NAME: ______________________________________ **CT**: ___________

HWA CHONG INSTITUTION

C2 PRELIMINARY EXAMINATIONS
H1 CHEMISTRY 8872
PAPER 2

10 September 2008 2 hr

INSTRUCTIONS TO CANDIDATES

1. This paper consists of **12** printed pages. You should also have a *Data Booklet* and a set of writing paper.
2. Answer **all** questions in **Section A** (Structured Questions) in the spaces provided in this Answer Booklet.
3. Answer any **two** questions in **Section B** (Free Response Questions) on the writing paper provided.

   Begin each question on a **FRESH** sheet of writing paper.
4. At the end of the examination, hand in this answer booklet and your answer scripts to **Section B SEPARATELY**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You may use a calculator.

You are reminded of the need for good English and clear presentation in your answers.

FOR EXAMINERS' USE ONLY

						TOTAL
Multiple Choice	**Section A (Structured)**		**Section B (Free Response)**			
	Q1	/ 8	Q5	/ 20		
	Q2	/ 7	Q6	/ 20		
	Q3	/ 13	Q7	/ 20		
	Q4	/ 12				
/ 30	**Subtotal**	**/ 40**	**Subtotal**	**/ 40**		**110**

Section A

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

1(a) Molecules of NH_3, H_2O and HF contain polar covalent bonds.

(i) State what is meant by each of the following terms:

covalent bond: ______________________________

____

polar bond: ______________________________

____

(ii) Arrange NH_3, H_2O and HF in order of increasing polarity of the bond in the molecules. Explain your answer.

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____

[4]

(b) The boiling points of the hydrides of some Period 2 elements are shown in the table below.

Compound	CH_4	NH_3	H_2O	HF
Boiling point / ^{o}C	-164	-33	100	19.5

With the aid of a simple diagram, explain why the boiling point of either H_2O or HF is much higher than that of methane.

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____

[2]

(c) When a NH_3 molecule reacts with H^+, an NH_4^+ ion is formed. Draw the structure of the NH_4^+ ion and state the bond angle.

Bond angle = _____________ [2]

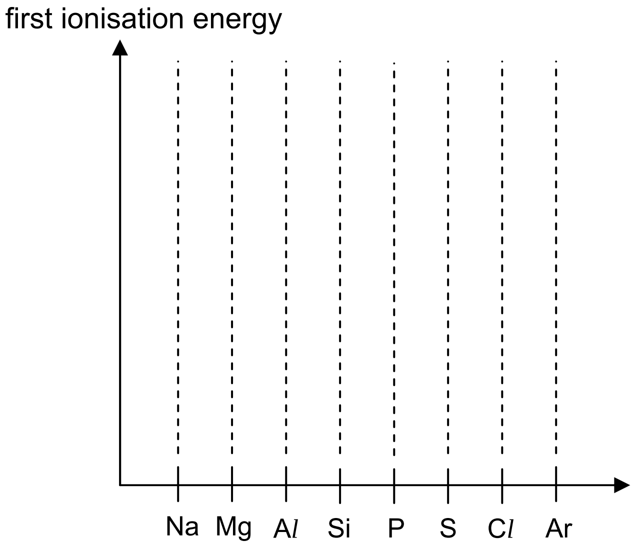
[Total: 8]

2(a) Define the term *first ionisation energy*.

____

____ [1]

(b) On the grid below, sketch the trend in first ionisation energy of the elements across Period 3 of the Periodic Table.



[2]

(c) Elements **P**, **Q** and **R** belong to the same group of the Periodic Table. The first four ionisation energies of **P**, **Q** and **R** are shown below.

Element	**P**	**Q**	**R**
First ionisation energy / kJ mol^{-1}	496	403	419
Second ionisation energy / kJ mol^{-1}	4562	2633	3052
Third ionisation energy / kJ mol^{-1}	6910	3860	4420
Fourth ionisation energy / kJ mol^{-1}	9543	5080	5877

(i) Deduce which group of the Periodic Table **P**, **Q** and **R** belong to.

(ii) Arrange **P**, **Q** and **R** according to increasing atomic number. Explain your answer.

[4]

[Total: 7]

3 Chlorine is a Group VII element in the Periodic Table. It was first produced in 1774 by German-Swedish chemist Carl Wilhelm Scheele by heating hydrochloric acid with manganese (IV) oxide. The products were chlorine, manganese (II) chloride and water. This method is not suitable for industrial production of chlorine. Instead, chlorine is now commonly recovered from sea water using electrolysis.

