ANDERSON JUNIOR COLLEGE
2009 PRELIMINARY EXAMINATION
HIGHER 1

CHEMISTRY

8872/02

Paper 2 **18 September 2009**

2 hours

Candidates answer Section A on the Question Paper.

Additional Materials : Writing Paper
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and PDG 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 any **two** questions on separate answer paper.

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

At the end of the examination, attach your answer for **Section B** to this question paper.

Name: ……( )

PDG: ……

For Examiner's Use		
Section A	Q1	
	Q2	
	Q3	
	Q4	
Section B		
	Total	80

This paper consists of **14** printed pages including this cover page.

Section A

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

1 **(a)** What is meant by the term *empirical formula*?

……

……[1]

(b) A gaseous hydrocarbon, **A**, has a composition by mass: C, 85.7 %; H, 14.3 %.

(i) Calculate the empirical formula of the hydrocarbon, **A**.

Empirical Formula of compound **A** : ……

(ii) When 10 cm^3 of **A** underwent complete combustion in excess oxygen, the remaining gases occupied 100 cm^3 at 120 ^oC and 1 atm. When the gases were cooled to room temperature and pressure, the volume of gases was reduced to 60 cm^3.

Determine the molecular formula of **A**.

[3]

(c) Draw the structural formulae of **all** the isomers of compound **A** and state the **type(s)** of isomerism displayed.

[4]

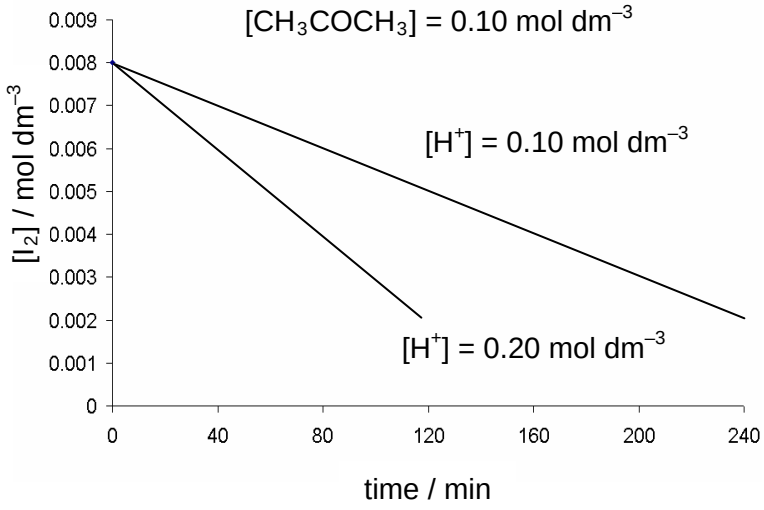
[Total: 8]

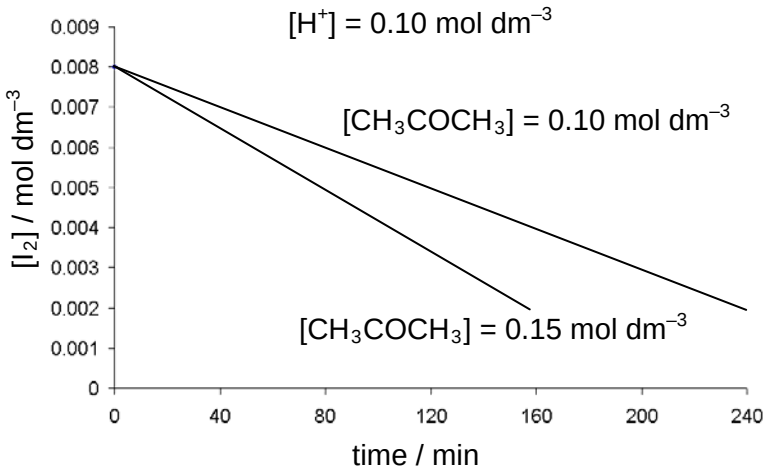
2 **(a)** The kinetics of the acid–catalysed reaction of propanone with iodine

$$CH_3COCH_3(aq) + I_2(aq) \longrightarrow CH_2ICOCH_3(aq) + HI(aq)$$

can be investigated experimentally by varying the concentrations of the three substances involved.

The following results were obtained in an experiment.





(i) Deduce the order of reaction with respect to

- iodine

Order of reaction with respect to iodine: ……

- hydrogen ions

Order of reaction with respect to hydrogen ions: ……..

