H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAM
Higher 1

CANDIDATE NAME

CLASS

TUTOR'S NAME

CHEMISTRY

8872/02

Paper 2

23 Sep 2009

Candidates answer Section A on the Question Paper.

2 hours

Additional Materials: Answer Paper
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.

Section **A**
Answer **all** questions.

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

For Examiner's Use	
A1	
A2	
A3	
B1	
B2	
B3	
Total	

This document consists of **14** printed pages.

Section A

Answer **all** questions in this section in the spaces provided.

For examiner's use only

1(a) A sample of carbon containing different isotopes was artificially enriched. The relative isotopic masses and its relative abundances determined in a mass spectrometer are given in the table below.

Relative isotopic mass	Relative abundance
^{12}C	85.0 %
^{13}C	10.0 %
^{14}C	5.0 %

Calculate the relative atomic mass of carbon in the sample to 1 decimal place. **[1]**

(b) A 0.100 mol of a hydrocarbon **T** was burnt completely to produce 26.4 g of carbon dioxide gas and 10.8 g of water.

The same mass of W when burnt under a container with 300 g of water at 30 ^{o}C was found to bring the water to boil. The process was known to be only 70% efficient.
The specific heat capacity of water is 4.2 J g^{-1} K^{-1}.

(i) Determine the molecular formula of the hydrocarbon W. **[2]**

For examiner's use only

(ii) Calculate the enthalpy change of combustion of W. **[2]**

(c) Arranging the following in order of increasing boiling points. Explain your choice in terms of structure and bonding.

H_2O, NH_3, NaCl, CH_4 **[5]**

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

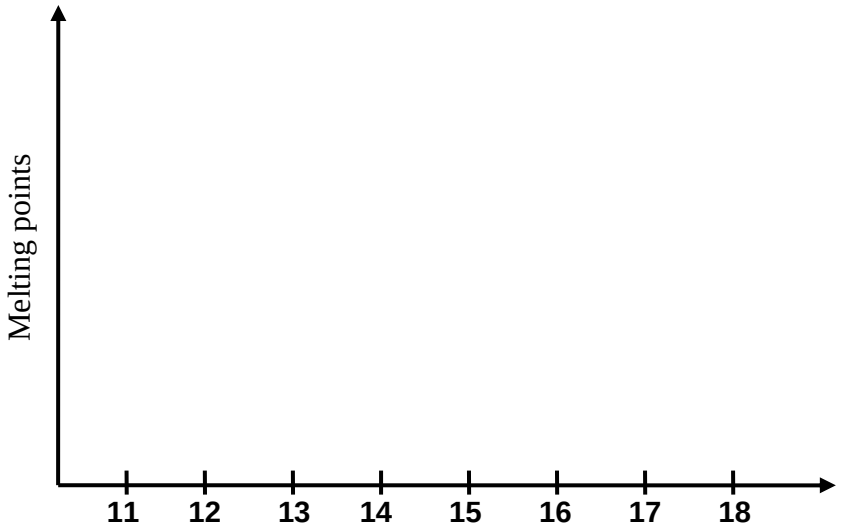
……

……

[Total: 10 marks]

For examiner's use only

2 (a) (i) Complete the graph below for the melting points of elements in period 3.



[1]

(ii) Explain the shape of your graph in terms of bonding and structure. **[5]**

……

……

……

……

……

……

……

……

……

……

……

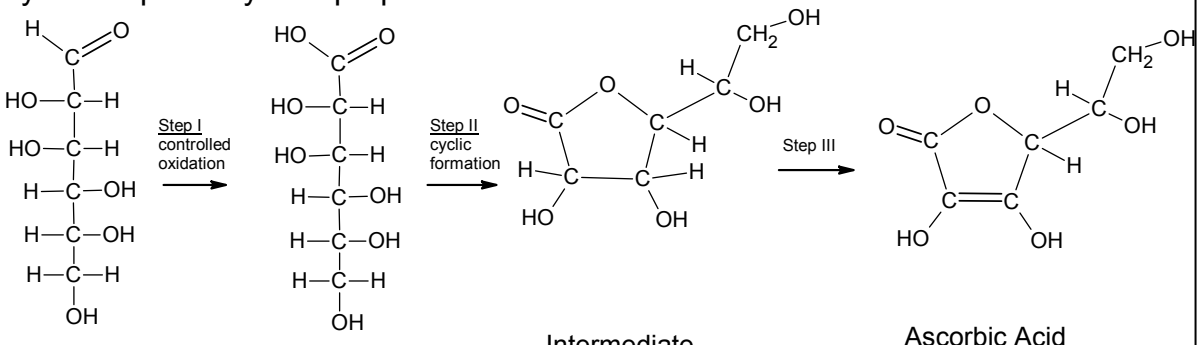
……

……

……

For examiner's use only

(b) The building block for ascorbic acid is the glucose molecule. The following synthetic pathway was proposed:



