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.
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 question paper consists of 16 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]

   $Fe^{2+} \rightarrow Fe^{3+} + e$

   $MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$ ***2 half-equation 1m***

   Overall equation : $5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$; ecf given

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

   No. of mol MnO_4^- = $5.00x10^{-6}$ x 0.011

   = $5.50x10^{-8}$

   No. of mol Fe^{2+} in $10.0cm^3$ = $5.50x10^{-8}$ x 5

   = $2.75x10^{-7}$; ecf given

   No. of mol of Fe^{2+} in $100cm^3$ = $2.75x10^{-7}$ x 10

   = $2.75x10^{-6}$

   Concentration of Fe^{2+} = $2.75x10^{-6}$ x (1000/100)

   = $2.75x10^{-5}$ $moldm^{-3}$; ecf given

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

   16.5mg = 1.65×10^{-2}g

   Mass of Fe in 1.00g of flour = $2.75x10^{-6}$ x 55.8

   = 1.535×10^{-4}g

   Mass of Fe in 100g of flour = $1.535 \times 10^{-4} \times 100$

   = 1.535×10^{-2} g ;

   The flour does not meet the requirement. ;

   marks given only with calculation

[Total marks: 6m]

[Turn over

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]

Relative atomic mass = 32 x 0.9493 + 34 x 0.0507 = 32.1 ;

(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]

Shape of molecule : Trigonal planar, 120^o ;;

S as the central atom. Each O atom forms a double bond with sulphur.
12 valence electrons surrounding the central atom. ;

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

compound	**melting point / ^{o}C**
SiO_2	2830
SO_3	17

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

SiO_2 has a giant covalent structure with strong covalent bonds between silicon and oxygen atoms. ;

SO_3 has a simple covalent structure with weak Van Der Waals forces of attraction between its molecules. ;

Hence, silicon dioxide requires more energy to overcome the strong covalent bonds between atoms as compared to the weak Van Der Waals forces of attraction between sulphur trioxide molecule. Melting point of silicon dioxide will be higher. ;

(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]

Lattice energy is proportional to $\text{L.E.} \propto \frac{q^+q^-}{r^+ + r^-}$

Since the product of the charges of the cation and anion is the same for both compound but the ionic radius of sulphide ion is larger than that of oxide ion due to an increased in the number of shells of electrons, hence, the lattice energy of sodium sulphide will be less exothermic since the electrostatic forces of attraction is weaker . ;

(Writing this explanation, students have to write formula for lattice energy).

Hence sodium sulphide will have have a lower melting point since its ions are held together by a slightly weaker electrostatic force as compared to sodium oxide. ;

<u>Alt explanation</u>

Comparing the lattice energy of Na_2O and Na_2S, the lattice energy of Na_2S will be less exothermic because the interionic distance of Na_2S will be larger than that of Na_2O due to the increase in size of the anion. Hence, the forces of attraction is weaker ;

Hence sodium sulphide will have a lower melting point since its ions are held together by a slightly weaker electrostatic force as compared to sodium oxide. ;

[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]

A first order reaction is a reaction whereby the rate of reaction is proportional to the concentration of the reactant, in this case H_2O_2. ***;***

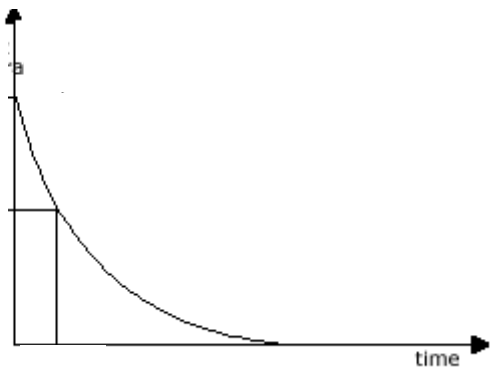
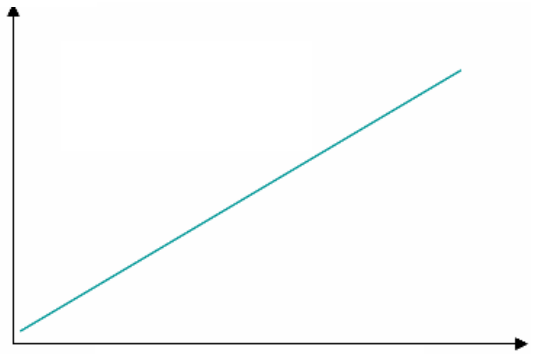
(ii) Hence, write a rate equation to show the decomposition of hydrogen peroxide. [1]