- propanone

Order of reaction with respect to propanone: ……....

(ii) Hence, write a rate equation for the reaction and determine a value for the rate constant *k*, including its units.

(iii) Hydrogen ions are found to catalyse the above reaction. Explain, with the aid of the Maxwell Boltzmann distribution curve, how the use of hydrogen ions can help to speed up the rate of reaction.

……..

……..

……[9]

(b) Many chemical compounds exist as crystalline solid structures.

Describe, with the aid of a diagram, the structure of crystalline solid iodine.

……

……..[2]

(c) Propanal, CH_3CH_2CHO, and propanone are isomers which can be distinguished by using aqueous iodine.

State the condition needed for this test and the observation made when the test is performed on propanal and propanone.

Conditions:

……..

Observations:

…….[2]

[Total: 13]

3 **(a)** Describe the variations in melting points of magnesium, silicon and sulfur. Explain these variations in terms of their structures and bonding.

……

……..

……

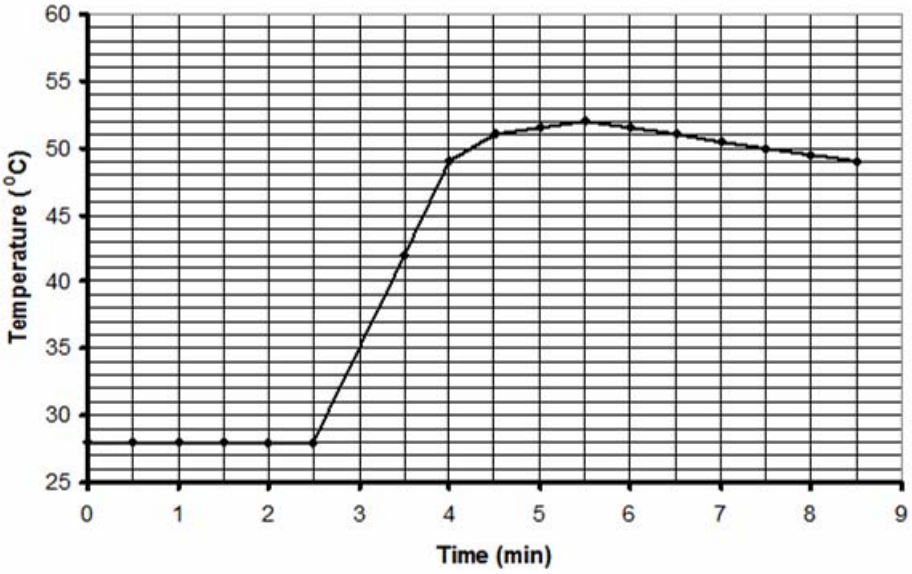
……..[3]

(b) In an experiment to determine the enthalpy change of reaction between magnesium and

hydrochloric acid, the following procedure was followed.

- The temperature of 40 cm^3 of 1 mol dm^{-3} hydrochloric acid was recorded for 2.5 minutes.
- 0.25 g of magnesium powder was added to the acid at **3 minutes.**
- The temperature of the mixture was recorded at regular intervals from 3.5 minutes.

The following results were obtained.



(i) From the graph obtained, determine the maximum temperature reached.

Maximum temperature reached = ……..

(ii) Write an equation for the reaction between magnesium and hydrochloric acid.

……..

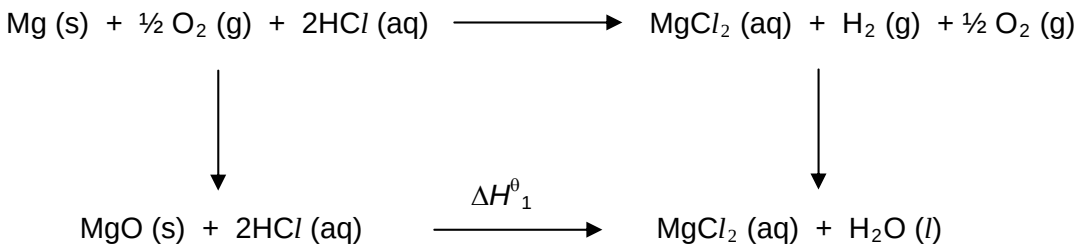
(iii) Calculate the enthalpy change of the reaction.

[You may assume the specific heat capacity of the mixture to be 4.2 J g^{-1} K^{-1}.]

