SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 1

CHEMISTRY **8872/02**
Preliminary Examination **16 September 2016**
Paper 2 **2 hours**

Additional Materials: Data Booklet
Writing papers

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark or blue pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** the 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 of part question.

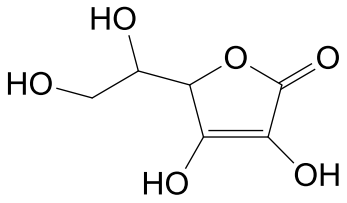
FOR EXAMINER'S USE		
P1 (MCQ)		/30
P2	Section A	
	1	/17
	2	/17
	3	/6
	Section B (please fill in the question number)	
		/20
		/20
Total		/110

This document consists of **15** printed pages.

Section A

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

1 Ascorbic acid is a naturally occurring organic compound with antioxidant properties. It dissolves well in water and is effective in the prevention of scurvy.



Ascorbic acid

A student analysed the ascorbic acid content found in Vitamin-C tablets using the following experimental procedure.

Step 1:
He prepared a 250 cm^3 mixture containing the following chemicals:

- Sulfuric acid, H_2SO_4
- Potassium iodide, KI
- 0.664 g Potassium iodate, KIO_3

This reaction mixture generates iodine which is essential for the analysis of ascorbic acid. The reaction is illustrated below.

$$KIO_3 + 5KI + 6H^+ \rightarrow 3I_2 + 6K^+ + 3H_2O$$

(a) Calculate the total number of moles of iodine liberated by the 250 cm^3 reaction mixture.

[2]

Step 2:
The student then separately weighed 6.863 g of Vitamin-C tablets and placed them into the 250 cm^3 reaction mixture from **Step 1**. The liberated iodine reacted with the ascorbic acid as follow.

$$C_6H_8O_6 \text{ (ascorbic acid)} + I_2 \rightarrow C_6H_6O_6 \text{ (dehydroascorbic acid)} + 2I^- + 2H^+$$

Step 3:
The student then pipetted 25.0 cm^3 of the reaction mixture from **Step 2** before proceeding with iodometric titration to investigate the amount of iodine which did not react with the ascorbic acid.

$$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$$

He found out that 9.60 cm^3 of 0.0787 mol dm^{-3} sodium thiosulfate was required for the iodometric titration.

(b) **(i)** Using the information provided, calculate the number of moles of iodine that has reacted with the sodium thiosulfate in the 25.0 cm^3 sample in **Step 3**.

[1]

(ii) Hence, determine the amount of iodine that has reacted with ascorbic acid.

[1]

(iii) Using your answer in **(b)(ii)**, determine the percentage by mass of ascorbic acid in the Vitamin-C tablet.

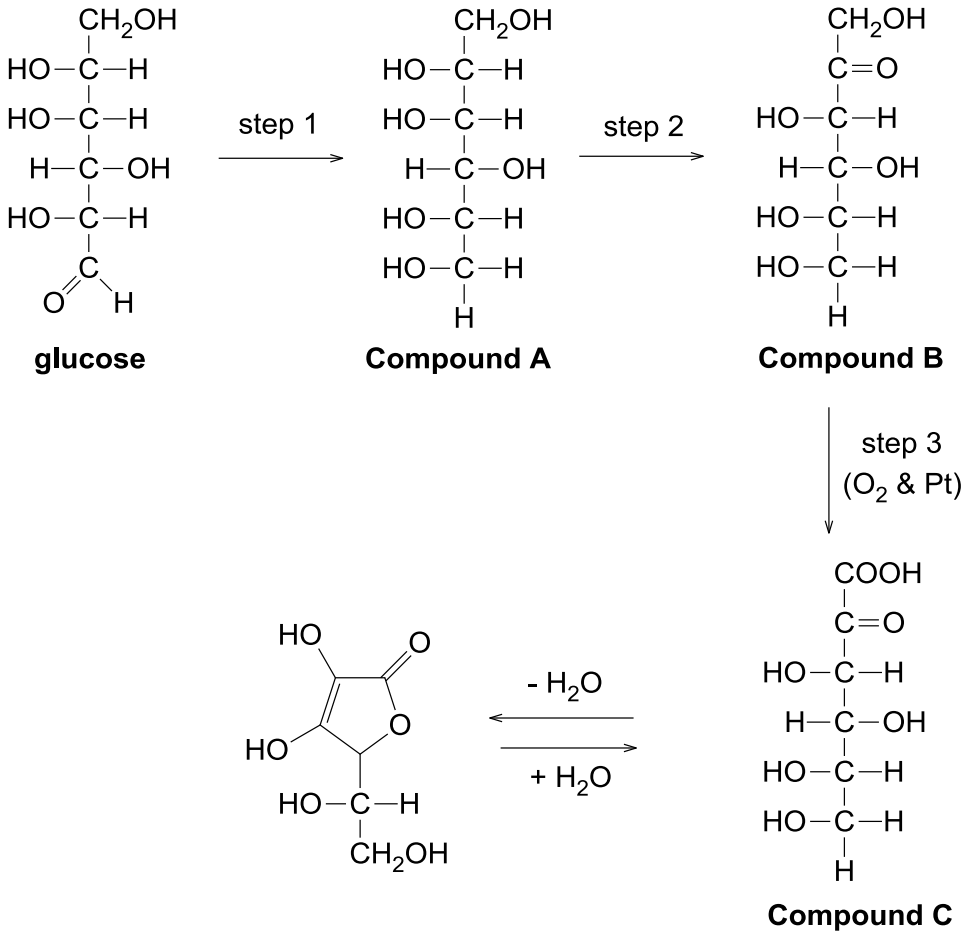
[1]

