Class Adm No

Candidate Name: _____

millennia institute

Promotional Examinations 2008
Pre-university 2

CHEMISTRY
HIGHER 1 8872/2

Monday 8th Sept 2008 2 hours

Additional materials:
Answer paper
Data Booklet
5 pieces of foolscap paper
Cover page

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, index number and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.

Section A
Answer **all** questions.

Section B
Answer any **two** questions on the writing papers.

At the end of the examination, hand in your answers to Section A and Section B separately.
Attach the cover page to your answer scripts for section B.

The number of marks is given in brackets[ ] at the end of each question or part question.

This question paper consists of 17 printed pages.

Section A: Structured Questions (40m)

Answer ALL questions in the spaces provided.

1. Acidified $KMnO_4$, which oxidizes iron(II) compounds, is used to estimate the amount of iron present in substances such as flour. 1.00g of flour was shaken vigorously with dilute H_2SO_4 and the volume of the solution was made up to $100cm^3$ in a volumetric flask.

   A $10.0cm^3$ portion of this solution was titrated against $5.00x10^{-6}$ $moldm^{-3}$ of $KMnO_4$ solution. $11.00cm^3$ of the $KMnO_4$ solution was required to completely oxidized the iron(II) salt to iron(III) salt.

   (i) Write a balanced equation to show the above reaction. [2]

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   (ii) Calculate the concentration of Fe^{2+} in the flour solution. [2]

   (iii) Hence, determine with calculation, if this flour meets the requirement of containing 16.5mg of iron per 100g of flour by law. [2]

[Total marks: 6m]

2. Sulphur and its isotopes are mainly used in medical applications. Sulphur also known as brimstone has been used for thousands of years to cure skin ailments. Ancient cultures relied on sulphur to treat a variety of illnesses as well as to make dyes and other useful products.

(a) The relative isotopic mass and percentage abundances of the isotopes of a sample of sulphur are shown in the table.

relative isotopic mass	% abundance
^{32}S	94.93
^{34}S	5.07

Calculate the relative atomic mass for sulphur in the sample. [1]

(b) Oxides of sulphur contribute towards air pollution. Draw a dot and cross diagram to show the bonding in a molecule of sulphur trioxide, SO_3.
Hence state the shape and bond angle of SO_3 [3]

(c) The melting points of silicon dioxide and sulphur trioxide are shown as follows:

compound	**melting point / ^oC**
SiO_2	2830
SO_3	17

Briefly relate these melting points to the structure and bonding in each of these oxides. [3]

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(d) The lattice energy of sodium oxide is – 2000 kJ mol^{-1}.

Explain how you would expect the numerical magnitude of the lattice energy of sodium sulphide, Na_2S, to compare with that of sodium oxide, Na_2O. Hence, predict the relative melting points of Na_2O and Na_2S. [2]

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[Total marks: 9m]

3. (a) A dilute aqueous solution of hydrogen peroxide, used to bleach hair, decomposes as shown by the equation.

$$2H_2O_2(aq) \rightarrow 2H_2O(g) + O_2(g)$$

The decomposition of hydrogen peroxide is known to be a *first order* reaction.

(i) Explain the meaning of the phrase in *Italics*. [1]

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(ii) Hence, write a rate equation to show the decomposition of hydrogen peroxide. [1]

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(b) Graphical method can also be used to determine the order of reaction for the decomposition of hydrogen peroxide. Hence, sketch

(i) a graph of concentration of hydrogen peroxide against time
(ii) a graph of rate of reaction against concentration of hydrogen peroxide

to show that the decomposition of hydrogen peroxide is a first order reaction. [3]

(i)	**(ii)**

(c) (i) Calculate the standard enthalpy change of reaction for the decomposition of hydrogen peroxide.
[Given : ΔH_f^o (H_2O_2) = -187.83 kJ mol^{-1}, ΔH_f^o(H_2O) = -285.83kJ mol^{-1}] [2]

(ii) Hence, sketch a clearly labelled energy profile diagram to illustrate the decomposition of H_2O_2. [1]

[Total marks: 8m]

4. Trifluroethyl vithyl ether was the first fluorinated volatile compound to be used in anaesthetia. A series of fluorinated compounds was investigated by Robbins(1946) who observed that the anaesthetic potency of a fluorinated compound was greatly increased with the insertion of a second compound. This work has been extended and Fluoethane was discovered in 1956.

