Name and Form Class	Index Number	Subject Tutor

ANGLO-CHINESE JUNIOR COLLEGE
DEPARTMENT OF CHEMISTRY
Preliminary Examination

CHEMISTRY **8872/02**
Higher 1

Paper 2 15 August 2017

2 hours

Candidates answer Section A on the Question Paper.

Additional Materials: Writing Paper
Data Booklet
Graph Paper

READ THESE INSTRUCTIONS FIRST

Write your 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, glue or correction fluid.

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.

For Examiner's Use	
Section A	
B5	
B6	
B7	
Total	

This document consists of **15** printed pages.

Section A

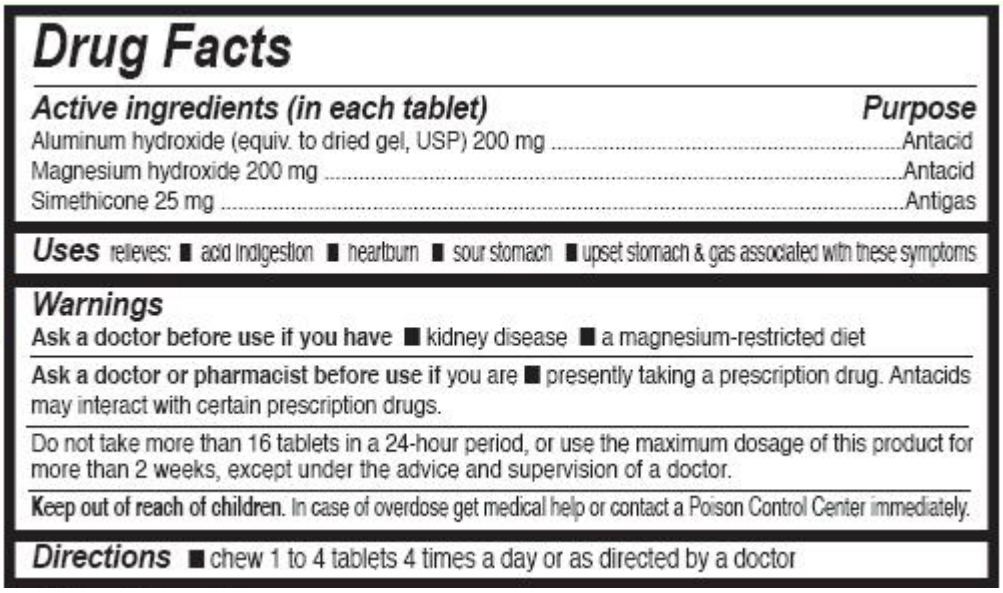
Answer **all** questions in this section in the spaces provided.

1 Aluminium is the most abundant Group 13 element and constitutes about 8 % of the Earth's crust. The extraction of aluminium is done by processing aluminium ore, bauxite to produce aluminium oxide also known as alumina.

A variety of aluminium compounds, for example aluminium chloride and aluminium hydroxide, are used for different purposes such as food additives, colouring and pharmaceuticals.

Aluminium hydroxide and magnesium hydroxide are antacids. They are used to treat symptoms of increased stomach acid, such as heartburn, upset stomach, sour stomach, or acid indigestion. Once ingested, they react with the hydrochloric acid in the stomach.

One label of a commercial product, Mintox™ is shown below.



Drug Facts

Active ingredients (in each tablet)	Purpose
Aluminum hydroxide (equiv. to dried gel, USP) 200 mg	Antacid
Magnesium hydroxide 200 mg	Antacid
Simethicone 25 mg	Antigas

Uses relieves: ■ acid indigestion ■ heartburn ■ sour stomach ■ upset stomach & gas associated with these symptoms

Warnings

Ask a doctor before use if you have ■ kidney disease ■ a magnesium-restricted diet

Ask a doctor or pharmacist before use if you are ■ presently taking a prescription drug. Antacids may interact with certain prescription drugs.

Do not take more than 16 tablets in a 24-hour period, or use the maximum dosage of this product for more than 2 weeks, except under the advice and supervision of a doctor.

Keep out of reach of children. In case of overdose get medical help or contact a Poison Control Center immediately.

