Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A Level

2410U20-1 – **NEW AS**

S16-2410U20-1

CHEMISTRY – Unit 2
Energy, Rate and Chemistry of Carbon Compounds

P.M. FRIDAY, 10 June 2016

1 hour 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 6.**	**10**	
Section B	**7.**	**11**	
	8.	**13**	
	9.	**9**	
	10.	**9**	
	11.	**18**	
	12.	**10**	
	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.8***(b)*.

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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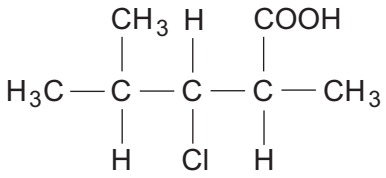
SECTION A

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

1. *(a)* Name the compound whose formula is shown below. [1]



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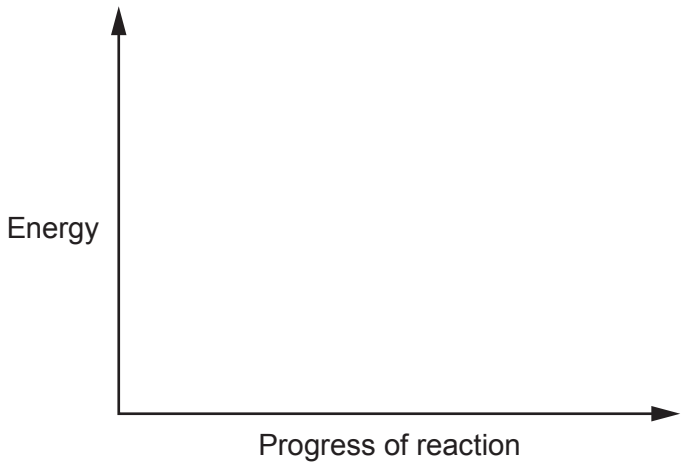
(b) Draw the skeletal formula of the compound shown in *(a)*. [1]

2. Respiration involves the release of energy by using foods. The equation for the respiration of glucose is shown below.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O \qquad \Delta H = -2900 \text{ kJ mol}^{-1}$$

Photosynthesis is the process by which plants store energy in foods. It can be thought of as the reverse of respiration.

On the axes below sketch and label the energy profile for the **photosynthesis** process. You should label the enthalpy change, ΔH, and the activation energy, E_a. [2]



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3. Draw a section of the addition polymer formed from the monomer below.

$$CH_3CH(OH)CH{=}CHCl$$

You should show **two** repeat units. [1]

4. Bromine reacts with methanoic acid according to the equation below.

$$Br_2(aq) + HCOOH(aq) \longrightarrow 2Br^-(aq) + 2H^+(aq) + CO_2(g)$$

A student wanted to follow the rate of the reaction and mixed solutions of known concentration of bromine and methanoic acid.

Suggest **two** methods which the student could use to follow the rate of this reaction as it proceeds. [2]

Method 1 .....

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Method 2 .....

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5. *(a)* State what feature of a molecule gives rise to *E*-*Z* isomerism. [1]

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(b) Does the molecule shown below show *E*-*Z* isomerism? Explain your answer. [1]

$CH_3CH_2CH{=}C(CH_3)_2$

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6. On warming, copper(II) oxide reacts with aqueous methanoic acid. Write the equation for this reaction. [1]

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SECTION B

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

7. Sian was given the following instructions for an experiment to find the enthalpy change for the reaction below.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

Instructions

- Weigh the magnesium.
- Place 25.0 cm^3 of 0.5 mol dm^{-3} hydrochloric acid in an insulating plastic container.
- Measure the initial temperature of the acid in the container.
- Add the magnesium to the acid and stir.
- Measure the highest temperature reached.

(a) Draw a labelled diagram showing how the apparatus is set up to carry out this experiment. You should show how the heat losses could be minimised. [3]

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(b) Sian recorded the following data.

Mass of magnesium strip = 0.1 g

Initial temperature of acid = 21.0 °C

Highest temperature reached = 35.5 °C

Use these data to calculate the enthalpy change for the reaction, ΔH.

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

Assume that 4.18 J is needed to raise the temperature of 1.0 cm^3 of all aqueous solutions by 1.0 °C and that the hydrochloric acid was in excess.

