HWA CHONG INSTITUTION
C2 Preliminary Examinations
Higher 1

CANDIDATE NAME		**CT GROUP**	**16S**
CENTRE NUMBER		**INDEX NUMBER**	

CHEMISTRY 8872/02

Paper 2 **11 September 2017**

Candidates answer Section A on the Question Paper. **2 hours**

Additional Materials: Answer paper
Data Booklet
Graph paper (2 sheets)

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue, correction fluid or tapes.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** the questions.

Section B
Answer **two** questions on separate answer paper.

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.

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			TOTAL
Multiple Choice	**Section A (Structured)**	**Section B (Free Response)**	
	Q1 / 20	**Q4 / 20**	
	Q2 / 10	**Q5 / 20**	
	Q3 / 10	**Q6 / 20**	
/ 30	**Subtotal / 40**	**Subtotal / 40**	**110**

Section A

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

1 **(a)** Nitrogen and hydrogen react together to form ammonia in the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

Industrially, the following conditions are used for the Haber process.

pressure	250 atm
temperature	450 ˚C
catalyst	finely divided iron catalyst

(i) With the aid of Le Chatelier's Principle, explain why a moderate temperature of 450 ^{o}C is used for the Haber process.

……

……

……

……

…… [2]

(ii) Explain how iron catalyst can increase the rate of formation of ammonia.

……

…… [1]

(iii) State and explain the effect of using a pressure of 400 atm on the position of equilibrium and the equilibrium constant.

……

……

……

……

…… [2]

Given that 4 moles of N_2 and 8 moles of H_2 are allowed to reach dynamic equilibrium in a 2 dm^3 vessel. It is found that the total number of moles of gases present in the vessel at equilibrium is 8.

(iv) Write a K_c expression for the equilibrium in the formation of ammonia.

[1]

(v) Calculate the number of moles of each gas at equilibrium, showing your workings clearly.

number of moles of N_2: ……...mol; H_2: ……...mol

NH_3: ……...mol
[2]

(vi) Hence, calculate the equilibrium constant and state its units.

K_c = ……. units = ……
[2]

(b) **(i)** Ammonia burns in oxygen to give nitrogen dioxide and steam. Write an equation, with state symbols, which represents the enthalpy change of combustion of ammonia.

…… [1]

(ii) Hence, use the following information to calculate a value for the enthalpy change of combustion of ammonia.

Enthalpy change of formation of nitrogen dioxide	- 34 kJ mol^{-1}
Enthalpy change of formation of steam	- 242 kJ mol^{-1}
Enthalpy change of formation of ammonia	- 46 kJ mol^{-1}

[2]

(iii) Using relevant information from the *Data Booklet* as well as your answer in **b(ii)**, calculate a value for the bond energy of the bond between the nitrogen atom and the oxygen atom in nitrogen dioxide, assuming that the bond energy of both bonds are the same.

bond energy: …… kJ mol^{-1}
[2]

(iv) The combustion of 44 g of ammonia produces 89 g of nitrogen dioxide. Calculate the percentage efficiency of this reaction.

[2]

(c) Ammonia reacts with bromoethane.

Write an equation for the reaction that occurs and give the reagent and conditions necessary. State fully which class of organic compound the product belongs to.

Equation: ……..

Reagents and conditions: ……..…….

Class of organic compound: …….. [3]

[Total: 20]

2 This question is about Period 3 elements and their compounds.

(a) Period 3 elements react with oxygen to form oxides.

(i) Describe the reaction of aluminium oxide and phosphorus(V) oxide with hydrochloric acid and sodium hydroxide, if any.

……

…… [2]

(ii) Write equations for all reactions that occur in **(b)(i)**.

aluminium oxide: ……

……

phosphorus oxide: ……

……
[3]

(b) **(i)** In the vapour phase, an equilibrium is established between aluminium chloride and its dimer as follows:

$$2AlCl_3(g) \rightleftharpoons Al_2Cl_6(g)$$

With the aid of a diagram, explain how the dimer is formed.

……

……

……

…… [3]

(ii) At 180 ^{o}C, aluminium chloride, Al_2Cl_6, sublimes. Explain, based on its structure and bonding, why it sublimes at a relatively low temperature.

