HWA CHONG INSTITUTION
C1 Promotional Examination
Higher 2

NAME		**CT GROUP**	**16S**

CHEMISTRY **9729/02**

Paper 2 Structured questions

30 September 2016

1 hour 10 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet.

READ THESE INSTRUCTIONS FIRST

Write your name and CT group on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.
A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

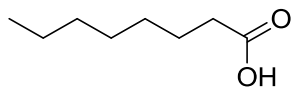
FOR EXAMINERS' USE ONLY

Paper 1	**Paper 2**		**Paper 3**		**Percentage**
Multiple Choice	**Structured**		**Free Response**		
	Q1	/ 12	Q1	/ 15	
	Q2	/ 13	Q2	/ 15	
	Q3	/ 15	Q3 / 4	/ 20	
	Deductions		Deductions		
/ 20	**Subtotal:**	**/ 40**	**Subtotal:**	**/ 50**	**100**

Answer **all** the questions in this section.

1 Fatty acids are carboxylic acids with a long hydrocarbon chain. The hydrocarbon chain can either be saturated or unsaturated.

(a) Caprylic acid is an example of a saturated fatty acid.



caprylic acid

When caprylic acid dissolves in a solvent, the hydrocarbon chain and the carboxylic acid functional group interact differently with the solvent. Caprylic acid has minimal solubility in water, but is soluble in tetrachloromethane, CCl_4.

(i) State the intermolecular forces of attraction acting between water molecules and between CCl_4 molecules.

Water: …………………………………… CCl_4: ………………………………………… [1]

(ii) In the table below, state the interaction that will occur between the relevant part of caprylic acid and water and CCl_4 respectively.

	Interaction with:	
	Water	**CCl_4**
Hydrocarbon chain of caprylic acid		
Carboxylic acid functional group of caprylic acid		

[2]

(iii) Using your answers in **(a)(i)** and **(a)(ii)**, explain why caprylic acid has minimal solubility in water, but is soluble in CCl_4.

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[1]

(b) In order to determine the degree of unsaturation of the hydrocarbon chains in fatty acids, the fatty acid is dissolved in CCl_4. A known excess of Br_2 or ICl is added in the dark, and further analysis is done to determine how much Br_2 or ICl reacted with the fatty acid.

(i) Br_2 and ICl react with the fatty acids in an electrophilic addition reaction. Explain why Br_2 and ICl are electrophiles.

Br_2: ....

....

ICl: ....

....

[2]

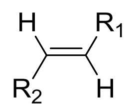
(ii) Explain why the reaction needs to be carried out in the dark.

....

....

[1]

(iii) Describe the electrophilic addition mechanism of the reaction that occurs between Br_2 and an unsaturated fatty acid represented by the generic structure below.



[2]

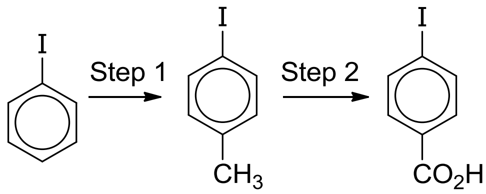
(c) IC*l* can react with benzene in the presence of a suitable catalyst to form iodobenzene. Explain why benzene undergoes a substitution reaction as compared to an alkene which undergoes an addition reaction.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

[1]

(d) Iodobenzene undergoes a sequence of reactions as shown below. State the reagents and conditions required for the transformations to take place.



Reagents and conditions for Step 1: ……………………………………………………………

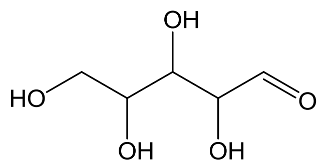
Reagents and conditions for Step 2: ……………………………………………………………

[2]

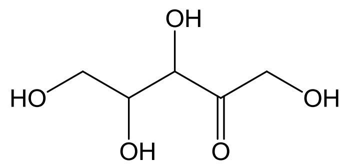
[Total: 12]

2 Ribose, xylulose, glucose and fructose are members of a family of compounds known as monosaccharides, or simple sugars.

Monosaccharides with 5 carbon atoms:

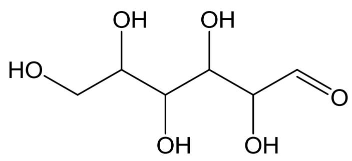


ribose

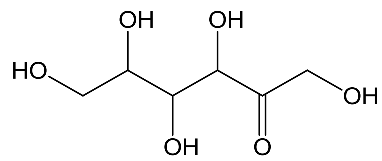


xylulose

Monosaccharides with 6 carbon atoms:

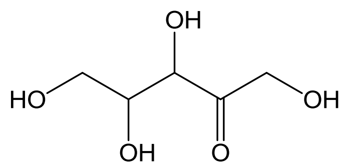


glucose



fructose

(a) **(i)** On the diagram of xylulose below, identify all chiral carbons by labelling them with an asterisk.



