2]

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(c) In the experiment, the concentration of bromide ions fell from $5.0\,mol\,dm^{-3}$ to $2.0\,mol\,dm^{-3}$ over the first 4 minutes. The initial concentration of bromate(V) ions was $1.0\,mol\,dm^{-3}$.

$$5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \longrightarrow 3Br_2(aq) + 3H_2O(l)$$

Using the equation, deduce the concentration of bromate(V) ions after 4 minutes. [1]

Concentration of bromate(V) ions = ... $mol\,dm^{-3}$

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10. (a) The enthalpy of neutralisation of an acid is defined as the enthalpy change when 1 mol of aqueous H^+ ions is neutralised by aqueous OH^- ions according to the equation shown. The reaction is exothermic.

$$H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$$

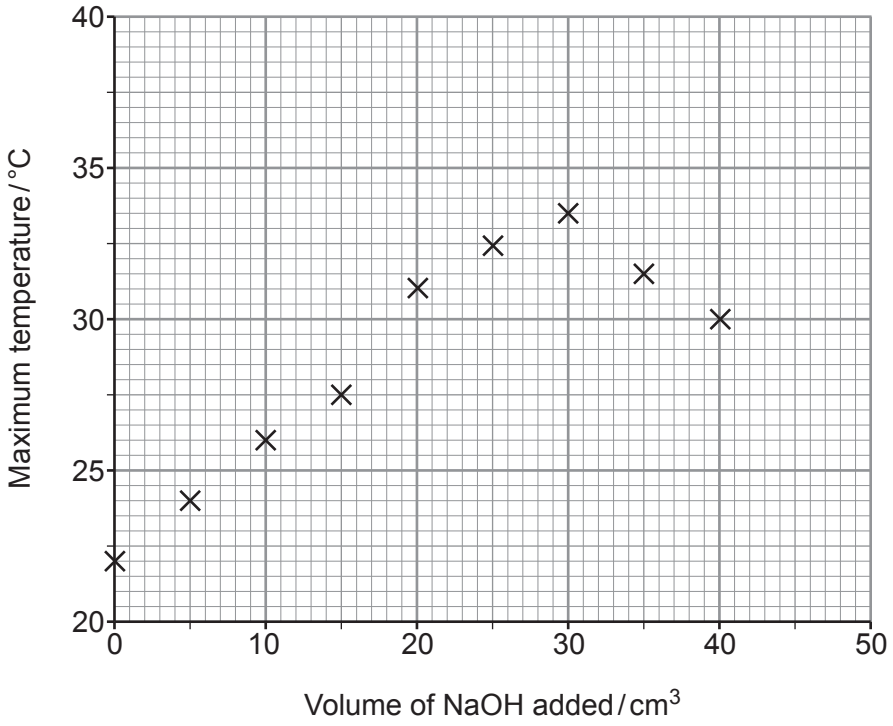
Some students followed the instructions below to determine the enthalpy change of neutralisation of methanoic acid, HCOOH.

1. Weigh 24.7 g of methanoic acid and mix with water to make 250 cm^3 of solution. Record the temperature of the solution.
2. Transfer eight 25.0 cm^3 portions of this solution into eight insulated cups.
3. Using a burette add 5.0 cm^3 of aqueous sodium hydroxide to the solution in the first cup. Stir and record the maximum temperature reached.
4. Add the following volumes of aqueous sodium hydroxide to each of the remaining cups in turn:

   10.0 cm^3 15.0 cm^3 20.0 cm^3 25.0 cm^3 30.0 cm^3 35.0 cm^3 40.0 cm^3

   Stir and record the maximum temperature reached in each cup.
5. Plot a graph of maximum temperature reached against volume of sodium hydroxide added.

Their results are plotted in the graph.



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(i) Name the apparatus used to transfer exactly 25.0 cm^3 of methanoic acid solution into the insulated cups. [1]

.....

(ii) State why a higher maximum temperature is recorded when increasing volumes of sodium hydroxide are added. [1]

.....

.....

(iii) Explain why the maximum temperature recorded decreases when more than 30 cm^3 of sodium hydroxide is added. [2]

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.....

(iv) On the graph, draw **one** straight line through the points that show an increase in maximum temperature and **another** straight line through the points that show a decrease in maximum temperature. [1]

(v) From the graph, deduce the volume of sodium hydroxide needed to neutralise 25.0 cm^3 of the methanoic acid solution and the temperature increase at that point.

Assume that the initial temperature of every 25.0 cm^3 of methanoic acid solution is 22.0 °C. [2]

Volume = ... cm^3

Temperature increase = ... °C

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(vi) Use your answers to part (v) to calculate the amount of heat released by the neutralisation reaction. [2]

Heat released = ... J

(vii) Calculate the number of moles of methanoic acid in 25.0 cm^3 of the solution and hence the enthalpy change of neutralisation of methanoic acid. [3]

Enthalpy change of neutralisation = ... $kJ\,mol^{-1}$

Examiner only

(b) The experiment is repeated using hydrochloric acid instead of methanoic acid and a more negative value of the enthalpy change of neutralisation is calculated.