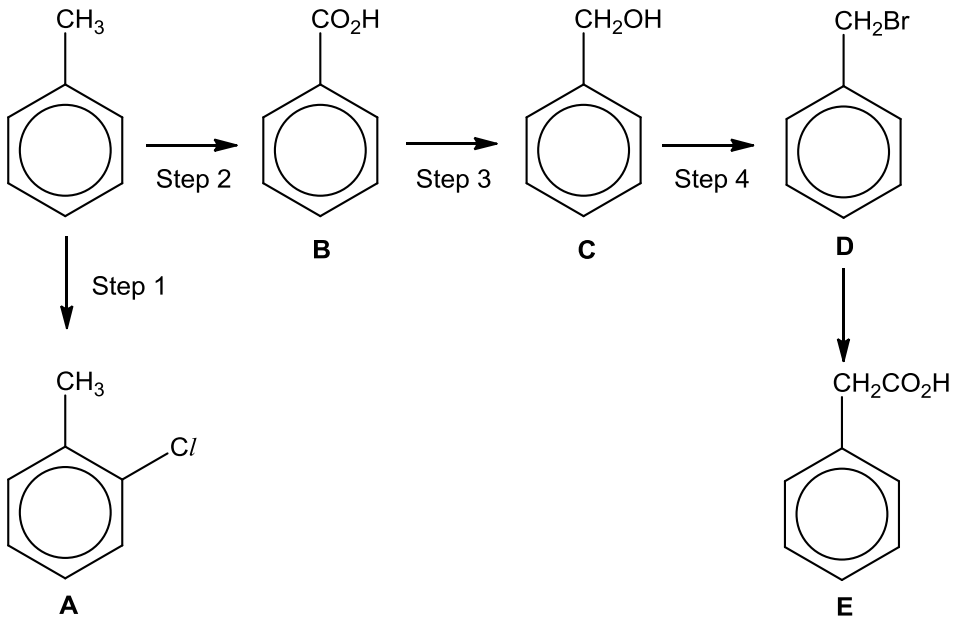
……

……

…… [2]

[Total: 10]

3 The following diagram shows some reactions of methylbenzene.



(a) State the reagents and conditions necessary for Step 1.

Reagents and conditions: ……[1]

(b) State the types of reaction for Steps 2 and 3.

Step 2: ……..

Step 3: ……...
[2]

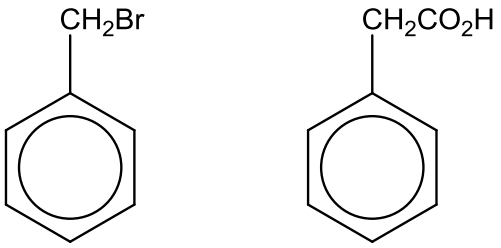
(c) Explain why **B** is acidic.

……

……

……..…… [2]

The structures of **D** and **E** are shown again below for parts **(d)** and **(e)**.



D **E**

(d) There is *another* method to obtain **D** from methylbenzene in *one* step. Give the reagents and conditions for this method and explain why this method is **not** preferred.

Reagents and conditions: ……..

……

……..…… [2]

(e) Propose a 2-step synthesis for the conversion of **D** to **E**. Give the reagents and conditions for all steps and the structure of any intermediate.

[3]

[Total: 10]

Section B

Answer **two** questions from this section on separate answer paper.

4 **(a)** In the production of instant noodles, a key step involves deep frying the noodles in cooking oil to remove all traces of moisture. By dehydrating the noodles in this manner, the shelf life of the product increases dramatically.

(i) Cooking oil is primarily made up of long hydrocarbon chains, and has an approximate boiling point of 300 °C, whereas water has a boiling point of 100 °C.

Explain why cooking oil has a higher boiling point by reference to the type of bonding involved. [3]

(ii) Predict and explain what you would observe when equal volumes of cooking oil and water is mixed. [2]

(iii) Using your answers from **(a)(i)** and **(a)(ii)**, explain how deep frying removes moisture from the noodles. [2]

(b) NaC*l*, also known as table salt, is an important seasoning used in instant noodles.

(i) Draw a 'dot-and-cross' diagram that shows the bonding in sodium chloride. [1]

(ii) Describe the structure and bonding of sodium chloride, and explain why sodium chloride has a high melting point, and is brittle. [3]

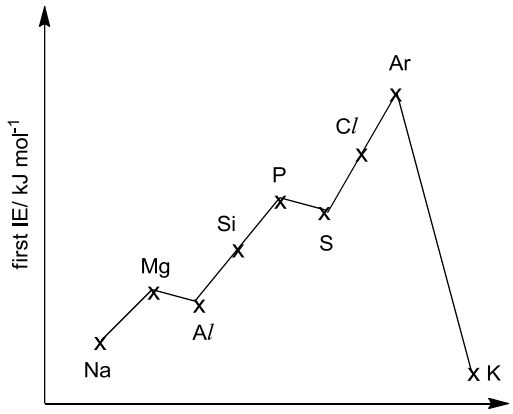
(iii) Define the term *lattice energy*. Explain how and why the lattice energies of sodium chloride, and sodium oxide, Na_2O, have different numerical values. [4]

