SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	
CLASS	

CHEMISTRY
9647/02

22 Aug 2013
2 hours

Preliminary Examination
Paper 2 Structured Questions (SPA)

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and class 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 work.

Answer **all** questions in the space provided.
You are advised to spend **30 minutes** on question 1.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part questions.

For Examiner's Use	
P1	/40
P2	/72
P3	/80
GRAND TOTAL	/192
%	
GRADE	

For Examiner's Use	
1(P)	/12
2	/12
3	/17
4	/12
5	/7
6	/12
TOTAL P2	/72

This document consists of **16** printed pages

For Examiners' Use

Answer all questions in the space provided

Planning

1 Hard water, or water that contains high mineral content, such as calcium ions, pose serious problems in many industries. Other potential ions that could be present include zinc (through corrosion of pipings) and aluminium ions (whereby aluminium salts are added during the water purification process to start certain precipitation reactions).

You are provided with a water sample that may contain the cations Ca^{2+}, Al^{3+} and Zn^{2+}. The solution may also contain carbonate ions, CO_3^{2-}, and halide ions (either bromide or iodide).

You are given only the following to conduct your test.

Reagent	**Apparatus**
• aqueous ammonia	• tests tubes
• aqueous sodium hydroxide	• funnel
• dilute sulfuric acid	• filter paper

(a) Using the above only, write out a plan to separate each cation into three separate solutions.

In your plan you should:

- give a full description of the procedures you would use;
- indicate the expected observations in each step.

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[5]

For Examiners' Use

(b) A student proposed to use concentrated sulfuric acid instead of dilute sulfuric acid in **(a)**.

(i) Discuss how this change may affect the expected observations in **(a)**.

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(ii) Identify **one** potential safety hazard when the student make this change and state how you would minimise this risk.

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[4]

(c) You are also required to identify the anions present in the solution.

(i) Propose two reagents to identify and distinguish between CO_3^{2-} and halide ion.

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(ii) Outline how you would use your chosen reagents, including conditions, to determine the anions present in the solution.

In your plan you should:

- give a full description of the of the order of adding the reagent;
- quantity of reagent and apparatus used;
- indicate the expected observations.

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[3]

[Total: 12]

For Examiners' Use

2 Iodometry is a technique used to analyse the concentration of an oxidising agent.

To a sample of hydrogen peroxide, excess but known amount of iodide is used which the oxidising agent oxidises the iodide to triiodide ion. The triiodide ion solution is then titrated against standard thiosulfate solution using starch indicator. The reactions are illustrated below.

Reaction 1 : $H_2O_2 + 3I^- + 2H^+ \rightarrow I_3^- + 2H_2O$

Reaction 2 : $I_3^- + 2S_2O_3^{2-} \rightarrow 3I^- + S_4O_6^{2-}$

(a) Iodine exists as a black solid at standard conditions. An aqueous solution of iodine can only be prepared by dissolving iodine in excess potassium iodide, KI (aq) to form a dark reddish-brown solution.

(i) Suggest a reason for the insolubility of iodine in water.

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(ii) Suggest with an equation, how the addition of excess potassium iodide aids in making iodine more soluble.

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(iii) Draw the structure of I_3^- formed and suggest its shape.

Shape: ……

[4]

