JURONG JUNIOR COLLEGE
PRELIMINARY EXAMINATION 2008

H1 CHEMISTRY PAPER 2
8872 / 2

Monday 18 August 2008 2 hour

Name: ________________________ (Index no.:____) Class: 07_____

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.

Write your name and index number and class in the spaces at the top of this page.

Write in dark blue or black pen in the spaces provided on the Question Paper.

You may use a pencil for any diagrams, graphs, or rough working.
Do not use highlighters or correction fluid.

Answer **all** questions.

INFORMATION FOR CANDIDATES

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

The number of marks is given in brackets [ ] at the end of each question or part question.
You are advised to show all workings in calculations.
You may use a calculator.

FOR EXAMINER'S USE	
Section A	
1	
2	
3	
4	
Section B	
TOTAL	**/ 80**

This question paper consists of 12 printed pages, including this page.

[Turn over

SECTION A (40 MARKS)

Answer **all** questions in the space provided.

1. World War I is sometimes known as 'the Chemists' War'. Knowledge of chemistry was applied towards developing high explosives and new methods of warfare such as the large scale use of poison gas.

Fritz Haber, a German chemist, worked on the use of chlorine as a poison gas. The first successful use of chlorine was at Ypres, Belgium, on 22 April 1915. 170 tonnes of chlorine contained in 5730 cylinders was released forming a grey-green cloud which drifted across French troops. Chlorine can damage the eyes, nose, throat and lungs and is fatal at concentrations of 1000 ppm and above (1 ppm = 1 mg dm^{-3}). Early counter-measures to chlorine included instructing troops to cover their mouths with gauze pads soaked in sodium hydrogen carbonate solution. Occasionally urine was used instead of the sodium hydrogen carbonate solution. Eventually, more effective counter-measures to chlorine were developed and thus other poison gases were introduced.

Victor Grignard, a Nobel Prize-winning chemist, worked on the manufacture of phosgene for France. Phosgene was deadlier than chlorine but some of the symptoms of exposure only showed up after 24 hours. Thus victims were initially still capable of continuing fighting.

The most effective gas used in World War was mustard gas, a blistering agent. Mustard gas did not have to be inhaled but attacked any exposed area of skin. Mustard gas often did not kill outright but it caused horrific injuries which strained medical resources.

(a) **(i)** Calculate the maximum amount of chlorine gas that could have released from one of the cylinders that was used at Ypres on 22 April 1915. (1 tonne = 1000 kg)

(ii) Determine the concentration of chlorine gas, in mol dm^{-3}, at 1000 ppm.

1. **(a)** **(iii)** In an accident, the chlorine gas from one such cylinder was released into a factory room of volume 25.0 m^3.

Determine if the concentration of chlorine gas was above the lethal concentration. Assume that the gas was released at room temperature and pressure.

[4]

(b) **(i)** The formula of phosgene is $COCl_2$. Draw the displayed formula for phosgene showing the bond angles clearly.

(ii) State the type of hybridisation for carbon in phosgene.

……………………………………………………………………………………

(iii) Phosgene contains both *σ bonds* and *π bonds.* Explain the terms in italics, drawing diagrams to show these bonds clearly. State the number of *σ bonds* and *π bonds* in phosgene.

(iv) The boiling point of chlorine is −34.4°C. Predict, with reasons, if phosgene would have a higher or lower boiling than chlorine.

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…………………………………………………………………………………… [7]

[Total: 11]

2. *The use of the Data Booklet is relevant to this question.*

The elements of Period 2 form some of the most common compounds that we come across.

(a) Define what is meant by the first ionisation energy of an element **E**.

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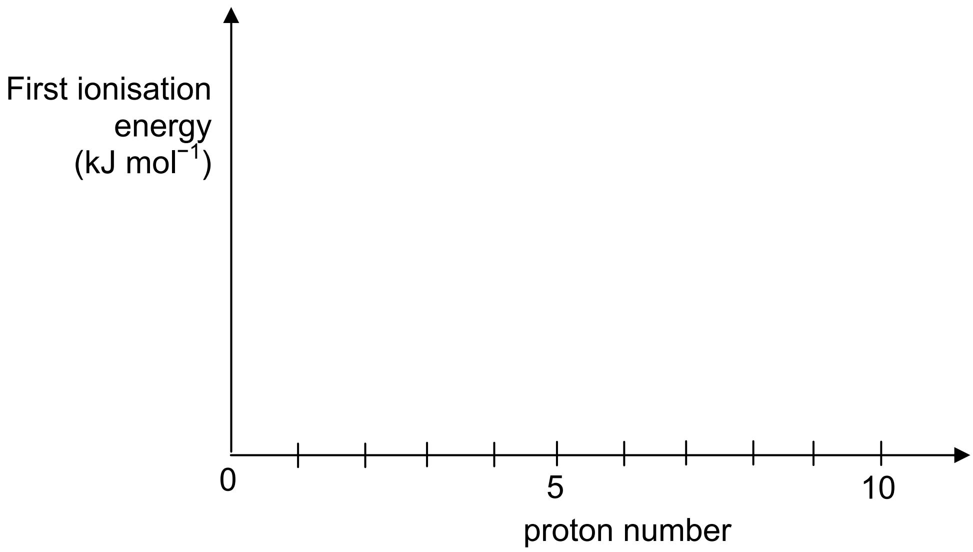
………………………………………………………………………………………… [1]

