Centre Number	Index Number	Name and Class

ANGLO-CHINESE JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
Advanced Level

CHEMISTRY **8872/02**
Higher 1

Paper 2 Structured & Free Response **24th August 2009**
2 hour

Candidates answer on the Question Paper & Writing Paper
Additional Materials: Data Booklet
Writing Paper
String

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions in Section A & answer **2 out of 3** questions in Section B
A Data Booklet is provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
At the end of the examination, fasten all your work securely together including the cover page.

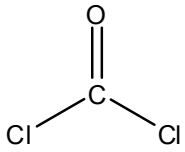
For Examiner's Use		
Question no.		**Marks**
Section A	**1**	
	2	
	3	
	4	
Section B (2 out of 3)		
Total		

This document consists of **10** printed pages.

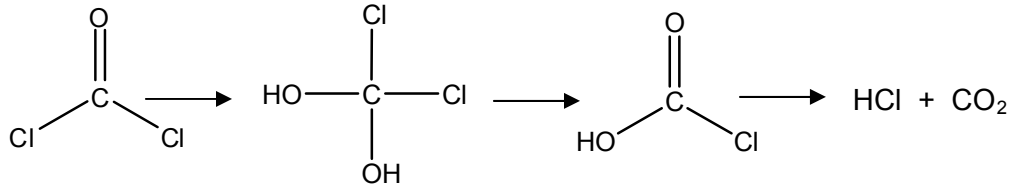
Section A

Answer **all** questions in the spaces provided on the question paper.

1 Carbonyl chloride, $COCl_2$ (structure as shown below), exists as a toxic gas which reacts rapidly with water to evolve two different acidic gases.



(a) (i) The reaction of carbonyl chloride with water is found to proceed via the reaction pathway as shown below: [1]



Intermediate A Intermediate B

Name the reaction that has occurred to produce the intermediate A.

(b) An unknown amount of carbonyl chloride was reacted with water (in excess).

$$COCl_2 + H_2O \rightarrow 2HCl + CO_2$$

The two acidic gases required 25.0cm^3 of 0.100mol dm^{-3} of NaOH for complete neutralization.

(i) Calculate the amount of NaOH that has reacted. [1]

(ii) Given that **complete neutralization** occurs for the two gases, write two equations to show the reactions of NaOH with HCl and NaOH with CO_2 respectively. [2]

(iii) Using your answers in (ii), calculate the volume of HCl evolved at room temperature and pressure given that 1 mol of a gas occupies a volume of 24 dm^3 under room temperature and pressure. [1]

(c) (i) Chlorine has an oxidation state of -1 in HCl. State the oxidation states of chlorine in ClO^- and ClO_3^-. [2]

(ii) ClO^-, hypochlorite, is a powerful oxidizing agent and is used commonly in household bleaches. Write a balanced redox reaction between ClO^- and I^- in an acidic medium given that ClO^- is converted to Cl^- at the end of reaction. [2]

[10 marks]

2 (a) When the hydrocarbon with the molecular formula of C_4H_{10} reacts with chlorine, monochlorinated products can be formed.

(i) What condition(s) is/are used for this reaction? [1]

(ii) Write a balanced equation for the above reaction. [1]

(iii) Draw the displayed formula of all the possible monochlorinated products formed. [4]

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

(c) (i) Write an equation to show how butane, C_4H_{10}, burns in excess oxygen. [1]

(ii) Use this equation and the following data to calculate the standard enthalpy change of combustion for butane. [2]
Enthalpy change of formation of $CO_2(g)$ = –393.4 kJ mol^{-1}
Enthalpy change of formation of $H_2O(l)$ = –285.8 kJ mol^{-1}
Enthalpy change of formation of $C_4H_{10}(g)$ = –125 kJ mol^{-1}

[10 marks]

3 (a) The following data apply to the compounds DCl_x and ECl_y.

