TEMASEK JUNIOR COLLEGE

PRELIMINARY EXAMINATIONS

HIGHER 1

CANDIDATE NAME	**ANSWERS**
CIVICS GROUP	/
CENTER NUMBER	S
INDEX NUMBER	

CHEMISTRY **8872/02**

Paper 2 **1 September 2015**

2 hours

Candidates answer section A on the Question Paper.

Additional Materials: Answer Paper, Graph Paper

Data Booklet

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** 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 or part question.

For Examiner's Use	
A1	/ 10
A2	/ 10
A3	/ 10
A4	/ 10
Section B	/ 40
Paper 1	/ 30
Total	

This document consists of **16** printed pages.

For examiner's use

1 (a) An acidified solution of $KClO_2$ oxidises $Fe^{2+}(aq)$ to $Fe^{3+}(aq)$. When 0.150 g of $KClO_2$ reacted with 0.500 mol dm^{-3} $Fe^{2+}(aq)$ in the presence of $H^+(aq)$, 11.30 cm^3 of $Fe^{2+}(aq)$ was needed for complete reaction.

(i) Suggest the final oxidation state of chlorine after complete reaction. Show your workings clearly.

- **No of moles of Fe^{2+} = $\frac{11.30}{1000}$ x $0.500 = 0.00565$ mol**

  No of moles of $KClO_2$ = $\frac{0.150}{106.6}$ =0.00141 mol

- **Mole ratio of $KClO_2$;Fe^{2+} = 0.00141:0.00565**
  = 1: 4

  $KClO_2 \equiv 4Fe^{2+}$

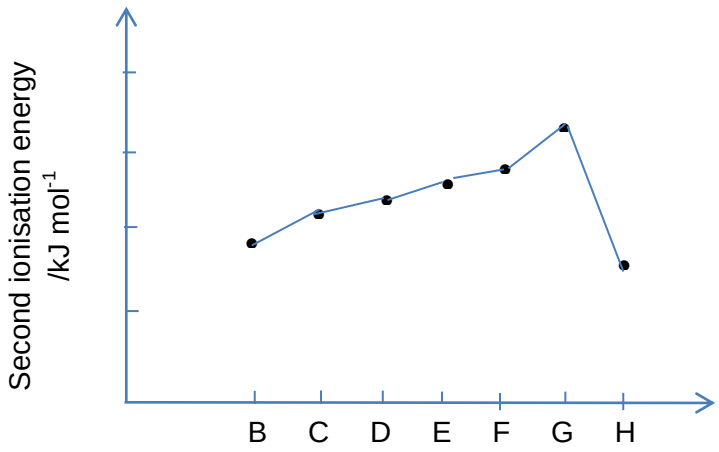
- **$KClO_2$ gained 4e, since in $KClO_2$ is Cl is +3 oxidation state and final state of Cl is -1**

(ii) State the full electronic configuration of Fe^{3+}.

- **$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$**

[4]

(b) The research student was given the second ionisation energies of seven consecutive elements in the Periodic Table as shown below:



(i) Define, with the aid of an equation, what is meant by *second ionisation energy of element* ***B***.

- **Second ionisation energy of element B is the <u>minimum energy</u> required to completely remove <u>one mole of valence electrons</u> from <u>one mole of ground state ions</u> in the gaseous state to form doubly charged gaseous ions.**
- **$B^+(g) \rightarrow B^{2+}(g) + e$**

For examiner's use

(ii) With reference to the graph above, deduce the Group of the *Periodic Table* to which **B** is likely to belong. Explain your answer.

- **Element H has a lower second ionisation energy than element G so the second electron is removed from outer quantum shell and element H is a group II element.**
- **Element B is in Group IV.**

OR

- **Element G has the largest second ionisation energy so the second electron is removed from inner quantum shell and element G is a group I element.**
- **Element B is in Group IV.**

[4]

(c) When the student passed a beam of protons through an electric field, it deflected 12° towards the negative plate.

Under identical conditions, the student passed a beam of doubly charged particles **J** through the electric field. The angle of deflection was found to be 1.5° towards the positive plate.