Directions ■ chew 1 to 4 tablets 4 times a day or as directed by a doctor

(a) **(i)** Write down the electronic configuration of A*l*.

……[1]

(ii) Why is the ionic radius of aluminium far smaller than its atomic radius?

……

……

……

……[1]

1 (a) (iii) Explain why aluminium forms compounds with an oxidation state of +3 but not sodium.

……

……

…….[1]

(b) (i) Which antacid in the tablet is more effective in reacting with the hydrochloric acid in the stomach? Support your answer with relevant working.

[2]

(ii) Calculate the maximum number of chewable tablets that a person can take in a week.

[1]

(iii) Assuming that a typical adult has a body mass of 70 kg, determine the maximum weekly intake of aluminium hydroxide in grams per kg of body mass.

[2]

1 (c) (i) Aluminium chloride is an active ingredient used in skin medication to control excessive sweating.

Aluminium chloride is often describe as *electron deficient*. Explain what is meant by *electron deficient*.

……

……

……[1]

(ii) In the vapour phase, aluminium chloride forms a gaseous product with a molar mass of 267 g mol^{-1}. With the aid of a clearly labelled diagram, explain how this product is formed from aluminium chloride.

[2]

[Total: 11]

2 In a university laboratory, the percentage purity of a sample of complex iron salt, $K_3Fe(C_2O_4)_3.3H_2O$ can be determined by analyzing the $C_2O_4^{2-}$ content through titrating with acidified $KMnO_4$.

1.20 g of impure $K_3Fe(C_2O_4)_3.3H_2O$ sample was dissolved and made up to 100 cm^3. 10.0 cm^3 of this solution was pipetted into a conical flask and 10.0 cm^3 of 1 mol dm^{-3} sulfuric acid was added. The mixture was heated and titrated with 0.0200 mol dm^{-3} $KMnO_4$. CO_2 is produced during the reaction.

It was determined that 12.30 cm^3 of $KMnO_4$ was required to reach the end-point.

(a) (i) Suggest why hydrochloric acid is not used to acidify the mixture.

……

……[2]

(ii) In the acidic medium, $C_2O_4^{2-}$ ions exist as $H_2C_2O_4$.
Write a half equation to show the conversion of $H_2C_2O_4$ to CO_2.

……[1]

(b) **(i)** Calculate the amount of $KMnO_4$ used to react with 10.0 cm^3 of the iron complex salt solution.

[1]

(ii) Using the half-equation below and your answer in **(a)(ii)**, calculate the amount of $C_2O_4^{2-}$ present in 10.0 cm^3 of the iron complex salt solution.

$$MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$$

[1]

(iii) Hence, determine the mass of $K_3Fe(C_2O_4)_3.3H_2O$ in 100 cm^3 of iron complex salt solution.
(molar mass of $K_3Fe(C_2O_4)_3.3H_2O$ = 491.1 g mol^{-1})

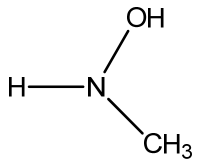
[2]

(iv) Calculate the percentage purity of the iron complex salt.

[1]

[Total: 8]

3 The emergence of multidrug-resistant bacteria has encouraged vigorous efforts to develop antibacterial agents. N-methylhydroxylamine has been found to show vast potential as an antibacterial agent.



N-methylhydroxylamine (pK_b = 8.04)

N-methylhydroxylamine has properties similar to ammonia and it dissolves in water as shown below:

$$CH_3NHOH(aq) + H_2O(l) \rightleftharpoons CH_3NH_2OH^+(aq) + OH^-(aq)$$

(a) Write the expression for the base dissociation constant of N-methylhydroxylamine in water.

[1]

(b) Calculate the base dissociation constant of the N-methylhydroxylamine solution.

[1]

An aqueous solution of 0.05 mol dm^{-3} hydrochloric acid was gradually added to 50.0 cm^3 of 0.02 mol dm^{-3} aqueous N-methylhydroxylamine.

(c) Determine the initial pH of N-methylhydroxylamine solution.

[2]

3 **(d)** Calculate the volume of hydrochloric acid needed at the equivalence point.