Rate = k[H_2O_2] ***;***

(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

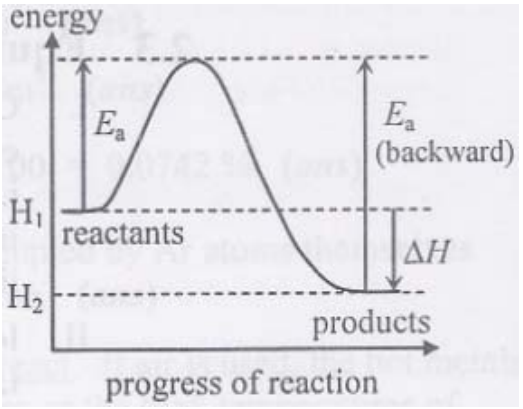
to show that the decomposition of hydrogen peroxide is a first order reaction. [3]

(i)	**(ii)**
[H_2O_2]  ***Show constant half-life ;*** ***Shape of graph ;***	[Rate]  [H_2O_2] ***;***

(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]

ΔH_{rxn} = [2(-285.83) + 0] – [2(-187.83)] = -196 kJ mol^{-1}

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



; Ecf given

[Total marks: 8m]

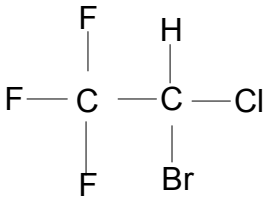
[Turn over

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]

No. of mol = 0.05/197.4 = 0.0002532

(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]

Mass of Fluothane in 50ml = 0.8 x 50 = 40g
No. of mol of Fluothane in 50ml = 40/ 197.4 = 0.20 ; ecf given
No. of mol of Fluothane absorbed by body = 0.024 x 0.20 = 0.0048
Volume of Fluothane needed = 0.0002532/0.0048 x 50 = 2.6ml ; ecf given

Alt method

Volume of vapour of Fluothane that is absorbed by the body for every 50ml of Fluothane injected = 0.024 x 50ml
= 1.2ml

Volume of Fluothane that is be absorbed by the body in order for patient to be unconscious for 8h = 0.05/0.8
= 0.0625ml ; ecf given

Volume of Fluothane that must be injected into the body = (0.0626/1.2) x 50
= 2.60ml
;ecf given

(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]

Cream/pale yellow ppt of AgBr is formed ;

$Ag^+ + Br^- \rightarrow AgBr(s)$;

(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]

The bond strength of C-Cl and C-F bonds are higher than C-Br. ;

More energy is needed to break these bonds as compared to C-Br. ;

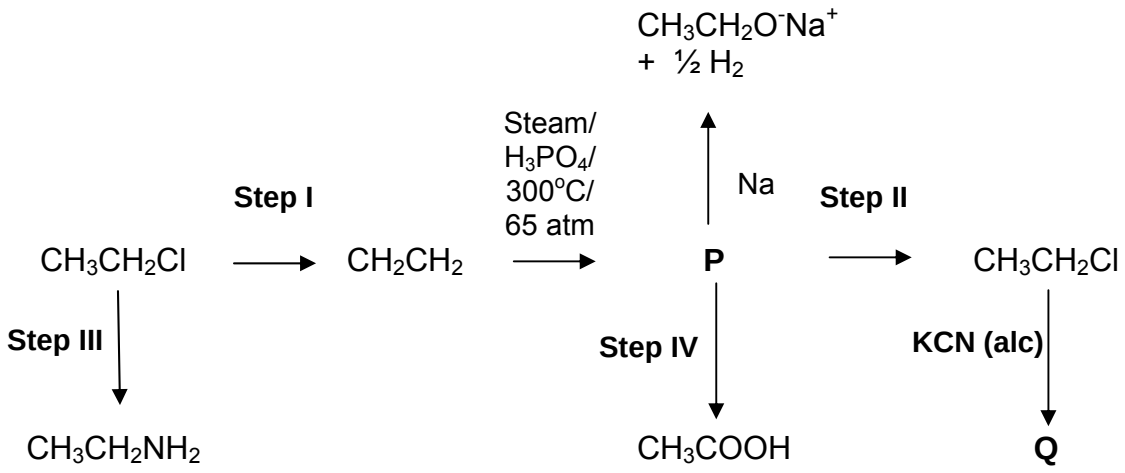
Hence, if C-Br is not broken in the hydrolysis, the C-Cl and C-F which requires more energy to break will not be broken too.