Chlorine gas is toxic. A concentration of 1000 ppm (parts per million by volume) is likely to be fatal after a few deep breaths. Chlorine was thus used as an offensive weapon in World War I in Flanders. It was first deployed in the morning of 22 April 1915 when the German army released the gas from hundreds of cylinders. The gas was carried by the wind to the British troops, causing chaos as many men died in agony and countless more were disabled by it. The threat was eventually countered by issuing gas masks. An initial form of the gas mask, termed the “hypo helmet”, was a hood that was dipped in sodium thiosulphate. Chlorine was converted to harmless chloride ions by thiosulphate ions, $S_2O_3^{2-}$, which were converted to sulphate (VI) ions, SO_4^{2-}.

(a) Give the chemical formula of the oxidizing agent used by Scheele.

____ [1]

(b) Suggest a reason why Scheele's method is not suitable for industrial production of chlorine.

____

____ [1]

(c) The molar volume of chlorine gas may be taken to be 24 dm^3 under room conditions.

(i) Estimate the density of chlorine gas in g cm^{-3} under room conditions.

(ii) Hence suggest why many more British soldiers died from chlorine poisoning in trenches rather than on hill tops.

____

____

[2]

(d) The reaction occurring in the "hypo helmet" is a redox reaction.

(i) Write the half-equation for the oxidation reaction.

____

(ii) Write the half-equation for the reduction reaction.

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(iii) Hence construct the overall equation for the redox reaction in the "hypo helmet".

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[3]

(e) Assuming that each "hypo helmet" effectively absorbed all the chlorine gas in 320 dm^3 of air containing 500 ppm of chlorine before being inactivated, and each helmet carried 30 cm^3 of sodium thiosulphate, calculate the concentration in mol dm^{-3} of sodium thiosulphate used.

[2]

(f) Describe the reactions, if any, of chlorine with sodium and with silicon. Include relevant equations in your answer.

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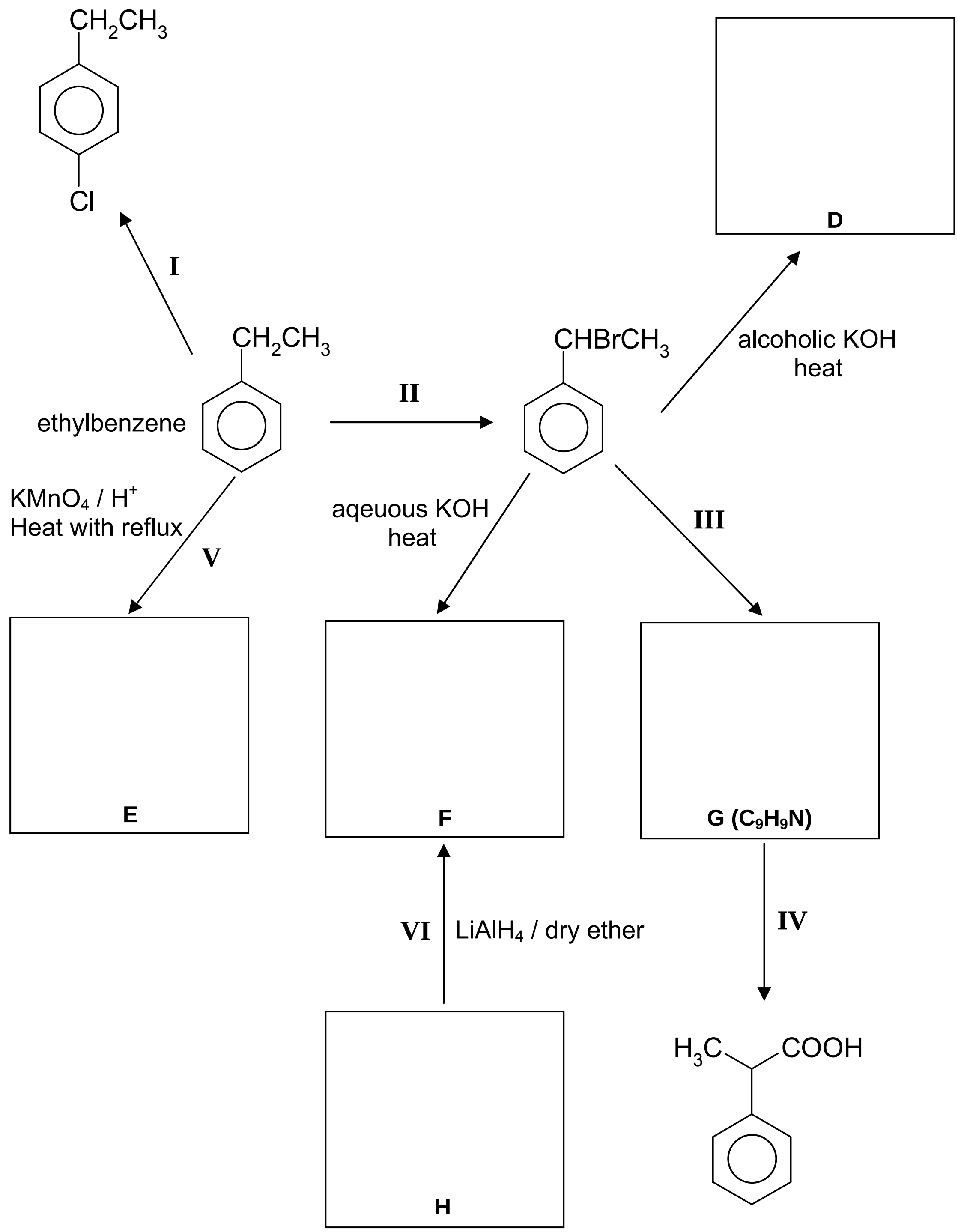
[4]