Fluothane, $CF_3CHBrCl$, is a volatile liquid commonly used as an anaesthetic in hospital. In anaesthetic systems, sodalime (which contains mainly NaOH) is used to remove the CO_2 breathed out by patients. In hospital, Fluoethane is administered before an operation is conducted. Fluoethane wll be converted in vapour when inside the human body and absorbed by the human body. For every 50ml of fluothane, the vapour concentration absorbed by human body when injected is 2.4%. For a typical person to be unconscious for 8h, 0.05g of Fluothane has to be absorbed. .

To confirm that Fluothane does not undergo hydrolysis, a mixture of Fluothane and sodalime(which contains mainly NaOH) was stirred for an hour. It was then acidified with nitric acid and tested with aqueous silver nitrate.

(a) Draw a structure of Fluothane. [1]

(b) In an operation, the patient needs to be unconscious for 8h.

(i) Calculate the number of moles of Fluothane that must be absorbed by the body. [1]

(iii) Hence or otherwise, calculate the volume of Fluothane that needs to be injected into the human body.
Assume that the density of Fluothane is 0.8 gcm^{-3} [2]

(c) Assuming that the bromide ions are produced in the hydrolysis of Fluothane, describe what would be observed when the product is acidified and tested with aqueous silver nitrate. Support your answer with and equation. [2]

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(d) The attempted hydrolysis did not break the C-Br bond in Fluothane. Hence it may be assumed that the other two types of bond, namely the C-Cl and C-F bond in Fluothane also remain intact in the hydrolysis. Give a reason for this assumption [2]

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(e) Another alkyhalide with the molecular formula CH_3CH_2Cl undergone a reaction under reflux in the presence of alcoholic KCN.

(i) Name the type of reaction for this reaction [1]

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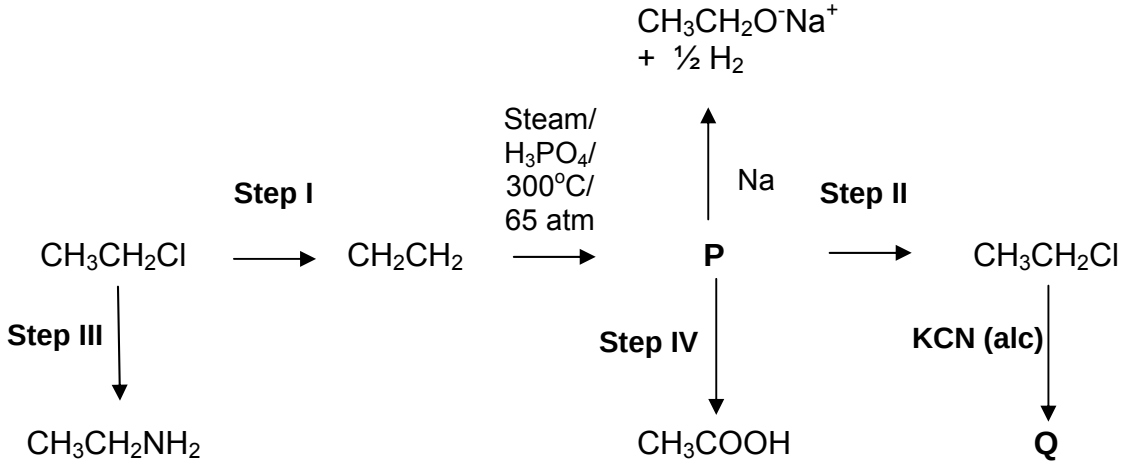
(ii) Draw the structural formulae of compounds P and Q in the following scheme. [2]



Structure of **P** :

Structure of **Q** :

(iii) Suggest possible conditions and reagents for reaction step **I**, **II, III and IV**. [4]

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(iv) Predict and explain, with the help of a diagram, if CH_3COOH is soluble in water. [2]

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[Total marks: 17m]

Section B: (2x 20m)

Answer two of the three questions in this section on the separate paper.

5. Calcium is a mineral that is needed for many functions of the body, especially bone formation and maintenance. Calcium can also bind to other minerals such as phosphate, and aid in their removal from the body.

