SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME	
CLASS	**INDEX NUMBER**

CHEMISTRY 8872/02

Preliminary Examination **19 August 2008**
Paper 2 **2 hr**

Additional Materials: Data Booklet
Writing Papers

READ THESE INSTRUCTIONS FIRST

Write your name 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 work.

SECTION A:
Answer **all** questions in the space provided.

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 the brackets [ ] at the end of each question or part questions.

For Examiner's Use	
Section A	
B5	
B6	
B7	

This document consist of **18** printed pages and **NO** blank page

1 Iron tablets containing iron (II) sulphate can be used to supplement the daily iron intake in diet. The Health Sciences Authority had regulated that all commercially available iron tablets must contain 15 to 18% by mass of iron.

(a) Acidified potassium manganate (VII), $KMnO_4$, which oxidises iron (II) sulphate, is used to estimate the amount of iron (II) ions, Fe^{2+}, present in Brand **A** iron tablet. 2.00 g of the iron tablet was dissolved in dilute acid and the volume of the solution was made up to 100 cm^3 in a volumetric flask. A 10.0 cm^3 portion of this solution was titrated against 2.50 x 10^{-4} mol dm^{-3} of potassium manganate (VII) solution. 13.50 cm^3 of the manganate (VII) solution was required to completely oxidise the Fe^{2+} present.

(i) Write the overall equation of the reaction between MnO_4^- and Fe^{2+}.

.....

(ii) Calculate the concentration of Fe^{2+} in the 100 cm^3 solution.

(iii) Hence, state with **reasoning** if the Brand **A** iron tablet meets the regulation stated by the Health Sciences Authority.

[4]

(b) Write the electronic configurations of Fe and Fe^{2+} ion.

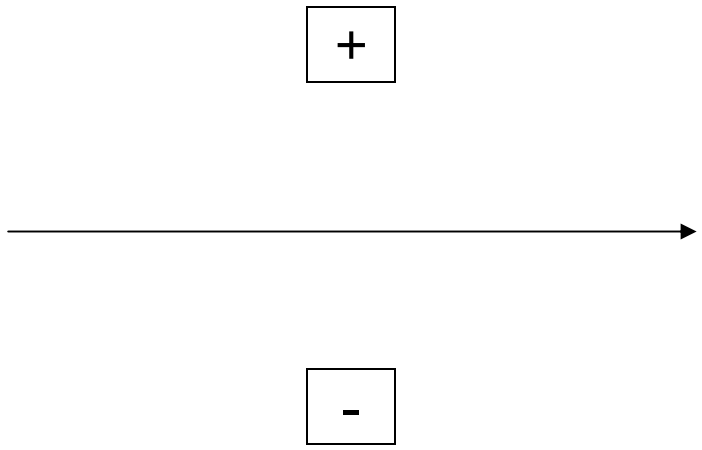
Fe: .....

Fe^{2+}: ..... **[1]**

(c) On the diagram below, show and label clearly how the beams of the following particles are deflected when subjected to an ***electric*** field.

(i) electron
(ii) proton
(iii) Fe atom

You should relate clearly the magnitude and the direction of deflection of each beam to the other. (Any pencil markings will NOT be graded.)