(iv) Describe the reactions of sodium chloride, aluminium chloride, A*l*C*l*$_3$, and silicon chloride, SiC*l*$_4$, with excess water. Write equations where appropriate. [4]

(v) Suggest what influence the type of bonding present in these three chlorides in **(b)(iv)** has on their reaction with water. [1]

[Total: 20]

5 **(a)** The diagram below shows the first ionisation energies of the elements sodium to potassium.



(i) Define the term *first ionisation energy*. [1]

(ii) Several factors influence the values of the first ionisation energies shown above.

For each of the pairs of elements listed below, explain the difference between the values of their first ionisation energies. You should use a different explanation for each pair.

sodium and potassium
magnesium and aluminium
phosphorus and sulfur
chlorine and argon [5]

(iii) **X** and **Y** are elements from Period 3.

Based on the data below, suggest the identities of the following elements, **X** and **Y**, from their successive ionisation energies in kJ mol^{-1} and explain your reasoning.

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
X	737	1451	7733	10542	13630	18020	21711	25661	31653	35458
Y	1251	2298	3822	5159	6542	9362	11018	33604	38600	43961

[4]

(b) Compound **A** has the molecular formula $C_9H_{12}O$. When **A** is exposed *uv* light in the presence of chlorine gas, it forms 3 monosubstituted compounds.

When **A** is heated with acidified potassium dichromate(VI), $K_2Cr_2O_7$, it forms compound **B**, which gives an orange precipitate in the presence of 2,4-dinitrophenylhydrazine.

When **A** is heated with excess concentrated sulfuric acid, it forms compounds **C**, **D**, and **E**, which are isomers of each other. In addition, **C** and **D** are stereoisomers.

Identify and suggest structures for **A**, **B**, **C**, **D** and **E**. Show how you deduced these structures and suggest the types of reactions that are occurring. [10]

[Total: 20]

6 **(a)** **(i)** Draw a 'dot-and-cross' diagram that shows the bonding in H_2O_2. [1]

(ii) Use your diagram in **(a)(i)** to suggest and explain the shape of H_2O_2. [2]

(iii) Suggest a value for the bond angle in H_2O_2, giving reasons for your choice. [2]

(b) H_2O_2 can be oxidised or reduced, depending on the species it is mixed with.

A stock solution of H_2O_2 was diluted by adding 20.0 cm^3 of the stock solution into a standard flask which was filled with distilled water to make a 100 cm^3 standard solution. 25.0 cm^3 of the standard solution was titrated with 0.200 mol dm^{-3} $KMnO_4$. 21.80 cm^3 of $KMnO_4$ solution was required to reach the end point. The following reaction occurs.

$$2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{2+} + 5O_2 + 8H_2O$$

(i) Explain whether H_2O_2 is acting as an oxidising agent or reducing agent in the titration. [1]

(ii) Determine the amount of H_2O_2, in moles, that reacted with $KMnO_4$. [2]

(iii) Hence, determine the concentration of H_2O_2 in the stock solution. [2]

(c) Hydrogen peroxide reacts with acidified iodide ions to liberate iodine according to the following reaction:

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow 2H_2O(l) + I_2(aq)$$

The rate of reaction was followed by measuring the concentration of the remaining iodide ions after fixed time intervals. An experiment was carried out, starting using 0.05 mol dm^{-3} hydrogen peroxide. The following results were obtained.

Time/s	**Experiment 1** $[H_2O_2]$ = 0.0500 mol dm^{-3}
	$[I^-]$/ mol dm^{-3}
0	10.00×10^{-4}
25	7.45×10^{-4}
50	5.60×10^{-4}
75	4.25×10^{-4}
100	3.15×10^{-4}

(i) Plot a graph of $[I^-]$ against time. [3]

(ii) Use your graph to find the order of reaction with respect to I^-. [2]

(iii) **Experiment 2** was carried out using 0.100 mol^{-3} H_2O_2 instead, and it was found that the initial rate of reaction doubled. State and explain the order of reaction with respect to H_2O_2. [1]

(iv) The order of reaction with respect to H^+ is zero. Hence, write the rate equation for the reaction. [1]

(v) Determine the initial rate of reaction. Hence, calculate the rate constant, giving its units. [3]

[Total: 20]