Glucose | Intermediate product 1 | Intermediate product 2 | Ascorbic Acid

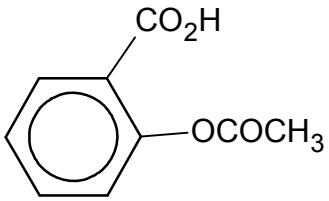
(i) State the type of reaction found in **step II** and hence **<u>circle</u>** the functional group(s) present in the <u>intermediate product 1</u> that is/are involved in the reaction**.** **[3]**

……

(ii) State the type of reaction present in **Step III**. **[1]**

……

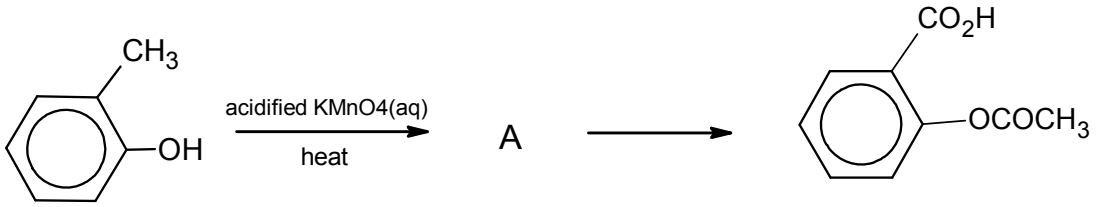
(c) Aspirin, also known as acetylsalicylic acid is often used as an analgesic (pain-remover) to relieve minor aches and pains. It is readily absorbed from the intestines since it diffuses rapidly into the tissues.



The molecule is hydrolysed by acids in the stomach.

(i) Draw the structural formulae of the hydrolysis products. **[2]**

Aspirin can be synthesised from 2-methylphenol via the following steps:

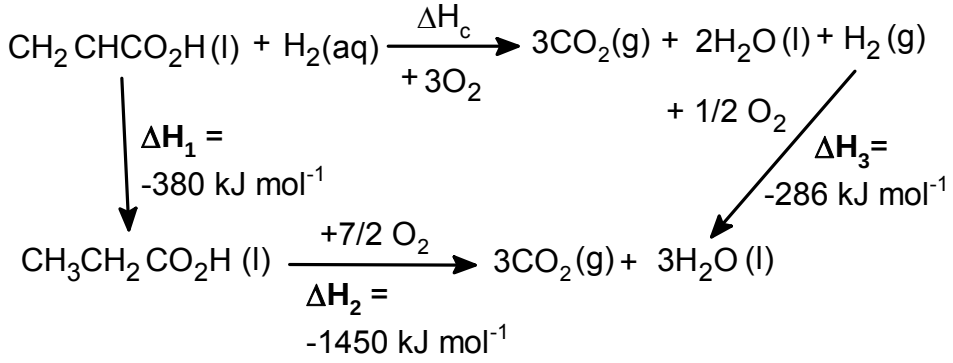


2-methylphenol Aspirin

(ii) Draw the structural formula of the intermediate **A**. **[1]**

(d) The enthalpy of combustion of Compound **A**, CH_2=$CHCO_2H$, can be determined either by direct measurement of the heat evolved using a bomb calorimeter or by indirect method using Hess Law.

The energy cycle involving Compound **A** is given below.



(i) Name the enthalpy change represented by ΔH_2 **[1]**

……

(ii) State the type of reaction for ΔH_1. **[1]**

……

(iii) Using Hess' Law, calculate the enthalpy change of combustion of compound **A**. **[1]**

[Total: 16 marks]

3(a) Hydrogen peroxide, H_2O_2, is a strong oxidizing agent and is used as an antiseptic. However, it is not stable at room temperature and will undergo decomposition reaction.