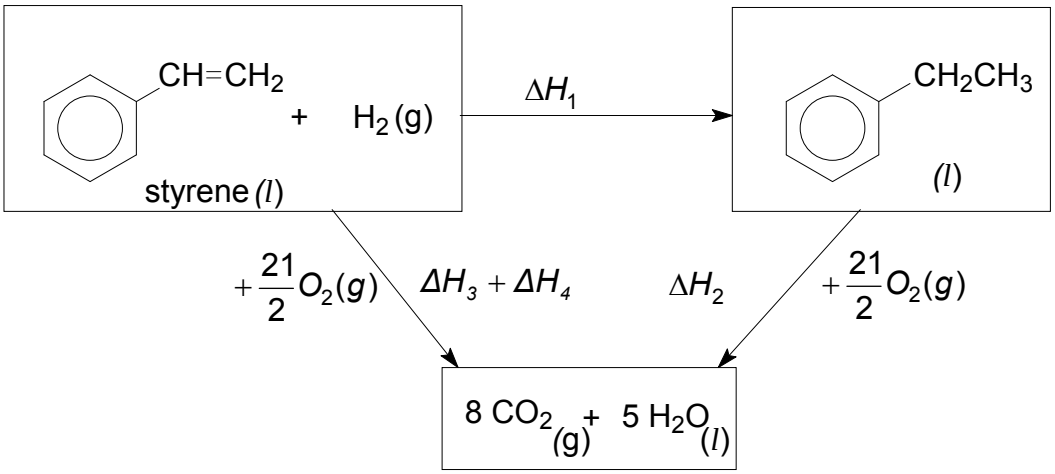


[3]

[Total: 8]

2 Styrene is an aromatic hydrocarbon that is a precursor to polystyrene, an important synthetic material that is used in the making of many substances such as plastic, rubber, insulation and fiberglass.

The diagram below shows an energy cycle involving the compound styrene.



(a) **(i)** Use the following data to calculate the standard enthalpy change of hydrogenation of styrene.

ΔH_C^e hydrogen	=	–286 kJ mol^{-1}
ΔH_C^e styrene	=	–4393 kJ mol^{-1}
ΔH_C^e ethylbenzene	=	–4562 kJ mol^{-1}

(ii) Calculate the amount of heat evolved when 1.000 g of styrene was burnt completely to heat up 200 cm^3 of water by 45.0 °C. Assume that the specific heat capacities of all solutions are 4.18 J g^{-1} K^{-1}, and that all solutions have a density of 1.0 g cm^{-3}.

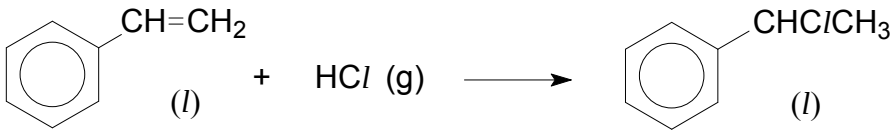
(iii) Using the answer in **(ii)**, calculate the enthalpy change of combustion of styrene.

(iv) Comment on the difference in values of standard enthalpy change of combustion of styrene in **(i)** and **(iii)**.

[4]

(b) Given the following information,

$\Delta H_f^{\ominus}$ styrene	=	+104 kJ mol^{-1}
$\Delta H_f^{\ominus}$ hydrogen chloride	=	–92 kJ mol^{-1}
$\Delta H_f^{\ominus}$ (2-chloroethyl)benzene	=	–58 kJ mol^{-1}



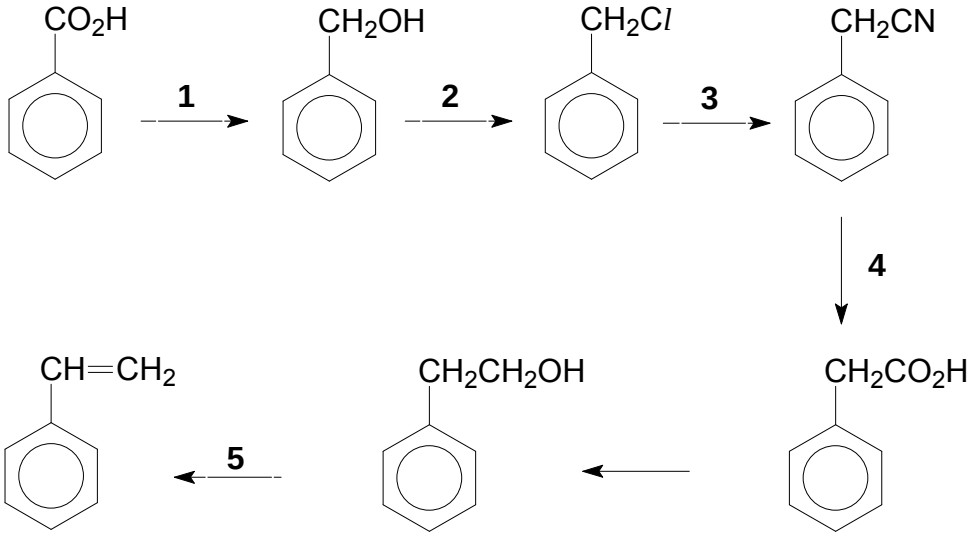
styrene

(i) Calculate the enthalpy change for the above reaction.

