Surname	Centre Number	Candidate Number
Other Names		2

GCE AS – NEW AS

B410U20-1

S16-B410U20-1

Part of WJEC

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

P.M. FRIDAY, 10 June 2016

1 hours 30 minutes

	For Examiner's use only		
	Question	Maximum Mark	Mark Awarded
Section A	1. to 5.	10	
Section B	6.	18	
	7.	20	
	8.	16	
	9.	16	
	Total	80	

B410U201 01

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.

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.7***(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.

Examiner only

SECTION A

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

1. 3-Ethyl-2-methylpentane is an alkane.

(a) Draw its **skeletal** formula. [1]

(b) Draw the displayed formula for the straight-chained isomer with the same molecular formula as 3-ethyl-2-methylpentane. [1]

2. Butane, C_4H_{10}, is used as a fuel. Write a balanced equation for its complete combustion. [1]

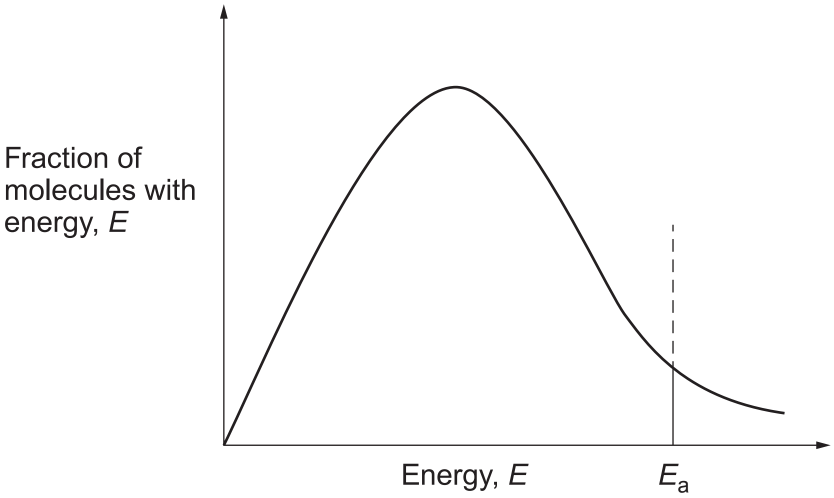
....

3. Give the formula of **one** example of an electrophile. [1]

....

Examiner only

4. The diagram below shows the distribution of molecular energies for a sample of ethene.



(a) On the same axes, draw another curve to show the distribution for the same sample of gas at a higher temperature. [1]

(b) E_a represents the activation energy. Explain what is meant by *activation energy*. [1]

....

....

5. Alkenes can be catalytically hydrogenated to alkanes.

(a) **Name** a suitable catalyst for this reaction. [1]

....

(b) State why this type of reaction is so commercially important. [1]

....

....

(c) Describe a test to show that alkenes contain a C$=$C double bond. Include reagents and expected observations. [2]

....

....

B410U201 03

10

SECTION B

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

6. *(a)* Geoff was given an unknown alcohol of molecular formula $C_4H_{10}O$. It was labelled **A**. He performed the following tests and noted his results in order to find the identity of **A**.

Test	Results
1. Heat **A** with acidified potassium dichromate(VI), distilling the product as it forms	Colourless liquid **B** is formed
2. Heat **A** with ethanoic acid and sulfuric acid	Sweet smelling liquid **C** is formed
3. Reflux **A** with acidified potassium dichromate(VI), followed by distillation	Colourless liquid **D** is formed
4. Add sodium hydrogencarbonate solution to liquid **D**	Effervescence of CO_2 and compound **E** is formed

After analysing his results Geoff concluded that compound **A** must be butan-1-ol. Assume that he is correct in order to answer parts (i) and (ii).

(i) Name compounds **B** and **C**. [2]

....

....

(ii) Give the formula of compound **E**. [1]

....

Examiner only

(iii) By considering **all** the alcohols of formula $C_4H_{10}O$, state if you agree with Geoff's conclusion. Give reasons to justify your answer. [5]

....