(a) In the laboratory, Calcium hydroxide reacts with ethanoic acid to give calcium ethanoate

Write a balanced equation to show the formation of calcium ethanoate [1]

(b) A liquid **X** (M_r 58) and calcium carbonate are produced when calcium ethanoate is heated.
Yellow precipitate is seen when **X** is warmed with aqueous alkaline iodine.
It has the following composition by mass: C : 62.1% ; H : 10.3% and O : 27.6%.

(i) Show, with calculation, what is the empirical formula of **X**? [2]

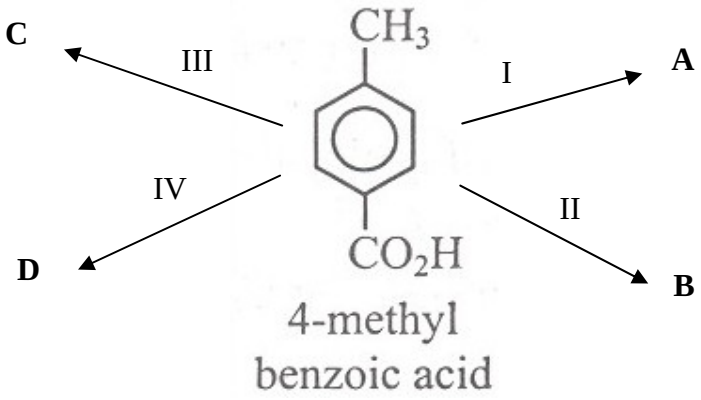
(iii) Hence, write a balanced equation to show the thermal decomposition of calcium ethanoate. [1]

(c) In the laboratory, a student was given 3 unlabelled bottles of solutions. The 3 bottles contains **X**, propanal and methyl ethanoate respectively.

Describe 2 chemical tests to distinguish between the 3 solutions.
(Test using aqueous alkaline iodine will not be accepted)

For each test, state the reagents, conditions and observations made with each compound.
Support your answer with equations [7]

(d) 4-methylbenzoic acid is a white crystalline solid that is *practically insoluble in water but dissolves in aqueous sodium hydroxide*. 4-methylbenzoic acid can undergo numerous reaction as shown in the diagram below.



Reaction	Regents and Conditions	Products
I	CH_3CH_2OH with concentrated H_2SO_4, heat under reflux	A
II	$KMnO_4$ heat under reflux	B
III	Br_2 with $FeBr_3$ as catalyst	C
IV	Cl_2 under UV Light	D

(i) Explain, with the help of an equation, why 4-methylbenzoic acid is insoluble in water but dissolves in aqueous sodium hydroxide. [2]

(ii) Draw the structural formula of compounds **A** to **D** [4]

(e) Chloroethanoic acid, ethanoic acid and ethanol display certain degree of acidity.
Arrange the three organic compounds in ascending order of acidity. Explain your answer. [3]

[Total marks: 20m]

6. (a) Mixtures of citric acid and its sodium salt are often used as food addictives. They are sometimes called “acidity regulators” because of their buffering action on the pH of foodstuffs. K_a of citric acid is 7.4×10^{-4} mol dm^{-3}

$$C_5H_7O_4CO_2H \rightleftharpoons C_5H_7O_4CO_2^- + H^+$$

(i) The concentration of citric acid is 0.22 mol dm^{-3}. Assuming that lemon juice contains only citric acid, what is the pH of lemon juice? [3]

(ii) Explain the term acidic buffer [2]

(iii) Write equations to show how the citric acid and its sodium salt buffer system regulate the acidity on addition of H^+ ions and OH^- ions. [2]