[1]

(e) State the volume of hydrochloric acid required to be added to another identical solution of N-methylhydroxylamine to obtain a solution which best resists pH change.

……[1]

(f) Calculate the pH of that solution.

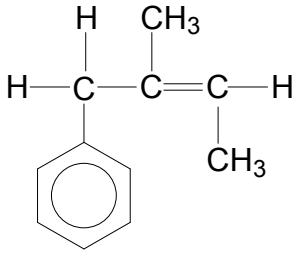
[1]

(g) Write **two** equations to show how the solution in **(e)** resists change in pH when small amounts of acid and alkali are added separately.

[2]

[Total: 9]

4 (a) Draw the structures of the organic product(s) formed when compound **A** below reacts with each of the following reagents.



compound **A**

Reagents and Conditions	Organic Product(s) formed
(i) HBr(g)	
(ii) $KMnO_4$; dilute H_2SO_4; heat under reflux	
(iii) Cl_2(g); $AlCl_3$; dark	

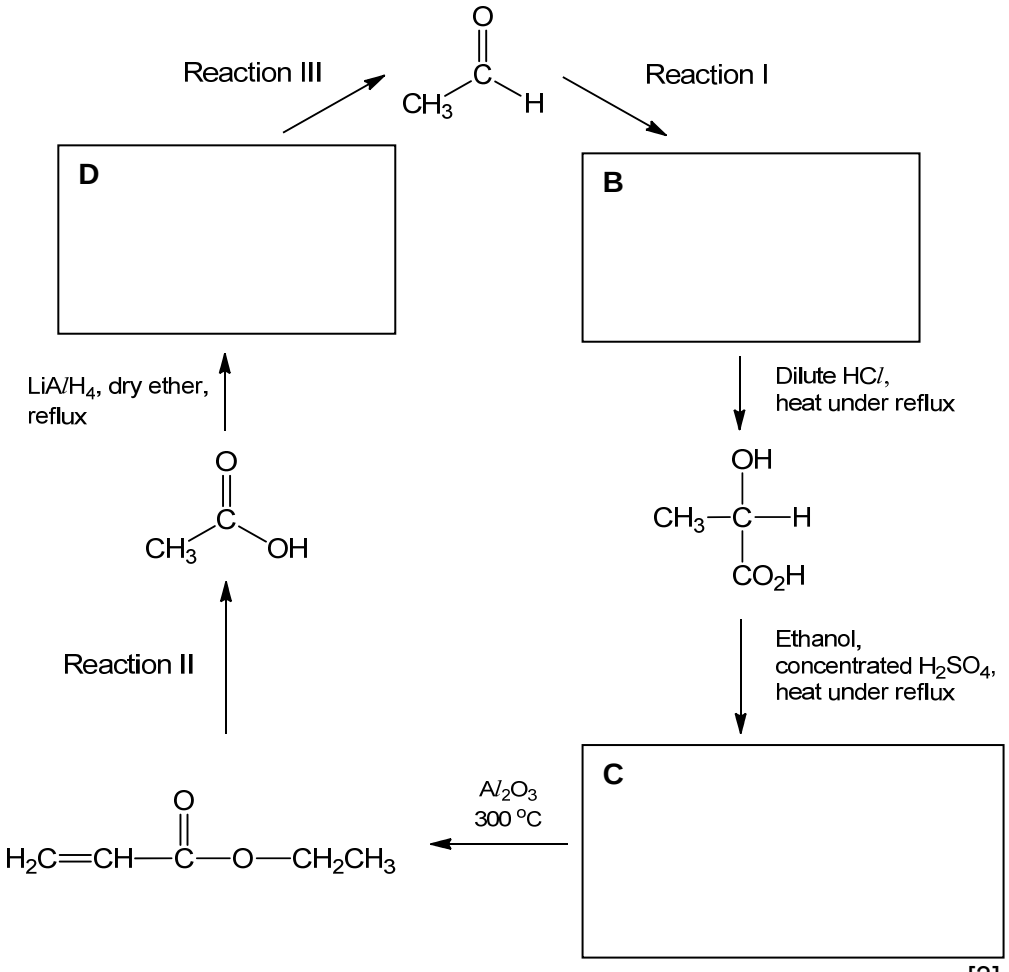
[4]

4 (b) State the type of isomerism exhibited by compound **A**, and hence draw the structures of the two isomers formed.