....

....

....

....

....

....

B410U201 05

(iv) Draw a labelled diagram of the apparatus Geoff should use to carry out the **distillation** in test 3. [3]

Examiner only

(b) 1-Chlorobutane can be warmed with aqueous sodium hydroxide to form butan-1-ol.

(i) Classify the type of reaction mechanism occurring and draw the mechanism for this reaction. [4]

Type of reaction mechanism ....

(ii) Use the infrared absorption frequencies given in the Data Sheet to explain how you would know if **all** the 1-chlorobutane has been converted into butan-1-ol. [2]

....

....

....

(iii) 1-Iodobutane also reacts with aqueous sodium hydroxide to form butan-1-ol. State, giving a reason, if this reaction is faster or slower than the one between 1-chlorobutane and aqueous sodium hydroxide under the same conditions. [1]

....

....

18

Examiner only

7. Halogenoalkanes are compounds in which one or more hydrogen atoms in an alkane have been replaced by halogen atoms. Halogenoalkanes have been known for centuries e.g. chloroethane was produced synthetically in the 15th century. Today they are widely used commercially; however many have also been shown to be serious pollutants.

(a) Halogenoalkanes can be formed directly from alkanes and alkenes but the ease of formation differs greatly. Briefly outline and explain this difference by considering the types of reactions involved and the bonding in the hydrocarbons. [6 QER]

(No reaction mechanisms are required)

....

....

....

....

....

....

....

....

....

....

....

(b) A compound is known to be either 1-chlorobutane or 1-iodobutane. Describe a test to show that the compound is 1-chlorobutane. Give any reagent(s) used and expected observation(s). [3]

....

....

....

....

....

B410U201
07

Examiner only

(c) 1-Chlorobutane can undergo an elimination reaction with hydroxide ions.

(i) Draw the displayed formula of the organic product of this reaction. [1]

(ii) State the conditions required for this reaction. [1]

....

(d) Explain why 1-chlorobutane has a higher boiling temperature than chloroethane. [2]

....

....

....

(e) CFCs have been shown to be serious pollutants due to their contribution to ozone depletion. Chemists are now replacing them with HFCs. Suggest **two** properties which HFCs should have. [2]

....

....

....

Examiner only

(f) The mass spectrum of a CFC shows two major signals at m/z 135 and 137 in the ratio of 3:1 and molecular ion peaks at 170, 172 and 174.

The CFC contains 14.0% carbon, 44.5% fluorine and 41.5% chlorine by mass.

It only has one peak in its ^{13}C NMR spectrum.

Use the information to find the structural formula for the CFC. Explain your reasoning. [5]

....

....

....

B410U201 09

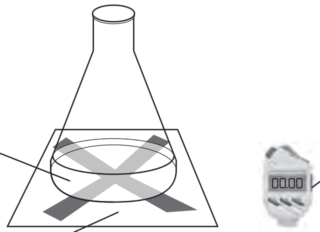
20

8. Sodium thiosulfate solution reacts with hydrochloric acid to produce a precipitate of sulfur. The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$$

Beverly is asked to investigate the effect of changing the concentration of sodium thiosulfate solution on the rate of reaction. She is given 1.00 mol dm^{-3} hydrochloric acid and told to make exactly 250 cm^3 of 0.200 mol dm^{-3} sodium thiosulfate solution.

She sets up the apparatus shown below.



In the first experiment, she uses an excess of acid (10.0 cm^3) and 30.0 cm^3 of sodium thiosulfate solution.

She starts the stopwatch when the acid is added to the sodium thiosulfate solution in the flask and stops it when she can no longer see the cross on the paper.

She rinses the flask thoroughly and repeats the experiment four times using different concentrations of sodium thiosulfate solution. Each time she uses 10.0 cm^3 of acid and 30.0 cm^3 of sodium thiosulfate solution and records the time taken for the cross to disappear.

Since the rate is inversely proportional to the time taken, she calculates 1/time for each concentration and obtains the following results.

