Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A LEVEL

2410U20-1

S18-2410U20-1

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

FRIDAY, 25 MAY 2018 – MORNING

1 hour 30 minutes

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

2410U201
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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)*(i).

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 structure of a secondary alcohol that contains 6 carbon atoms. [1]

2. Draw the **skeletal** formula of 3-chloro-2,2-dimethylpentane. [1]

3. Explain why ethanol is soluble in water but ethane is not. [2]

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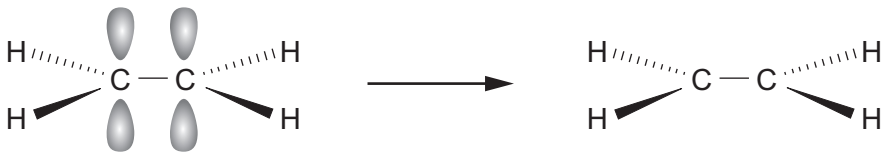
4. Complete the diagram to show the formation of the π-bond in ethene. [1]



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5. *(a)* Complete the equation for the fermentation of glucose. [1]

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

(b) Name the substance generally used to catalyse this reaction. [1]

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6. Draw **two** repeat units for the polymer formed from the monomer pent-2-ene. [1]

7. Draw diagrams to show the structures of the *E* and *Z* isomers of 2-bromopent-2-ene.
Label the isomers *E* and *Z*. [2]

2410U201
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10

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SECTION B

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

8. A student was told that he could prepare chloroethane, C_2H_5Cl, by mixing ethane with chlorine. He added 2.0 g of ethane to excess chlorine and left the mixture exposed to ultraviolet light for several hours. He was then able to use a university laboratory to see whether chloroethane had been made.

(a) State an instrumental method by which the sample could be analysed. Explain how this would show that chlorination had occurred. [2]

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(b) State why it is necessary to use ultraviolet light when making chloroethane from ethane. Give equations to show the mechanism for the formation of chloroethane. [4]

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(c) The student found that he had made 1.0 g of chloroethane. Calculate his percentage yield. [3]

Percentage yield = ... %

(d) The student was disappointed by the yield he obtained but his teacher told him that the yield was always poor due to other products being formed in this reaction.

Identify **two** other organic products, apart from chloroethane, and explain how they are formed. [2]

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2410U201
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9. *(a)* (i) The average bond enthalpy of a C—C bond is quoted as 348 kJ mol^{-1}.

Explain what is meant by *bond enthalpy*. [2]

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(ii) Ethyne, C_2H_2, contains a C≡C. It reacts with hydrogen in a similar way to ethene.

$$H—C{\equiv}C—H \quad + \quad 2H_2 \longrightarrow C_2H_6$$

Some average bond enthalpies are given in the table.

Bond	Average bond enthalpy / kJ mol^{-1}
C≡C	839
C—C	348
C—H	413
H—H	436

Use the data to calculate the enthalpy change, ΔH, for the reaction of ethyne and hydrogen. [3]

ΔH = ... kJ mol^{-1}

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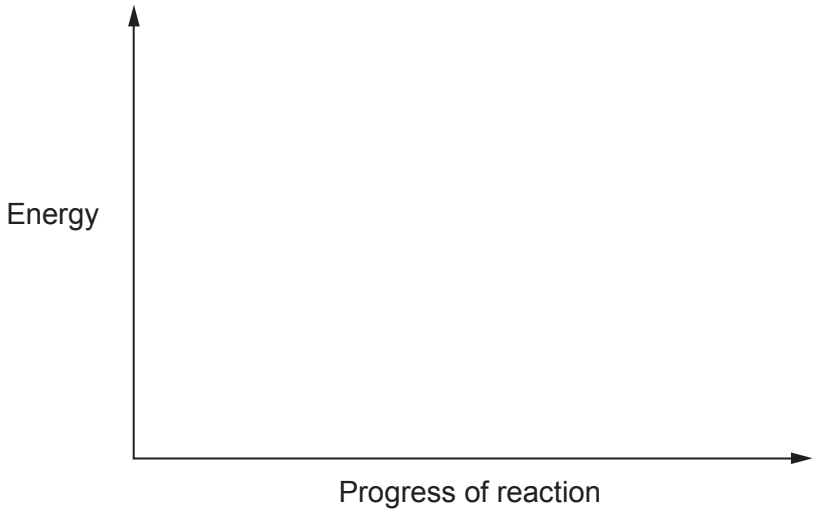
(iii) Use your answer to part (ii) to sketch an energy profile diagram for this reaction on the axes below. Label ΔH and the activation energy, E_a, on your diagram. [2]



