NAME: _____ CT: _____

HWA CHONG INSTITUTION

C2 PRELIMINARY EXAMINATION
8872 H1 CHEMISTRY
PAPER 2

18 September 2009 **2 hours**

INSTRUCTIONS TO CANDIDATES

1. This paper consists of **11** printed pages. You should also have a *Data Booklet*, a set of writing paper and a cover page for **Section B**.
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.

   Tie your answer scripts to **Section B** behind the cover page provided.
4. At the end of the examination, hand in your answers to **Section A** and **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 EXAMINER'S USE

			TOTAL
Multiple Choice	**Section A (Structured)**	**Section B (Free Response)**	
	Q1 / 8	Q5 / 20	
	Q2 / 16	Q6 / 20	
	Q3 / 8	Q7 / 20	
	Q4 / 8		
/ 30	**Subtotal / 40**	**Subtotal / 40**	**110**

Section A

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

1 (a) Copper exists as ^{63}Cu and ^{65}Cu isotopes. The relative abundance of ^{65}Cu is 30.8.

(i) Define the term *relative atomic mass.*

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……....

(ii) Calculate the relative atomic mass for copper.

(iii) Complete the following table with the number of elementary particles (electrons, protons, and neutrons) that are contained in the ion for the isotope of copper.

Ion	protons	neutrons	electrons
$^{63}Cu^{2+}$			

[3]

(b) The hydrated double salt, **A**, $Cu(NH_4)_x(SO_4)_y.6H_2O$ has a M_r of 399.5. Its formula may be determined from the following experimental data.

(i) 2.00 g of salt **A** was boiled with excess sodium hydroxide. The ammonia expelled was collected by absorption in 40.0 cm^3 of 0.500 mol dm^{-3} hydrochloric acid in a cooled flask. Subsequently, this solution required 20.0 cm^3 of 0.500 mol dm^{-3} sodium hydroxide for neutralisation.

Calculate the mass of ammonium ion present in 2.00 g of salt **A.**

(ii) A second sample of 2.00 g of salt **A** was dissolved in water and treated with an excess of barium chloride solution. The mass of barium sulfate precipitated, after drying, was found to be 2.33 g.

Calculate the mass of sulfate ion in 2.00 g of salt **A.**

(iii) Determine the formula of the hydrated salt **A.**

[5]

[Total: 8]

2 (a) Element ***X*** forms a chloride ***X***C*l*$_n$ which melts at 3 °C. When 0.500 g of the chloride reacts with an excess of acidified silver nitrate, 1.19 g of AgC*l* are formed.

Another 0.500 g sample of the chloride is heated strongly and chlorine gas is given off. When the residue is treated with an excess of acidified silver nitrate, only 0.714 g of AgC*l* is precipitated.

Calculate a value of n and identify ***X***.

[5]

(b) The melting points of three chlorides are given below.

Compound	**Formula**	**Melting Point / °C**
Sodium chloride	NaC*l*	801
Potassium chloride	KC*l*	772
Aluminium chloride	A*l*C*l*$_3$	180

Explain the difference in the melting points, in terms of structure and bonding, between:

(i) NaC*l* and KC*l*

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……

(ii) NaC*l* and A*l*C*l*$_3$

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……

[4]

(c) Aluminium chloride sublimes at 180 °C. In the vapour phase, an equilibrium is established between aluminium chloride and its dimer.

$$2AlCl_3(g) \rightleftharpoons Al_2Cl_6(g)$$

Describe and explain the effect on the position of this equilibrium of increasing

(i) the pressure

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……

(ii) the temperature

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……

(iii) Describe and explain, with the aid of a suitable diagram, how the rate of the above reaction is affected by a decrease in temperature.

[7]

[Total: 16]

3 **(a)** Explain what is meant by the term *bond enthalpy*.

……...……....

……...……....

[1]

(b) Gaseous ethanal burns as shown by the following equation:

$$CH_3CHO(g) + \frac{5}{2}O_2(g) \rightarrow 2H_2O(g) + 2CO_2(g)$$

(i) Using bond energies given in the *Data Booklet*, calculate the enthalpy change for the combustion of ethanal as shown in the equation above.

(ii) Given that the experimentally determined value for enthalpy change of combustion of ethanal is -1160 kJ mol^{-1}, explain the discrepancy between this value and your answer in **(b)(i)**.