Experiment	$Na_2S_2O_3$ concentration / mol dm^{-3}	1/time (× 1000) / s^{-1}
1	0.200	41.7
2	0.160	33.3
3	0.120	25.0
4	0.080	16.7
5	0.040	8.33

(a) Draw a graph on the grid below to show these results. [4]

(b) Use the graph to find the time taken, in seconds, if the experiment had been carried out using 0.030 mol dm^{-3} sodium thiosulfate solution. [2]

Time = ... s

Examiner only

(c) Suggest another method that Beverly could have used to follow the rate of this reaction. [1]

....

....

(d) Calculate how much solid hydrated sodium thiosulfate, $Na_2S_2O_3.5H_2O$, Beverly used to make the original solution. [2]

Mass = ... g

(e) Describe how Beverly prepared the 0.120 mol dm^{-3} sodium thiosulfate solution that she used in experiment 3 from the original 0.200 mol dm^{-3} solution. Name any apparatus used. [2]

....

....

....

(f) State why all experiments were carried out using the same total volume of liquid. [1]

....

....

(g) Gerard told Beverly that it was a waste of time to rinse the flask between each experiment. Is he correct? Justify your answer. [2]

....

....

....

....

Examiner only

(h) Beverly broke the conical flask while rinsing it after experiment 4 and Gerard gave her a 250 cm^3 conical flask for experiment 5. However, Beverly said that she could not use the flask as it would affect the results. Suggest what effect, if any, this would have on the time taken for the cross to disappear in this experiment. Explain your answer. [2]

....

....

....

....

....

....

16

Examiner only

9. *(a)* Kathryn is asked to determine the enthalpy change of solution of ammonium nitrate, NH_4NO_3, using the following method.

- Weigh 7.40 g of ammonium nitrate
- Weigh 50.0 g of water in a polystyrene cup
- Record the temperature of the water
- Add the ammonium nitrate and stir until it has all dissolved
- Record the minimum temperature of the solution

She noted that the temperature fell from 20.0 °C to 10.8 °C.

(i) Calculate the molar enthalpy change of solution of ammonium nitrate, in kJ mol^{-1}, giving your answer to an appropriate number of significant figures. [4]

ΔH = ... kJ mol^{-1}

(ii) Kathryn's results gave a lower value than the literature value. Suggest **two** improvements to her method and explain how they would lead to a more accurate value. [4]

....

....

....

....

....

(iii) During the experiment the balance broke before Kathryn could weigh the water. Describe how else she could precisely measure 50.0 g of water. Explain why this method can be used. [2]

....

....

....

Examiner only

(b) The polymer PTFE is formed from the monomer tetrafluoroethene, $CF_2{=}CF_2$.
The monomer can be produced by the thermal cracking of chlorodifluoromethane, $CHClF_2$, according to the reaction.

$$2CHClF_2 \rightleftharpoons CF_2{=}CF_2 + 2HCl$$

Enthalpy changes of reaction can be calculated using standard enthalpy changes of formation, $\Delta_f H^\theta$, or average bond enthalpies, E.

Some standard enthalpy changes of formation and average bond enthalpies are given in the tables below.

Compound	$\Delta_f H^\theta$ / kJ mol^{-1}
$CF_2{=}CF_2$	−658.3
$CHClF_2$	−485.2
HCl	−92.3

Bond	E / kJ mol^{-1}
C=C	612
C—Cl	338
C—F	484
C—H	412
H—Cl	431

(i) Calculate the standard enthalpy change of reaction using the standard enthalpy change of formation values. [2]

ΔH^θ = ... kJ mol^{-1}

(ii) Calculate the standard enthalpy change of reaction using the average bond enthalpy values. [3]

ΔH^θ = ... kJ mol^{-1}

Examiner only

(iii) Which calculation leads to the more accurate value? Justify your answer. [1]

....

....

16

END OF PAPER

Examiner only

For continuation only.

Examiner only

BLANK PAGE