Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A LEVEL

2410U20-1

S19-2410U20-1

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

THURSDAY, 23 MAY 2019 – MORNING

1 hour 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 6.**	**10**	
Section B	**7.**	**18**	
	8.	**15**	
	9.	**12**	
	10.	**11**	
	11.	**14**	
	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.

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

Section A Answer **all** questions in the spaces provided.
Section B Answer **all** questions in the spaces provided.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

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.10***(a)*.

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.

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SECTION A

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

1. Draw the **skeletal** formula of 2-bromo-3-methylbutane. [1]

2. Write the equation that corresponds to the standard molar enthalpy change of formation of magnesium carbonate, $MgCO_3$. [2]

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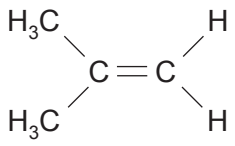
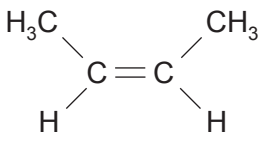
3. The compounds shown below have the same molecular formula.



A



B

State which of these compounds can exist as *E-Z* isomers.

Explain your answer and name the isomer. [2]

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Name of isomer .....

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4. Halogenoalkanes are hydrolysed by aqueous sodium hydroxide. State and explain which of 1-fluoropropane, 1-chloropropane and 1-bromopropane is hydrolysed most rapidly. [2]

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5. *(a)* State the type of polymerisation involved when 2-fluorobut-2-ene, $CH_3CF{=}CHCH_3$, forms a polymer. [1]

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(b) Draw **one** repeat unit of the polymer formed when 2-fluorobut-2-ene is polymerised. [1]

6. Complete the equation for the formation of ethanol by the fermentation of glucose. [1]

$C_6H_{12}O_6 \longrightarrow$ ..... + ...

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Turn over.

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SECTION B

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

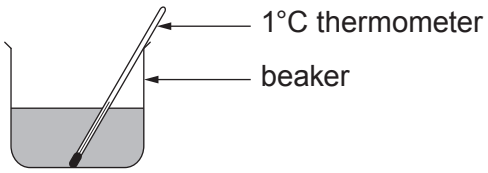
7. *(a)* A student was asked to find the enthalpy change of reaction, ΔH, for the thermal decomposition of calcium hydroxide.

$$Ca(OH)_2(s) \longrightarrow CaO(s) + H_2O(g)$$

This enthalpy cannot be measured directly so Hess's Law is generally used to calculate its value from the enthalpy changes for the reactions of calcium oxide and calcium hydroxide with hydrochloric acid.

The student added a known mass of calcium oxide to hydrochloric acid and measured the temperature change. This was repeated using a known mass of calcium hydroxide. In each experiment 50.0 cm^3 of 1.40 mol dm^{-3} hydrochloric acid was used.

The diagram shows the apparatus used.



When 1.90 g of calcium oxide was used a temperature rise of 20.5 °C was observed.

(i) The equation for the reaction of calcium oxide with hydrochloric acid is shown.

$$CaO(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l)$$

Use this equation to show that the hydrochloric acid was in excess in the reaction with calcium oxide. [3]

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(ii) Calculate the energy released in this reaction between calcium oxide and hydrochloric acid. [1]

Energy released = ... J

(iii) Calculate the molar enthalpy change for the reaction between calcium oxide and hydrochloric acid. [2]

$$CaO(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l)$$

Enthalpy change = ... kJ mol^{-1}

sign value

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(iv) The value of the molar enthalpy change of reaction for the reaction between calcium hydroxide and hydrochloric acid is –196 kJ mol^{-1}.

Use Hess's Law and your answer to part (iii) to calculate the enthalpy change of reaction for the decomposition reaction.

$$Ca(OH)_2(s) \longrightarrow CaO(s) + H_2O(g)$$

Show clearly how you obtained your answer.

(If you do not have an answer in part (iii), assume that the enthalpy change of reaction is –110 kJ mol^{-1}. This is **not** the correct value.) [2]

Enthalpy change = ... kJ mol^{-1}

(v) Suggest **two** changes to the apparatus shown that would give a more accurate value for the enthalpy changes of the reactions. Give a reason for your answer in both cases. [2]

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(b) Methanol, CH_3OH, is a liquid at room temperature and its molar enthalpy of combustion, $\Delta_c H$, can be found directly.

(i) Write the equation corresponding to the standard enthalpy change of combustion of methanol. [1]

.....