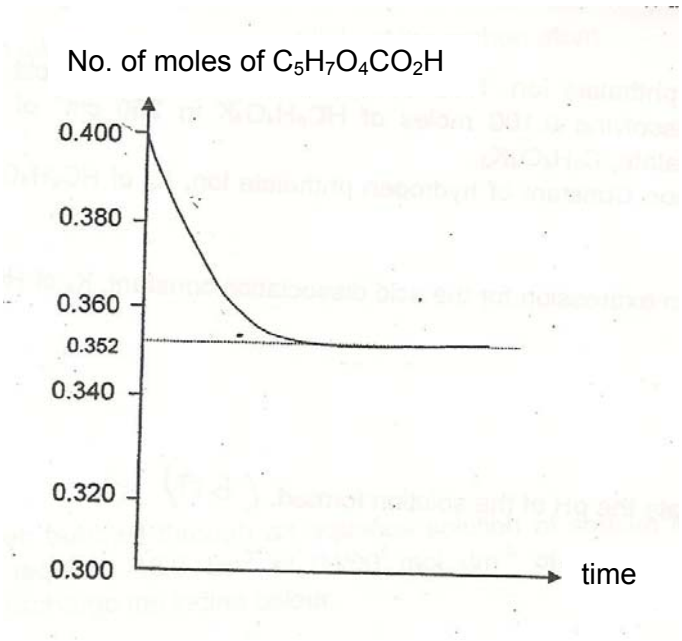
(b) Upon heating, citric acid reacts with ethanol according to the following equation as shown below.

$$C_5H_7O_4CO_2H(l) + C_2H_5OH(l) \rightleftharpoons C_5H_7O_4CO_2C_2H_5(l) + H_2O(l)$$

A mixture with the following composition was heated in a closed container and the reaction was allowed to reach equilibrium.

Compound	No. of moles
$C_5H_7O_4CO_2H$	0.400
C_2H_5OH	0.600
$C_5H_7O_4CO_2C_2H_5$	0.100
H_2O	0.100

The graph shows how the number of moles of $C_5H_7O_4CO_2H$ varies with time.



(i) Write an expression for the equilibrium constant, K_c for the reaction above. [1]

(ii) Calculate the equilibrium constant, K_c. [2]

(iii) Explain how the equilibrium composition and K_c would change if more citric acid is added to the equilibrium mixture. [3]

(c) The table below gives the result of three experiments carried out to study the rate of reaction between nitrogen monoxide, and hydrogen.

$2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$

Experiment	Initial Concentration / $moldm^{-3}$		Initial rate of reaction / $moldm^{-3}\ s^{-1}$
	[NO]	$[H_2]$	
1	0.0020	0.012	0.0033
2	0.0040	0.012	0.013
3	0.0060	0.014	0.030

(i) Determine the order of reaction with respect to nitrogen monoxide and hydrogen [2]

(ii) Calculate the rate constant, stating its units [2]

(iii) With the help of a Maxwell Boltzmann diagram, explain how the rate of reaction is increased in the presence of a catalyst. [3]

[Total marks: 20m]

7. (a) Gas used in camping stoves are available in canister, mainly butane. To determine the *standard enthalpy change of combustion* of butane, a student heated a 500cm^3 of water on the stove and measured the temperature rise. The canister was weighed before and after the experiment so as to obtain the mass of gas used. The table below shows the results obtained.

Initial mass of canister /g	5.0
Final mass of canister /g	1.6
Initial temperature /^{0}C	25
Final temperature /^{0}C	69

(i) Define the term standard enthalpy change of combustion [1]

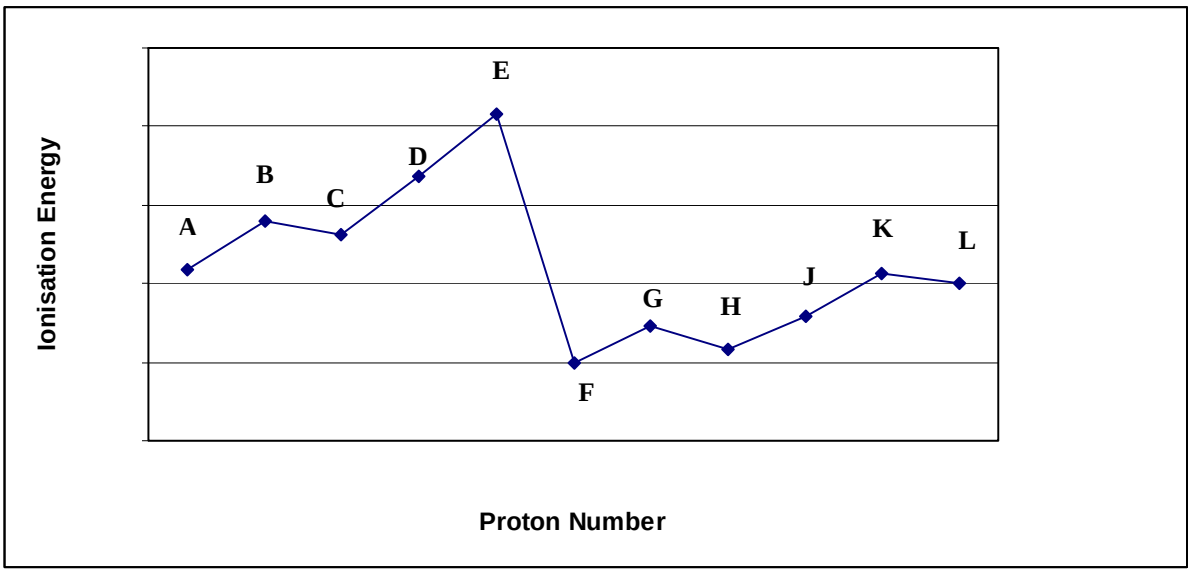
(ii) Write a balanced equation for the combustion of butane [1]