(b) Enthalpy changes of reaction are often found indirectly. The enthalpy change for the reaction of ethyne with hydrogen, as shown in part *(a)*, can be determined by using enthalpy changes of combustion.

The table gives some enthalpy changes of combustion, $\Delta_c H^\theta$.

Substance	Enthalpy change of combustion, $\Delta_c H^\theta$ / kJ mol^{-1}
hydrogen, H_2	–286
ethyne, C_2H_2	–1300
ethane, C_2H_6	–1600

Use these enthalpy changes to calculate the enthalpy change, ΔH, for the reaction of ethyne and hydrogen. [3]

$$C_2H_2 + 2H_2 \longrightarrow C_2H_6$$

ΔH = ... kJ mol^{-1}

2410U201
07

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(c) The theoretical values that you have calculated in parts *(a)*(ii) and *(b)* are both the enthalpy change for the reaction between ethyne and hydrogen.

Suggest a reason why these values are not the same. [1]

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(d) Suggest the type of reaction that occurs between ethyne and hydrogen. [1]

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10. *(a)* Halogenoalkanes can be hydrolysed using water in a similar way to using aqueous sodium hydroxide.

A student carried out an experiment to investigate the rate of reaction for the hydrolysis of halogenoalkanes using water. The student used aqueous ethanol to dissolve the halogenoalkane and then added a few drops of aqueous silver nitrate. He timed how long it took to produce a precipitate. He obtained the results shown in the table.

Halogenoalkane	Time / s
1-chloropropane, C_3H_7Cl	300
1-bromopropane, C_3H_7Br	90
1-iodopropane, C_3H_7I	15

The student tried to explain these results and he looked on the internet to find the following data.

Bond	Bond enthalpy / kJ mol^{-1}
C—H	413
C—C	348
C—F	485
C—Cl	328
C—Br	276
C—I	240

Element	Electronegativity
chlorine	3.16
bromine	2.96
iodine	2.66
carbon	2.55

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(i) Use both sets of data to explain the student's results. Include an equation to show the hydrolysis reaction between a halogenoalkane and aqueous sodium hydroxide and name this type of reaction mechanism. [6 QER]

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(ii) Write an **ionic** equation, including state symbols, for a reaction that produces a silver halide precipitate. [1]

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(iii) Suggest a practical method by which the student could have obtained these results. [2]

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(iv) Suggest the difference that the student would have observed in his experiments if he had not added ethanol to the water before adding the halogenoalkane. [1]

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(b) Chlorofluorocarbons, CFCs, were historically used for a variety of commercial and domestic purposes but nowadays their use is very restricted.

(i) Outline the adverse environmental effects of the use of CFCs.

You do not need to include any equations for the reactions involved. [4]

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(ii) Use relevant data in part *(a)* to explain why hydrofluorocarbons, HFCs, have replaced CFCs in many of their uses. [2]