(c) When hot acidified potassium manganate(VII) is added to ascorbic acid, acidic hydrolysis and oxidation occur simultaneously.

Draw all carbon-containing products.

[2]

(d) The following reaction scheme shows the outdated but historically important synthesis of ascorbic acid from glucose



(i) Suggest the reagents and condition required to convert glucose to compound **A**.

……...

[1]

(ii) State the type of reaction that occurs in step 2.

……..

[1]

(iii) State the functional group that is present in glucose and compound **B** which is not present in compound **A**. Hence, with an aid of a chemical equation, suggest how this functional group can be positively identified.
(You may use either glucose or compound **B** for the equation.)

Functional group: ……

Reagent to use: ……

Observation: ……

……...

Equation:

[4]

(iv) Propose a simple test-tube reaction to differentiate compound **B** and **C**.

……...

……...

……...

.....

[2]

(v) Propose a chemical test to differentiate compound **B** and glucose.

……...

……...

……...

.....

[2]

[Total: 17]

2 (a) Carboxylic acid and alcohol react together in the presence of sulfuric acid to produce ester. The following equilibrium will be established.

$$RCOOH\ (l) + R'OH\ (l) \rightleftharpoons RCOOR'\ (l) + H_2O\ (l)$$

(i) Write an expression for the equilibrium constant, K_c, for the reaction between alcohol and carboxylic acid.

[1]

(ii) State Le Chatelier's Principle and suggest how it can be used to predict the effect of increasing concentration of RCOOH on the equilibrium concentration of RCOOR'.

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[2]

(iii) An alcohol of molecular formula C_3H_8O can react with ethanoic acid to generate the sweet-smelling compound.

Draw two possible structures for the alcohol and state the type of isomerism involved.

Type of isomerism: …….

[3]

(iv) 3.00 moles of ethanoic acid are mixed with 3.00 moles of ethanol. When equilibrium was established, 2.33 moles of ethyl ethanoate are present. The total volume of the reaction mixtures is 1.5 dm^3.

Using the information provided, calculate a value for K_c.

[2]

(v) Given the enthalpy change of formation of the following molecules, calculate the enthalpy change of reaction when ethanoic acid and ethanol undergo esterification process.

Molecules	**$\Delta H^{\ominus}_f$ / kJ mol^{-1}**
Ethanoic acid	-487
Ethanol	-287
Ethyl ethanoate	-481
Water	-286

[2]

(vi) Hence, state the enthalpy change of reaction when ethyl ethanoate undergo acidic hydrolysis

……...

[1]

(vii) Construct a reaction pathway diagram illustrating the acidic hydrolysis of ethyl ethanoate.

[2]

(b) **(i)** Comment on the acidity between ethanoic acid and chloroethanoic acid.

……...
……...
……...
.....
……...
……...
……...
.....

[3]

(ii) State the reagent and condtion required for the formation of chloroethanoic acid from ethanoic acid.

……...

[1]

[Total: 17]

3 (a) (i) Write equations to show the reaction of the elements magnesium and phosphrous with excess oxygen.

……...

……...

[2]

(ii) State the types of structure present in the oxides of magnesium, silicon and phosphorus.

oxide of magnesium: ……

oxide of silicon: ……

oxides of phosphorus:…….. [1]

(iii) Suggest if each of the oxides of magnesium, silicon and phosphorus dissolves in water or undergoes a reaction with water. Write equation, if any, to support your answer.

……...

……...

……...

.....

……....