[2]

(c) Ethanal is a flammable liquid with a fruity smell. It occurs naturally in ripe fruit, coffee and fresh bread. A synthetic route involving ethanal is shown below.

(i) Draw the structural formulae of compounds **B**, **C** and **D** in the boxes below.



[3]

4 (c) (ii) Suggest reagents and conditions for

Reaction I, ...

Reaction II, ...

Reaction III, ...

[3]

[Total: 12]

Section B

Answer **two** questions from this section on the separate answer papers.

5 (a) In an experiment, the effect of reactant concentration on the rate of reaction between hydrogen peroxide and potassium iodide at 298K was investigated.

The rate of formation of iodine in the reaction:

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

is given by:

$$\text{rate} = k[H_2O_2]^a[I^-]^b[H^+]^c$$

whereby a, b and c are the orders of reaction.

The iodine liberated in the above reaction was reacted with a fixed amount of sodium thiosulfate until no more sodium thiosulfate was left. The excess iodine caused the solution to become coloured. By adding a few drops of starch, the iodine showed up more clearly as it formed a blue-black complex.

The time taken for the formation of the blue-black complex was measured. The reciprocal of this time ($\frac{1}{t}$) is used as a measure of the initial rate of reaction.

Concentration of KI/ mol dm^{-3}	Time/ s
0.10	5.5
0.075	7.4
0.050	11.3
0.025	22.7

(i) Plot a graph of initial rate against concentration of iodide ions. [3]

(ii) Hence, use your graph to determine the order of reaction with respect to iodide ions. [1]

(iii) In theory, the orders of reaction with respect to hydrogen peroxide and acid are one and zero respectively. [2]

Using your answer in (**a)(ii)** and given that $[H_2O_2]$ = 0.01 mol dm^{-3}, $[I^-]$ = 0.02 mol dm^{-3}, $[H^+]$ = 0.0005 mol dm^{-3} and rate = 2.30 x 10^{-6} mol dm^{-3} s^{-1}, determine the rate constant for this reaction and state its units.

(iv) Suggest what would happen to the initial rate of reaction if the temperature is changed to 308K. [1]

(b) (i) Describe the reactions, if any when separate samples of sodium and phosphorus are added to water containing universal indicator. [2]

(ii) Explain the acid-base character of oxides of sodium and phosphorus in water. Suggest the pH of any aqueous solution formed. [2]

5 (c) When heated with chlorine under suitable conditions, hydrocarbon **X,** C_6H_{14} forms a total of only 3 mono-chlorinated products.

(i) Draw the three possible chlorinated products of **X**. [3]

(ii) The following table provides the rate of abstraction of a hydrogen on a primary, secondary and tertiary carbon. [2]

Type of C	$-CH_3$	$-CH_2R$	$-CHR_2$
Relative rate	1	4	6

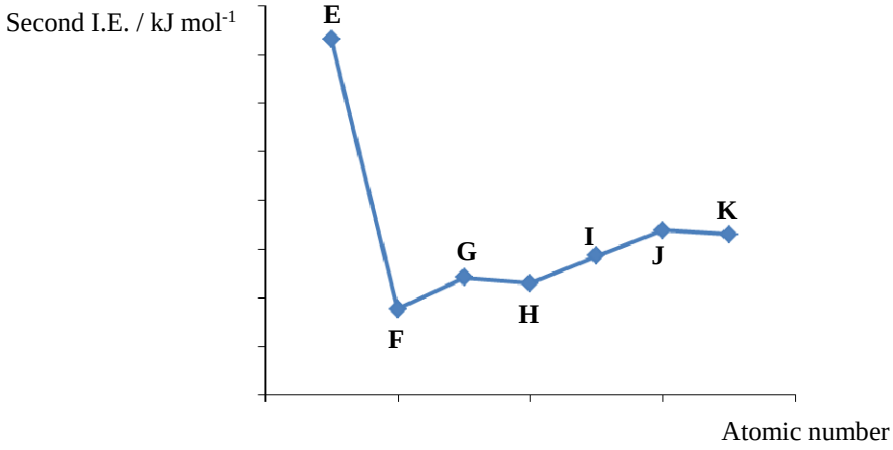
What is the expected ratio of the mono-chlorinated products of **X** formed?