(ii) Draw and label suitable apparatus as it is being used in an experiment to determine the enthalpy change of combustion of methanol. [2]

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(c) The equation for the combustion of ethene is shown.

$$C_2H_4(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(g) \qquad \Delta_c H^\theta = -1387 \text{ kJ mol}^{-1}$$

(i) Use this and the values of the average bond enthalpies in the table to calculate the average bond enthalpy of C—H. [4]

Bond	Average bond enthalpy / kJ mol^{-1}
C═C	614
O═O	495
C═O	799
O—H	465

Average bond enthalpy = ... kJ mol^{-1}

(ii) State why the apparatus you have drawn in part *(b)* cannot be used to determine the enthalpy change of combustion of ethene. [1]

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8. Many factors affect the rate of a chemical reaction.

(a) Explain why a change in concentration affects the rate of a reaction. [2]

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(b) Under certain conditions nitrogen monoxide reacts with carbon monoxide and oxygen according to the equation below.

$$NO(g) + CO(g) + O_2(g) \longrightarrow NO_2(g) + CO_2(g)$$

A study of the rate of this reaction, using varying initial concentrations of nitrogen monoxide and oxygen, gave the following data.

Experiment number	Concentration NO / mol dm^{-3}	Concentration O_2 / mol dm^{-3}	Initial rate of reaction / mol $dm^{-3} s^{-1} \times 10^{-4}$
1	1.0×10^{-4}	1.0×10^{-4}	4.40
2	2.0×10^{-4}	1.0×10^{-4}	17.6
3	3.0×10^{-4}	1.0×10^{-4}	39.6
4	2.0×10^{-4}	2.0×10^{-4}	17.6

(i) Use the data to determine how the concentration of NO affects the rate of the reaction. Explain your answer by referring to the experiment numbers. [2]

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(ii) Use the data to determine how the concentration of O_2 affects the rate of the reaction. Explain your answer by referring to the experiment numbers. [2]

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(iii) Suggest a method that could be used to follow changes over time as the reaction of nitrogen monoxide, carbon monoxide and oxygen proceeds. Explain your answer. [2]

$$NO(g) + CO(g) + O_2(g) \longrightarrow NO_2(g) + CO_2(g)$$

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(iv) Describe the environmental implications on the atmosphere if the reaction above occurs on a large scale. [2]

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(v) The reaction shown is one of many that are catalysed in a catalytic converter. State where in a car a catalytic converter is used and name a suitable catalyst. [2]

Catalytic converter used in .....

Catalyst used .....

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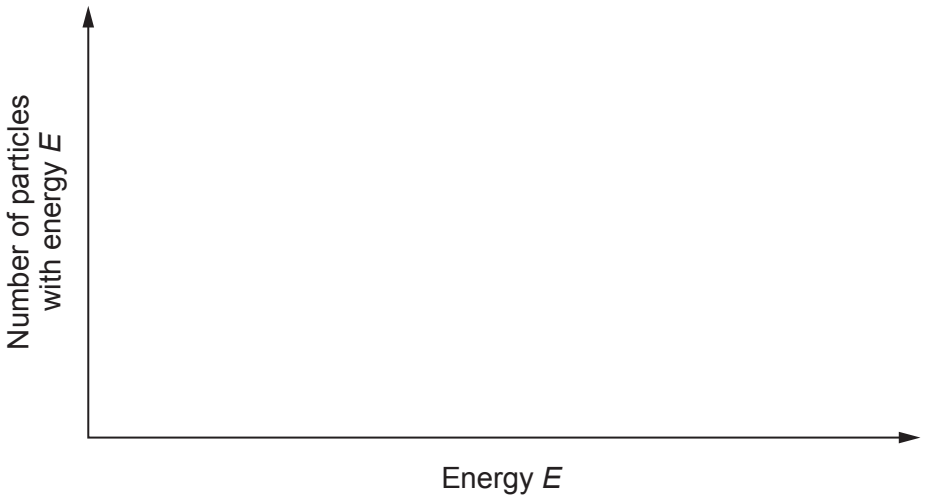
(c) On the axes below draw a Boltzmann distribution curve of the energies of molecules at a certain temperature.

Use this curve to explain how a catalyst increases the rate of a reaction. [3]



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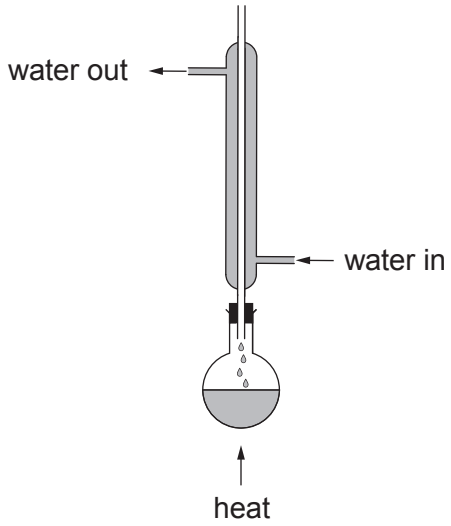
9. *(a)* Alcohols react with carboxylic acids to form esters. To prepare a pure sample of an ester a condenser can be used in the first stage.