[1]

(ii) Every carbon atom in a monosaccharide is bonded to one oxygen atom. However, monosaccharides differ from each other in the total number of carbon atoms, the position of their carbonyl (C=O) group and/or their stereochemistry.

Suggest the structure of a three-carbon monosaccharide that does not exhibit enantiomerism.

[1]

(iii) Suggest the general molecular formula for a monosaccharide with n carbon atoms.

……………………………………………………………………………………………………

[1]

(iv) Two glucose molecules may undergo a condensation reaction to form the disaccharide maltose, in the process eliminating a molecule of water.

Suggest the molecular formula of maltose.

……………………………………………………………………………………………………

[1]

The disaccharide sucrose may be hydrolysed to give glucose and fructose. The reaction is slow but its rate may be increased with the addition of some H^+ ions.

$$\text{sucrose} + H_2O \xrightarrow{H^+} \text{glucose} + \text{fructose}$$

Sucrose, glucose and fructose are optically active, thus the kinetics of the hydrolysis reaction may be studied using a polarimeter. Optically active compounds may be termed dextrorotatory or laevorotatory as follows.

Type of optically active compound	Effect on plane-polarised light	Angle of rotation observed using polarimeter
dextrorotatory	clockwise rotation	positive (+)
laevorotatory	anticlockwise rotation	negative (−)

The rate equation may be written as:

$$\text{Rate} = k[\text{sucrose}]^x[H_2O]^y[H^+]^z$$

The value of z is known to be 1. As $[H_2O]$ and $[H^+]$ are constant, the rate equation may be reduced to

$$\text{Rate} = k_{eff}[\text{sucrose}]^x$$

25.0 cm^3 of 0.580 mol dm^{-3} sucrose was mixed with 25.0 cm^3 of 1.00 mol dm^{-3} HC*l* at 30 °C. A jacketed polarimeter tube, also kept at a constant temperature of 30 °C, was filled with a portion of the resulting solution and the stopwatch was started. At various suitable time t, the angle of rotation A_t was observed and recorded in the table below.

Time t / min	0	11	25	45	73	112	More than 2 days
Observed angle of rotation A_t / °	+16.1	+14.3	+12.2	+9.6	+6.7	+3.6	−4.4 (=A_{final})
$(A_t - A_{final})$ / °	20.5	18.7	16.6	14.0	11.1	8.0	

The reaction is assumed to have gone to completion after more than two days, when the angle of rotation was recorded for the last time.

(b) **(i)** Sucrose and glucose are dextrorotatory.

Is fructose dextrorotatory or laevorotatory? Circle the correct term and support your choice using relevant experimental data.

Fructose is	dextrorotatory	laevorotatory

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………………………………………………………………………………………………… [1]