(b) Sketch how the first ionisation energies of the elements change from lithium to neon.



[1]

(c) Explain the difference between the first ionisation energy of

(i) carbon and nitrogen

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…………………………………………………………………………………

…………………………………………………………………………………

(ii) nitrogen and oxygen

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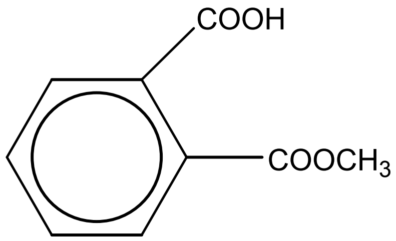
[2]

[Total: 4]

3. **(a)** The terms *strong* and *weak* are used to describe the strength of an acid. The active ingredient in aspirin is a monobasic acid called acetylsalicylic acid.

acetylsalicylic acid : 

A 25.0 cm^3 sample of aqueous acetylsalicylic acid was placed in a conical flask. The pH of this solution was 2.8. When a titration was performed, 20.00 cm^3 of 0.200 $mol\,dm^{-3}$ aqueous sodium hydroxide was required to neutralize the acid.

[*The formula of acetylsalicylic acid may be simplified as RCOOH for the rest of (a)(i) to (a)(iii).*]

(i) Calculate the initial concentration of acetylsalicylic acid in the conical flask.

(ii) Use your answer in **(a)(i)** and the above data to show that acetylsalicylic acid is a *weak* acid. Fully explain your answer.

(iii) Write an expression for the acid dissociation constant, K_a, for acetylsalicylic acid. Hence determine its K_a value.

[5]

3. (b) The following table shows K_a values for three organic acids.

Acid	K_a / mol dm^{-3}
CH_3COOH	1.75×10^{-5}
$CH_2ClCOOH$	1.36×10^{-3}
$CHCl_2COOH$	5.53×10^{-2}

(i) State and explain the trend in K_a values for the three acids.

(ii) How would you expect the acidity of benzoic acid to compare with that of the ethanoic acid? Explain.