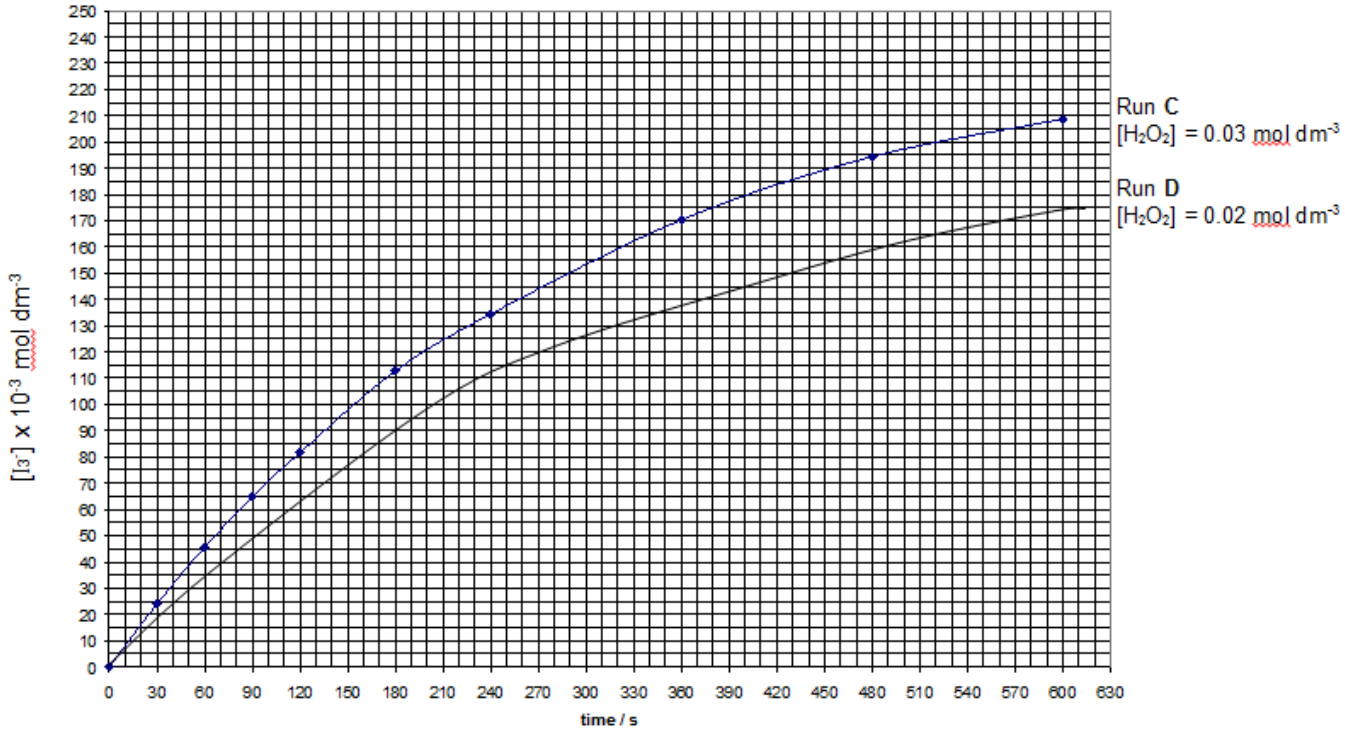
(b) 250 cm^3 of hydrogen peroxide was reacted with acidified iodide ions of various concentrations in a series of experiment named Run **C**.

The concentration of the triiodide liberated at respective times can be determined via the iodometric titration.

Run **C** was conducted with concentration of hydrogen peroxide held constant at 0.0300 mol dm^{-3} while varying the concentration of iodide. It is known that the rate of reaction is independent to hydrogen ions.

The rate of reaction can be measured by the increase in the concentration of triiodide formed over time and it was found out that the maximum concentration of triiodide produced was 240 x 10^{-3} mol dm^{-3} in Run **C**.

The concentration of hydrogen peroxide used in run **D** was 0.0200 mol dm^{-3}.



For Examiners' Use

(i) Using the graph above and relevant information, determine the order of reaction with respect to hydrogen peroxide, iodide and hydrogen ion.

(ii) In run **C**, the excess hydrogen peroxide was titrated with 10.00 cm^3 of 0.10 mol dm^{-3} of acidified potassium manganate(VII).

Determine the total amount of triiodide formed.