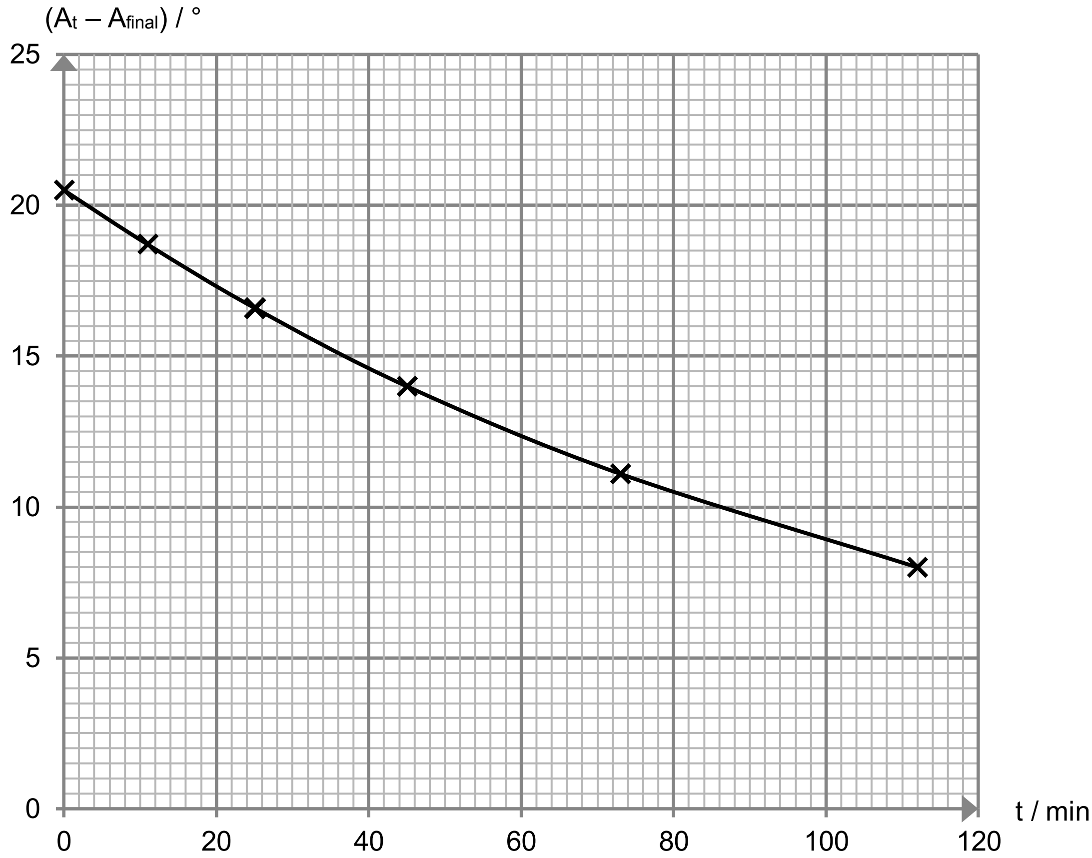
(ii) Explain why $[H^+]$ is taken as constant in the experiment.

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

(iii) The difference (A_t – A_{final}) is proportional to [sucrose] at time t. The graph of (A_t – A_{final}) against t is plotted below.

Use the graph to deduce the value of x, the order of reaction with respect to sucrose.



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[2]

(iv) Find a value for k_{eff}, stating its units.

[2]

(v) Using the rate equation,

$$\text{Rate} = k_{eff}[\text{sucrose}]^x$$

calculate the rate of reaction immediately upon mixing the sucrose and HC*l* solutions.

[1]

(vi) Suggest two **different** changes to the experiment which would result in a lower value of k_{eff} than that in **(b)(iv)**.

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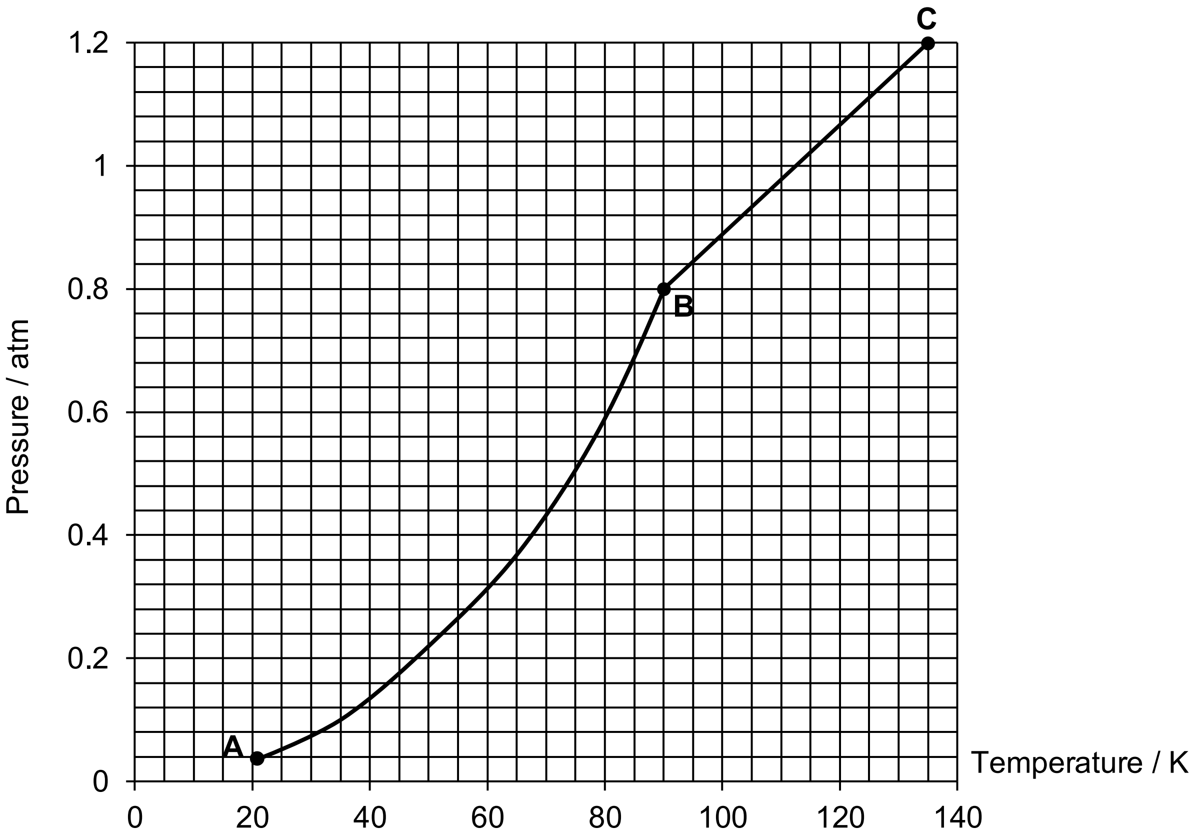
[2]