(i) Draw the dot and cross diagram of H_2O_2. **[1]**

(ii) State, with reason, the shape about the oxygen atom. **[2]**

……

……

(iii) State the oxidation number of O in the reactants and products. **[1]**

O in H_2O_2 :_____ O in H_2O = _____ O in O_2 = _____

(iv) Hence write two balanced half and overall equations for the decomposition of H_2O_2. **[2]**

For examiner's use only

(b) The rate of H_2O_2 decomposition can be catalysed by adding small amounts of MnO_2. Using an appropriate diagram, explain in molecular terms, how the presence of MnO_2 catalyst increases the rate of decomposition of H_2O_2. **[4]**

For examiner's use only

(c) An experiment in the laboratory found that iodide ions are oxidized by hydrogen peroxide according to the equation below:

H_2O_2 (aq) + $2H^+$ (aq) + $2I^-$ (aq) → I_2 (aq) + $2H_2O$ (l)

Assuming the rate of the above reaction is zero order with respect to $[H^+]$, determine the order of reaction with respect to $[H_2O_2]$ and $[I^-]$ based on the experimental results shown below. Hence determine the value for the rate constant of the reaction, stating the units.

Expt	$[H_2O_2]$ / mol dm^{-3}	$[I^-]$ / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	0.01	0.02	0.8×10^{-4}
2	0.01	0.03	1.2×10^{-4}
3	0.03	0.04	4.8×10^{-4}

[4]

[Total: 14 marks]

Section B

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

1(a) **(i)** Aluminium(III) oxide and phosphorous(V) chloride differ in their behaviour with water.

Write balanced equations (if any) for each of the behaviour. **[2]**

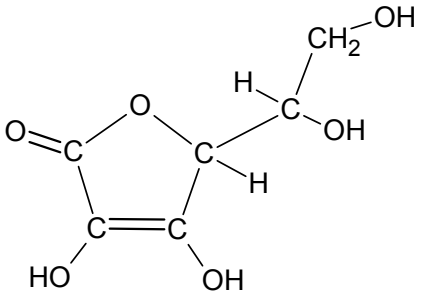
(ii) Explain these differences in terms of the different structures and types of chemical bonding in the compounds. **[2]**

(b) In each of the following reactions, describe the way in which the oxide of the named element is reacting and discuss whether its behaviour is what you would expect from the position of the element in the Periodic Table:

(i) Silicon: $MgO + SiO_2 \rightarrow MgSiO_3$

(ii) Beryllium: $2\ NaOH + BeO \rightarrow Na_2BeO_2 + H_2O$ **[3]**

(c) Ascorbic acid, also known as vitamin C is required for the synthesis of collagen in humans. A vitamin C deficient diet leads to a disease called scurvy. Ascorbic acid is known to be water soluble and is commonly used as food additives.