Identify the ion **J**.

since J is doubly charged and the deflection is towards the positive plate : J^{2-}

$$\textbf{angle of deflection} \propto \frac{\textbf{charge}}{\textbf{mass}}$$

- **mass of J^{2-} = (12 x 2) / 1.5 = 16**
- **J is O^{2-}**

[2]

[Total: 10]

For examiner's use

2 **(a)** Acid rain has harmful effects on aquatic animals, plants and infrastructure. It contains sulfuric acid formed from sulfur trioxide. Sulfur trioxide is produced upon atmospheric oxidation of sulfur dioxide from coal burning.

(i) Write an equation for the formation of sulfuric acid from sulfur trioxide.

- **$SO_3 + H_2O \rightarrow H_2SO_4$**

Even before the existence of acid rain, unpolluted rain water was slightly acidic due to dissolved CO_2. The solubility of *pure* carbon dioxide gas in water is 88 cm^3 per 100 cm^3 of water under room conditions.

(ii) Given that air contains 0.033% by volume of carbon dioxide, calculate the concentration in mol dm^{-3} of carbon dioxide dissolved in unpolluted rain water.

If air contains 0.033% by volume of carbon dioxide,

- **Volume of CO_2 dissolved per 100 cm^3 water = $\frac{0.033}{100} \times 88 = 0.0290$ cm^3**
- **No. of moles of CO_2 dissolved per 100 cm^3 water = $\frac{0.0290}{24000} = 1.21 \times 10^{-6}$ mol**
- **Concentration of dissolved CO_2 in water = $\frac{1.21 \times 10^{-6}}{\frac{100}{1000}} = 1.21 \times 10^{-5}$ mol dm^{-3}**

Dissolved carbon dioxide forms carbonic acid in water, causing the pH of unpolluted rain water to be 5.63.

(iii) Calculate the $[H^+]$ in unpolluted rain water.

pH = -lg$[H^+]$ = 5.63

- **$[H^+] = 10^{-5.63} = 2.34 \times 10^{-6}$ mol dm^{-3}**

Some fishes and shellfish die at low pH values. Lakes with limestone-rich soil can maintain a relatively stable pH even when acid rain falls due to the HCO_3^-/CO_3^{2-} buffer system.

(iv) With aid of an equation, explain how lakes with limestone-rich soil maintain a relatively stable pH in presence of acid rain.

- **$CO_3^{2-} + H^+ \rightarrow HCO_3^-$**
  The base, CO_3^{2-} (from limestone), reacts with H^+ to form HCO_3^-. <u>Negligible changes in pH as H^+ ions are removed</u>.

[6]

(b) Oxides and halides of Period 3 elements have many applications.

A farmer intends to add a magnesium-containing compound to his farmland to correct magnesium deficiency and raise soil pH.

(i) Suggest whether the farmer should add magnesium oxide or magnesium chloride to his farmland.

- **Magnesium oxide**

For examiner's use

(ii) Explain your answer in **(b)(i)** by describing the reactions of the compound suggested with water and acid. Write equations where appropriate and state the pH of the solution formed when the compound is dissolved in water.

- **MgO reacts with water to a very small extent (or almost insoluble in water) due to its high lattice energy, forming magnesium hydroxide, $Mg(OH)_2$, which is sparingly soluble. <u>pH of solution formed is 9</u>.**

- **$MgO(s) + H_2O(l) \rightleftharpoons Mg(OH)_2(aq)$**

MgO also raises pH by removing/reacting with acid to form salt and water.

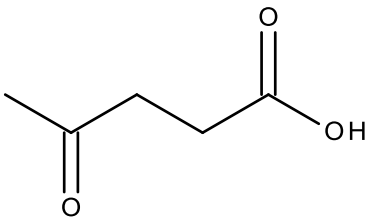
- **$MgO(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O(l)$**

[4]

[Total: 10]

For examiner's use

3 (a) Levulinic acid is a keto-acid which is derived from degradation of cellulose and is a potential precursor to biofuels.



Levulinic acid

(i) Arrange pentanoic acid, levulinic acid and pentan-1-ol in order of increasing pK_a, explaining your answer.