Suggest and explain a reason for this difference. [2]

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.....

.....

(c) (i) Write the equation for the reaction that occurs when solid copper(II) carbonate is added to aqueous methanoic acid to form aqueous copper(II) methanoate, $(HCOO)_2Cu$.

Include state symbols. [2]

.....

(ii) State what is observed during the reaction in part (i). [2]

.....

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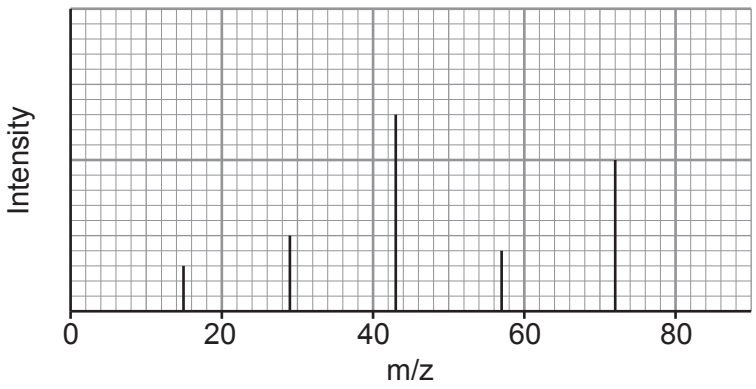
Turn over.

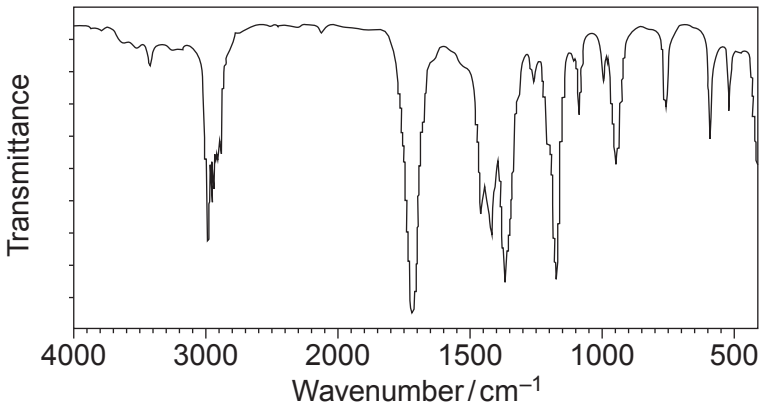
11. (a) Compound **X** contains carbon, hydrogen and oxygen only. It has no reaction with acidified potassium dichromate.

Simplified versions of its mass spectrum, IR spectrum and ^{13}C NMR spectrum are shown.

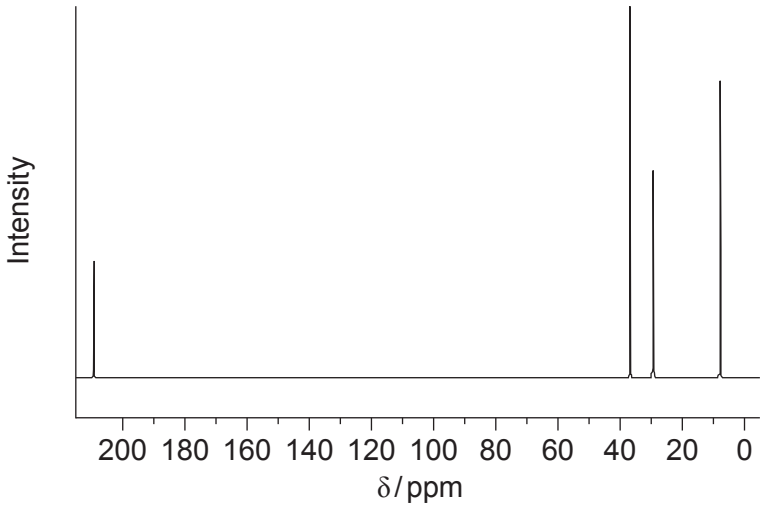
Mass spectrum



IR spectrum



^{13}C NMR spectrum



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Identify compound **X**.