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

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

Nucleophilic substitution. [Hydrolysis is not acceptable]

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



P : CH_3CH_2OH
Q : CH_3CH_2CN

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

Step I: NaOH(alc), reflux

Step II: PCl_5

Step III: excess concentrated NH_3, (no marks if "excess" is missing) ; heated in sealed tube

Step IV : Acidified $KMnO_4$ / $K_2Cr_2O_7$ heat under reflux.

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

CH_3COOH is soluble in water. ;
It is polar and able to form <u>hydrogen bonds</u> with water molecules.
(together with diagram) ;

[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**? [1]

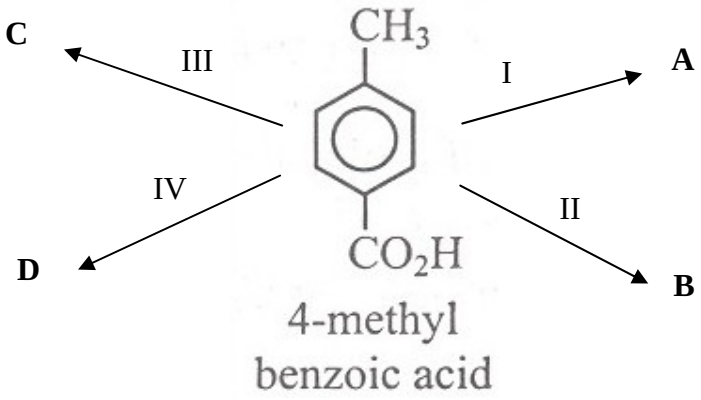
(iii) Hence, write a balanced equation to show the thermal decomposition of calcium ethanoate. [1]

(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 on 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]

Answer for Qn 5

(a) $Ca(OH)_2 + 2CH_3COOH \rightarrow Ca(CH_3COO)_2 + 2H_2O$;

(b) (i) Empirical Formula : C_3H_6O ; with table ;

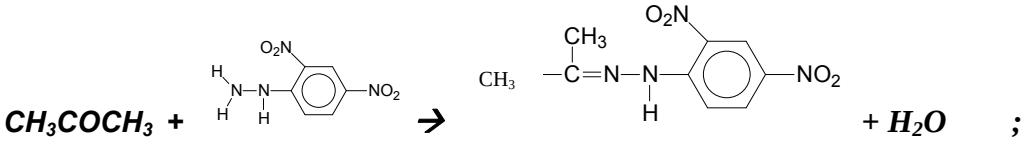
(iii) $Ca(CH_3COO)_2 \rightarrow CH_3COCH_3 + CaCO_3$;

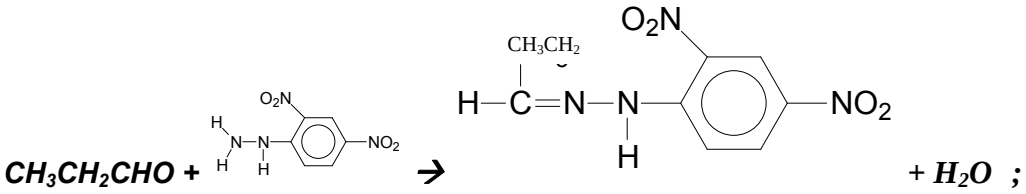
(c) To distinguish methyl ethanoate from X and propanal,

Add 2,4-dinitrophenylhydrazine to each compound and warm. ;

Observation : CH_3COCH_3(ketone) and propanal gives an orange ppt. ;