(ii) The reaction above can be performed when ethylbenzene is treated with a small quantity of chlorine in the presence of ultraviolet light. Both(1-chloroethyl)benzene and (2-chloroethyl)benzene are produced. Predict the approximate ratio in which they are formed.

[2]

(c) A student accidentally poured some hot acidified potassium manganate (VII) into a bottle of styrene, forming benzoic acid. In order to salvage the styrene, he decided to adopt the following synthetic route.



Suggest the correct reagents and conditions for the synthetic steps **1** to **5**.

Step **1**

reagent(s): .....

conditions: .....

Step **2**

reagent(s): .....

conditions: .....

Step **3**

reagent(s): .....

conditions: .....

Step **4**

reagent(s): .....

conditions: .....

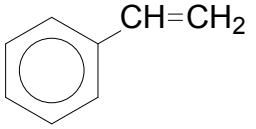
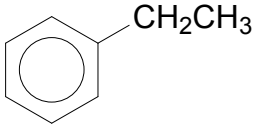
Step **5**

reagent(s): .....

conditions: .....

[5]

(d) Complete the following table below:

Compound	Number of carbon atom(s)		
	sp	sp^2	sp^3
			
			

[1]

[Total: 12]

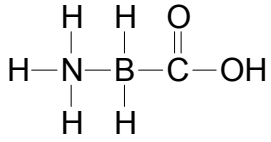
3 Because boron has one less electron than carbon, and nitrogen has one more, many B-N compounds are known as iso-electronic and iso-structural with their C-C analogues. Although the former have similar shapes and boiling point, they are very different to the carbon compounds in their chemistry, mainly due to the electronegativity difference between the two elements.

Compounds iso-electronic with saturated hydrocarbons, known as amino-boranes, may be prepared by the reaction of amines or ammonia with diborane, the simplest being the analogue of ethane (CH_3CH_3):

$$B_2H_6(g) + 2NH_3(g) \longrightarrow 2BH_3NH_3(s)$$

The two are very different physically. Ethane is gaseous at room temperature, having a boiling point of -89^{o}C, whereas the B-N compound is solid at room temperature. However, the melting and boiling point of NH_3BH_3 is undetermined because the compound decomposes before it melts.

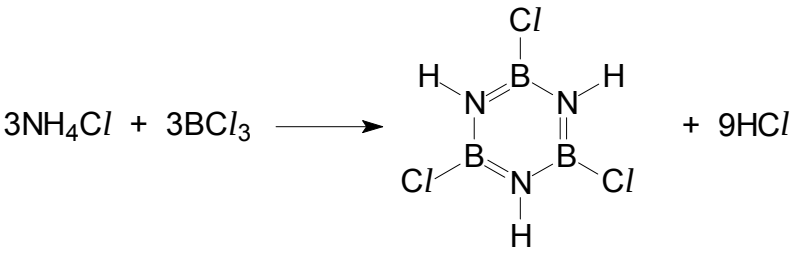
Several analogues of carboxylic acids are known, such as ammonia carboxyborane.



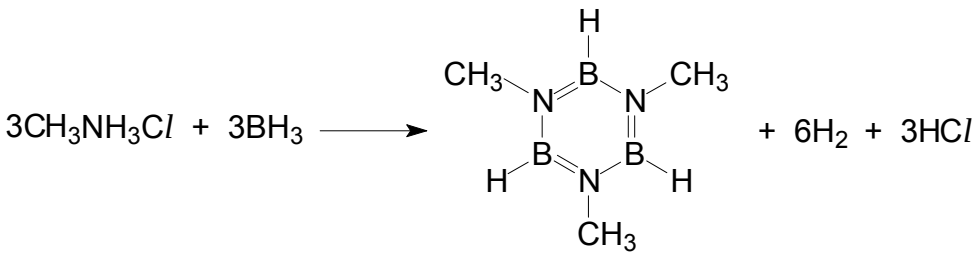
Some of these compounds display significant physiological activity, including tumour inhibition and reduction of serum cholesterol in certain cases.