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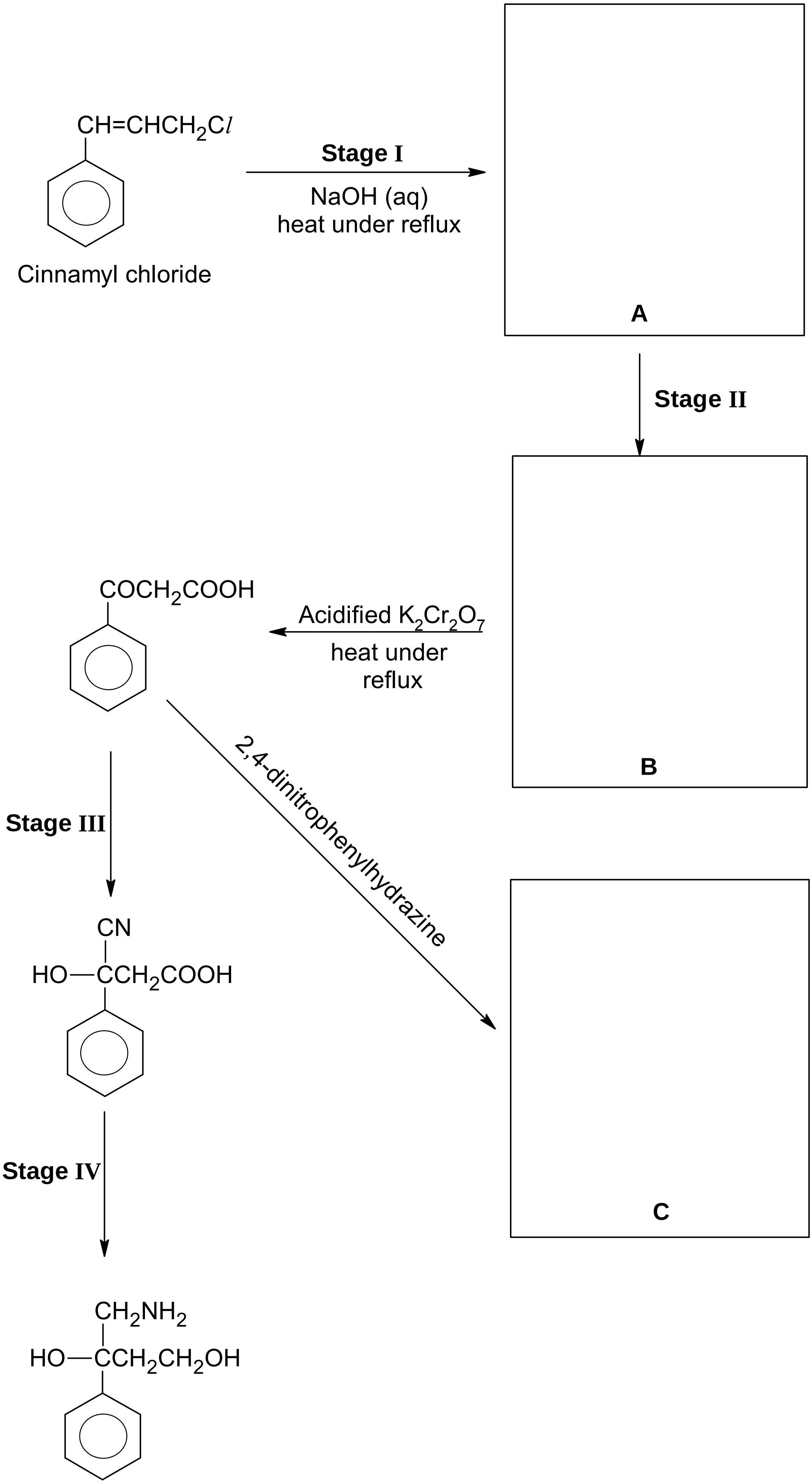
[4]

[Total: 9]

4. A reaction scheme involving cinnamyl chloride is shown below.



4. **(a)** **(i)** Draw the structures of compounds **A** to **C** in the boxes provided.

(ii) State the type of reaction and reagents and conditions required for **Stages II** to **IV.**

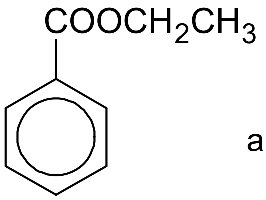
Stage	Reagents and conditions	Type of Reaction
II		
III		
IV		

(iii) Write a balanced equation for the reaction in **Stage IV**.

……………………………………………………………………………………… [10]

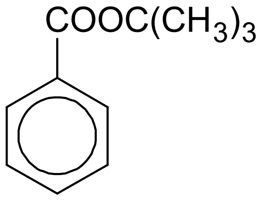
4. (b) Describe a laboratory test which will distinguish the following pairs of compounds from each other. You should include the reagents and conditions needed and the expected observations for each compound in your answer.

(i)



W

and



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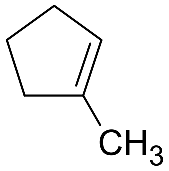
(ii)



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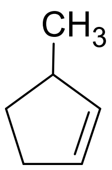
and



Z

[6]

[Total : 16]

SECTION B (40 MARKS)

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

5. **(a)** Ethane is a major component in natural gas which an important petrochemical feedstock. An experiment was carried out as follows to determine the enthalpy change of combustion of ethane, contained in the gas cylinder of a gas stove.

A large beaker of water was placed on the gas stove and heated. The temperature rise of the water was recorded. The gas cylinder was also weighed before and after heating to determine the mass of gas used. The following results were obtained.

Mass of ethane used = 2.5 g
Mass of water heated = 500 g
Temperature rise = 40 ^{o}C

(i) Define, using ethane as an example, the term *standard enthalpy change of combustion*. Include a balanced equation, with state symbols, in your answer.

(ii) Use the data above to calculate the enthalpy change of combustion of ethane. [Assume the specific heat capacity of water = 4.2 J K^{-1} cm^{-3}.]

(iii) The standard enthalpy change of combustion of ethane is −1559.7 kJ mol^{-1}. Suggest an explanation for the difference between this and your value in **a(ii)**. [5]

(b) **(i)** Using the bond energies given in the *Data Booklet*, calculate another value for the standard enthalpy change of combustion of ethane.

(ii) Hence, calculate the standard enthalpy change of formation of ethane, using your answer in **b(i)** and the following data.