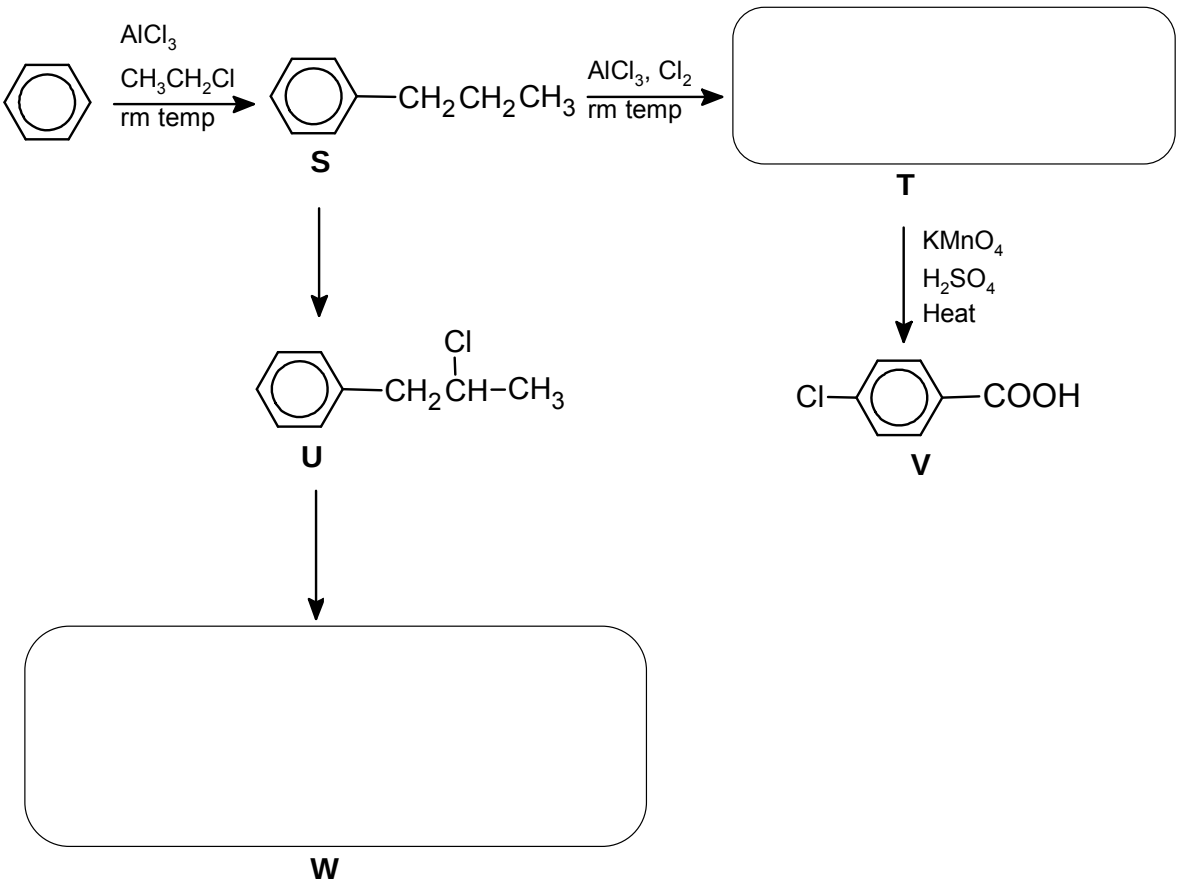
Ascorbic Acid

(i) Name the four functional groups present in the ascorbic acid compound. **[2]**

(ii) Explain in terms of structure and bonding, why Ascorbic Acid is water soluble. **[2]**

(ii) The ascorbic acid molecule was reacted with acidified potassium dichromate (VI) followed by 2,4-dinitrophenylhydrazine. Draw the structural formula of the product formed. **[2]**

(d) Benzene is used as the starting reagent for the production of many aromatic compounds shown below.



(i) Give the corresponding structural formula for **T**. **[1]**

(ii) Suggest the reagents and conditions needed to convert **S** to **U**. **[1]**

(iii) **U** can react with a suitable reagent to give **W**, C_9H_{10}, which exists as a pair of geometric isomers.

Name the reaction for the formation of **W** and hence suggest the reagents and condition needed to form **W**. **[2]**

(iv) Draw the pair of geometric isomers of **W**. **[2]**

[Total: 20 marks]

2(a) The reaction between 2–hydroxypropanonic acid and ethanol occurs as follows:

$CH_3CH(OH)CO_2H\ (aq) + CH_3CH_2OH\ (aq) \rightleftharpoons CH_3CH(OH)CO_2CH_2CH_3\ (aq) + H_2O\ (aq)$

The above reaction was carried out by heating 500 cm^3 of 0.10 mol dm^{-3} 2–hydroxypropanonic acid with 500 cm^3 of 0.10 mol dm^{-3} of ethanol for some time in the presence of acid catalyst. When the reaction vessel was subsequently cooled rapidly in ice bath, it was found that 1.67×10^{-2} mol of acid and ethanol was left in the reaction vessel.

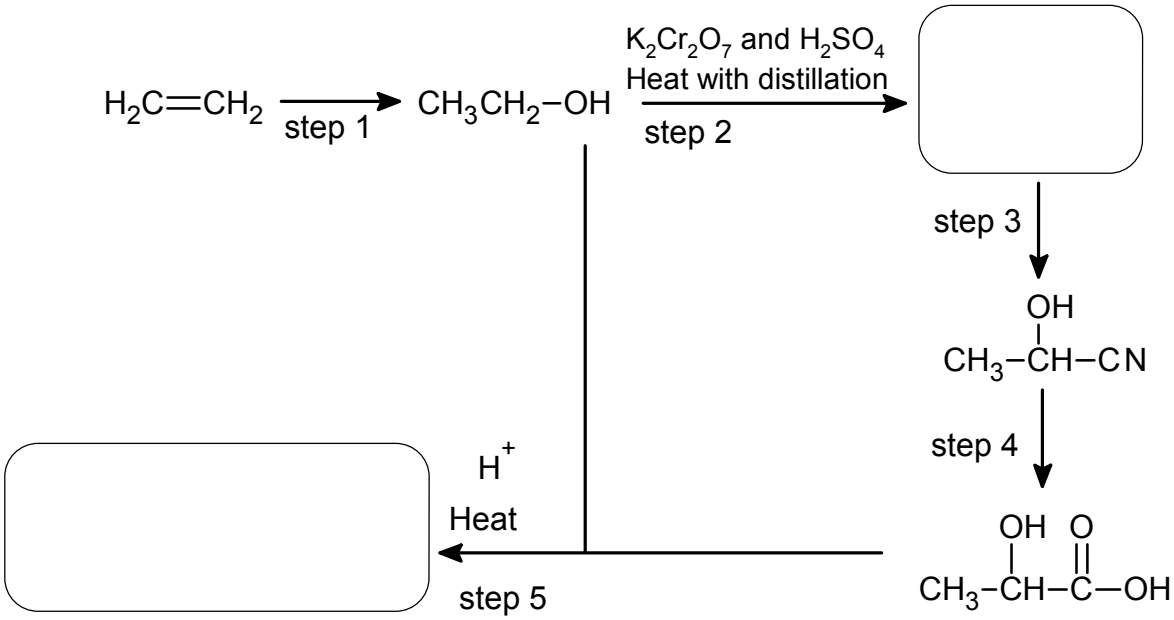
(i) Explain the purpose of cooling the reaction vessel rapidly. [1]