(iii) Assuming that the process of heat transfer is only 80% efficient, calculate the enthalpy change of combustion of butane [3]

(iv) From theory, the given standard enthalpy change of combustion is -2877kJ mol^{-1}. State one possible source of error that may have occurred when carrying out such experiment resulting in the difference between the given value and that obtained in (a)(iii) . [1]

(v) Hence, state one precaution that should be taken to overcome the error mentioned in (a)(iv). [1]

(b) The first ionization energies of 11 elements **A** to **L** in both period 2 and 3 are shown below.

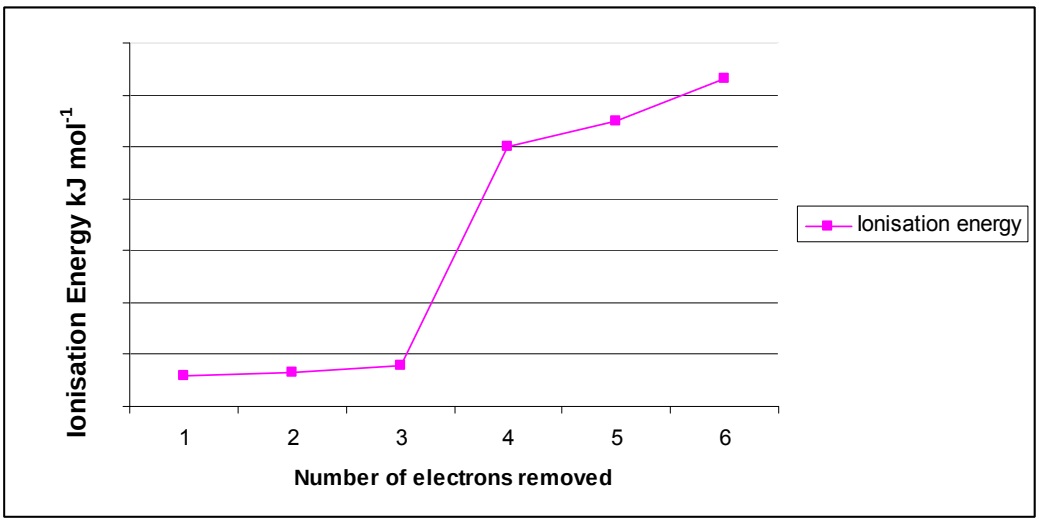


(i) **C** and **L** belong to the same group.
Name <u>another</u> pair of elements which are in the same group. [1]

(ii) With reference to the answer in (b)(i), state the group which the pair belongs and hence write the electronic configuration for these 2 elements. [2]

(iii) **C** and **L** belong to the same group. Explain why the ionisation energy of **L** is lower than that of **C**. [2]

(c) It is found that oxide of **H** does not react with water but its chloride dissolves in water readily to give an acidic solution. A sketch of the ionization energy of the first six electrons of **H** is as shown below.



(i) What is element **H** ? [1]

(ii) Explain why oxide of **H** does not react with water. [1]

(iii) Explain why chloride of **H** reacts with water to give an acidic solution. Support your answer with equations. [1]

(d) It is found that the nature of oxides changes from **F** to **L**.

(i) State the nature of the oxides from **F** to **L**. [1]
(ii) For each nature of the oxide, give an example to support your answer. [4]

[Total marks: 20m]

-- END OF PAPER –