Compound	Melting Point (°C)	Boiling Point (°C)	Solubility in water (g per 100cm^3)
DCl_x	714	1412	54.3
ECl_y	-22.6	76.8	0.08

(i) Explain in terms of structure and bonding the differences in volatility for DCl_x and ECl_y. [3]

(ii) Given that a solution of pH ≈ 6 is obtained when DCl_x is dissolved in water, deduce the identity of DCl_x and write a balanced equation to explain how an aqueous solution of pH ≈ 6 is obtained. [2]

(b) The hydrolysis of the ester, ethyl ethanoate, with sodium hydroxide requires the action of heat.

$$CH_3COOCH_2CH_3 + NaOH \longrightarrow CH_3COONa + CH_3CH_2OH$$

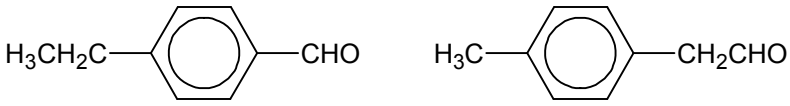
(i) Describe, and explain in molecular terms, how the rate of the reaction is affected by a decrease in temperature. [3]

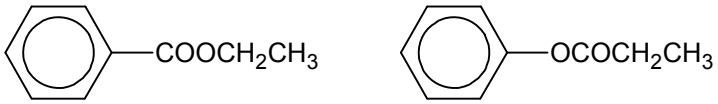
(ii) The above reaction is a *second order reaction*. Explain what the phrase in italics means. [1]

(iii) What is the effect on the rate of this reaction if a given volume of the reaction mixture is diluted with an equal amount of solvent? [1]

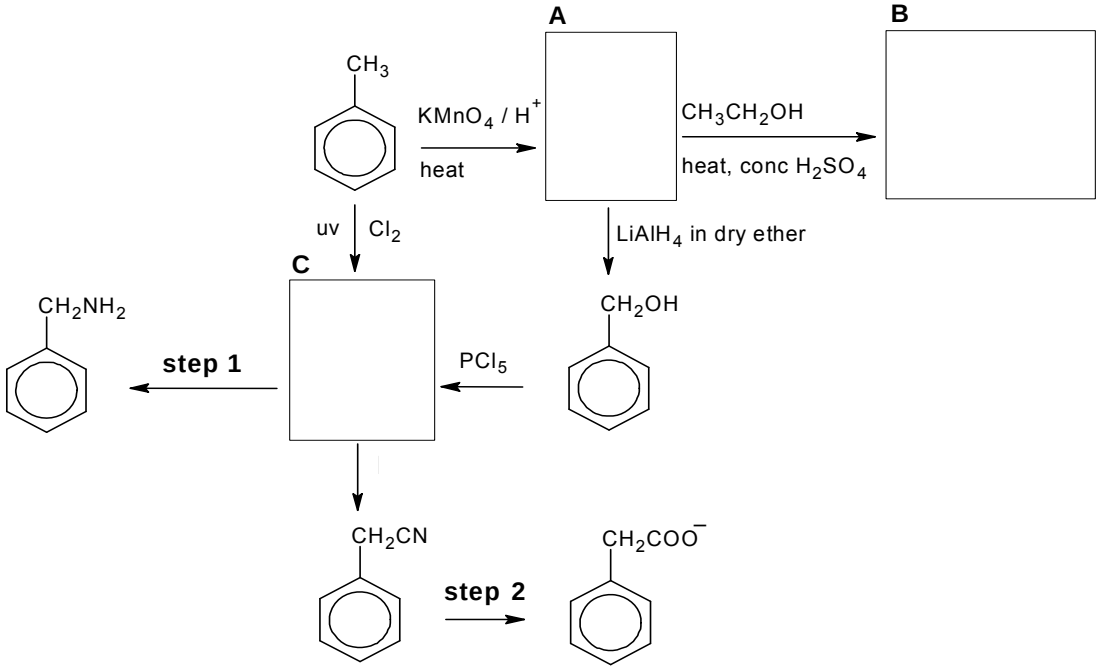
[10 marks]

4 Describe a chemical test by which you could distinguish the following pairs of organic compounds. You should state the reagents and conditions, observations and write balanced equations.