.....

[3]

[Total: 6]

Section B

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

4 **(a)** Sodium, magnesium, aluminium, silicon, phosphorus and sulfur are elements in Period 3 of the Periodic Table. Sketch and explain the trend for the following:

(i) Atomic radius

[2]

(ii) Melting point

[8]

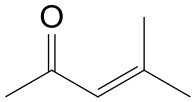
(b) Using equations, suggest what will happen when aluminium oxide and phosphorus pentaoxide are placed in separated test-tubes containing aqueous sodium hydroxide and hydrochloric acid.

[3]

(c) Aluminium chloride is an inorganic substance that can be used in organic chemistry. Suggest, with an equation, the pH of the solution when aluminium chloride undergo hydrolysis with water.

[2]

(d) Compound **E** is an intermediate use in the synthesis of MIBK which is commonly found in paint solvent.



Compound **E**

Draw the structural formula of the products formed when compound **E** undergoes reaction with

(i) Cold alkaline potassium manganate(VII)

[1]

(ii) Hot acidified potassium manganate(VII)

[2]

(e) **(i)** Write a balanced chemical equation illustrating the reduction process when hydrogen gas is bubbled into compound **E**.

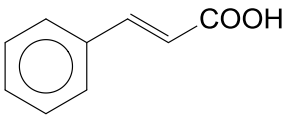
[1]

(ii) Using relevant data from the *Data Booklet*, determine the enthalpy change of reaction for the reduction process in **(e)(i)**.

[1]

[Total: 20]

5 **(a)** Cinnamic acid has a honey-like odour and is obtained from the oil of cinnamon. It has a pK_a of 4.44.



cinnamic acid

(i) Calculate the pH of a 0.1 mol dm^{-3} solution of cinnamic acid. [2]

(ii) Explain with the aid of two balanced equations, how cinnamic acid and sodium cinnamate, acts as a buffer solution.

[You may represent the formula of cinnamic acid by *RCOOH*.]

[2]

(b) A student carried out an experiment to measure the standard enthalpy change of neutralisation between cinnamic acid and sodium hydroxide.

The student added 25.0 cm^3 of 2.5 mol dm^{-3} cinnamic acid to 40.0 cm^3 of 1.5 mol dm^{-3} sodium hydroxide in a polystyrene cup. The maximum temperature rise recorded is 10.4 °C.

Given that the neutralisation process was 85% efficient, calculate the standard enthalpy change of neutralisation for the reaction between cinnamic acid and sodium hydroxide.

[2]

(c) Lithium aluminium hydride is a useful reducing agent in organic chemistry. It can be used to reduce cinnamic acid.

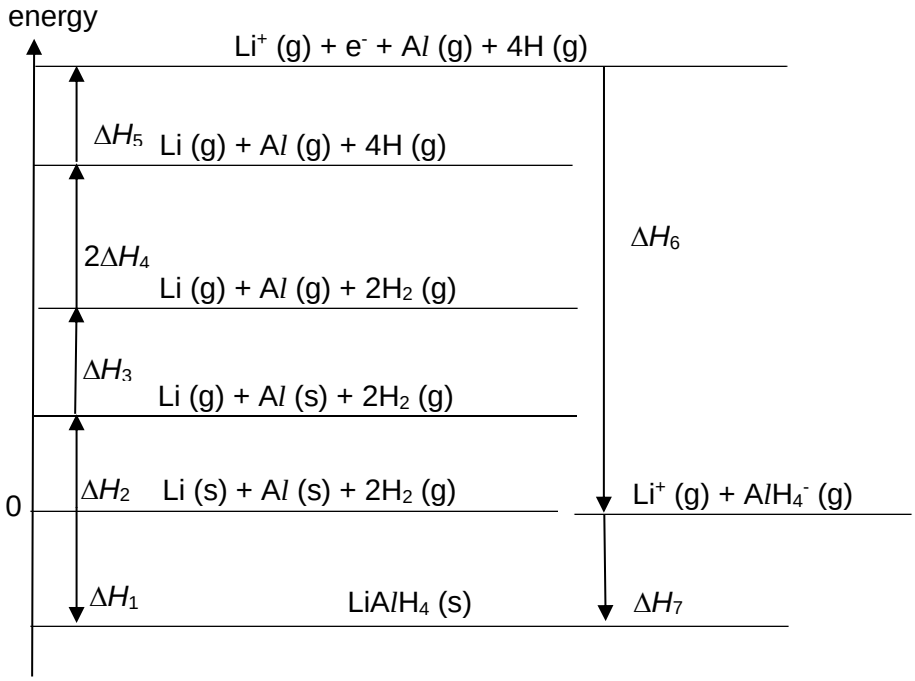
(i) Draw the structure of the product formed from the reduction of cinnamic acid by $LiAlH_4$.