(iii) State one environmental effect of chlorinated products of **X**. [1]

(iv) Describe a simple chemical test to distinguish the chlorinated products of **X** from hydrocarbon **X**. [3]

[Total: 20]

6 **(a)** Carbon forms the backbone of organic compounds and is in Period 2 of the Periodic Table. The second ionisation energy of some consecutive elements in Period 2 are plotted.



(i) Write an equation to represent second ionisation energy of carbon. [1]

(ii) By considering electronic configurations, explain why the second ionisation energy of carbon is lower than that of boron. [2]

(iii) Which letter represents carbon in the plot? Explain your answer. [2]

(b) Ethanoic acid and ethanol react together in the presence of concentrated sulfuric acid as the catalyst. The following equilibrium is established, in which the ester, ethyl ethanoate, is formed.

$$CH_3COOH(l) + CH_3CH_2OH(l) \rightleftharpoons CH_3COOCH_2CH_3(l) + H_2O(l)$$

(i) State Le Chatelier's Principle. [1]

(ii) Use Le Chatelier's Principle to predict and explain how the position of equilibrium of this reaction would be affected when sodium hydroxide is added. [2]

(iii) Equimolar amounts of ethanoic acid and ethanol were mixed and at equilibrium, 1.00 mole of ethyl ethanoate is present. The total volume of the reaction mixture is 0.5 dm^3. [3]

Given that the value of K_c for the reaction between ethanoic acid and ethanol is 4.0, determine the initial concentration of ethanoic acid.

(c) Other than ethanoic acid, there are other compounds that have the same molecular formula, $C_2H_4O_2$. [3]

Give the skeletal formulae of **three** other possible isomers, with different functional groups from each other, which have this molecular formula.

6 (d) In the laboratory, there are three bottles of chemicals which are unlabelled. The three bottles contain one of the following, but not in the order given. [6]

Ethanoic acid

Propanone

Propanal

Suggest two simple chemical tests that will allow you to distinguish between the three unlabelled bottles. State clearly the observations and write equations for the reactions that occur.

[Total:20]

7 Diethylene glycol (DEG), with the formula $(HOCH_2CH_2)_2O$, is used in a wide range of industrial products. It is poisonous and has been involved in a number of prominent mass poisonings spanning back to 1937.

(a) Following its ingestion, DEG is rapidly absorbed and distributed within the human body which is made up of up to 60% water.

State and draw the type of bonding between DEG and water. [3]

(b) DEG is produced by the hydrolysis of the cyclic ethylene oxide, $(CH_2)_2O$.

$$2\ (CH_2)_2O + H_2O \rightarrow HO–CH_2CH_2–O–CH_2CH_2–OH$$

(i) The oxygen atom is bridging the two carbon atoms in the cyclic ethylene oxide. Draw the 'dot-and-cross' diagram of ethylene oxide with all bonding electrons and non-bonding electrons shown clearly. [1]

(ii) State a value for the bond angle around the oxygen atom in ethylene oxide molecule. [1]

(iii) Predict and explain whether ethylene oxide would be more soluble in propanone or hexane. [2]

(iv) Use the *Data Booklet* to calculate the enthalpy change when ethylene oxide is hydrolysed and show clearly which bonds are broken and formed in the above equation. [3]

(c) An organic compound **P**, $C_{10}H_{11}O_2Br$, does not react with aqueous sodium carbonate. However, it reacts slowly on heating in aqueous sodium hydroxide to form a water-soluble compound **Q**, $C_3H_5O_3Na$ and an insoluble oil **R**, C_7H_8O. [10]

The acidification of compound **Q** gives compound **S** which reacts with 2 moles of phosphorous pentachloride to give copious fumes. **R** gives benzoic acid upon oxidation.

Deduce the structures of compounds **P**, **Q**, **R** and **S**. Explain the chemistry of the reactions described and write equations where appropriate.

[Total:20]

End of Paper