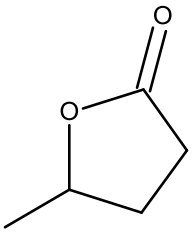
● Levulinic acid < pentanoic acid < pentan-1-ol

● Levulinic acid and pentanoic acid are both carboxylic acids and are stronger acids than pentan-1-ol which is an alcohol as the carboxylate anions are <u>stabilised</u> by the delocalisation of the <u>negative charge over the two oxygen atoms</u>. Levulinic acid has an <u>electron-withdrawing carbonyl group which further disperses the negative charge</u> of the carboxylate ion, thereby stabilising it and hence it is the strongest acid.

● The <u>negative charge on the alkoxide is localised on the oxygen</u> and the <u>alkyl group ($CH_3CH_2CH_2CH_2^-$) is electron-releasing</u> which intensifies the charge. Thus, pentan-1-ol is less acidic than both levulinic acid and pentanoic acid.

(ii) Carboxylic acids are often used as precursors in the synthesis of esters.

Devise a 2-step synthesis to convert levulinic acid to the cyclic ester shown below. Suggest the reagent and conditions used in each step and the structural formula of the intermediate formed.



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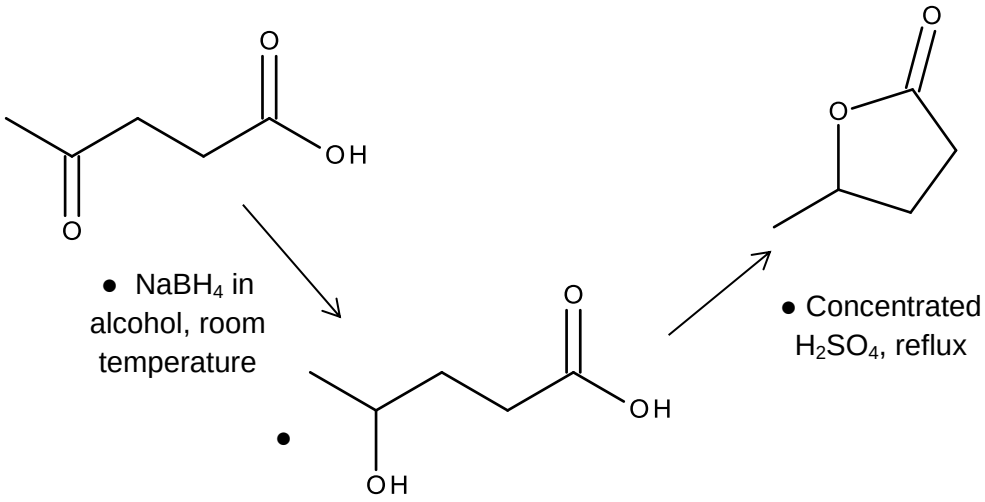
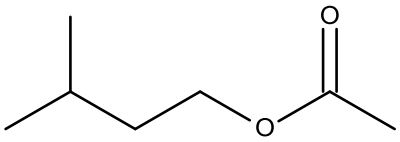


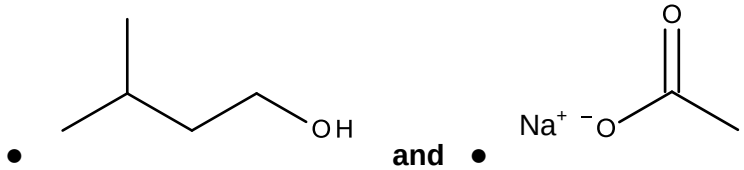
[6]

(b) Another ester, isopentyl acetate, is responsible for the smell associated with bananas. It is used as flavouring in a variety of processed foods such as cakes and sweets.



Isopentyl acetate

(i) Draw the structure of the organic compounds formed when isopentyl acetate is heated with NaOH(aq).



(ii) Isopentyl acetate is found to be only slightly soluble in water. In terms of structure and bonding, suggest an explanation for this.

Both isopentyl acetate and water have <u>simple molecular structures</u>.