[Total: 13]

4 The following reaction scheme shows some reactions starting with ethylbenzene.



(a) In the boxes provided, draw the structural formulae of the organic compounds **D** to **H**. [5]

(b) Only one of the organic compounds **D** to **H** has molecules where carbon atoms have undergone sp, sp^2 and sp^3 hybridisation. State which compound it is.

____ [1]

(c) Give the reagents and conditions for reactions **I**, **II**, **III** and **IV**.

Reaction **I**: ____

Reaction **II**: ____

Reaction **III**: ____

Reaction **IV**: ____

[4]

(d) Write balanced equations for reactions **V** and **VI**, using the symbols [O] and [H] as appropriate.

Reaction **V**: ____

Reaction **VI**: ____

[2]

[Total: 12]

SECTION B

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

5(a) At high temperatures, $PCl_5(g)$ dissociates as follows:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g) \qquad \Delta H = +93 \text{ kJ mol}^{-1}$$

A 2.60 mol sample of PCl_5 was placed in a sealed 10 dm^3 container and heated to a fixed temperature, $\mathbf{T_1}$. At equilibrium, 1.40 mol of PCl_5 remained unreacted.

(i) Write an expression for the equilibrium constant, K_c, for this reaction and calculate its value at temperature $\mathbf{T_1}$, giving its units.

(ii) The numerical value of K_c at another temperature $\mathbf{T_2}$ is 0.150. Deduce which of the temperatures, $\mathbf{T_1}$ or $\mathbf{T_2}$, is higher.

(iii) Predict the effect, if any, on the equilibrium percentage dissociation of PCl_5 if the volume of the container is increased at a fixed temperature.

(iv) State the effect, if any, on the value of K_c of a higher initial amount of PCl_5 at a fixed temperature.

(v) Explain with the aid of a diagram, whether the rate of the reaction at temperature $\mathbf{T_2}$ is higher or lower than the rate at temperature $\mathbf{T_1}$.

[12]

(b) Compound **A** has molecular formula, C_4H_8O. Reaction of **A** with hot acidified potassium manganate (VII) produces compound **B**, $C_3H_4O_4$, and effervescence is observed. One mole of **B** requires two moles of NaOH for complete neutralization. **A** decolourises aqueous bromine rapidly to form compound **C**, $C_4H_9O_2Br$ as the major product. Both **A** and **C** turn hot orange acidified potassium dichromate (VI) green. When treated with phosphorus pentachloride, **A** gives white fumes and compound **D**, C_4H_7Cl, is formed.

Suggest a possible structure for each of the compounds **A** to **D**. Explain the chemistry of the reactions described. [8]

6(a) Methanol, CH_3OH, is a convenient liquid fuel.

An experiment was conducted to determine the enthalpy change of combustion of liquid methanol. 1.82 g of methanol was burned to heat 150 g of water. The temperature of the water rose from 298 K to 362 K. [The specific heat capacity of water is 4.18 J K^{-1} g^{-1}]

(i) Define the term *standard enthalpy change of combustion*.

(ii) Use the given data to calculate a value for the enthalpy change of combustion of liquid methanol.

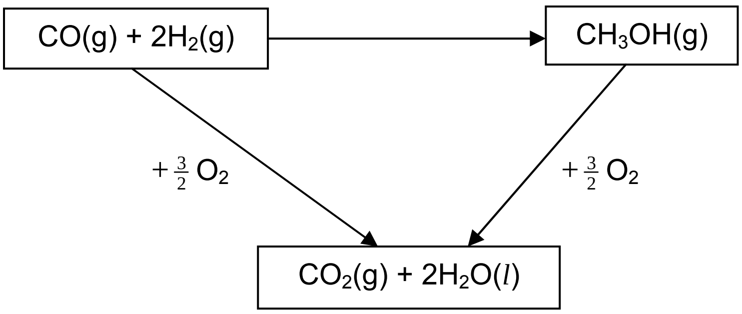
Methanol can be synthesised from methane and steam through a process that occurs in two stages.