[8]
[Total : 12]

For Examiners' Use

3 In the 1970s, a new compound, fukinolic acid, was isolated from the leaves, leaf stems, and flower stalks of the plant, *Petasites japonicus*. Hydrolysis of fukinolic acid produced other compounds, one of which is fukiic acid, $C_{11}H_{12}O_8$.

The data given in the table below are based on **1 mole** of **fukiic acid**.

Reaction	Reagent	Amount required in mol	Observation(s)
1	Potassium metal	6	Colourless gas collected. White solid formed which is soluble in water.
2	Dilute NaOH	4	Colourless solution formed.
3	$Cr_2O_7^{2-}$ / H^+ heat under reflux	1	Unknown compound X (M_r = 270) gives orange precipitate with Brady's reagent.
4	Thionyl chloride	4	Pungent choking gas Thick white fumes obtained which bleaches damp blue litmus.
5	Concentrated HNO_3	3	Yellow liquid formed.
6	$LiAlH_4$ in dry ether	2	Colourless solution formed.
7	Ethanolic $NaBH_4$	1	No reaction

In this question, when identifying the functional groups, your answers should be unambiguous.

(a) Comment if ***fukiic acid*** is aromatic.

.....

.....

[1]

(b) **(i)** State the number of moles of gas formed in reaction **1**.

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(ii) List the likely functional groups present in reaction **1**.

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(iii) Which of the functional group(s) you have named in **(b)(ii)** is confirmed by reaction **4**?

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[4]

For Examiners' Use

(c) **(i)** What is the type of reaction taking place in reaction **2** ?

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(ii) What is the role of the reagents used in reactions **6** and **7**?

……

(iii) Suggest possible reason(s) to the difference in the observations made in reactions **6** and **7**.

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(iv) State which reaction, other than reaction **2**, confirms your deduction of the functional group present in ***fukiic acid***.

Explain your rationale clearly.

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[5]

(d) **(i)** Deduce the molecular formula of unknown **X** formed in reaction **3**.

……..

(ii) What type of reaction takes place when Brady's reagent is added to unknown **X** ?

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(iii) Suggest the functional group(s) present in **(d)(ii)** and make clear, logical deductions from reaction **3** only.

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[5]

For Examiners' Use

(f) You now have enough information to determine the structural formula of ***fukiic acid***.

(i) Propose the structure of ***fukiic acid***.

(ii) Explain clearly why you have placed the functional groups in their particular positions.

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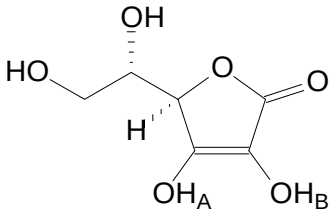
[2]

[Total : 17]

For Examiners' Use

4 Ascorbic acid is an antioxidant commonly found in fruits, better known as vitamin C. Its structure is as shown below.



ascorbic acid
(M_r = 176.0)

When ascorbic acid dissociates in aqueous solution, the proton labelled H_A is released to form the ascorbate ion.

Values of the acid dissociation constant, K_a, for ascorbic acid and other organic acids are given below.

acid	**formula**	**K_a / mol dm^{-3}**
Ascorbic acid	given above	7.9×10^{-5}
Acetic acid	CH_3COOH	1.8×10^{-5}
Formic acid	HCOOH	1.8×10^{-4}

(a) (i) Write the acid dissociation constant expression for ascorbic acid.

(ii) Hence or otherwise, calculate the pH of 0.5 mol dm^{-3} ascorbic acid.

(iii) With the aid of a labelled diagram, explain why H_A is the acidic proton.

……

……

[5]

For Examiners' Use

(b) Kordel's Acid Free C is a health supplement that provides vitamin C in the form of the non-acidic calcium ascorbate. This is suitable for consumption by people with sensitive stomachs who are unable to tolerate vitamin C in its original acidic form.

(i) Write an equation to show how non-acidic vitamin C is effective in controlling acidity levels in the stomach.

(ii) Calculate the pH of a solution of ascorbic acid and calcium ascorbate at its optimal buffering capacity.