No visible change when 2,4-dinitrophenylhydrazine is added to methyl ethanoate



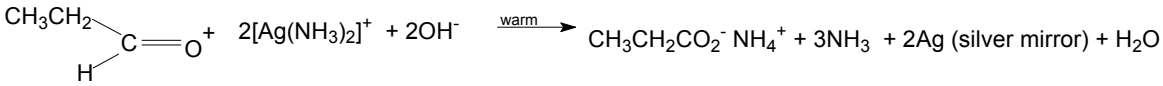


To distinguish X from propanal

Add tollen's reagent to each compound and warm ;

Observation : propanal gives an silver mirror. ;

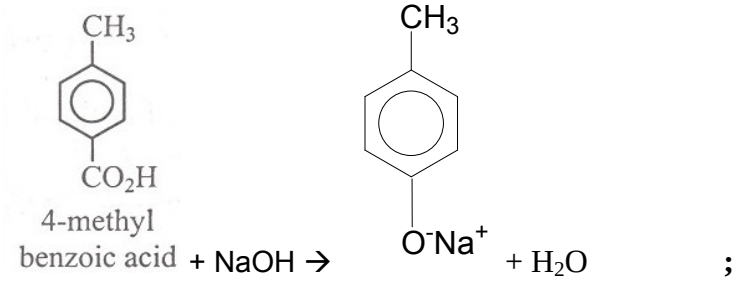
No visible change when tollen's reagent is added to X and methyl ethanoate.



;

(d) (i) 4-methylbenzonic acid is insoluble in cold water due to the presence of hydrophobic benzene ring. ;

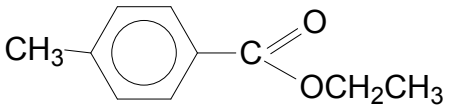
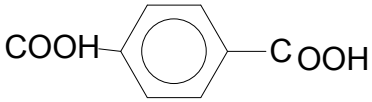
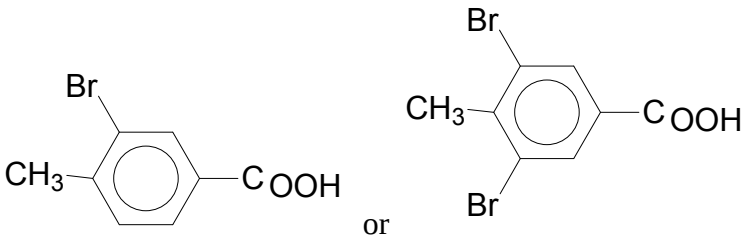
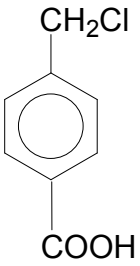
However, the carboxylic acid reacts with NaOH(aq) to give an ionic salt. Therefore, it is soluble in NaOH.



;

over

(ii)

A	
B	
C	
D	

(e) Ethanol< Ethanoic acid < Chlroethanoic acid ;

Comparing ethanol and ethanoic acid, the extent of ionisation of alcohol is less than the extent of ionisation of acid.
Carboxylic acid is a stronger acid because the carboxylate anion CH_3COO^- is more stable than the alkoxide CH_2O^- due to the ability to disperse the negative charge between the two oxygen atoms ;

Comparing ethanoic acid and chloroethanoic acid, the extent of ionisation of chloroethanoic acid is more than the extent of ionisation of acid.
Cl has an electron- withdrawing effect
The negative charge of the anion is dispersed, thus increasing the stability of the anion. Therefore, it is the most acidic. ;

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]

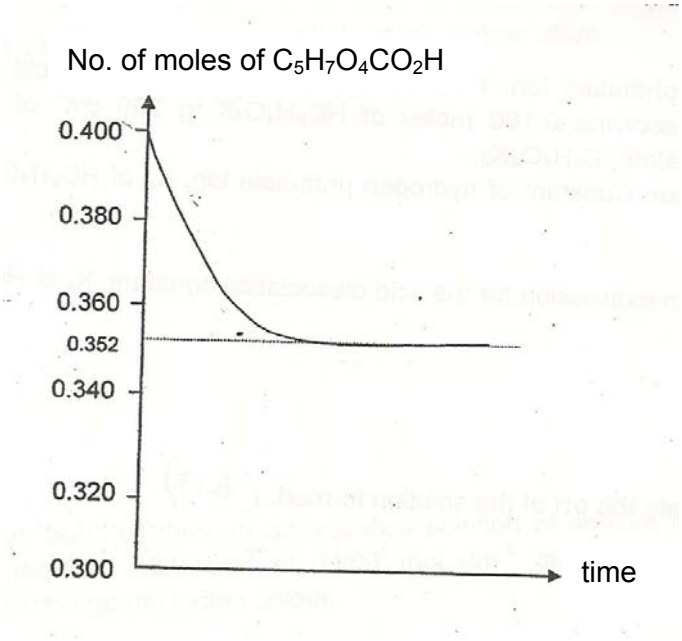
(b) Upon heating, citric acid reacts with ethanol according to the following equation as shown below.