Stage 1	$CH_4(g) + H_2O(g) \rightarrow 3H_2(g) + CO(g)$	$\Delta H = +206$ kJ mol^{-1}
Stage 2	$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$	$\Delta H = -91$ kJ mol^{-1}

(iii) Draw and label the energy profile diagram for ***Stage 1***.

(iv) Explain why ***Stage 2*** is usually carried out at a temperature of 500 K.

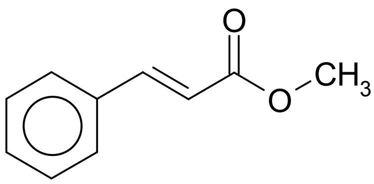
(v) With the aid of the energy cycle below, calculate a value for the enthalpy change of combustion of gaseous methanol.
[Enthalpy change of combustion of CO(g) = –283 kJ mol^{-1}
Enthalpy change of combustion of $H_2(g)$ = –286 kJ mol^{-1}]



(vi) Using your answers to **(ii)** and **(v)**, find a value for the enthalpy change of vaporisation of methanol.

[12]

(b) Methyl cinnamate is the product of the reaction between cinnamic acid and methanol.



methyl cinnamate

(i) Predict whether methyl cinnamate is soluble in water.

(ii) What type of stereoisomerism would cinnamic acid show? Draw the stereoisomers of the acid.

(iii) A sample of methyl cinnamate is heated with aqueous sodium hydroxide. Write an equation for the reaction and state the type of reaction occurring.

(iv) What organic product would be obtained when methyl cinnamate is reacted with cold, dilute alkaline $KMnO_4$?

(v) Suggest a commercial use for methyl cinnamate.

[8]

7(a) RCOOH is a weak acid. It reacts with sodium hydroxide as follows:

$$RCOOH(aq) + NaOH(aq) \rightarrow RCOO^{-}Na^{+}(aq) + H_2O(l)$$

A solution of acid was prepared by dissolving 2.41 g of RCOOH in water and making the volume up to 250 cm^3 in a volumetric flask. A 25.0 cm^3 sample of this solution was placed in a conical flask and titrated with 0.150 mol dm^{-3} NaOH(aq).

(i) Write an expression for the acid dissociation constant, K_a, of RCOOH.

(ii) Find the pH of the sodium hydroxide solution used.

(iii) After 10.85 cm^3 of NaOH(aq) had been added into the conical flask, a solution which would best resist pH changes was obtained. At this point the concentrations of RCOOH and $RCOO^-$ in the conical flask were equal. Calculate the relative molecular mass, M_r, of RCOOH and hence suggest the structural formula of the acid.

(iv) Write **an** equation to show how the solution in **(iii)** could resist a change in pH due to the addition of an acid **or** an alkali.

(v) Choose, giving a reason, the most suitable indicator for the titration from the table below. State the colour of the solution at the equivalence point.

Indicator	**pH at which colour changes**	**Colour at pH 3**	**Colour at pH 11**
bromocresol green	4 – 6	yellow	blue
bromothymol blue	6 – 8	yellow	blue
phenolphthalein	8 – 10	colourless	red

[9]

(b) The following data were obtained by studying the reaction between compounds **A**, **B** and **C** at a constant temperature.

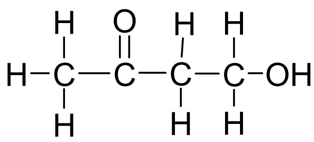
Experiment No	Initial concentration / mol dm^{-3}			Initial rate / mol dm^{-3} s^{-1}
	A	**B**	**C**	
1	0.20	0.10	0.40	0.80×10^{-3}
2	0.20	0.40	0.40	3.20×10^{-3}
3	0.10	0.80	0.40	1.60×10^{-3}
4	0.10	0.30	0.20	0.60×10^{-3}

(i) Deduce the order of reaction with respect to each of the compounds **A**, **B** and **C**.

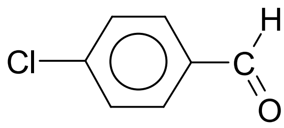
(ii) Hence, write the rate equation and calculate the rate constant for the reaction at this temperature.

[5]

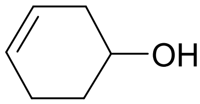
(c) For each of the compounds **J**, **K** and **L**, describe a simple test-tube test which would identify each compound from the other two compounds. Each test should give a positive result only for the identified compound. You should include the reagents, conditions and observations for each test. Equations are not required.



J



K



L

[6]

- End of paper -