SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME

CLASS

CHEMISTRY **8872/02**
JC 2 Preliminary examination **20 August 2015**
Paper 2 **2 hours**

Additional Materials: Data Booklet
Writing paper

READ THESE INSTRUCTIONS FIRST

Candidates answer on the question paper.

Write your name and class on all the work you hand in.

Write in dark or blue pen.

Do not use paper clips, glue or correction fluid.

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

At the end of the examination, fasten all your work securely together.

FOR EXAMINER'S USE		
P1 (MCQ)		30
P2	A1	8
	A2	9
	A3	16
	A4	7
	B5	20
	B6	20
	B7	20
Total		110

This document consists of **13** printed pages and **3** blank page.

For Examiner's use

Section A

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

1 Elements **A**, **B**, **C**, **D** and **E** are five consecutive elements from Period 3 and 4 of the Periodic Table. The following shows the successive ionisation energies of element **C**.

No. of electrons removed	1	2	3	4	5	6	7	8
Ionisation energy / kJ mol^{-1}	1260	2300	3850	5150	6542	9362	11018	33604

(a) **(i)** Deduce and explain which group element **C** belongs to.

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(ii) Hence, state the identity of element **C** and write down its electronic configuration.

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[4]

(b) Explain the following observations, giving equations where appropriate.

(i) The first ionisation energy of element **B** is lower than the first ionisation energy of element **A**.

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For Examiner's use

(ii) A strongly acidic solution is formed when the chloride of **A** reacts with water.

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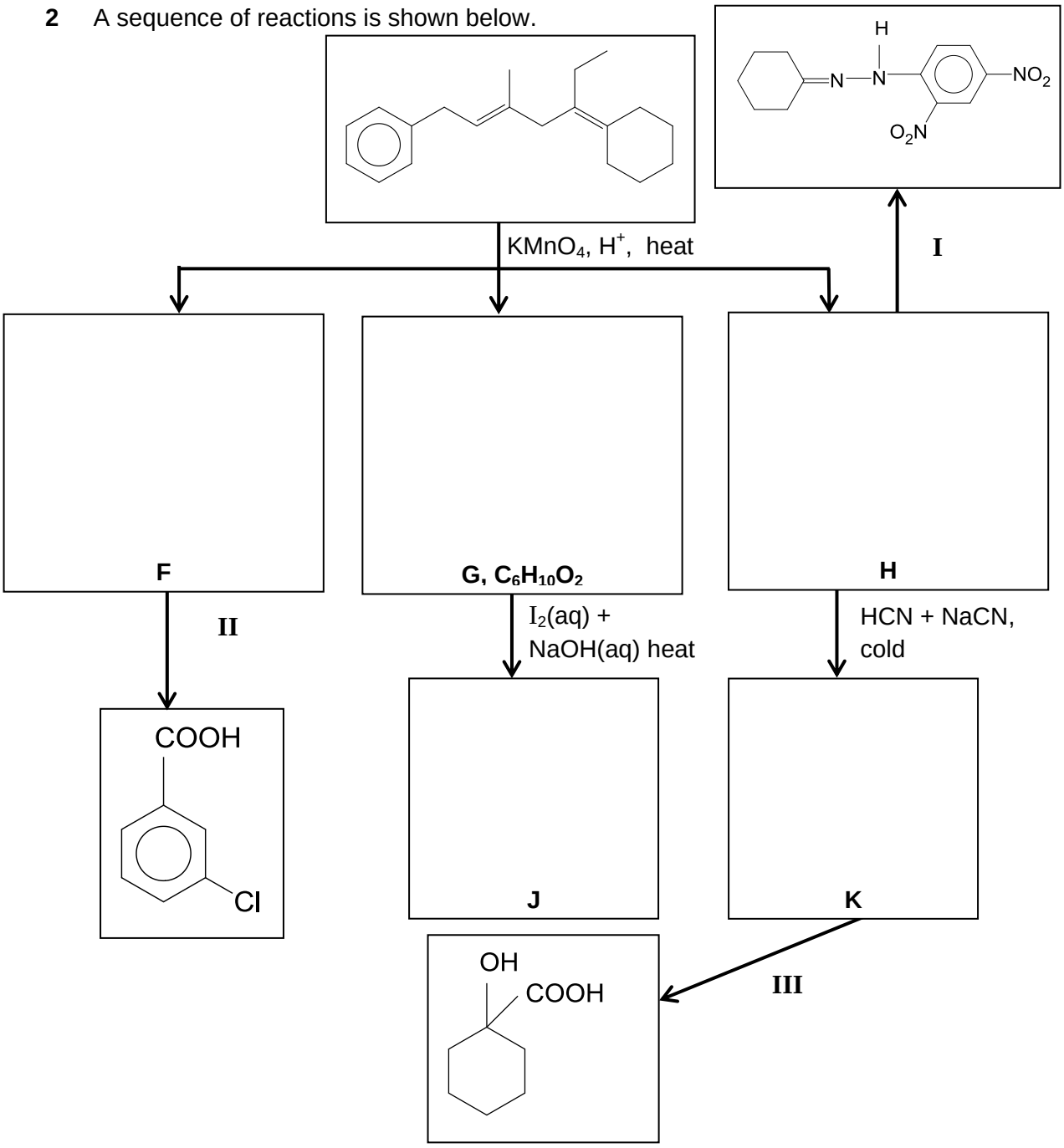
[4]

