JURONG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME		CLASS	

CHEMISTRY

9746/02

Paper 2 Structured

25 August 2009

1 hour 30 minutes

Candidates answer on the Question Paper

Additional Materials: Data Booklet

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 working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
A Data Booklet is provided. Do not write anything on the *Data Booklet*.

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	
1	
2	
3	
4	
5	
6	
7	
Total	

This document consists of **15** printed pages and **2** blank pages.

[Turn over

1. **(a)** The volume of a sample of SO_2 was monitored at various pressures while keeping temperature constant. The following results were obtained.

P/ kPa	V/ m^3	PV/ kPa m^3
6.0	0.375	
12.0	0.188	
18.0	0.125	

(i) Draw diagrams to illustrate the shape of SO_2 and SO_3 molecule.

Include the name of the shape in your diagrams.

(ii) For each pressure stated above, calculate the values of PV, giving **each** of your numerical answers to **one** decimal place.

(iii) Using your answer **(a)(ii)**, deduce with justification whether the sample of SO_2 is behaving ideally.

……..

(iv) Suggest a reason for this behaviour of SO_2 in the sample.

[7]

1. **(b)** A 2:1 mixture by volume of SO_2 and O_2 at an initial pressure of 15 atm is allowed to reach equilibrium at 250 °C.

$$2SO_2\,(g) + O_2\,(g) = 2SO_3\,(g)$$

The equilibrium pressure was found to be 11 atm.

(i) Calculate the partial pressure of each gas at equilibrium.

(ii) Hence calculate the value of K_p, stating its units.

(iii) State and explain the effect of lowering pressure on the yield of SO_3.

……

……

……

……

……

[6]

1. (c) (i) $2SO_2\,(g) + O_2\,(g) \rightarrow 2SO_3\,(g)$ $\Delta H = -197$ kJ mol^{-1}

The enthalpy change of atomisation of oxygen is +248 kJ mol^{-1}.

On the grid below, incorporate these enthalpy changes into an energy cycle for calculating the average bond energy of S=O bond.

Energy/ kJ mol^{-1}

(ii) Hence calculate the average bond energy of the S=O bond.

[3]

[Total: 16]

2. **(a)** When dissolved in water, iron(III) chloride undergoes hydrolysis and gives off heat in an exothermic reaction. The resulting brown solution is acidic.

Given the charge density of Fe^{3+} is very similar to that of Al^{3+}, explain, with the aid of an equation, why iron(III) chloride solution is acidic.

……. [1]

(b) An important application of iron(III) chloride solution is etching copper from copper-based metals in printed circuit boards.

Etching of copper occurs in two steps:

$FeCl_3 + Cu \rightarrow FeCl_2 + CuCl$ Step **I**

$FeCl_3 + CuCl \rightarrow FeCl_2 + CuCl_2$ Step **II**

(i) Write the electronic configuration of copper in $CuCl$.

……

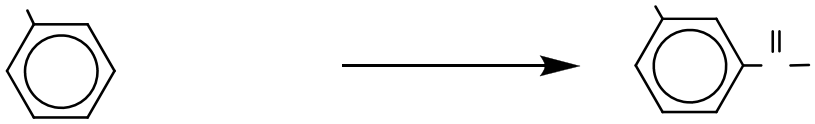
(ii) Hence predict, with explanation, the colour of $CuCl$ solution.

……

……

……. [3]

2. **(c)** Anhydrous iron(III) chloride is also used as a catalyst in the synthesis of 3-nitrophenylethanone from nitrobenzene and ethanoyl chloride, CH_3COCl.



The first step in the above reaction is the formation of acylium carbocation:

$$FeCl_3 + CH_3COCl \longrightarrow FeCl_4^- + CH_3\overset{+}{C}O$$

acylium carbocation

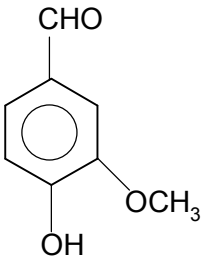
Describe the subsequent step(s) in the mechanism for the reaction of nitrobenzene to form 3-nitrophenylethanone. In your answer, show any relevant charges, lone pairs of electrons and movement of electrons.