(iii) Given that the mass of ascorbic acid used to create the buffer solution in **(b)(ii)** is 5.00 g, find the change in pH when 0.01 g of calcium hydroxide is added to the buffer solution.

[4]

(c) Write balanced equations for any reaction that occurs when calcium ascorbate is added separately to acetic acid and formic acid. If nothing is formed, write 'no reaction' and explain your answer clearly.

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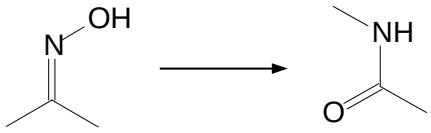
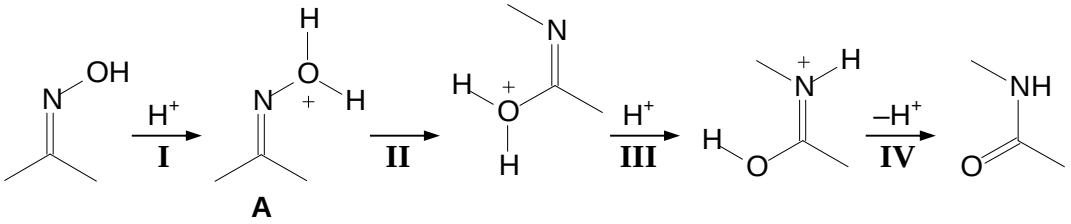
[3]
[Total : 12]

For Examiners' Use

5 **(a)** The Beckmann rearrangement reaction is one useful method of preparing amides by heating an oxime with concentrated sulfuric acid. An example for the synthesis of *N*-methylethanamide is shown below.



The reaction is thought to proceed via the following stages.



(i) Name the type of reaction occurring in step **I**.

……..

(ii) State the oxidation number of nitrogen in compound **A**.

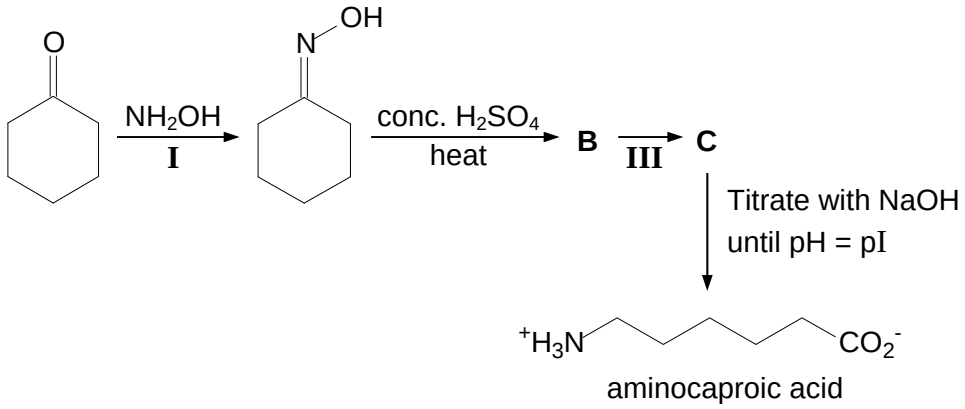
……

(iii) Outline the mechanism occurring in the step **IV**, showing clearly the movement of lone pairs of electrons with the use of curly arrows.

[3]

For Examiners' Use

(b) Aminocaproic acid is commonly used to treat excessive postoperative bleeding. The Beckmann rearrangement can be used as the second step in the synthesis of aminocaproic acid from cyclohexanone.



(i) Suggest the type of reaction occurring in step **I**.

……

(ii) State the reagents and conditions used in step **III**.

……

(iii) Draw the structures of compounds **B** and **C**.

B	**C**

[4]

[Total: 7]

For Examiners' Use

6 (a) Group II alkali metals and its compounds are used extensively. In particular, strontium salts (such as oxides, nitrates and carbonates) are commonly used as an inexpensive colorant in pyrotechnics as they emit brilliant flames when combusted.