[Total: 13]

3 (a) Oxygen is a colourless gas essential to life on earth. It condenses at 90 K to give a pale blue liquid. The air inside a flask of fixed volume 1.25 dm^3 is evacuated, and some liquid oxygen is placed into the flask. The pressure inside the flask is recorded at different temperatures to obtain the following graph.



From point **A** to **B**, liquid oxygen is being converted to gaseous oxygen. Assume that gaseous oxygen behaves ideally and the volume of the liquid oxygen is negligible.

(i) State **two** ways in which the properties of an ideal gas differ from those of real gases.

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.... [2]

(ii) Explain the trend of the graph from **B** to **C**, in terms of molecular behaviour.

....

....

.... [2]

(iii) Use the graph to determine the mass of liquid oxygen that was added into the container.

[2]

(iv) At **C**, an electrical discharge is introduced into the container which causes some oxygen to be converted into ozone, O_3.

$$3O_2(g) \rightarrow 2O_3(g)$$

After the reaction, the total pressure drops to 1.14 atm. What is the partial pressure of oxygen after the reaction?

[1]

(b) The experiment in **(a)(iv)** simulates what happens during lightning in a thunderstorm where oxygen in the air can be converted into minute amounts of ozone, giving the 'smell' of rain.

(i) Given that the standard enthalpy change of formation of ozone gas is +143 kJ mol^{-1}, determine the standard enthalpy change of reaction for:

$$3O_2(g) \rightarrow 2O_3(g)$$

and hence, explain why the reaction will be non-spontaneous under standard pressure.

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……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

[3]

(ii) Suggest why the reaction in **b(i)** would occur during thunderstorms when it is a non-spontaneous reaction.

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…………………………………………………………………………………………………
[1]

(iii) From your answer in **(b)(i)**, comment on the position of equilibrium that would be obtained for: $3O_2(g) \rightleftharpoons 2O_3(g)$ when an oxygen-ozone gas mixture is allowed to reach equilibrium at constant temperature.

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…………………………………………………………………………………………………
[1]

(c) Due to the use of chlorofluorocarbons, the ozone layer in the stratosphere started to deplete in the 1970s. However, recent data from NASA suggests that the ozone layer is recovering and could potentially be restored to pre-1970 levels by 2065.

The Chapman cycle below shows the natural processes through which ozone is continually being formed and destroyed in the stratosphere.

<u>Formation of ozone</u>

$O_2 \xrightarrow{uv} 2O$ -------(1)
$O + O_2 \rightarrow O_3$ -------(2)

<u>Destruction of ozone</u>

$O_3 + O \rightarrow 2O_2$ -------(3)
$O_3 \xrightarrow{uv} O_2 + O$ -------(4)
$2O \rightarrow O_2$ -------(5)

(i) In the Chapman cycle, the rates of reactions (1) and (4) may be slower than that of (2), (3) and (5). Suggest a reason why (1) and (4) may be the slower reactions.

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[1]

(ii) Chlorofluorocarbons can form chlorine radicals which catalyse reaction (3), causing an imbalance in the Chapman cycle. In the mechanism, a chlorine radical reacts with an ozone molecule to form $ClO\bullet$ as an intermediate. Suggest the elementary steps in this mechanism for reaction (3).

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…………………………………………………………………………………………………
[2]

[Total: 15]

~END OF PAPER~