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

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]

Ans for Qn 6

(a) (i) $C_5H_7O_4CO_2H \rightleftharpoons C_5H_7O_4CO_2^- + H^+$

$K_a = \dfrac{[C_5H_7O_4CO_2^-][H^+]}{[C_5H_7O_4CO_2H]}$

Since the degree of dissociation, α *is very small,* $[HA]_{eqm} \approx [HA]_{initial}$

$7.4 \times 10^{-4} = \dfrac{[H^+]^2}{[0.22]}$

$[H^+] = 0.0128\ moldm^{-3}$

$pH = -\log_{10}(0.0128)$

$= 1.89$

(ii) **An acidic buffer is a solution whose pH remains almost unchanged if a little acid or alkali is added to it. ; Acidic buffer is formed when there is presence of a weak acid and its conjugate base ;**

(iii) $C_5H_7O_4CO_2^- + H^+ \rightarrow C_5H_7O_4CO_2H$;

$C_5H_7O_4CO_2H + OH^- \rightarrow C_5H_7O_4CO_2^- + H_2O$;

(b)(i) $K_c = \dfrac{[C_5H_7O_4CO_2C_2H_5][H_2O]}{[C_5H_7O_4CO_2H][C_2H_5OH]}$

(ii) Let the volume of the reaction be v.

		$C_5H_7O_4CO_2H$	+	C_2H_5OH	⇌	$C_5H_7O_4CO_2C_2H_5$	+	H_2O
No. of mol. initially		0.400		0.600		0.100		0.100
Change of mol		0.400- x		0.600 - x		0.100 + x		0.100 + x
No. of mol. at eqm		0.352		0.552		0.148		0.148 ;
Eqm conc.		0.352/v		0.552/v		0.148/v		0.148/v

$K_c = \dfrac{[0.148/v][0.148/v]}{[0.352/v][0.552/v]} = 0.113$;

(iii) When more citric acid is added, the concentration of citric acid and ethylcitrate increase while the concentration of ethanol will decrease. ;

The equilibrium will remove the citric acid by reacting with ethanol to form ethylcitrate.

Hence, forward equilibrium is favoured and the equilibrium will shift to the right. ;

K_c *remains unchanged ;*

(c) (i) Order of reaction w.r.t to NO is 2
Comparing expt 1 and 2, keeping $[H_2]$ constant, when [NO] doubles, initial rate of reaction increase by 4 times. ;

Order of reaction w.r.t to H_2 is 1

$$\frac{k\,[0.002]^2\,[0.012]^m}{k\,[0.006]^2\,[0.014]^m} = \frac{0.0033}{0.030}$$

m=0

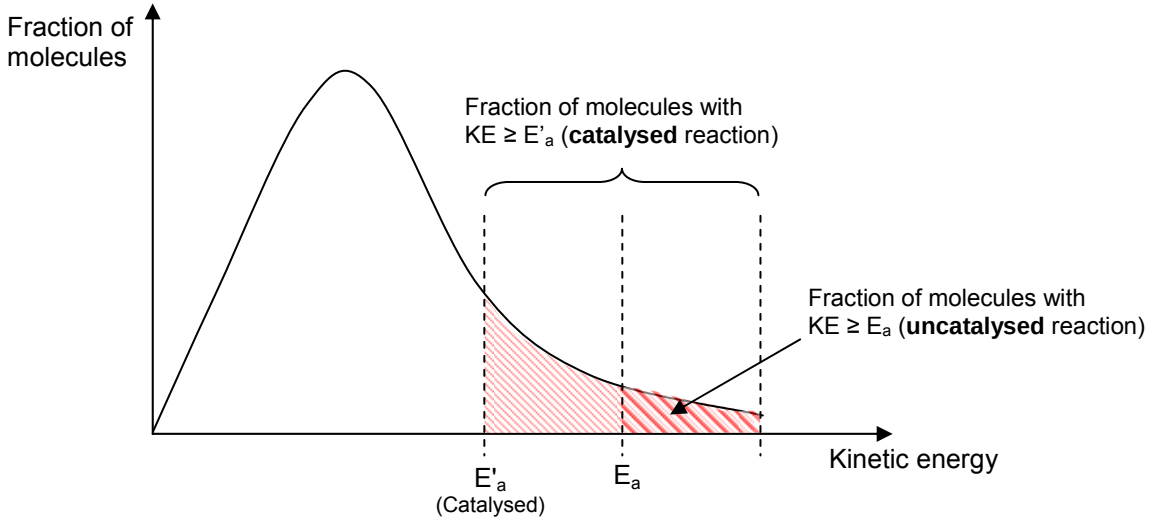
- ***no mark given if only order of reaction written.***