(a) (i)  [2]

(ii)  [3]

(b) With reference to the reaction scheme shown below, draw the structures of compounds **A** to **C**. State the reagents and conditions required to bring about steps **1** and 2 as labeled in the reaction scheme. [10 marks] [5]



Step 1:		**Step 2:**
A:	**B:**	**C:**

[10 marks]

Section B

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

1 (a) In the Haber process ammonia is manufactured from its elements. The highest equilibrium yield of ammonia in the Haber process should occur at a high pressure and at a low temperature. In practice, however these conditions are not used.

(i) Write a balanced equation for the Haber process and state whether it is endo- or exo-thermic [2]

(ii) What are the three usual operating conditions of the Haber process? [2]

(iii) What factors other than Le Chatelier's principle affect this choice? [2]

(iv) Predict what would happen to the position of equilibrium if the operating temperature was changed to 1000K. Why? [2]

(v) How will the yield of ammonia be affected if the reactant gases were passed through a tower packed with lumps of a more efficient catalyst? Explain. [2]

A mixture containing equal number of moles of the reactant gases was heated to **T** K and **P** atm. The equilibrium mixture was found to contain the following concentration of gases in mol dm^{-3}

Nitrogen: 0.285; Hydrogen: 0.855; Ammonia: 0.217

(vi) Write an expression for the equilibrium constant, Kc, for the reaction as given by your balanced equation in (a) (i) and calculate a value for the equilibrium constant [2]

(ii) Use the above data to calculate the average Mr of the gaseous mixture at equilibrium [1]

(iii) Predict how the average molecular mass of this gaseous mixture will change if the pressure was increased. Explain. [2]

(b) A student mixed excess chloroethane with concentrated aqueous ammonia, sealed the vessel and heated it to produce ethylamine. However the yield of the intended product was very low.

(i) Suggest why the yield of the desired product was low. [2]

(ii) What change(s) could he do to improve the yield? [1]

A better yield of ethylamine can be produced by reducing ethanenitrile, CH_3CN, with $LiAlH_4$ in dry ether.

(iii) Suggest a suitable halogenoalkane that can be used to produce ethanenitrile, CH_3CN. [1]

(iv) What reagents and conditions would be needed for this conversion [1]

2 Ethane-1,2-diol and phenol are organic compounds containing hydroxyl groups. Ethane-1,2-diol, $(CH_2OH)_2$ is an important solvent, while phenol is an antiseptic.

(a) (i) Draw a fully displayed formula of a molecule of ethane-1,2-diol. Show clearly any lone pairs present. [2]

(ii) Draw a diagram to show how hydrogen bonding occurs between two molecules of ethane-1,2-diol. [2]

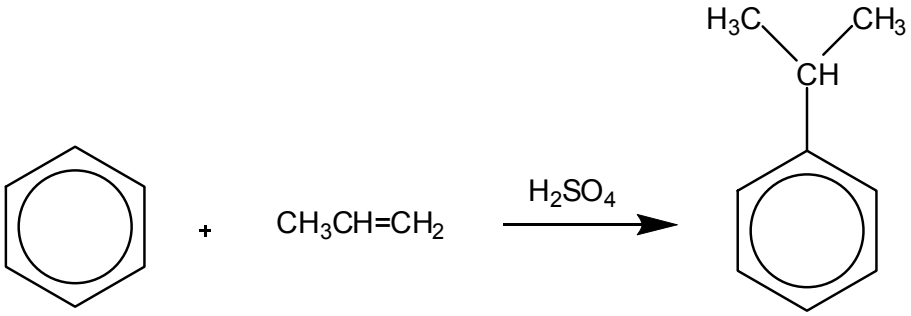
(b) Ethane-1,2-diol may be formed by bubbling gas **A** through cold dilute, acidified $KMnO_4$.