(iv) By using the answer obtained in **(b)(iii)** and given the following energy cycle and

thermochemical data, determine the standard enthalpy change of reaction between magnesium oxide and hydrochloric acid, ΔH^{θ}_1.

ΔH^{θ}_f (MgO) = - 600 kJ mol^{-1}
ΔH^{θ}_f (H_2O) = - 286 kJ mol^{-1}

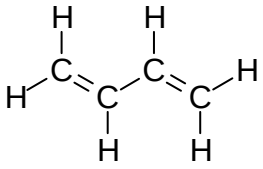


ΔH^{θ}_1 =
……

[7]

[Total: 10]

4. Synthetic rubber, which is widely used to make the tyres of automobiles, is made from 1,3-butadiene. The structure of 1,3-butadiene is shown below:



1,3-butadiene

(a) What type of hybridization is present in the 1,3-butadiene molecule?

……..[1]

(b) Sketch the shapes of the hybrid orbitals around one carbon atom in the 1,3-butadiene molecule.

[1]

(c) 1,3-butadiene reacts with aqueous bromine and aqueous potassium manganate(VII). State what you would observe and write an equation for each of the reactions, showing the structures of the products.

(i) 1,3-butadiene and aqueous bromine in the dark

Observation:……...

Equation:……

(ii) 1,3-butadiene and cold aqueous potassium manganate(VII)

Observation:……...

Equation:……

[4]

(d) Ethanedioic acid, $H_2C_2O_4$, is a product that can be obtained from 1,3-butadiene.

In an experiment to analyse a sample of ethanedioic acid, 20.0 cm^3 of 0.0200 mol dm^{-3} of acidified potassium manganate(VII), $KMnO_4$ was required to completely react with 25.0 cm^3 of ethanedioic acid sample. Ethanedioic acid was oxidized to carbon dioxide gas in the reaction.

(i) Construct an equation to illustrate the oxidation of ethanedioic acid to carbon dioxide. Hence, write a balanced equation for the reaction between MnO_4^- and $H_2C_2O_4$.

(ii) Calculate the concentration of ethanedioic acid in mol dm^{-3}.

[3]

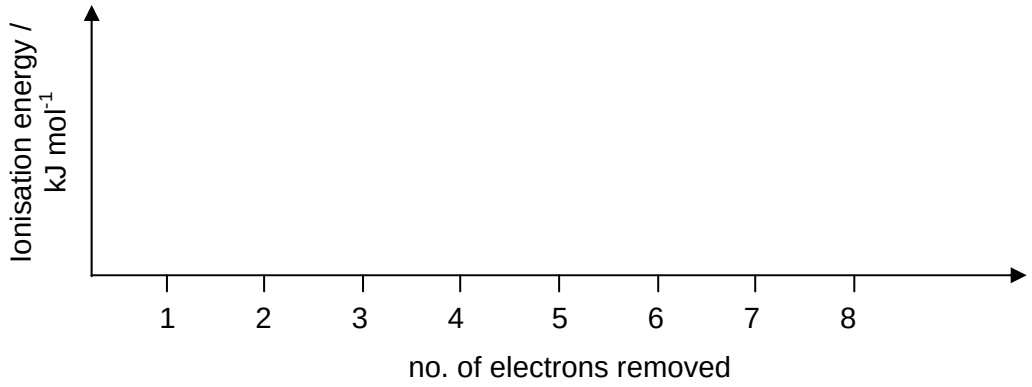
[Total: 9]

Section B

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

5. This question involves Group VI elements and their compounds.

(a) **(i)** Copy the grid provided below and show how the first 8 ionisation energies of sulfur change as electrons are removed successively.



(ii) State the electronic configurations of S^+ and Cl^+.

(ii) Hence explain why the **<u>second</u>** ionisation energy of chlorine is less than that of sulfur.

[5]

(b) In an investigation to determine the kinetics of the decomposition of hydrogen peroxide, the time taken for a fixed volume of oxygen gas to be produced was monitored in several experiments.

$$2H_2O_2(aq) \longrightarrow 2H_2O(l) + O_2(g)$$

The results were tabulated below.