(ii) rate = $k[NO]^2[H_2]$

$$k = \frac{0.0033}{[0.002]^2} = 825\ mol^{-1}\ dm^3\ s^{-1}$$

(iii) Catalyst provides an alternative reaction path with lower activation energy than that for the uncatalysed reaction. ;

∴The number of reactants with energy greater than this lowered activation energy increases, leading to an increase in the frequency of collisions between these molecules and thus the rate of reaction. ;



Correctly labeled diagram (1m)

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]

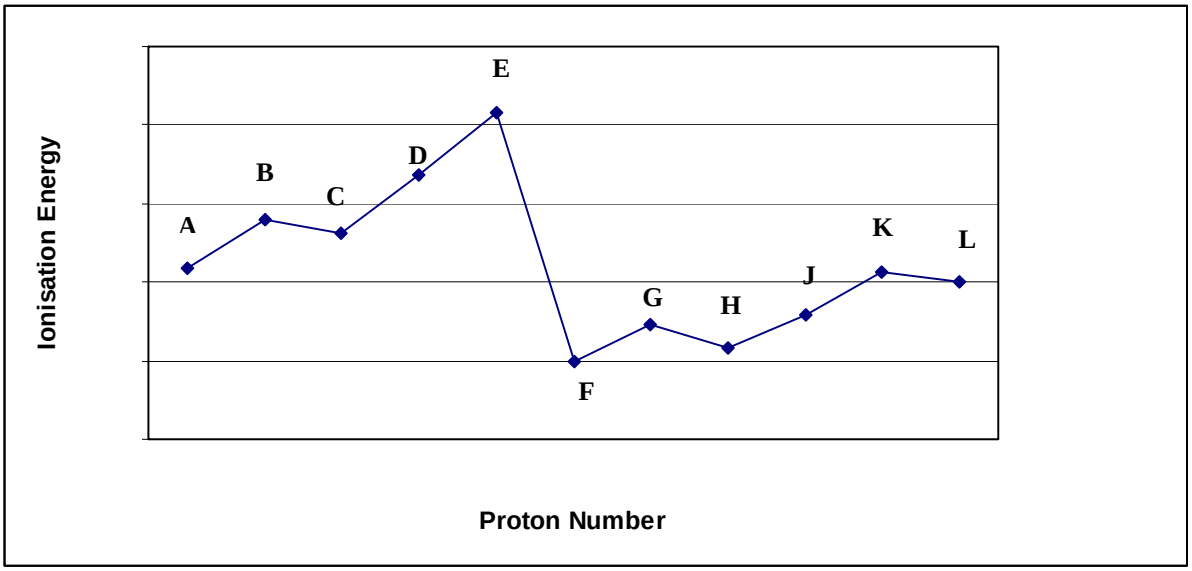
(ii) Write a balanced equation for the combustion of butane [1]

(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.