(i) What is the identity of gas **A**? [1]

(ii) What would be observed during this reaction? [1]

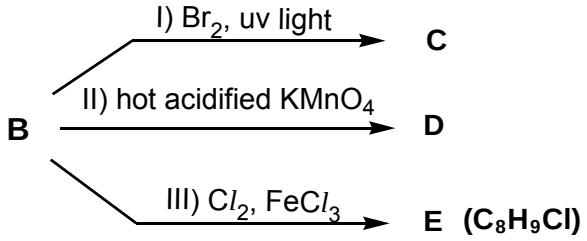
(iii) Explain, in terms of structures and bonding, why **A** is a gas and ethane-1,2-diol is a liquid at room temperature. [3]

(c) In the synthesis of phenol, the first stage of the process involves the following step given below.



(i) Under similar condition, gas **A** can also react with benzene to form product **B**. What is the identity of product **B**? [1]

(ii) Product **B** can be used as an additive in unleaded petrol. Some chemical transformations of product **B** are given below.



What are the identities of product **C** and **D**? [2]

(iii) Draw all the structural isomers of E. [3]

(d) The halogenoethanes C_2H_5Cl, C_2H_5Br and C_2H_5I differ in their physical properties and reactivities.

(i) Suggest and explain how the boiling points of these compounds differ. [2]

(ii) Explain how the size of the halogen atom X affect the reactivities of C-Cl, C-Br and C-I bonds towards nucleophilic reagents. [3]

3 (a) $CH_3CH_2CH_2OH \xrightarrow{\textbf{I}} \textbf{A} \xrightarrow{\textbf{II}} \textbf{B} \xrightarrow{\textbf{III}} CH_3CH_2CH(OH)COOH$ [4]

2-hydroxybutanoic acid can be produced from propan-1-ol according to the above reaction scheme.

(i) Identify compounds **A** and **B**.

(ii) State the reagents and conditions for steps **I**, **II** and **III**.

(b) Arrange propanoic acid, propan-1-ol and 2-hydroxybutanoic acid in increasing order of acid strength. Explain your answer. [4]

(c) Propanoic acid is used as a preservative to prevent mould and bacterial growth in food. A sample of propanoic acid solution was obtained from a food processing factory for analysis.

(i) Given that the equation for the dissociation of propanoic acid is [1]

$$C_2H_5COOH \rightleftharpoons C_2H_5COO^- + H^+$$

write the expression for its equilibrium.

(ii) Titration of 10.0 cm^3 of the sample required 6.70 cm^3 of 0.005 mol dm^{-3} NaOH for neutralization. Calculate the concentration of propanoic acid in this solution. [2]

(iii) Further analysis of the sample found that pH of the solution is 3.5. Using your answers from parts (i) and (ii), calculate K_a of propanoic acid. [2]

(d) pH of blood is buffered at 7.4 by the presence of carbonic acid, H_2CO_3, and hydrogencarbonate, HCO_3^-, where the dissociation of carbonic acid is given by the equation

$$H_2CO_3\,(aq) \rightleftharpoons HCO_3^-\,(aq) + H^+\,(aq)$$

(i) Explain what is meant by a buffer. With the use of relevant equations, explain how the above system can act as a buffer. [3]

(ii) Assuming that the K_a of carbonic acid is 4.37×10^{-7} mol dm^{-3}, use its expression for acid dissociation to find the ratio of $\frac{[HCO_3^-]}{[H_2CO_3]}$ in the blood sample of a healthy individual. [2]

Propanoic acid is formed in the body during normal metabolic processes. When excess acid accumulates in the blood and cannot be removed from the body, a condition known as acidemia occurs. This is a situation where blood pH falls below the norm of 7.4.

(iii) The $\frac{[HCO_3^-]}{[H_2CO_3]}$ ratio of a blood sample was found to be 6.17. Determine the pH of the sample to show that the patient was suffering from acidemia. [1]

(iv) Suggest what might be given to the patient to relieve the symptoms of acidemia. [1]