(i) State the colour emitted in the combustion of strontium salts.

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(ii) Strontium carbonate acts as a weak Lewis base and can be used to produce strontium nitrate by simple use of the corresponding acid.

Write a chemical equation for the described chemical reaction.

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(iii) 'Despite having similar thermal stabilities, carbonates are generally preferred over nitrates as they are not hygroscopic.'

Explain why nitrates are less preferred.

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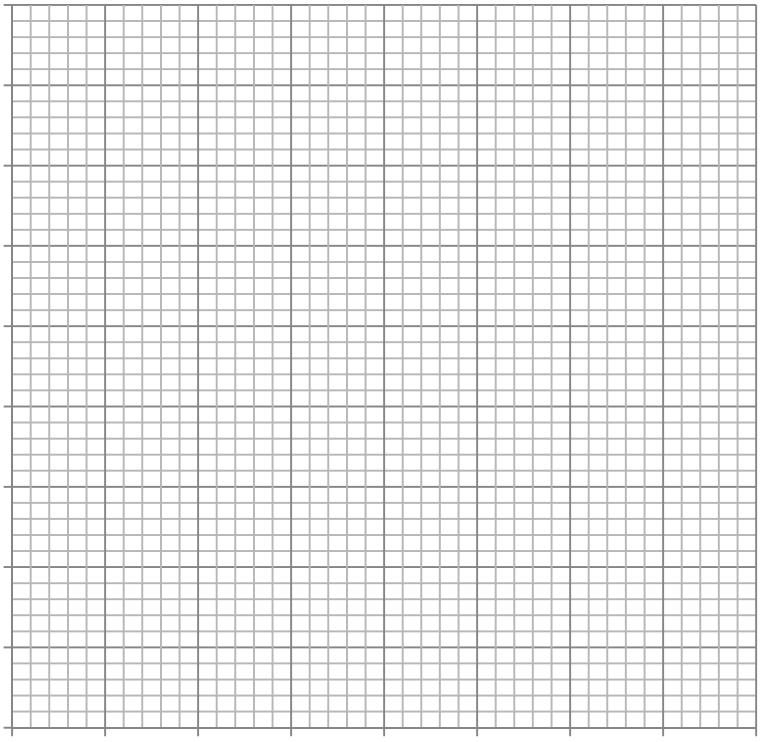
[3]

For Examiners' Use

(b) Group II carbonates decompose in a similar manner as the nitrates. The following table shows the temperature at which group II carbonates decompose.

Carbonate	Ionic radius / nm	Decomposition temperature / K
$MgCO_3$	0.065	523
$CaCO_3$	0.099	1098
$SrCO_3$	0.113	***x***
$BaCO_3$	0.135	1573

(i) Using the given data, plot a graph on the grid provided below for decomposition temperature against ionic radius.



(ii) From your graph, state the decomposition temperature of strontium carbonate.

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(iii) Using your plotted graph, comment on the thermal stability of group II carbonates.

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[6]

For Examiners' Use

(c) Given the following information on strontium oxide and strontium carbonate, construct an energy level diagram to determine the enthalpy change of formation of carbon dioxide gas.

$SrO\ (s) + CO_2\ (g) \rightarrow SrCO_3\ (s)$ $\quad \Delta H = -234\ kJ\ mol^{-1}$

$2SrO\ (s) \rightarrow 2Sr\ (s) + O_2\ (g)$ $\quad \Delta H = +1184\ kJ\ mol^{-1}$

$2SrCO_3\ (s) \rightarrow 2Sr\ (s) + 2C\ (s) + 3O_2\ (g)$ $\quad \Delta H = +2440\ kJ\ mol^{-1}$

$\Delta H_{f\ (CO2)}$ = _____ $kJ\ mol^{-1}$

[3]

[Total : 12]

END