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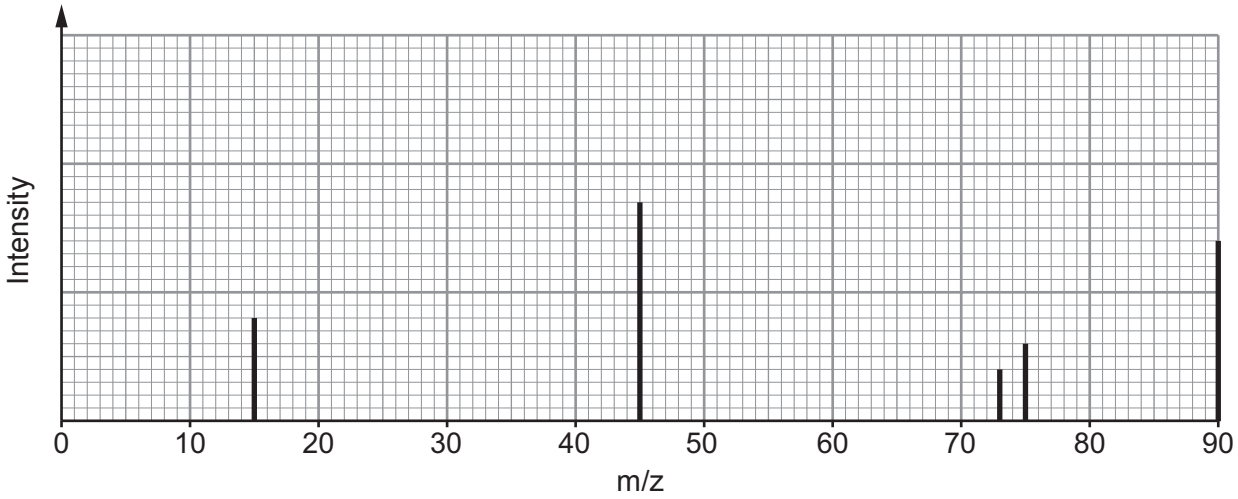
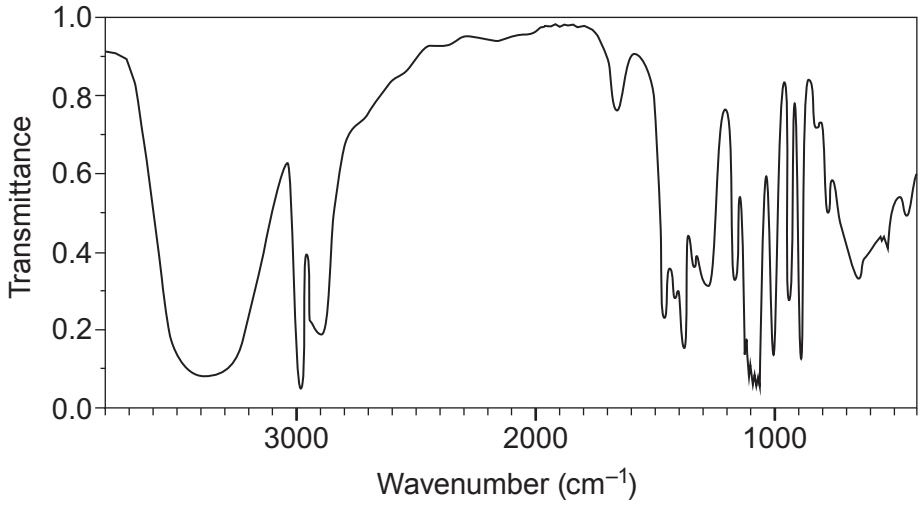
11. Compound **X** contains only carbon, hydrogen and oxygen. On analysis it was found to contain 53.3 % carbon and 11.1 % hydrogen by mass.

A simplified form of the mass spectrum and the infrared absorption spectrum for **X** are shown.





The low resolution ^{1}H NMR spectrum of **X** has three peaks.

When **X** is warmed with excess acidified potassium dichromate(VI) there is a colour change. The organic product of this reaction does **not** react with aqueous sodium carbonate.

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(a) Use **all** the data given to find the structure of compound **X**. Explain what information can be found from each piece of data. [10]

Structure of **X**

Examiner only

(b) (i) State the type of reaction that occurs when **X** is warmed with acidified potassium dichromate(VI). [1]

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(ii) Draw the structure of the organic product formed when **X** reacts with acidified potassium dichromate(VI). [1]

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12. *(a)* Iodide ions can be oxidised to iodine by reaction with acidified hydrogen peroxide.

$$H_2O_2 + 2I^- + 2H^+ \longrightarrow I_2 + 2H_2O$$

The rate of reaction can be followed in a clock reaction by the appearance of a blue-black colour.

An experiment was carried out to determine the effect on the rate of reaction of varying the concentration of iodide ions. All other volumes and concentrations were kept constant. The results are shown in the table.