NO_2

[2]

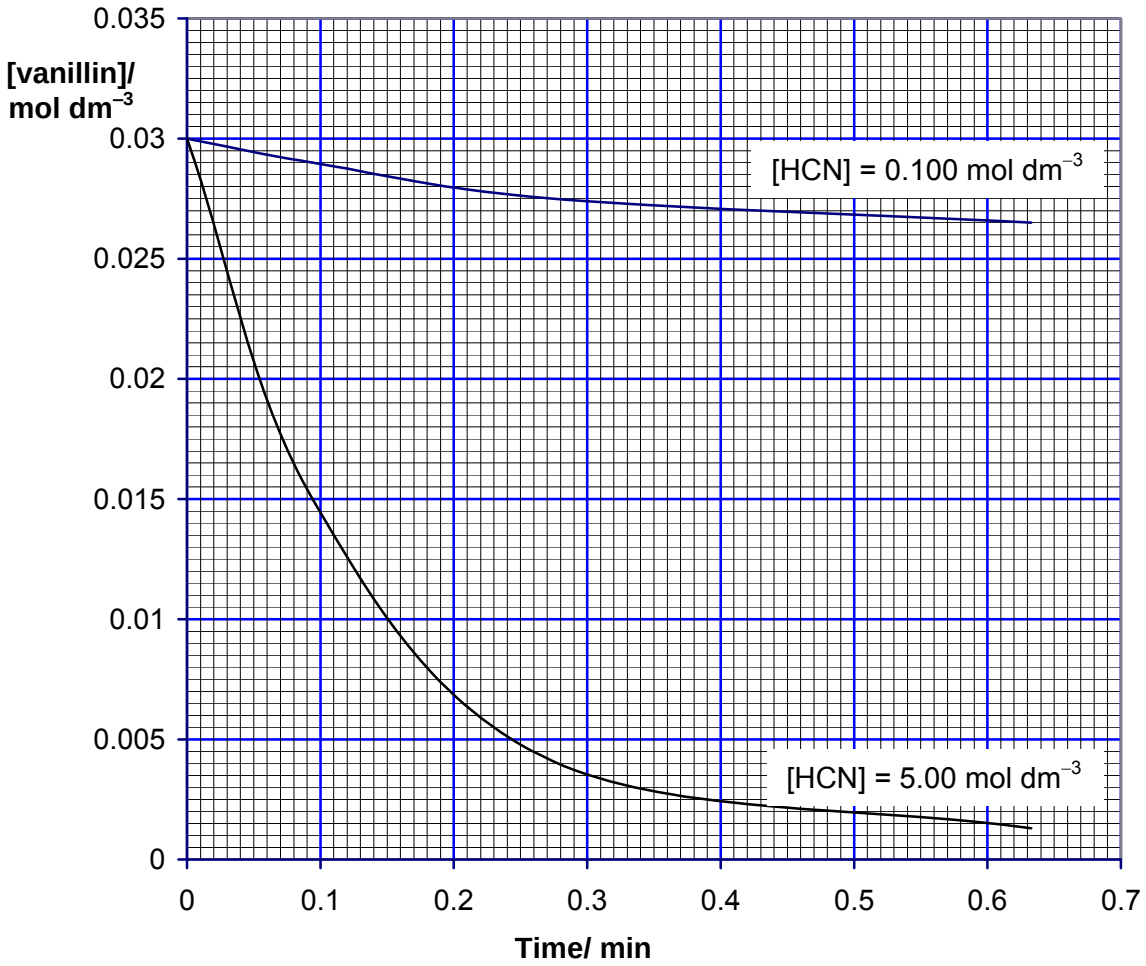
[Total: 6]

3. *Vanillin* is used widely as a flavoring, usually in sweet foods such as ice cream and chocolate. It exists as a yellow solid and dissolves readily in water to form a yellow solution.



vanillin

The kinetics of the reaction between vanillin and HCN were investigated using two different initial concentration of HCN. Both experiments were conducted at 25 °C in a pH 9.0 buffer.