Borazine, $B_3N_3H_6$, is iso-electronic and iso-structural with benzene, but the two compounds have little chemical resemblance. The former does not have the same delocalized π electron structure as benzene, since the π electrons are concentrated on the nitrogen atoms, and hence it can be regarded as having three electron-rich, reactive double bonds. Unlike benzene, borazine undergoes electrophilic addition readily. For example, 1 mol of borazine reacts with 3 mol of HC*l* to form a compound which is analogous to 1,3,5-trichlorocyclohexane.

Many symmetrically tri-substituted derivatives of borazine have been prepared. The following are two examples of such preparation.



***B*-trichloroborazine**



***N*-trimethylborazine**

(a) Draw the dot-and-cross diagram of BH_3NH_3 and state the type of bond between boron and nitrogen. **[2]**

(b) By referring to the intermolecular forces of attraction involved, explain the difference in boiling points between ethane and its amino-borane analogue. **[2]**

(c) Write an equation to illustrate the acidic nature of ammonia carboxyborane. **[1]**

(d) Suggest a name of the carbon analogue of ammonia carboxyborane. **[1]**

(e) Construct a balanced equation for the reaction between borazine and hydrogen chloride. Calculate the volume of HC*l* (measured at room temperature and pressure) needed to react completely with 16.08g of borazine. **[2]**

(f) Suggest the reagents for the synthesis of *B*-trimethyl-*N*-trichloroborazine. Draw the displayed formula of this product. **[2]**

[Total: 10]

4 (a) In biological system, internal pH of most living cells is close to 7.4. Even a slight change in pH can be fatal because the chemical processes in the cell are very sensitive to the concentration of hydronium ion (H_3O^+) and hydroxide ions (OH^-).

The most important buffer for maintaining acid-base balance in the blood is the carbonic acid, H_2CO_3 and bicarbonate, HCO_3^- buffer.

$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$$

In addition, the lungs work to regulate concentration of H_2CO_3 in blood by expelling CO_2 via the following equilibrium:

$$H_2CO_3(aq) \rightleftharpoons H_2O(l) + CO_2(g)$$

During exercise, increase in metabolism results in the production of H_3O^+ and *acidosis* is said to occur when blood pH falls below 7.4.

(i) Explain, using a relevant equation, how the H_2CO_3/HCO_3^- buffer responds to prevent acidosis from occurring.

(ii) Using *Le Chatelier's Principle*, suggest how excess amount of H_2CO_3 is removed by the lungs.

(iii) Hence, suggest a reason for the heavy breathing after strenuous exercise.

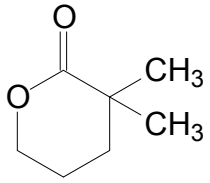
[4]

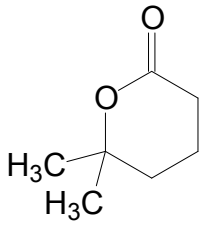
(b) Esters are a class of chemical compounds and functional groups. Esters consist of an inorganic or organic acid in which at least one -OH (hydroxyl) group is replaced by an -O-alkyl (alkoxy) group.

(i) In the boxes below, draw the structural formulae of any <u>three straight-chained</u> esters with the molecular formula $C_5H_{10}O_2$.

(ii) Write an equation for the basic hydrolysis of **one** of these esters.

(iii) Suggest a chemical test to distinguish between the two cyclic esters.





[6]

[Total: 10]

Section B

Answer **two** of the following three questions on separate answer paper.

5(a) This question is on the oxides of nitrogen.

At 1280°C, nitrogen monoxide and hydrogen react as follows:

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

The results of some investigations of the rate of this reaction are shown below.

Experiment	[NO] / mol dm^{-3}	[H_2] / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	0.005	0.002	1.3×10^{-5}
2	0.010	0.002	5.0×10^{-5}
3	0.010	0.004	10.0×10^{-5}

(i) Use the data above to determine the order of the reaction with respect to
I nitrogen monoxide
II hydrogen

(ii) Hence, write a rate equation for the reaction and determine a value for k, stating the units.