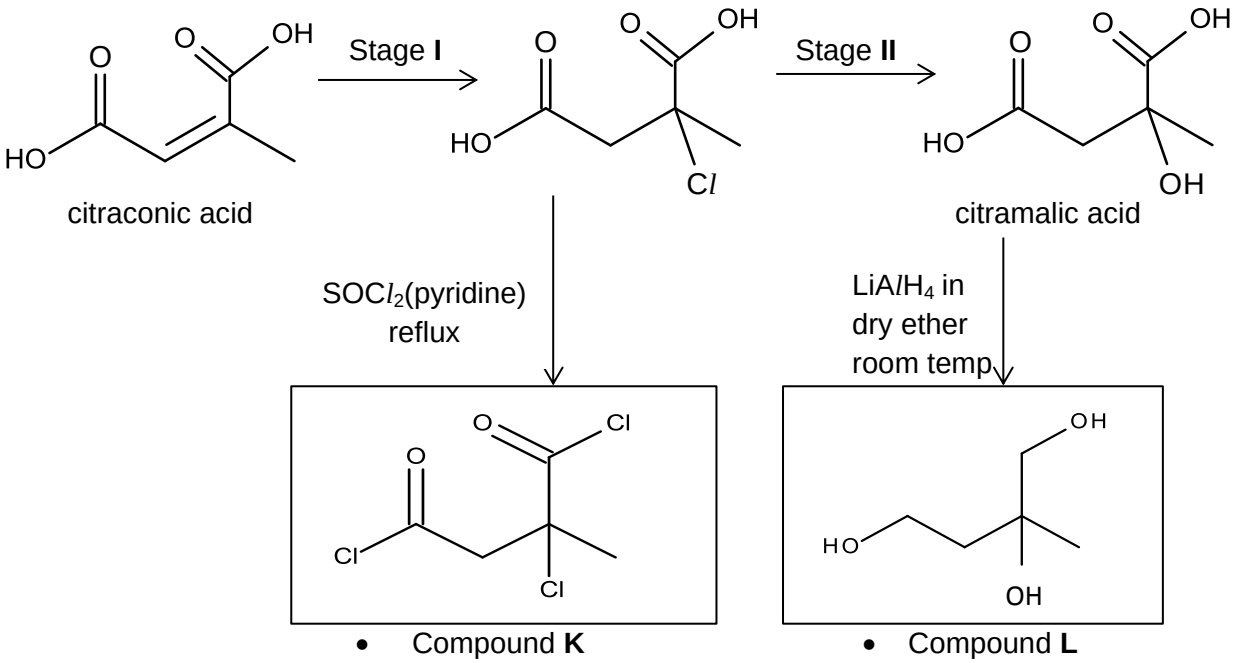
The <u>energy released from the hydrogen bonding/van der Waals' interaction</u> formed between isopentyl acetate and water molecules <u>release insufficient energy to overcome the van der Waals interaction</u> between isopentyl acetate molecules and <u>hydrogen bonding between water molecules</u>. Therefore, isopentyl acetate is only slightly insoluble in water.

●● 1 m for the three interactions, 1 m for explanation in terms of energy released. [4]

[Total: 10]

For examiner's use

4 Citramalic acid can be obtained from citraconic acid. Citraconic acid is used as a fire retardant. The following reaction scheme shows some of the reactions of citraconic acid.



(a) State the functional groups present in citramalic acid. [1]

- **Carboxylic acid and tertiary alcohol**

(b) State the reagents and conditions needed for Stages **I** and **II**. [3]

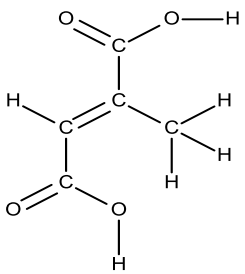
	Reagents and Conditions
Stage **I**	• **HC*l*(g), room temperature**
Stage **II**	• **NaOH(aq), reflux,** • **followed by H_2SO_4(aq)**

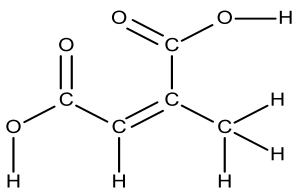
(c) State the type of reaction for Stage I and Stage II. [2]

- **Stage I : Electrophilic addition**
- **Stage II: Nucleophilic Substitution**

(d) Draw the structures of the organic compounds **K** and **L** in the boxes in the scheme. [2]

(e) Draw the displayed formula for the stereoisomers of citraconic acid. [2]





[Total: 10]