(a) Assuming that the reaction produces a colourless product, suggest one plausible method by which the concentration of vanillin may be followed during the course of the reaction.

……

……

…… [1]

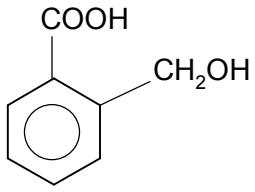
3. **(b)** Using the graph, determine the order of the reaction with respect to vanillin. Show working on the graph.

[2]

(c) In the experiment using 0.100 mol dm^{-3} HCN, the half-life of the reaction is 4.75 min. Hence determine, with explanation, the order of reaction with respect to HCN.

[2]

(d) **Q** is a structural isomer of vanillin. When treated with an acid catalyst, it forms a compound **R** with the molecular formula $C_8H_6O_2$.



Q

State the type of reaction that occurred and draw the structure of **R**.

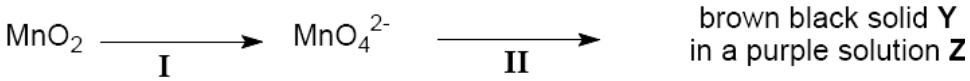
Type of reaction ……

Structure of **R**

[2]

[Total: 7]

4. **(a)** Manganese commonly occurs as the ore pyrolusite, which is mainly manganese(IV) oxide. Manganese(IV) oxide undergoes a two-step reaction under alkaline condition to produce compounds **Y** and **Z**.



(i) The brown solid **Y** contains 63.8% by mass of manganese and 36.2% by mass oxygen. Using these information, determine the empirical formula of **Y**.

(ii) Suggest the identity of **Z** and state the type of reaction that occurs at step **II**. Construct a balanced equation for the reaction.

Identity of **Z** …….

Type of reaction …….

Equation:

[4]

(b) A Leclanché cell consists of a zinc anode and a carbon cathode coated with MnO_2. During discharge, MnO_2 is converted to Mn_2O_3.

(i) Write the ion-electron equations for the reaction which occurs during discharge at the anode and cathode respectively.

Anode ……..

Cathode ……..

(ii) The voltage of this Leclanché cell is found to be 1.5 V. With reference to the *Data Booklet*, calculate $E^{\ominus}$(MnO_2/Mn_2O_3).

[3]

[Total: 7]

5. **(a)** Elements **X** and **W** belong to Period 3 of the Periodic Table. Both elements **X** and **W** have giant lattices. When water is added to chlorides of **X** and **W**, solutions of pH 7 and 2 are formed respectively.

(i) Identify the elements **X** and **W**.

X is …….

W is ……..

(ii) Write an equation to illustrate the action of water with the chloride of **W**.

……. [3]

(b) The oxides MgO, Al_2O_3 and SiO_2 are all used as refractory materials due to their high melting points

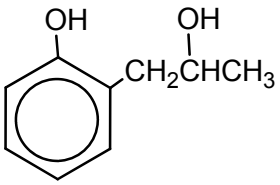
If a sample of one of the oxides was provided as a white powder, describe the reactions you could carry out on the powder to determine which of the three oxides it was.

In your answers, include the reagents used for each test and describe the observations.

[4]

[Total: 7]

6. The structure of compound **A** is shown below.



A

(a) Name **two** functional groups other than phenyl group, present in compound **A**.

……..……... [1]

(b) Draw the structural formula of each of the organic products formed when compound **A** is treated with the following reagents and conditions.