[Total: 8]

For Examiner's use

2 A sequence of reactions is shown below.



(a) In the appropriate boxes draw the structures of compound **F**, **G**, **H**, **J** and **K**.

(b) For the reaction in the scheme shown above state

(i) the reagents and conditions for reactions **II** and **III**,

Reaction **II:** ……..

Reaction **III:** ……..……..

(ii) the type of reaction for reactions **I** and **III**.

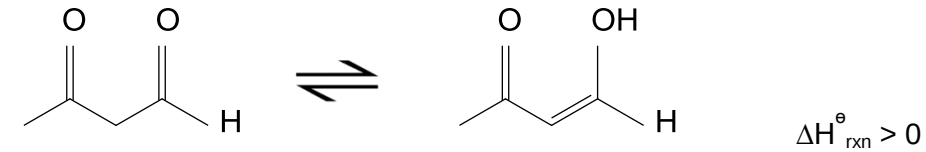
Reaction **I:** ……....

Reaction **III:** ……..

[Total: 9]

3 Aldehydes are commonly used to produce resins to make plastics and adhesives. It exists in equilibrium with its isomer, enol through a process called enolization. The reaction involves the transfer of one proton and the shift of the double bond. An example of enolization of acetaldehyde is shown below.

For Examiner's use



acetylacetaldehyde enol

$\Delta H^{\ominus}_{rxn} > 0$

(a) (i) Write an expression for the equilibrium constant, K_c, for this reaction.

(ii) It was found that 76% of acetylacetaldehyde exist as an enol when dissolved in water. Calculate the equilibrium constant, K_c, for this reaction.

(iii) Explain the significance of this value on the equilibrium position and the relative concentrations of the two species present at equilibrium.

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(iv) Suggest what will happen to the composition of the equilibrium mixture when the system is heated.

For Examiner's use

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[6]

(b) Acetylacetaldehyde can undergo oxidation with potassium dichromate(VI) under heat to form a carboxylic acid.

(i) Write two **redox** half-equations to represent the reaction between acetylacetaldehyde and $Cr_2O_7^{2-}$ ions and prove that the overall equation is as follows:

$$3CH_3COCH_2CHO + Cr_2O_7^{2-} + 8H^+ \rightarrow 3CH_3COCH_2COOH + 4H_2O + 2Cr^{3+}$$

(ii) 8 cm^3 of liquid acetylacetaldehyde was dissolved in water and made up to 250 cm^3. 25.0 cm^3 of this solution was titrated with 0.10 mol dm^{-3} acidified potassium dichromate(VI). Given that the density of acetylacetaldehyde is 0.956 g cm^{-3}, calculate the volume of potassium dichromate(VI) required to complete the titration.

(iii) Propose a simple chemical test that allows you to confirm the presence of acetylacetaldehyde and state any observations clearly.