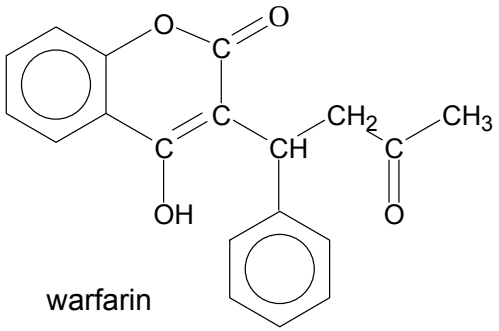
……....

……....

[3]

(c) Warfarin is used to destroy rodents and as an anticoagulant (blood thinner) for preventing blood clots after a heart attack.

The structural formula of warfarin is as shown.



warfarin

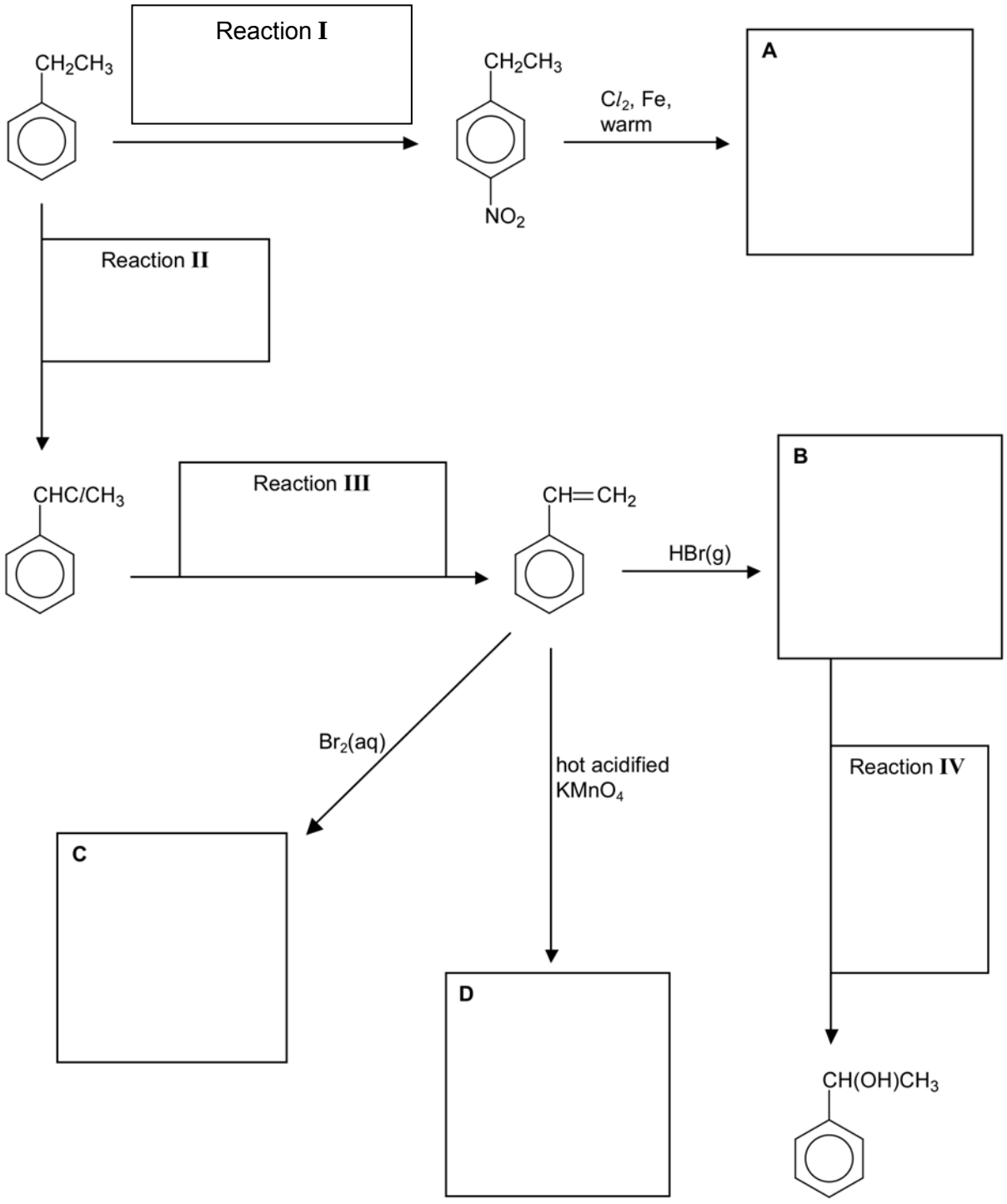
Give the structural formula(e) of the organic product(s) formed when warfarin reacts with:

(i) hydrogen cyanide with trace potassium cyanide
(ii) 2,4-dinitrophenylhydrazine
(iii) hydrogen gas in the presence of platinum catalyst

[4]

[Total: 8]

4 For the reaction scheme below, state the reagents and conditions for Reactions **I** to **IV** and draw the structures of the organic compounds **A** to **D** in the boxes provided.