Experiment	$[H_2O_2]$ / mol dm^{-3}	Time taken for 100 cm^3 of O_2 to be produced / min
1	0.10	40
2	0.15	25
3	0.30	13

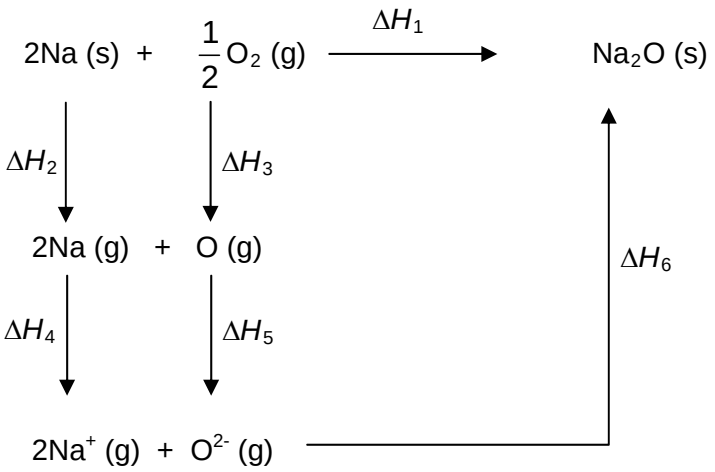
(i) Deduce the order of the reaction with respect to hydrogen peroxide.

(ii) By using Collision Theory, explain how the rate of decomposition of hydrogen peroxide would be affected when equal volumes of hydrogen peroxide and water were mixed together.

(iii) Explain why hydrogen peroxide is miscible in water. Illustrate your answer with a suitable diagram.

[5]

(c) Sodium oxide, Na_2O, is used as a material in ceramics and glasses. The formation of Na_2O from its elements may be represented by an energy cycle below.



(i) ΔH_4 represents the first ionisation energy of sodium. Write an equation, with state symbols, which represents this and use the *Data Booklet* to calculate a value for ΔH_4.

(ii) Enthalpy change of atomisation of oxygen can be represented as follows:

$$\frac{1}{2}O_2(g) \longrightarrow O(g)$$

By using appropriate data from the *Data Booklet*, calculate a value for the enthalpy change of the above reaction.

(iii) Calculate the lattice energy of sodium oxide using the following data and the values you obtained in **(c)(i)** and **(c)(ii)**.

$\Delta H_1 = -414$ kJ mol^{-1}
$\Delta H_2 = +214$ kJ mol^{-1}
$\Delta H_5 = +657$ kJ mol^{-1}

(iv) How would you expect the melting point of sodium oxide to compare with that of aluminium oxide? Explain your answer.

[7]

(d) When 0.10 g of aluminum sample was reacted with an excess aqueous sodium hydroxide, an aluminum–containing product was formed and 75 cm^3 of hydrogen was given off. The aluminum–containing product of this reaction was the same as that from the reaction between aluminum oxide and sodium hydroxide. All volumes were measured at room temperature and pressure conditions.

(i) From your knowledge of the latter reaction, construct an equation for the reaction between aluminum and sodium hydroxide.

(ii) Hence calculate the percentage purity of the aluminum sample.

[3]

[Total: 20]

6 **(a)** An active ingredient in antiperspirants is aluminium chloride, a compound which shows interesting changes in its physical properties over a range of temperature.

- At room temperature, aluminium chloride exists as a solid.
- It sublimes at 190 ^{o}C and the vapour formed has an M_r of 267.

When a large amount of water is added to aluminium chloride solid, it dissolves.

(i) Draw a dot-and-cross diagram to describe the bonding in aluminium chloride vapour at 190 ^{o}C and suggest a value of the bond angle, C*l*-A*l*-C*l*.

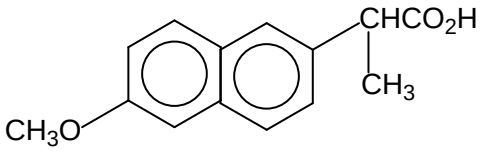
(ii) Based on the diagram drawn in **(a)(i)**, give reasons to account for the bonding in the compound.

(iii) Write an equation to illustrate what happens when excess water is added to aluminium chloride solid.

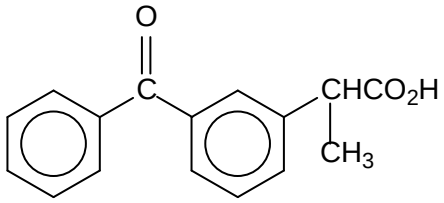
(iv) Describe and explain, with the aid of an equation, what you would observe when a strip of zinc sheet is added to the solution formed.

[7]

(b) People who are allergic to aspirin can take substitute medicines. *Naprofen* and *Ketoprofen* are two aspirin substitutes which are now available over the counter.