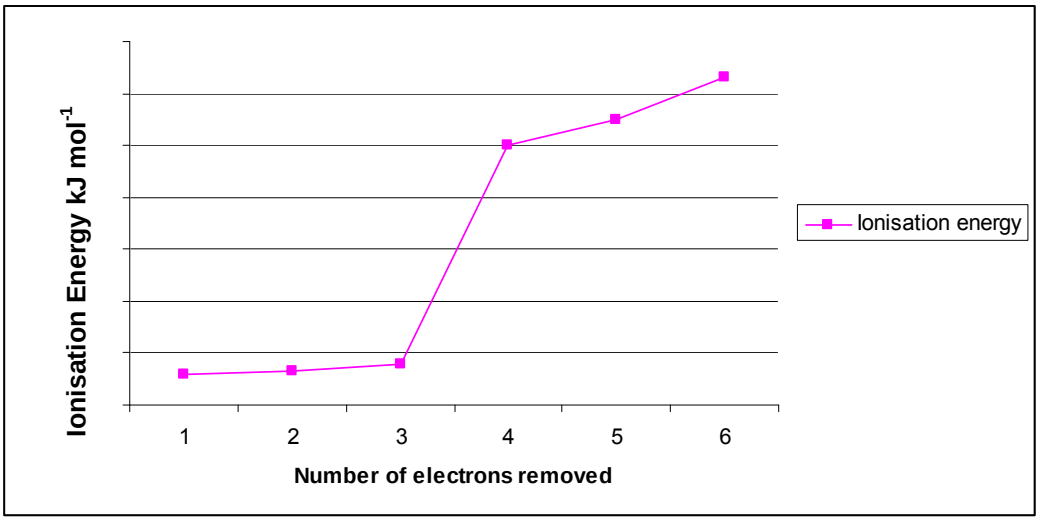


(i) **C** and **L** belong to the same group.
Name <u>another</u> pair of elements which are in the same group. [1]

(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 ionization 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 –

Ans for Qn 7

(a) (i) Standard enthalpy change of combustion is the enthalpy change when one mole of a substance is completely burnt in excess oxygen under standard conditions of 1 atm and 298K. ;

(ii) C_4H_{10} + 13/2 O_2 → 4CO_2 + 5 H_2O ;

(iii) Heat evolved = 500 x 4.18 x 44
= 91.9kJ ;
Heat evolved if burning is 100% efficient = 91.9/0.8
= 114.95kJ ;

No. of mol of butane = 3.4/58 = 0.0586

ΔH_c = 114.95/0.0586 = -1961kJ mol^{-1} (no sign means no marks) ;

(iv) Ensure that proper lagging is done to minimize heat loss to the surrounding./ Ensure that the thermometer is fully immersed in the water and the maximum temperature is recorded. ;

(v) Heat is lost to the surrounding. ;

(b)(i) A & J or B&K ;

(ii) A & J belongs to Group IV, B&K belongs to Group V ;
A : $1s^2\ 2s^2\ 2p^2$ B : $1s^2\ 2s^2\ 2p^3$
J : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ K : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$;

(iii) Down the group, the number of shells of electrons increase.
Shielding effect increase and nuclear charge increase too.
The increase in shielding effect outweighs the increase in nuclear charge. ;
Hence attraction between the valence electrons and the nucleus in L is weaker than that in C. ;
Therefore, less energy is needed to remove an electron from L.

(c)(i) H is Aluminium ;
(ii) Al_2O_3 do not dissolve in water because they have high lattice energies and thus, making dissolution difficult ;
(iii) $AlCl_3$ dissolves in water with hydrolysis to give acidic solution
The acidic nature is due to the relatively small but highly charged Al^{3+} ion which polarises the surrounding water molecules and causes them to give up H^+ ions.

$AlCl_3$ (s) + $6H_2O$(l) ⟶ $[Al(H_2O)_6]^{3+}$ (aq) + $3Cl^-$ (aq)
$[Al(H_2O)_6]^{3+}$ (aq) ⟶ $[Al(H_2O)_5(OH)]^{2+}$ (aq) + H^+ (aq), pH ≈ 3 ;
(no marks for just writing explanation)

(d) (i) The nature of oxides changes from basic to amphoteric to acidic
(ii) Na_2O (s) + 2HCl (aq) → 2NaCl (aq) + H_2O (l) ;
Al_2O_3 (s) + 6HCl (aq) → 2$AlCl_3$ (aq) + 3H_2O (l) ;
Al_2O_3 (s) + 2NaOH (aq) + 3H_2O (l) → 2Na $Al(OH)_4$ (aq) ;
SO_2 (g) + 2NaOH (aq)→ Na_2SO_3 (aq) + H_2O (l) ;