Give your answer in kJ mol^{-1}. [3]

ΔH = ... kJ mol^{-1}

(c) Efan repeated the experiment using 0.20 g of magnesium and 50.0 cm^3 of 0.1 mol dm^{-3} hydrochloric acid. Although he used his data correctly to calculate the enthalpy change of reaction for 1 mol of magnesium, his answer was numerically much less than that obtained by Sian. By using the data above and that in part *(b)*, explain why Efan obtained a different value for ΔH. [2]

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(d) Sian used a one-decimal place balance to weigh the magnesium. Calculate the maximum percentage error in the mass of magnesium she used. Show clearly how you obtained your answer. [2]

Maximum percentage error = ... %

(e) Burning magnesium, when placed in a gas-jar containing chlorine, forms magnesium chloride and energy is released.

$$Mg(s) + Cl_2(g) \longrightarrow MgCl_2(s)$$

Suggest why this reaction cannot be used to measure the enthalpy change for the reaction that forms magnesium chloride from magnesium. [1]

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8. *(a)* (i) Define the term *standard enthalpy change of combustion*, $\Delta_c H^\theta$. [2]

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(ii) The standard enthalpy change of combustion of ethane is –1561 kJ mol^{-1}.

The values of some average bond enthalpies are shown in the table below.

Bond	Average bond enthalpy / kJ mol^{-1}
C—C	348
O=O	495
C=O	799
O—H	463

$$C_2H_6 + \ldots\ldots O_2 \longrightarrow 2CO_2 + 3H_2O$$

Balance the equation for the combustion of ethane and use the information given to calculate the average bond enthalpy for a C—H bond. [4]

Bond enthalpy = ... kJ mol^{-1}

(iii) Suggest a reason why bond enthalpies are described as being **average** bond enthalpies. [1]

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(b) Charcoal consists mainly of carbon. It has been produced for many centuries by heating wood in the absence of oxygen. Natural gas consists mainly of methane and is obtained from underground sources. It was formed in a similar way to coal and oil.

The enthalpy changes of combustion of carbon and methane are in the table.

Substance	Enthalpy change of combustion / kJ mol^{-1}
carbon, C	–394
methane, CH_4	–889

Two students were discussing the use of charcoal and methane as fuels.

One said that 'methane produced more heat per gram when burned so that it was a better fuel'.

The other student said that 'the use of charcoal contributed less to the overall increase of carbon dioxide levels in the atmosphere'.

Discuss these two statements. [6 QER]

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9. All hydrocarbons can be burned but, apart from in combustion reactions, alkenes are more reactive than alkanes.

(a) Describe the bonding in propene and use this to explain its reactivity. [5]

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(b) Draw the mechanism for the reaction between propene and bromine. You should show any relevant dipoles, lone pairs of electrons and curly arrows to indicate the movement of pairs of electrons. [4]

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10. Halogenoalkanes are hydrolysed when heated with aqueous sodium hydroxide.

(a) (i) Write the equation to show the hydrolysis of 3-chloro-2-methylpentane with aqueous sodium hydroxide. You should show clearly the structure of the organic reagent and product. [1]

(ii) State the name of the mechanism for the reaction taking place in part (i). [1]

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(iii) Describe a chemical test to show that this hydrolysis reaction has occurred. Include the test and the result expected. [2]

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(b) The rate of reaction between a halogenoalkane and aqueous sodium hydroxide was measured when different concentrations of reagents were used. The results are shown in the table.

Experiment	Initial concentration $OH^-(aq)$ / mol dm^{-3}	Initial concentration halogenoalkane / mol dm^{-3}	Initial rate of reaction / mol dm^{-3} s^{-1}
1	0.10	0.10	1.20×10^{-5}
2	0.10	0.20	2.40×10^{-5}
3	0.10	0.30	3.60×10^{-5}
4	0.20	0.10	1.20×10^{-5}
5	0.30	0.10	1.20×10^{-5}

(i) Use these data to deduce how the concentration of each reagent affects the rate of reaction. Explain how you reached your conclusions. [2]

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(ii) What would be the effect on the initial rate of reaction if the halogen in the halogenoalkane were changed from chlorine to bromine? You should assume that this is the only change made. Explain your answer. [3]

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11. *(a)* Esters are formed when carboxylic acids are heated with alcohols in the presence of concentrated sulfuric acid. This is a reversible reaction that is carried out by heating the reagents under reflux.