You **must** use information from **all** the sources given and explain how you used it. [8]

Compound **X**

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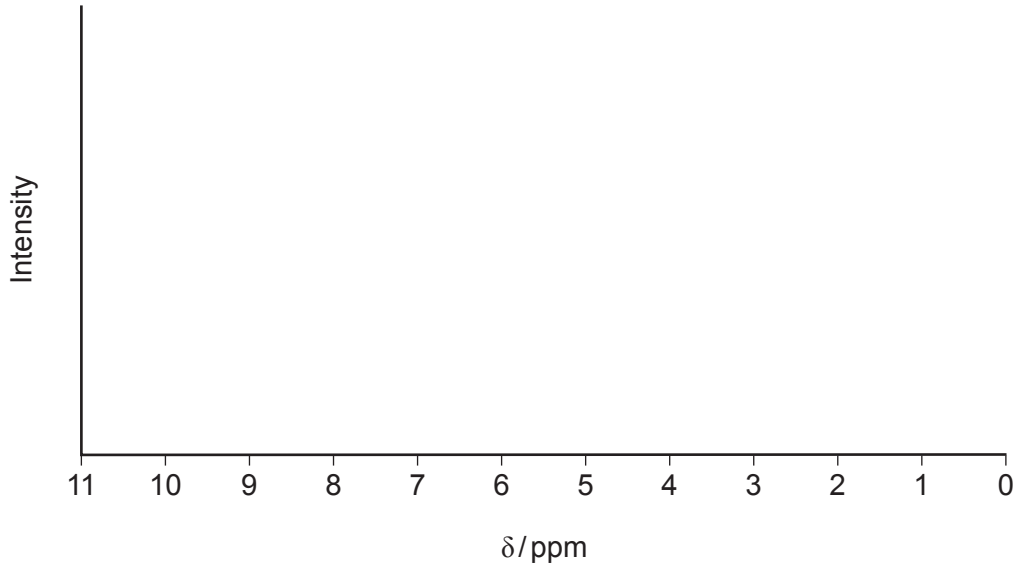
(b) On the axes below, complete the low resolution ^{1}H NMR spectrum you would expect for the compound you identified in part (a).

You should indicate where you would expect to see peaks **and** the relative intensities of the peaks. [2]



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12. (a) **Y** is a halogenocompound in which each molecule contains one atom of chlorine, bromine or iodine.

(i) Describe a chemical test to determine which halogen is present in **Y**. [3]

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.....

(ii) **Y** contains four carbon atoms in each molecule. The percentage by mass of halogen present in **Y** is less than 40%.

Identify **Y**. Explain how you reached your conclusion. [2]

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(b) (i) Halogenoalkanes react with aqueous sodium hydroxide.

Draw the mechanism to show the reaction of 1-chloropropane with aqueous sodium hydroxide.

You should include all charges, partial charges and lone pairs, and curly arrows to show electron movement. [4]

(ii) Name the type of reaction shown in part (i). [1]

.....

(c) Halogenoalkanes can also take part in an elimination reaction.

2-Chloropentane undergoes elimination in a similar way to 1-chloropropane.

(i) Give the reagent and conditions needed for 2-chloropentane to undergo elimination. [1]

.....

(ii) When 2-chloropentane undergoes elimination, two structural isomers are formed.

Give the structures of these **two** isomers. [2]

13

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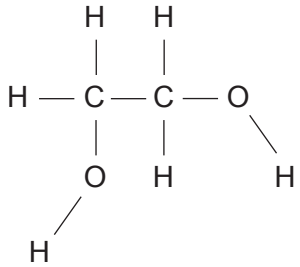
13. (a) In cold weather the wings of an aeroplane can become covered in ice. For safety reasons the wings must be de-iced.

The liquid ethane-1,2-diol, CH_2OHCH_2OH, is used, mixed with water, since this lowers the freezing temperature of water and causes the ice to melt.

(i) Use the diagram below to show the intermolecular forces that allow ethane-1,2-diol to dissolve in water. [3]



(ii) Suggest a reason why the addition of ethane-1,2-diol lowers the freezing temperature of water. [1]

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(b) Ethane-1,2-diol can be oxidised to ethanedioic acid, $(COOH)_2$.

(i) Suggest an oxidising agent suitable to carry out this reaction. [1]

.....

(ii) Write the equation for this reaction. Use [O] for the oxidising agent. [2]

.....

(iii) To ensure complete oxidation the reagents are refluxed.

Draw and label the apparatus as it is being used in this reaction. [2]

(iv) A sample of the reacting mixture was taken during the reflux process and a mass spectrum was produced. One of the peaks recorded was at m/z 58.

Suggest the identity of the **molecular ion** that gave this peak. [1]

.....

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(v) The reaction can be used to prepare a sample of solid ethanedioic acid. This is generally hydrated as $(COOH)_2.xH_2O$ where x is an integer.

2.00 g of ethane-1,2-diol was oxidised and 3.94 g of hydrated ethanedioic acid was produced.

Calculate the relative molecular mass of hydrated ethanedioic acid and hence the value of x in its formula. [4]

x = ...

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(vi) I. Complete the equation for the reaction which occurs when ethanedioic acid is heated with excess methanol in acidic conditions.

Clearly show the structure of the organic product. [2]

II. Name the type of functional group present in the organic product. [1]

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END OF PAPER

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

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