[1]

(ii) The following data will be useful in this question.

	kJ mol^{-1}
Li (s) → Li (g)	+159.5
Al (s) → Al (g)	+314
Al (g) + 4H (g) + e^- → AlH_4^- (g)	-1341
Li^+ (g) + AlH_4^- (g) → $LiAlH_4$ (s)	-640

The enthalpy change of formation of $LiAlH_4$ can be found using the energy cycle below.



In the energy cycle above, what enthalpy change is represented by ΔH_7?

[1]

(iii) Use the *Data Booklet* to obtain the values of the enthalpy change for ΔH_4 and ΔH_5.

[2]

(iv) Use the energy cycle to calculate the enthalpy change of formation of $LiAlH_4$ (s).

[1]

(d) An organic compound **F** has the molecular formula C_4H_7Cl.

F is known to react with the following inorganic chemicals to generate other organic substances.

(1) Hot alcoholic potassium hydroxide to form compound **G**, C_4H_6.

(2) Steam in the presence of acid catalyst to generate compound **H**, C_4H_9ClO.

When compound **G** is reacted with hot acidified potassium manganate(VII), only carbon dioxide and water are produced.

Compound **H** is known to undergo oxidation with acidified potassium dichromate(VI) to produce compound **L**, C_4H_7ClO.

Compound **H** and **L** both produce compound **K**, $C_3H_6O_3$ when heated with sodium hydroxide followed by aqueous iodine with subsequent acidification with dilute hydrochloric acid.

Deduce the identities of **F, G, H, L** and **K**.

[9]

[Total: 20]

6 **(a)** Pure hydrogen peroxide, H_2O_2, was long believed to be unstable. Its decomposition follows a first order reaction.

$$H_2O_2 \rightarrow H_2O + \tfrac{1}{2}O_2$$

(i) Sketch a graph of $[H_2O_2]$ against time and use your graph to show clearly how you could determine the order of reaction with respect to H_2O_2.

[2]

(ii) As H_2O_2 decomposes slowly at room temperature, catalysts such as manganese(IV) oxide are often added. Explain the effect of a catalyst on the rate constant for this reaction.

[2]

(iii) Raising temperatures is another method to increase the rate of decomposition. Use the Maxwell-Boltzmann curve to describe how a higher temperature does so.

[3]

(b) In the presence of UV light, H_2O_2 decomposes to form hydroxyl free radicals, •OH.

(i) Draw the 'dot-and-cross' diagram for H_2O_2.

[1]

(ii) Using relevant data from the *Data Booklet*, suggest the relative rate of the formation of •C*l* from chlorine gas as compared to •OH from hydrogen peroxide.

[2]

(iii) Propylamine, $CH_3CH_2CH_2NH_2$, may be formed via the following reaction pathway involving free radical substitution in the first step.

$$CH_3CH_2CH_3 \xrightarrow[Cl_2,\ uv]{\textbf{Step I}} CH_3CH_2CH_2Cl \xrightarrow{\textbf{Step II}} CH_3CH_2CH_2NH_2$$

State the reagents and condition required in step **II**.

[1]

(iv) As the yield from the reaction in **(b)(iii)** is low, propose a 3-step synthetic route to produce propylamine from ethene instead. Show clearly the reagents and conditions as well as intermediates involved.

[3]

(c) The kinetics of the reaction between hydrogen peroxide and iodide ions in acidic solution was studied.

$$H_2O_2 + 2I^- + 2H^+ \rightarrow 2H_2O + I_2$$

Four separate experiments were carried out to determine the relative rates by varying the concentrations of the reactants. The results obtained are given in the table below.

Expt	$[H_2O_2]$ / mol dm^{-3}	$[I^-]$ / mol dm^{-3}	$[H^+]$ / mol dm^{-3}	relative rate
1	0.03	0.03	0.03	1.0
2	0.05	0.03	0.03	1.6
3	0.05	0.01	0.06	0.53
4	0.03	0.01	0.03	0.33

(i) Use the data to deduce the orders of reaction with respect to H_2O_2, I^- and H^+. Show your working clearly.

[3]

(ii) Hence, write the rate equation and state the units of the rate constant.

[2]

(iii) Unreacted iodide ions may be easily separated by adding silver nitrate solution, followed by filtration. State the identity of the precipitate and its colour.

[1]

[Total: 20]

END OF PAPER