For Examiner's use

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[6]

(c) **(i)** Deduce which of the two acids, CH_3COCH_2COOH or $CH_3COCHCl COOH$, has a higher pK_a value.

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(ii) Propose a simple test-tube test which can be achieved in the school laboratory to differentiate CH_3COCH_2COOH from $CH_3COCHCl COOH$.

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[4]
[Total: 16]

For Examiner's use

4 Aluminium reacts with fluorine, chlorine and oxygen to form aluminium fluoride, aluminium chloride and aluminium oxide respectively.

(a) Using chemical equations only, explain the action of water on aluminium chloride and suggest a pH value of the solution.

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[2]

(b) The melting point of aluminium fluoride, aluminium chloride and aluminium oxide is 1291°C, 192°C and 2072°C respectively. Using bonding and structure, explain the differences in their melting points.

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[3]

(c) Write chemical equations to show how aluminium oxide reacts separately with hydrochloric acid and sodium hydroxide.

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[2]

[Total: 7]

Section B

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

5 2-bromobutane is an isomer of 1-bromobutane. It is an irritant and harmful when ingested.

(a) (i) 2-bromobutane reacts with aqueous sodium hydroxide. The product **M**, $C_4H_{10}O$, formed is commonly used as fuel, cleaning agent and paint remover. Write a balanced chemical equation showing the production of **M** and state the type of reaction that has taken place.

(ii) Gaseous form of product **M** can be combusted to carbon dioxide and water according to the following equation.

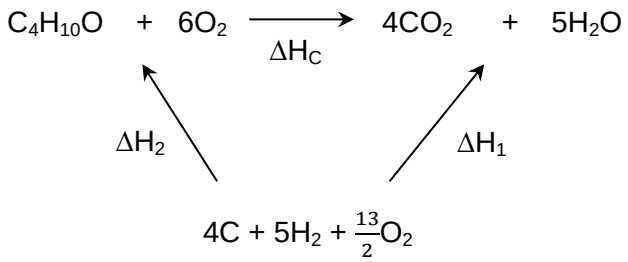
$$C_4H_{10}O\ (g) + 6O_2\ (g) \rightarrow 4CO_2\ (g) + 5H_2O\ (l)$$

Using bond energy from the *Data Booklet*, calculate the enthalpy change of combustion, in kJ mol^{-1}. Leave your answer to **four** significant figures.

(iii) Hence, using relevant data from the *Data Booklet*, determine the mass of the product **M** required to boil 100 cm^3 of water from 25°C given that the process efficiency is 80%.

[6]

(b) (i)



Compound	ΔH^{θ}_f / kJ mol^{-1}
$CO_2(g)$	-394
H_2O (*l*)	-286

Use the energy cycle above, your results from **(a)(ii)** and the standard enthalpy changes of formation in the table above to calculate the enthalpy change of formation of $C_4H_{10}O$.