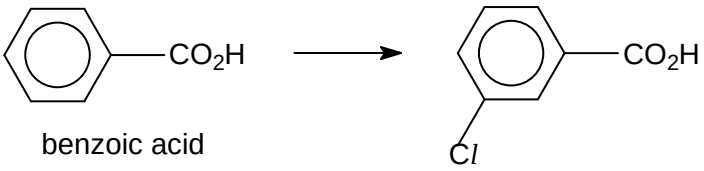
Naprofen



Ketoprofen

(i) Suggest an advantage for preparing the drugs in the salt form.

Ketoprofen can be synthesized through a series of steps in the Voskanian Synthesis. The first step is given below.



benzoic acid

In this step, chlorine is added to benzoic acid in the presence of aluminium chloride. The reaction between chlorine and aluminium chloride is shown below:

$$AlCl_3 + Cl_2 \longrightarrow AlCl_4^- + Cl^+$$

(ii) Explain how the reaction between A*l*C*l*$_3$ and C*l*$_2$ aids in the formation of 3 - chlorobenzoic acid.

(iii) What is the type of reaction involved when benzoic acid is converted to 3 - chlorobenzoic acid?

(iv) Draw the structures of two other isomers that can be formed.

(v) Suggest a simple chemical test which can be used to distinguish between *Naprofen* and *Ketoprofen*. Write the formula(e) of the product(s) formed for the positive test.

[8]

(c) On heating gaseous phosphorus pentachloride, the following equilibrium is set up:

$$PCl_5\ (g) \rightleftharpoons PCl_3\ (g) + Cl_2\ (g) \qquad \Delta H = +\ 120\ kJ\ mol^{-1}$$

(i) To obtain more chlorine gas, should the reaction be heated or cooled? Give a reason for your answer.

(ii) When 0.40 mol of PCl_5 is heated in a 2 l container, 0.30 mol of PCl_3 is obtained at equilibrium. Write an expression for the equilibrium constant, K_c for the reaction and calculate its value, giving its units.

[5]

[Total: 20]

7 **(a)** Citric acid, $C_5H_7O_4CO_2H$, is sometimes added to shampoos to wash out wax and grease from the hair, as well as provide a refreshing citrus scent.

(i) A 0.20 mol dm^{-3} citric acid has a pH of 1.93. Justify that citric acid is a weak acid.

(ii) Write an expression for the acid dissociation constant, K_a, of citric acid.

(iii) Hence, calculate the value of the acid dissociation constant of citric acid. Include its unit.

$$C_5H_7O_4CO_2H \rightleftharpoons C_5H_7O_4CO_2^- + H^+$$

[4]

(b) A chemistry student wanted to formulate a shampoo with the maximum buffer capacity so that there will be minimal damage to the hair.

In an attempt to prepare a buffer for the shampoo, she titrated 20.0 cm^3 0.100 mol dm^{-3} sodium hydroxide against 0.20 mol dm^{-3} citric acid.

(i) What is the pH of the aqueous sodium hydroxide used?

(ii) Calculate the volume of citric acid required to completely neutralize the sodium hydroxide.

(iii) Which of the indicators, from the table below, can be used for the titration above? Explain your answer.

Indicator	pH range of colour change
bromophenol blue	2.8 – 4.6
phenol red	6.8 – 8.5

(iv) When excess citric acid is added, a buffer solution is obtained.

Explain, with the aid of equations, how the mixture can act as a buffer on the addition of a small amount of acid and alkali.

(v) The resulting buffer best resists pH changes when the concentrations of citric acid and that of sodium citrate are the same.

By using the expression of the acid dissociation constant in **a(ii)**, determine the pH at which the buffer best resists pH changes.

(vi) By means of a suitable sketch, illustrate how the pH of the solution changes with the addition of citric acid. Indicate the following points on your diagram clearly.

- Initial pH of the solution
- Volume of citric acid needed to reach the end point of the titration

[9]

(c) Lactic acid, $CH_3CH(OH)CO_2H$, is commonly known as 'milk acid' as it is commonly found in sour milk products like yogurt and cottage cheese.

(i) Stating from a suitable alcohol of your choice, devise a 3-stage synthesis of lactic acid. Suggest reagents and conditions for each step, and draw the structural formula of each intermediate compound.

(ii) In the presence of a small amount of concentrated sulfuric acid, heated under reflux conditions, lactic acid forms a compound $C_6H_8O_4$, which is no longer soluble in water. Suggest the structure of this compound.

[7]

[Total: 20]

- End of Paper -