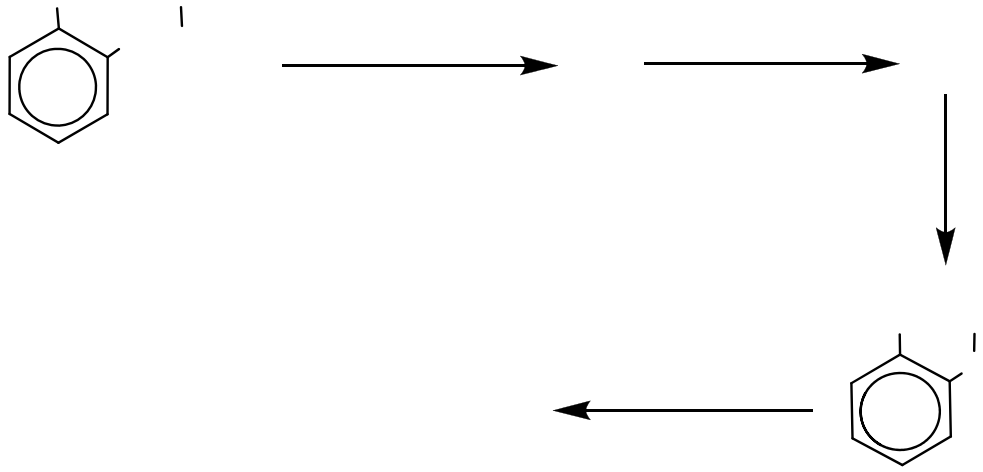
(i) acidified potassium dichromate (VI) and heat under reflux

(ii) aqueous I_2, NaOH, heat

(iii) Thionyl chloride, $SOCl_2$

[4]

6. **(c)** Compound **A** can be converted to compound **D** using the synthetic route shown below.



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

B

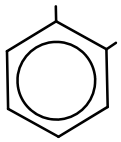
C

E

(ii) Suggest reagents and conditions required in Reaction **I**.

Reaction **I**: …….. [5]

6. **(d)** Suggest, with reasons, how the basicity of compound **D** might compare with that of compound **F** as shown below.



[2]

[Total: 12]

7. To understand patients suffering from knee joint rheumatoid arthritis, scientists often study amino acid sequence of the cartiliage protein isolated from their knees.

(a) In the study of a segment of the polypeptide structure of cartiliage protein from a rheumatoid arthritis patient, the segment containing 11 amino acids was digested using an enzyme. The fragments obtained were separated using electrophoresis.

Analysis of the fragments gave the following results:

Leu-Pro-Val-Lys-Val

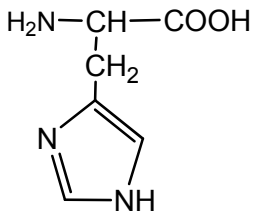
Ile-His-Cys-Pro-Gly

Cys-Pro-Gly-Val-Leu-Pro

Deduce the *primary structure* of this segment of cartiliage protein.

…….. [1]

(b) The amino acid, histidine (his), which is found in cartiliage protein, has the following structure.



histidine

Explain, in terms of R-group interaction in the histidine amino acid residue, how a low pH might affect the tertiary structure of the cartiliage protein.

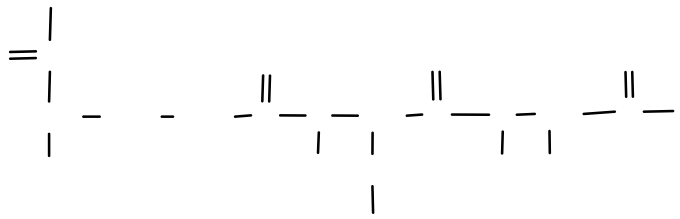
…….....

…….....

…….....

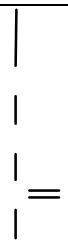
……..... [1]

7. **(c)** A tri-peptide, glutathione, is often isolated from cartiliage protein. Being an antioxidant, glutathione helps protect cells from reactive oxygen species such as free radicals and peroxides.



It consists of three amino acids, glutamic acid (glu), cysteine (cys) and glycine (gly). Each of these amino acid is represented as $RCH(NH_2)CO_2H$, where R is the side chain of the amino acid residue.

The R groups of the above mentioned amino acids are given below:

Glutamic acid (glu)	Cysteine (cys)	Glycine (gly)
		

O

(i) What feature of glutathione's structure is not found in typical peptide structures?

……

……

……

(ii) It was found that the presence of Zn^{2+} reduces the function of cartiliage protein due to its binding to the cysteine (cys) residue of the glutathione fragment

Suggest how Zn^{2+} affects the *tertiary structure* of the cartiliage protein and prevents its optimal functioning.

……

……

……

…… [3]

[Total: 5]