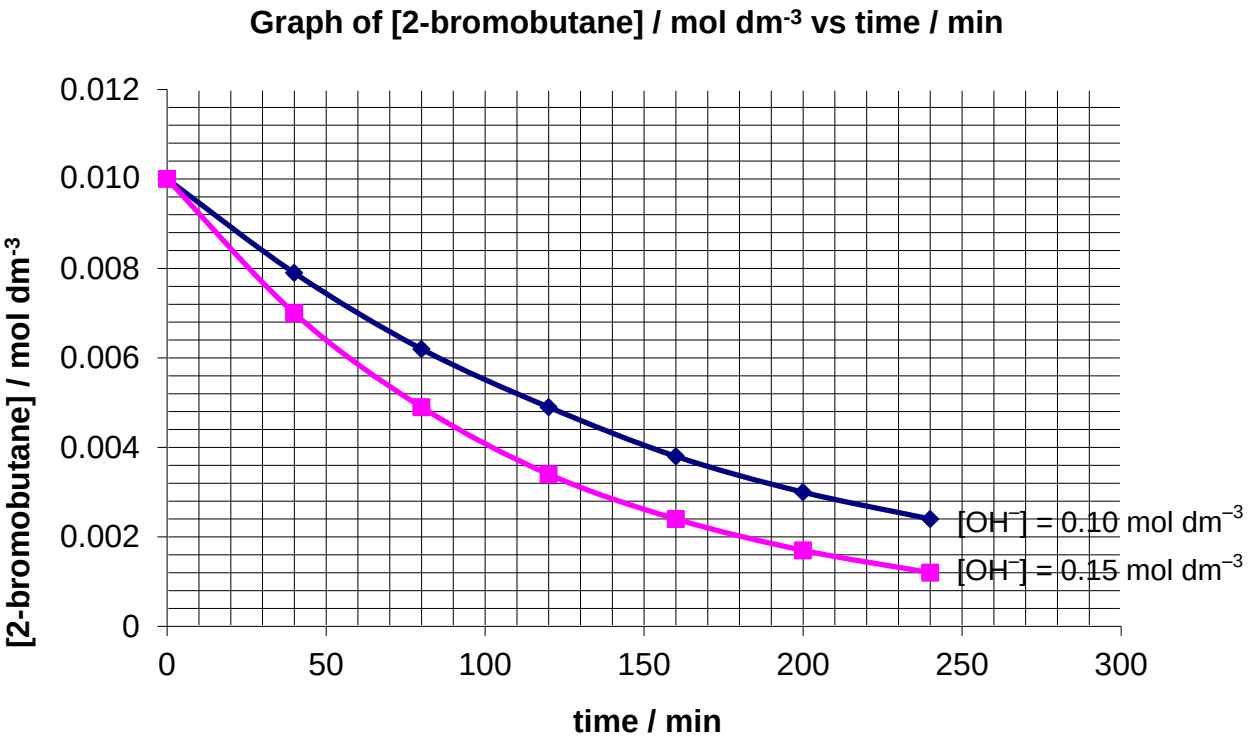
(ii) Using your answer from **(b)(i)**, construct a reaction pathway diagram for the formation of product **M**.

[4]

(c) Product **M** from **(a)(i)** was reacted with hot concentrated sulfuric acid to form compound **Q**, **R** and **S.** Draw the structural formula of **Q**, **R** and **S** and suggest the different types of isomerism present between them.

[4]

(d) The experimental results obtained from two experiments between 2-bromobutane and aqueous sodium hydoxide were plotted on the graph below.

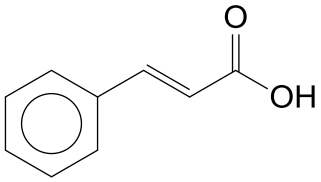


(i) Use the graph to determine the order of reaction with respect to bromoalkane and sodium hydroxide. Justify your answer in each case.

(ii) Determine the rate constant for this reaction and state its units.

[6]
[Total: 20]

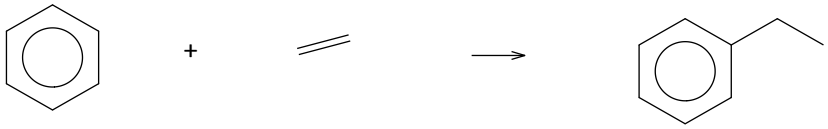
6 Styrene is the precursor in the production of useful plastic material polystyrene. The first synthetic pathway used for the preparation of styrene involves cinnamic acid as its main reagent. This method was eventually ceased due to its high production cost and low solubility of cinnamic acid in organic solvent.



Cinnamic acid

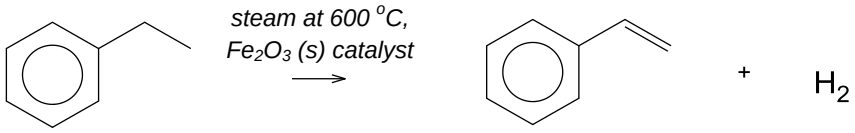
Currently, more than 99% of styrene is produced from ethylbenzene. In **Stage 1**, benzene combines with ethene in an acid-catalysed chemical reaction as shown below.

Stage 1:



Next, gaseous ethylene is mixed in high-temperature steam and passed over a solid iron (III) oxide catalyst bed to produce styrene:

Stage 2:



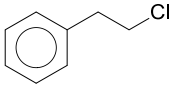
Styrene

(a) **(i)** State the types of reaction undergone in **Stage 1** and **Stage 2.**

(ii) Using the concept of hybridisation, suggest if styrene is a planar molecule.