(i) Name the method being used with the condenser positioned in this way. Explain why it is necessary to use the condenser. [2]

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(ii) Name the method used to separate the product from the liquid mixture. State which property of an ester allows this method of separation to be used. [2]

Method .....

Property .....

(iii) Name the catalyst most commonly used in the preparation of an ester. [1]

.....

(iv) Write the equation for the reaction between methanoic acid and butan-2-ol. [2]
Clearly show the structure of the ester formed.

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(b) A compound is known to be one of butan-2-ol, $CH_3CH_2CH(OH)CH_3$, 2-methylpropanoic acid, $CH_3CH(CH_3)COOH$, and 3-hydroxybutanoic acid, $CH_3CH(OH)CH_2COOH$.

Choose **two** chemical tests that will enable you to determine which one it is.

Complete the table below.

Give the reagent(s) for each test and the observation expected for a positive result.

For each test put a **tick (✓)** in the box to show the compound that gives a positive result and a **cross (×)** for those that do not. [5]

Reagent(s)	Observation expected for positive result	butan-2-ol	2-methylpropanoic acid	3-hydroxybutanoic acid

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10. *(a)* Students were discussing the reactivity of organic compounds. One said that reactivity was due to dipoles produced by differences in electronegativity.

Show that this is not correct by discussing the difference in reactivity between alkanes and alkenes. You should include reference to the bonding in both series.

[6 QER]

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(b) In the 19th century Cannizzaro discovered a reaction that involved disproportionation. Such reactions involve the same substance being both oxidised and reduced.

The equation for the Cannizzaro reaction is shown.

$$2C_6H_5CHO + H_2O \longrightarrow C_6H_5CH_2OH + C_6H_5COOH$$

(i) State why this reaction is classified as *disproportionation*. [1]

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(ii) A chemist used 9.50 g of C_6H_5CHO in the reaction above and made 3.39 g of $C_6H_5CH_2OH$.

Calculate the percentage yield that this mass of $C_6H_5CH_2OH$ represents. [3]

Percentage yield = ... %

(iii) Cannizzaro's reaction is usually carried out using aqueous sodium hydroxide, rather than with water as shown in the equation above.

Write the equation for the Cannizzaro reaction of C_6H_5CHO with aqueous sodium hydroxide. [1]

.....

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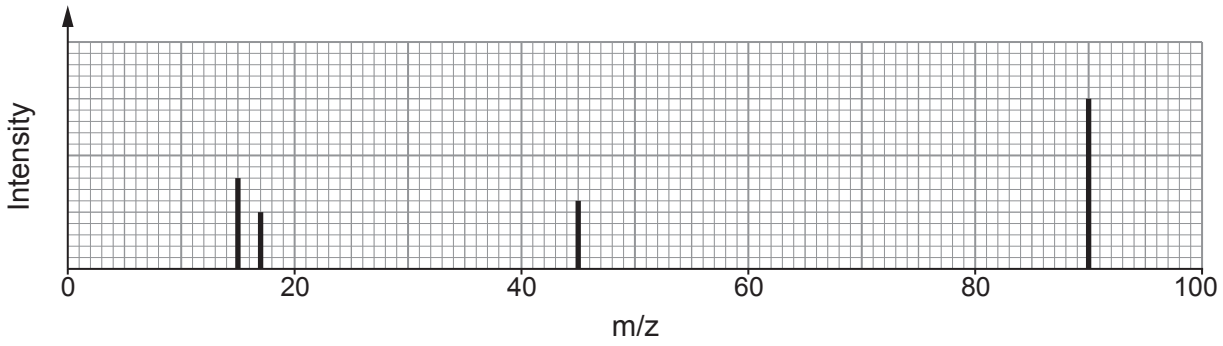
11. *(a)* Compound **X** contains only carbon, hydrogen and oxygen.