(iii) Discuss the effect on the rate of this reaction when the concentration of NO is halved and the concentration of H_2 is tripled simultaneously.

(iv) With the aid of the Boltzmann distribution, explain how the presence of a catalyst increases the rate of the above chemical reaction.

[9]

(b) Another oxide of nitrogen, dinitrogen pentoxide, N_2O_5, decomposes to nitrogen dioxide, NO_2, and nitrogen trioxide, NO_3, as follows:

$$N_2O_5\,(g) \rightarrow NO_2\,(g) + NO_3\,(g)$$

The activation energy of the reaction is 154 kJ mol^{-1} and the enthalpy change of the reaction is +136 kJ mol^{-1}.

(i) Define the term *activation energy*.

(ii) Determine the activation energy for the reverse reaction.

[2]

(c) Two of the oxides of nitrogen can co-exist in the equilibrium

$$\underset{\text{colourless}}{N_2O_4(g)} \rightleftharpoons \underset{\text{brown}}{2NO_2(g)} \qquad \Delta H = +58 \text{ kJ mol}^{-1}$$

(i) Write an expression for K_c, indicating the units.

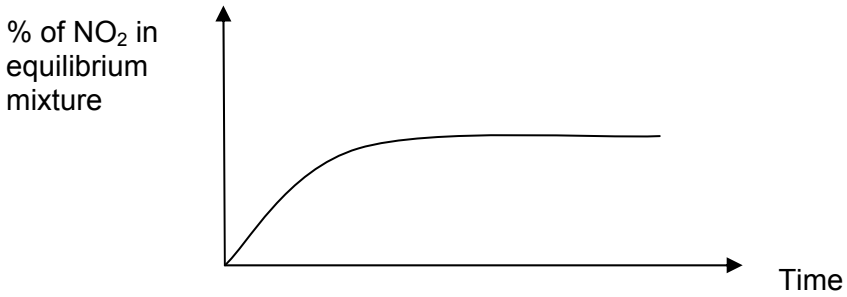
(ii) 1 mol of dinitrogen tetraoxide, N_2O_4, was introduced into a vessel of volume 10.0 dm^3 at a temperature of 70 °C. At equilibrium, 50% of N_2O_4 had dissociated. Calculate K_c.

(iii) The graph below shows 1 mol of N_2O_4 in a vessel of volume 10.0 dm^3. Copy the graph and sketch on the same axes as shown below, the new graph that would be obtained if the experiment in **(c)(ii)** was carried out using

I 2 mol of N_2O_4 in a vessel of volume 10.0 dm^3

II 2 mol of N_2O_4 in a vessel of volume 20.0 dm^3

Label each graph clearly on your sketch.



(iv) Using *Le Chatelier's Principle*, predict and explain the observations when the equilibrium mixture in **(c)(ii)** is cooled.

(v) Suggest why the reaction below is not a very useful method of making NO_2.

$$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$$

[9]

[Total: 20]

6(a) Describe qualitatively the variation in atomic radius from sodium to chlorine. **[2]**

(b) (i) Write equations to illustrate the reaction of oxides of magnesium and phosphorus with water and indicate the pH of the resultant solution.

(ii) Using sodium hydroxide and hydrochloric acid as examples, write equations to illustrate the amphoteric behaviour of aluminium oxide. **[4]**

(c) The table below illustrates the pH value of some chlorides after it was dissolved in water.

Chlorides	pH
Sodium chloride	7
Magnesium chloride	6
Aluminium chloride	3
Phosphorus trichloride	1

Using your *Data Booklet*, account for the difference in pH of magnesium chloride and aluminium chloride solutions. Include equations in your answer. **[4]**

(d) Ethanol is a central nervous system depressant and has significant psychoactive effects in sub-lethal doses. Based on its abilities to change the human consciousness, ethanol is considered a drug.

The amount of ethanol in the body is typically quantified by blood alcohol content (BAC). BAC is usually measured as mass per volume. For example, a BAC of 0.02% means 0.002 grams of alcohol per 10 grams of individual's blood. The table below summarises the symptoms associated with ethanol consumption.