(i) Draw a labelled diagram of the apparatus you would use to carry out a reaction under reflux. [3]

(ii) Explain how the apparatus that you have drawn in part (i) results in the process of reflux. [1]

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(iii) Why is it necessary to use a reflux technique in this type of reaction? [1]

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(iv) State the function of the concentrated sulfuric acid in this reaction. [1]

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(b) The equation shows the reaction between ethanoic acid and methanol.

$$CH_3COOH + CH_3OH \rightleftharpoons CH_3COOCH_3 + H_2O$$

When 3.00 g of ethanoic acid was heated under reflux with 1.28 g of methanol in the presence of concentrated sulfuric acid for 10 minutes it was found that 1.18 g of methyl ethanoate was formed.

(i) Suggest how the methyl ethanoate could be separated from the mixture formed in the reaction vessel. [1]

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(ii) Calculate the percentage of theoretical yield of methyl ethanoate obtained. Show your working. [3]

Percentage yield = ... %

(iii) Suggest **one** change that could be made to this preparation to improve the percentage yield of methyl ethanoate. Explain your suggestion. [2]

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(c) Two reactions of organic compound **A** are shown below.

Compound **B** is a straight-chain hydrocarbon with the formula C_4H_8.

(i) What type of reaction is taking place when compound **A** is heated with concentrated sulfuric acid to form compound **B**? [1]

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(ii) Draw the displayed formulae of **two** possible isomers of **A**. [2]

(iii) What colour **change** is seen when compound **A** reacts with the $Cr_2O_7^{2-}/H^+$ solution? [1]

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(iv) What type of reaction is taking place when compound **A** is heated with $Cr_2O_7^{2-}/H^+$ to form compound **C**? [1]

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(v) Draw a displayed formula of compound **C**. [1]

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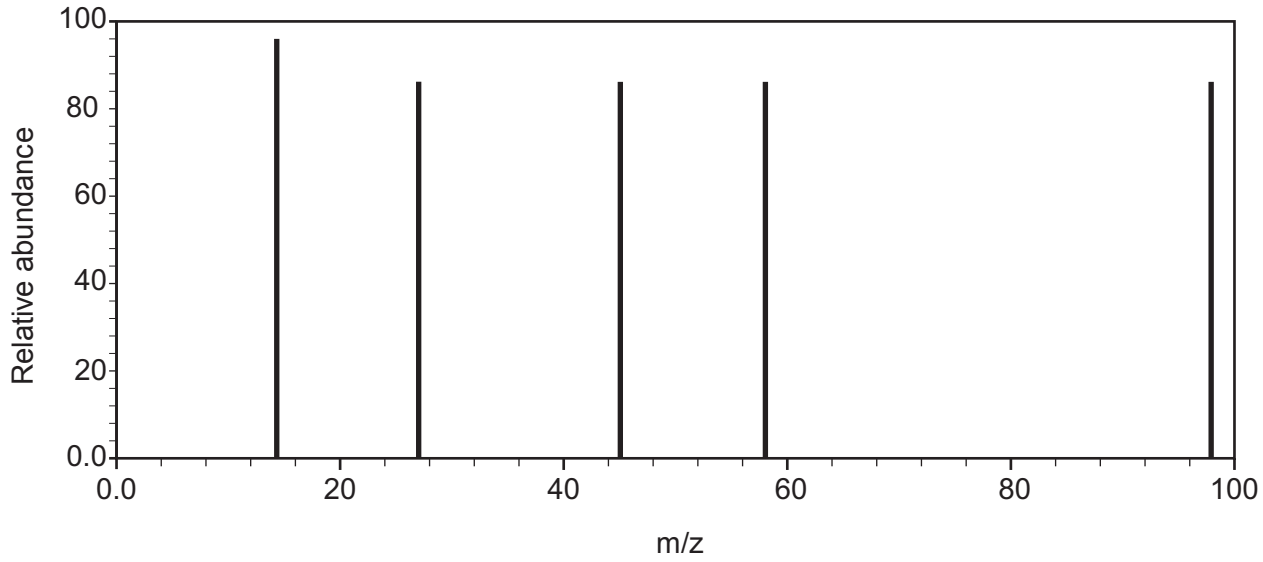
12. Chemists are investigating an unknown compound **X**. They obtain information from a variety of sources.

Compound **X** contains 61.2 % carbon, 6.1 % hydrogen and 32.7 % oxygen by mass. A simplified mass spectrum of compound **X** is shown below.



When solid sodium carbonate is added to an aqueous solution of **X** effervescence is observed.

There are 5 peaks in the ^{13}C NMR spectrum of **X**.

1 mol of **X** reacts completely with 320 g of bromine in the dark.

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

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