[Total: 8]

Section B

Answer any **two** questions from this section on separate writing paper.

5 (a) The table below shows the enthalpy changes of hydration (ΔH_{hyd}) of some Group II cations and the lattice energies (LE) of their sulfates.

Element (M)	$\Delta H_{hyd}(M^{2+})$ /kJ mol^{-1}	LE(MSO_4) /kJ mol^{-1}
Ca	−1562	−2484
Sr	−1413	−2480
Ba	−1273	−2374

(i) Describe and explain the trend observed in the enthalpy change of hydration for the given Group II cations.

(ii) The enthalpy change of solution (ΔH_{soln}) for barium sulfate is +27 kJ mol^{-1}. Using this data and the information given in the table, determine the enthalpy change of hydration for the sulfate anion.

[4]

(b) Barium ethanedioate, BaC_2O_4, is used as a green pyrotechnic colorant in specialized pyrotechnic compositions. It is formed from barium chloride according to the equation below:

$$BaCl_2(aq) + Na_2C_2O_4(aq) \rightarrow BaC_2O_4(s) + 2NaCl(aq)$$

(i) State the types of bonding found in BaC_2O_4.

(ii) Using a dot-and-cross diagram, deduce the shape and bond angle in the ethanedioate portion of BaC_2O_4.

[4]

(c) The chlorides of the elements in the third period differ in their bonding and their reactions with water.

(i) Sketch a graph of the pH of the solutions of the **chlorides** from sodium to phosphorus.

(ii) Describe the structure and bonding of the chlorides of magnesium and silicon. Write equations with state symbols of the reactions of these chlorides with water.

[5]

(d) Butanedioic acid, also known as succinic acid, is widely used as a food additive in the food industry. A student proposes the following synthetic route to obtain butanedioic acid.

$$CH_2{=}CH_2 \xrightarrow{\mathbf{I}} \mathbf{A} \xrightarrow{\mathbf{II}} \mathbf{B} \xrightarrow{\mathbf{III}} HO_2CCH_2CH_2CO_2H$$

butanedioic acid

(i) State the reagents and conditions required in steps **I** to **III** and draw the structures of **A** and **B**.

(ii) Describe a simple chemical test to distinguish butanedioic acid from ethene.

[7]

[Total: 20]

6 **(a)** 8.00 g of solid potassium chromate(VI), K_2CrO_4, is dissolved in acid to make a 100 cm^3 solution. A dynamic equilibrium occurs in the mixture according to the equation below:

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

(i) What do you understand by the term *dynamic equilibrium*?

(ii) Write the K_c expression for the above equilibrium mixture.

(iii) At pH 5.75, **one-fifth** of the original amount of chromate(VI) ions remain. Calculate the concentration of chromate(VI) ions at this pH.

(iv) Hence, calculate the value of K_c and state its units.

[6]

(b) 100 cm^3 of potassium iodide was added to 100 cm^3 of a sample of acidified potassium dichromate(VI) to react with all the dichromate(VI) ions present. 25.0 cm^3 of the resulting mixture required 21.50 cm^3 of a 0.20 mol dm^{-3} of sodium thiosulfate solution for complete reaction.

(i) Write a balanced equation for the reaction of potassium iodide with potassium dichromate(VI).

(ii) Calculate the concentration of the potassium dichromate(VI) in the sample.

[4]

(c) Under different conditions, acidified potassium dichromate(VI) reacts with **A**, C_4H_8O, to yield **B** or **C**. When treated with hot concentrated acidified potassium manganate(VII), both **B** and **C** give the same organic product CH_3CO_2H and carbon dioxide gas. However, only **B** and not **C** will undergo reaction with 2,4-dinitrophenylhydrazine.

(i) Deduce the structures of **A** to **C**.

(ii) What type of isomerism is shown by **A**? Illustrate your answer with suitable diagrams.

(iii) Suggest the condition for the reaction of **A** to give **B**.