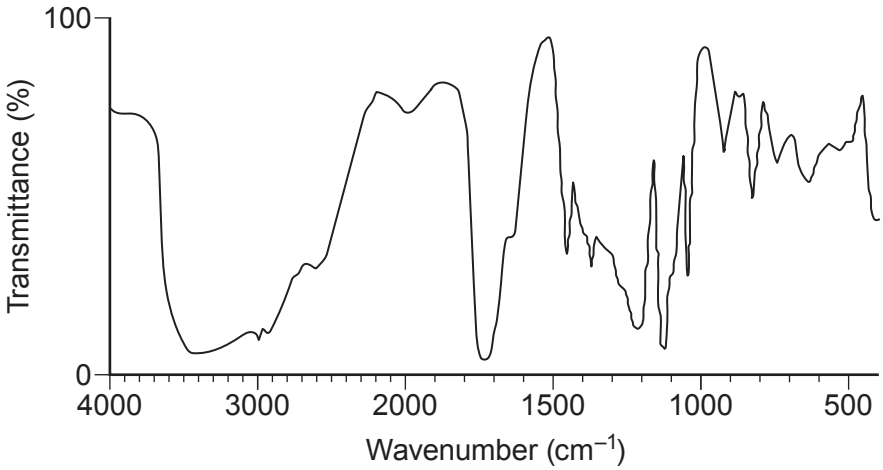
On analysis **X** was found to contain 40.0 % carbon and 6.67 % hydrogen by mass.

A simplified form of the mass spectrum, the IR spectrum and the low resolution ^{1}H NMR spectrum of **X** are shown.

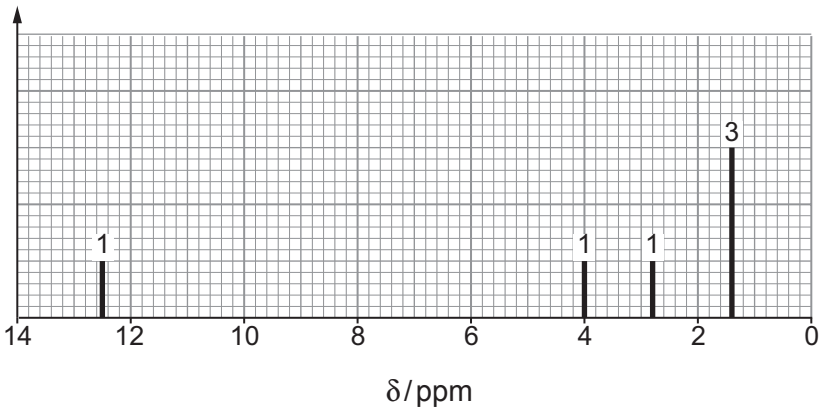
Mass spectrum



IR spectrum



^{1}H NMR spectrum



The numbers above the peaks show the relative areas of the peaks.

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Use this information to identify compound **X**.

You must use information from **all** the sources given and explain how you used it. [10]

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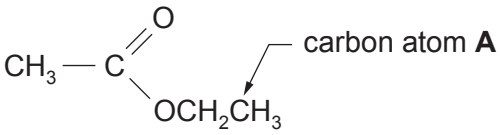
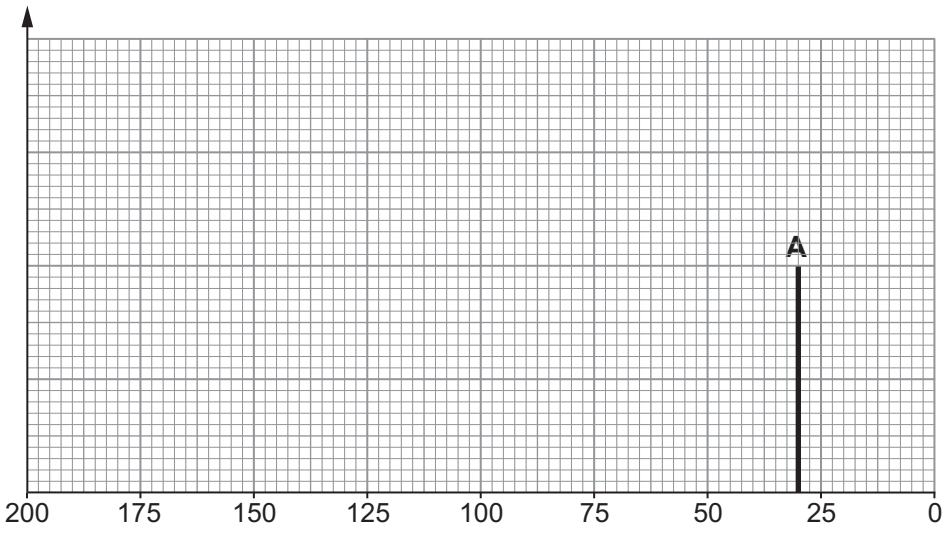
(b) Information about the structure of organic compounds can also be found using a ^{13}C NMR spectrum.

(i) On the axes below sketch the ^{13}C NMR spectrum that you would expect to obtain from ethyl ethanoate.



Label the diagram to show the species causing each peak.
The peak caused by carbon atom **A** is already included. [3]



(ii) A student said that valuable information about the nature of a sample being analysed could be obtained from the peak heights in both the ^{13}C and ^{1}H NMR spectra.

Comment on whether the student is correct. Give a reason for your answer. [1]

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