(iii) Using bonding and structure, explain why cinnamic acid is not soluble in organic solvent.

(iv) Cinnamic acid can be synthesized in three steps, whereby one of the steps involves the reagents and conditions in **Stage 2**.

Propose this synthetic pathway with the use of (chloroethyl)benzene, 

as the starting material.

(v) Describe a simple chemical test to distinguish cinnamic acid and styrene. State any observations clearly.

(vi) Using an appropriate sketch of the Boltzmann distribution curve, explain how the use of iron (III) oxide affects the rate of reaction in **Stage 2**.

[12]

(b) Ethylbenzene is treated with bromine under different conditions to form two isomeric bromides, **T** and **U**.

- When **T** undergoes reflux with acidified potassium manganate (VII), **X** with a molecular formula $C_7H_5BrO_2$ is formed.
- **U** reacts with hot alcoholic sodium hydroxide to give styrene, $C_6H_5CH{=}CH_2$.

U was subjected to further reaction via a 2-step reaction pathway.

$$\mathbf{U} \xrightarrow{\text{Step I}} \mathbf{V} \xrightarrow{\text{Step II}} \mathbf{W}$$

- Both **V** and **W** produces a pale yellow precipitate with warmed with alkaline aqueous iodine.
- **W** reacts with 2,4-dinitrophenylhydrazine to give an orange precipitate but does not react with Fehling's solution.

(i) Explain why **W** reacts with with 2,4-dinitrophenylhydrazine but does not react with Fehling's solution.

(ii) State the reagents and conditions for Step **I** and **II**, and hence suggest the structural formulae of **V** and **W**.

(iii) Hence, write a balanced chemical equation for the reaction in step **II**.

(iv) Draw the structures of **T** and **X.**

[8]

[Total: 20]

7 **(a)** Lactic acid is a monoprotic acid with the formula $CH_3CH(OH)CO_2H$ (*Mr = 90.0*) and is found primarily in sour milk products, such as yogurt and cheese. It has been registered as an anti-bacterial agent. In solution, lactic acid ionises a proton from the carboxyl group producing the lactate ion.

(i) The percentage of lactic acid in food product can be calculated using the following formula.

$$\%\text{Latic acid} = \frac{\text{volume of alkali (dm}^3) \times \text{ concentration of alkali (mol dm}^{-3}) \times 9}{\text{weight of sample (g)}}$$

Using the formula, calculate the percentage of lactic acid present in a sample of 20 g yogurt dissolved in 20 cm^3 of distilled water which required 25.0 cm^3 of 0.500 mol dm^{-3} of sodium hydroxide for complete neutralisation. Leave your answer to **4** significant figures.

(ii) Using your answer in **(a)(i)**, prove that the concentration of the lactic acid in the yogurt is about 6.00×10^{-4} mol dm^{-3}.

(iii) Given that the pH of the yogurt is 4.72, justify why lactic acid is classified as a weak acid.

(iv) With the aid of chemical equations, show how a solution containing equal concentration of lactic acid and sodium lactate moderates the pH when small amounts of acid or base is added.

(v) Calculate the pH of the solution when an **additional** 30 cm^3 of sodium hydroxide was added to the sample of the yogurt mentioned in **(a)(i).**

(vi) With an aid of a diagram, explain why lactic acid has an apparent relative molecular mass of 180.0 in an organic solvent.

[11]

(b) State the type of reaction that has occurred and predict the product(s) when lactic acid undergoes the following reaction. You are to include balanced chemical equations in your answer.

(i) Lactic acid reacts with ethanol in the presence of hot concentrated sulfuric acid to form two organic products.

(ii) Lactic acid reacts with lithium aluminium hydride in dry ether to form compound **Z**.

[6]

(c) **(i)** Compound **Z** from **(b)(ii)** can be formed from an alkene. Name the alkene and suggest the reagent and conditions required for the reaction.

(ii) Suggest reagent and conditions on how the alkene mentioned in **(c)(i)** can be converted into a saturated hydrocarbon.

[3]

[Total: 20]

END OF PAPER