Concentration I^- / mol dm^{-3}	Time for appearance of blue-black colour / s	Rate / $s^{-1} \times 1000$
0.1	56	18
0.2	20	.....
0.3	18	.....
0.4	12	.....
0.5	10	.....

(i) Use rate = $\frac{1000}{\text{time}}$ to calculate the rate for each experiment and complete the table. [1]

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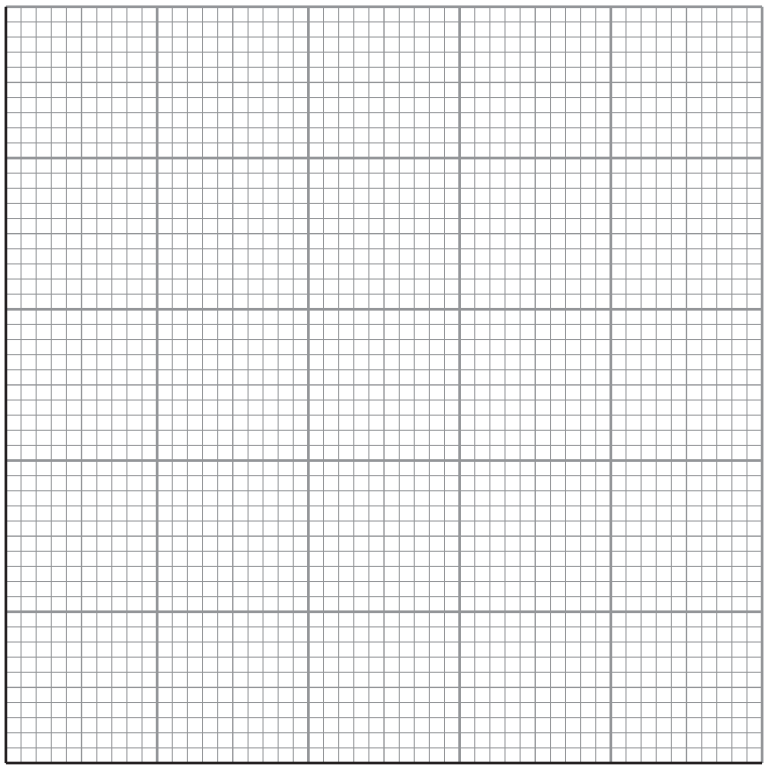
(ii) On the axes below, plot the concentration of I^- against rate and draw a suitable line. [3]



(iii) From the graph deduce the relationship between concentration of I^- and rate of reaction. [1]

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(iv) **Use the graph** to calculate the time the reaction would take to turn blue-black using a 0.15 mol dm^{-3} solution of I^-. Show clearly how you obtained your answer. [2]

Time = ... s

Examiner only

(v) For each experiment the rate was calculated using the time taken to produce excess iodine. Explain why this is only an approximation for the rate **as the reaction proceeds**. [2]

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(b) (i) Draw a Boltzmann energy distribution curve. Label the axes. [2]

(ii) Use this energy distribution curve to explain how catalysts affect the rate of a reaction. [2]

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13. *(a)* Explain what is meant by a carbon-neutral fuel. [3]

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(b) Ethane and an unknown alkane were burned in oxygen.

It follows from the equation below that one volume of ethane produced two volumes of carbon dioxide and three volumes of water vapour.

$$C_2H_6(g) + \frac{7}{2}O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(g)$$

10 cm^3 of the unknown alkane C_xH_y burned according to the following equation.

$$C_xH_y(g) + (x + \frac{y}{4})O_2(g) \longrightarrow xCO_2(g) + \frac{y}{2}H_2O(g)$$

The total volume of carbon dioxide and water vapour produced was 20 cm^3 more than the original volume of C_xH_y and oxygen. All volumes were measured at the same temperature and pressure.

(i) State the volumes of carbon dioxide and water vapour produced on burning 10 cm^3 of the unknown alkane in terms of x and y. [1]

Volume carbon dioxide = ... cm^3

Volume water vapour = ... cm^3

(ii) Calculate the value of y. [2]

y = ...

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

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