BAC %	Symptoms
0.050	Euphoria, talkativeness, relaxation
0.10	Central nervous system depression, impaired motor and sensory function, impaired cognition
0.14	Decreased blood flow to brain
0.30	Stupefaction, possible unconsciousness
> 0.40	death

$$\text{Ethanol} \xrightarrow{1} \text{Ethanal} \xrightarrow{2} \text{Ethanoic acid}$$

Ethanol within the human body is converted into ethanal by the enzyme alcohol dehydrogenase in step **1** and then into ethanoic acid by the enzyme acetaldehyde dehydrogenase in step **2**.

(i) State the reagents and conditions that can be used to replace alcohol dehydrogenase and acetaldehyde dehydrogenase in the laboratory.

(ii) Write the acid dissociation expression for ethanoic acid.

(iii) Account for the difference in acidity between ethanoic acid and propanoic acid.

A forensic technician from the Traffic Police titrated 25.0 cm^3 of 0.0300 mol dm^{-3} ethanoic acid with 25.0 cm^3 of 0.0300 mol dm^{-3} sodium hydroxide. The ethanoic acid used for the titration was metabolised from an ethanol containing blood sample which weighs 10 g.

(iv) Write an equation of the above titration and identify the Brønsted acid and Brønsted base, and their conjugate base and conjugate acid.

(v) From the information pertaining to BAC%, determine the symptom shown by the drunk driver.

(vi) Given the pH of the equivalence point to be 8, choose suitable indicator(s) from the list below and provide a reason for your choice of indicator(s).

Indicator	Low pH colour	Transition pH range	High pH colour
Phenol Red	red	6.8-8.4	purple
Bromothymol blue	yellow	6.0-7.6	blue
Naphtholphthalein	colourless	7.3-8.7	greenish blue
Thymolphthalein	colourless	9.3-10.5	blue
Alizarine Yellow R	yellow	10.2-12.0	red

[10]

[Total: 20]

7(a) 0.066 g of hydrocarbon **P** when vapourised, was found to occupy 12 cm^3 at room temperature and pressure. This volume of gaseous hydrocarbon **P** was completely burnt with 200 cm^3 of oxygen which is in excess. On cooling to room temperature, the residual gases occupied a volume of 164 cm^3. Upon passing the residual gas through potassium hydroxide, this volume decreased to 44 cm^3.
When treated with cold dilute alkaline potassium manganate (VII), **P** forms compound **Q**.

However, on heating **P** with acidified potassium manganate (VII), 2 products, compound **R**, C_8H_8O and compound **S** are formed. **S** has the following composition by mass: C, 40.0%; H, 6.7%; O, 53.3%.

When **R** was warmed with 2,4-dinitrophenylhydrazine, an orange precipitate, **T** was obtained.

On refluxing **Q** with ethanoic acid in the presence of concentrated sulphuric acid, compound **U**, $C_{14}H_{18}O_4$ is obtained.

(i) Determine the formula of hydrocarbon **P**.

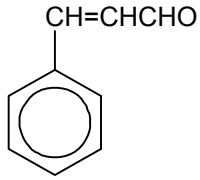
(ii) Calculate the empirical formula of compound **S** and hence determine its molecular formula, given the M_r of compound **S** is 60.0.

(iii) Deduce, with reasoning, the structures of **P**, **Q**, **R**, **S**, **T** and **U**.
Chemical equations are not required.

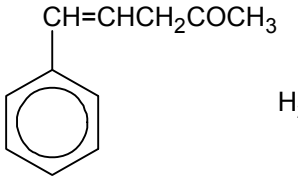
[15]

(b) Recent research has suggested that cinnamon could be an effective pesticide against the larvae of mosquitoes, thus helping in the fight against malaria.

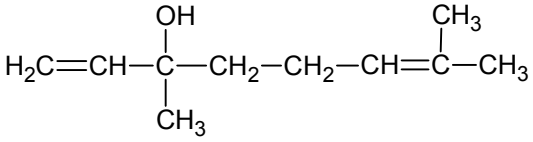
Each of the following three compounds, which are present in cinnamon, appears to be effective as a pesticide.



A



B



C

For each of the compounds **A** to **C**, state the reagents and conditions which would distinguish it from the other two and describe the observations that would be seen.

[5]

[Total: 20]

~END~