[7]

(d) Benzenesulfonic acid ($C_6H_5SO_3H$) is used in the manufacturing of dyes. It ionises in water according to the following equation:

$$C_6H_5SO_3H(aq) + H_2O(l) \rightleftharpoons C_6H_5SO_3^-(aq) + H_3O^+(aq) \quad K_a = 5.9 \times 10^{-4} \text{ mol dm}^{-3}$$

(i) Given a 0.10 mol dm^{-3} solution of benzenesulfonic acid, suggest how you would prepare a buffer solution with maximum buffer capacity, stating clearly the quantities of chemical(s) used.

(ii) With the aid of an equation, explain how this solution acts as a buffer when small amount of hydroxide ions are added.

[3]

[Total: 20]

7 (a) (i) What do you understand by the term *ionisation energy*?

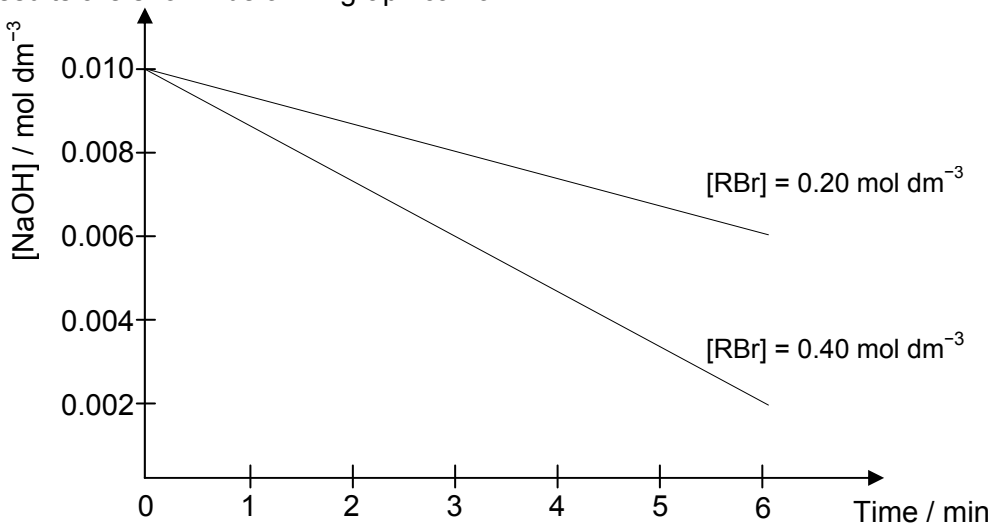
(ii) Sketch a graph of the first ionisation energies of the elements lithium to sodium (inclusive) against proton (atomic number). Explain the variation in ionization energy illustrated by this graph. [6]

(b) Iron and aluminium both form (+3) cations.

(i) Write the electronic configuration of **both** the elements and their cations.

(ii) Explain why the ionic radius of Fe^{3+} is bigger than that of Al^{3+}. [3]

(c) A bromoalkane, RBr, is hydrolysed by aqueous NaOH. The reaction rate was studied using two sets of experiments in which the initial concentration of RBr was varied in turn, and the initial concentration of aqueous NaOH kept constant at 0.010 mol dm^{-3}. The results are shown below in graphical form.



(i) Using the graph above, deduce the order of reaction with respect to **both** RBr and aqueous NaOH. Hence, write a rate equation for the reaction.

(ii) The mechanism for the reaction is proposed as follows:

Step I: $RBr \xrightarrow{\text{slow}} R^{\oplus} + Br^{\ominus}$

Step II: $R^{\oplus} + OH^{\ominus} \xrightarrow{\text{fast}} ROH$

Using the information provided and your answers in **(i)**, sketch and label a reaction pathway diagram for the reaction. Assume that the overall reaction is exothermic. [5]

(d) An organic compound **D**, $C_{10}H_{11}O_2Br$, does not react with sodium hydrogencarbonate solution but reacts slowly on heating in sodium hydroxide to form a water-soluble substance **E**, $C_3H_5O_3Na$ and an insoluble compound **F**, C_7H_8O. **F** on oxidation gives benzoic acid. **E** with sodium produces hydrogen and **G**, $C_3H_4O_3Na_2$. **E** also reacts with hot alkaline aqueous iodine to give a yellow precipitate.

Deduce the structural formulae of **D** to **G**, explaining clearly your reasoning for all the reactions described above. [6]

[Total: 20]