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

(iii) Calculate the concentration of the ester present at equilibrium and hence determine the value of K_c, stating its units. [3]

(iv) State and explain, in terms of La Chatelier's Principle, the effect on the position of equilibrium if a small amount of ester was added to the reaction before it was rapidly cooled. [1]

(b) The synthesis of the ester can be done by using ethane as the starting reagent shown below.



(i) State the reagents and conditions for Steps 1 and 3. [4]

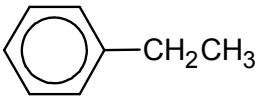
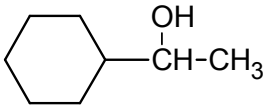
(ii) Draw the structure of the products of Step 2 and 5. [2]

(iii) Name the type of reaction taking place in Step 4. [1]

(c) Suggest a simple chemical test to distinguish the following pairs of compounds. Your answers should include the reagents and conditions for each test and the observations you would expect to see for each compound.

(i) $CH_3CHClCH_3$ and CH_3CHICH_3 [3]

(ii) $CH_3C(OH)ClCH_2CH_3$ and $CH_3COCH(OH)Cl$ [2]

(iii)  and  [2]

[Total: 20 marks]

3(a) Ethanoic acid is an organic compound and is able to function like mineral acid by providing H^+ (aq) ions in solution. The numerical value for the acid dissociation constant, K_a, of ethanoic acid is 1.74×10^{-5}.

(i) Given the pH of ethanoic acid is 2.88 determine the concentration of the H^+ ions present in solution. **[1]**

(ii) State with reason whether ethanoic acid is a weak or strong acid. **[1]**

(iii) Write a balanced equation to show how ethanoic acid functions as an acid in aqueous solution and hence write the expression for the acid dissociation constant, K_a. **[2]**

(iv) Based on your answers from (a)(i) - (iii), determine the initial concentration of ethanoic acid. **[1]**

(b) When 20 cm^3 of 0.050 mol dm^{-3} sodium hydroxide was added into a bottle containing 40 cm^3 of 0.050 mol dm^{-3} ethanoic acid and some universal indicator. The colour of the resulting solution changed from red to orange. When 5 cm^3 of 0.050 mol dm^{-3} of sodium hydroxide or hydrochloric acid was added, the colour of the solution remained orange.

(i) Deduce the species present in the solution after sodium hydroxide was added into the bottle. Hence, state the type of solution formed.. **[2]**

(ii) By means of suitable equations, explain how the species present in the resulting solution is able to cause the colour of the solution to remain orange upon adding small volumes of sodium hydroxide or hydrochloric acid. **[4]**

(c) An organic compound **E**, C_4H_8, can exists as a pair of geometrical isomers.

E undergoes reduction to give butane, C_4H_{10}.

Oxidation of 1 mole of **E** using potassium manganate (IIV) solution produces 2 moles of **F**, $C_2H_4O_2$.

However, changing the oxidation conditions produces **G**, $C_4H_{10}O_2$.

E reacts with aqueous bromine to give **H**, C_4H_9OBr, which gives a positive test when warmed with alkaline aqueous iodine.

(i) State the reagents and conditions needed for the reduction of **E** to form butane. **[2]**

(ii) Draw the structure of the 2 isomers of **E**. **[2]**

(iii) Give the structural formula of **F**. **[1]**

(iv) Name the functional group present in G and hence suggest the conditions needed to produce **G**. **[2]**

(v) Write a balanced equation when **H** reacts with alkaline aqueous iodine. **[2]**

[Total: 20 marks]

- END OF PAPER -