Standard enthalpy change of combustion of graphite = –394 kJ mol^{-1}
Standard enthalpy change of combustion of hydrogen = –286 kJ mol^{-1} [4]

(c) When compound **P** (C_8H_{10}) is treated with chlorine under different conditions, two isomeric chlorides, **Q** and **R** (C_8H_9Cl) are formed. **Q** reacts with hot concentrated alcoholic potassium hydroxide to give phenylethene, $C_6H_5CH{=}CH_2$, but with hot aqueous sodium hydroxide, it forms **S**. **S** gives a pale yellow precipitate with warm aqueous alkaline iodine. **R** is inert towards hot aqueous sodium hydroxide but is oxidised by hot acidified potassium manganate(VII) solution to an acid **T**, $C_7H_5ClO_2$.

(i) Deduce the identities of compounds **P** to **T**, explaining the chemistry of the reactions wherever possible.

(ii) Suggest the conditions needed and state the type of reaction undergone to obtain **R** from **P**. [11]

[Total: 20]

6. **(a)** Sulfuric acid is a strong acid which dissociates in water to form hydrogen ions and sulfate ions.

Draw a diagram to show the bonding in a sulfate ion, SO_4^{2-}, clearly stating its shape and bond angle. [2]

(b) The key stage in the manufacture of sulfuric acid is the reaction between sulfur dioxide and oxygen.

$$2SO_2(g) \ + \ O_2(g) \ \rightleftharpoons \ 2SO_3(g) \qquad \Delta H = -197 \text{ kJ mol}^{-1}$$

(i) Write an expression for K_c for this reaction.

(ii) 2.0 mol of sulfur dioxide and 1.0 mol of oxygen was allowed to reach equilibrium in a 2.0 dm^3 vessel at 500 ^oC. The equilibrium mixture was found to contain 0.84 mol of sulfur trioxide.

Calculate the equilibrium constant, K_c, at this temperature and state its units.

(iii) State and explain the effect on the position of this equilibrium of increasing

- the temperature,
- the pressure.

(iv) Deduce and explain the effect on the equilibrium constant and the yield of sulfur trioxide if a catalyst is introduced to the reaction chamber. [10]

(c) The table below shows the melting points of SO_2 and oxides of other Period 3 elements.

Compound	Formula	Melting point / °C
sodium oxide	Na_2O	1132
aluminium oxide	Al_2O_3	2980
sulfur dioxide	SO_2	−70

(i) Briefly relate the melting points of these oxides to their structure and bonding.

(ii) Describe the reactions, if any, of each of these oxides with water, stating the approximate pH of any solution formed, and writing a balanced equation for any reaction that takes place. [8]

[Total: 20]

7. Bromoalkanes are often used in the synthesis of other organic compounds as they can undergo a wide variety of reactions.

(a) Explain the terms *order of reaction* and *half-life*. [2]

(b) A bromoalkane, RBr, is hydrolysed by aqueous sodium hydroxide.

(i) Write a balanced equation for the reaction and suggest the type of reaction.

(ii) The following results were obtained from three experiments on such a hydrolysis.

Experiment Number	[RBr] / mol dm^{-3}	[OH$^-$] / mol dm^{-3}	Initial rate of reaction / mol dm^{-3} s^{-1}
1	0.0100	0.200	6.16×10^{-5}
2	0.0100	0.300	9.25×10^{-5}
3	0.0200	0.300	1.85×10^{-4}

Determine the order of reaction with respect to RBr and OH^-.

(iii) Write the rate equation for the reaction and calculate a value for the rate constant, giving its units.

(iv) Explain how the rate of the hydrolysis reaction will be affected when the experiment is conducted at a lower temperature. Illustrate your answer with a diagram where appropriate. [8]

(c) Bromoalkanes are often used in the synthesis of other organic compounds as they can undergo a wide variety of reactions.

A bromoalkane **J**, $C_6H_{13}Br$, was heated with aqueous sodium hydroxide. The product **K**, $C_6H_{14}O$, when distilled with aqueous potassium dichromate, gives **L**, $C_6H_{13}O$. An orange red precipitate is formed when **L** is treated with Fehling's solution.

K and **L**, on heating with acidified potassium manganate(VII), both give **M**, $C_6H_{12}O_2$. **J,** on heating with ethanolic sodium hydroxide, gives **N**, C_6H_{12}. **N** on heating under reflux with acidified potassium manganate(VII), gives 2,2-dimethylpropanoic acid and a colourless gas.

(i) Draw the displayed formula of 2,2-dimethylpropanoic acid.

(ii) Deduce the identities of compounds **J** to **N**, explaining the chemistry of the reactions wherever possible. [10]

[Total: 20]