



**SERANGOON JUNIOR COLLEGE**  
**General Certificate of Education Advanced Level**  
**Higher 1**

**CANDIDATE  
NAME**

**CLASS**

**CHEMISTRY**  
**JC 2 Preliminary examination**  
**Paper 2**

**8872/02**  
**20 August 2015**  
**2 hours**

Additional Materials: Data Booklet

**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		
<b>P1 (MCQ)</b>		
		<b>30</b>
<b>P2</b>	<b>A1</b>	<b>8</b>
	<b>A2</b>	<b>9</b>
	<b>A3</b>	<b>16</b>
	<b>A4</b>	<b>7</b>
	<b>B5</b>	<b>20</b>
	<b>B6</b>	<b>20</b>
	<b>B7</b>	<b>20</b>
<b>Total</b>		<b>110</b>

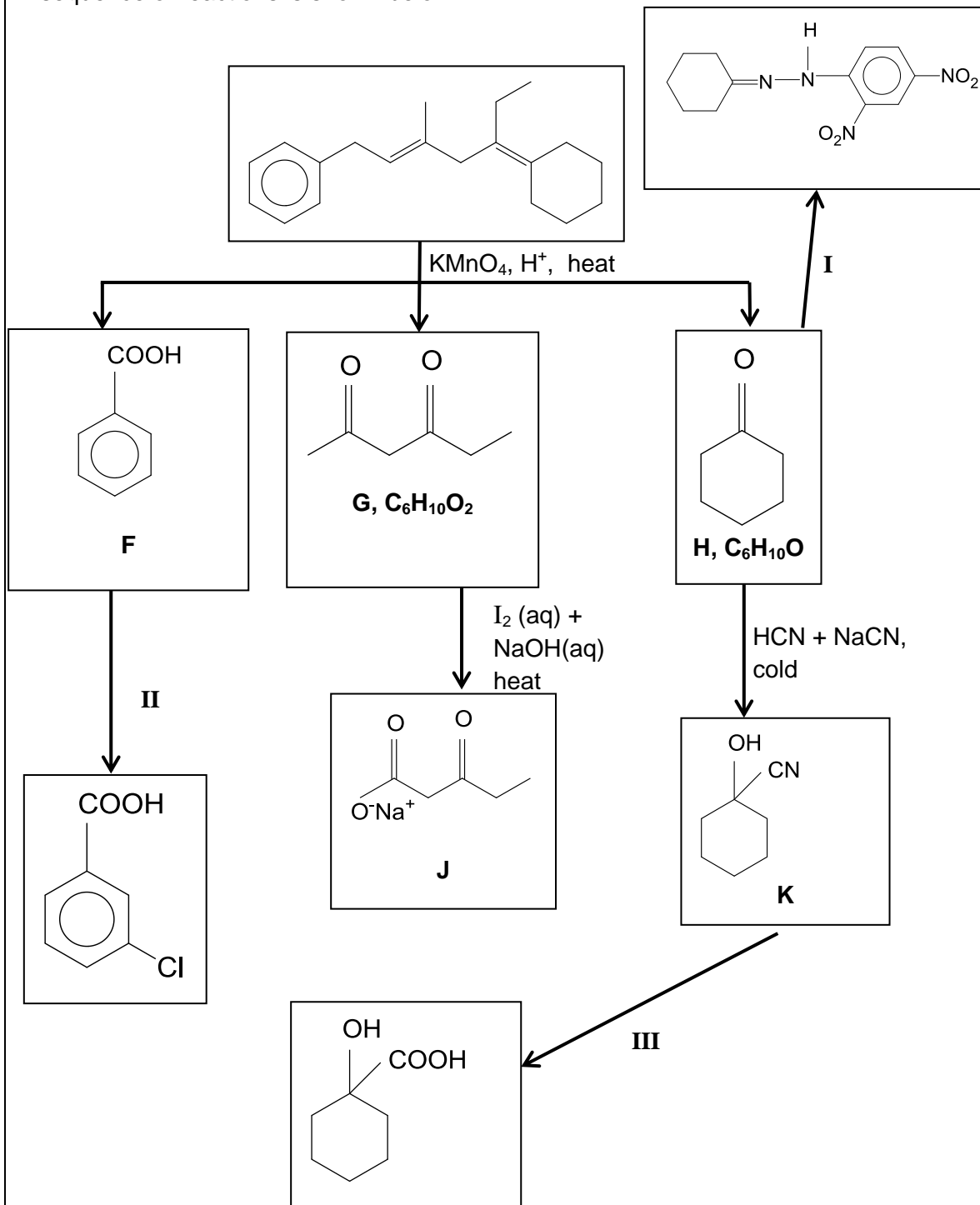
This document consists of **13** printed pages and **3** blank page.

## Section A

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

1	Elements <b>A</b> , <b>B</b> , <b>C</b> , <b>D</b> and <b>E</b> are five consecutive elements from Period 3 and 4 of the Periodic Table. The following shows the successive ionisation energies of element <b>C</b> .									
	No. of electrons removed		1	2	3	4	5	6	7	8
	Ionisation energy / kJ mol <sup>-1</sup>		1260	2300	3850	5150	6542	9362	11018	33604
(a)	(i)	Deduce and explain which group element <b>C</b> belongs to.								[2]
		<b>Group VII.</b>  <b>Largest jump in ionisation energy from 7<sup>th</sup> to 8<sup>th</sup> electron.</b> Thus, there are 7 valence electrons. The <b>8<sup>th</sup> electron is located in an inner principal quantum shell</b> nearer the nucleus, thus experience stronger electrostatic forces of attraction, requiring much more energy to remove.								
	(ii)	Hence, state the identity of element <b>C</b> and write down its electronic configuration.								[2]
		<b>Chlorine</b> . Electronic configuration: <b>1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>5</sup></b> .								
(b)	Explain the following observations, giving equations where appropriate.									
	(i)	The first ionisation energy of element <b>B</b> is lower than the first ionisation energy of element <b>A</b> .								[2]
		B is sulfur: <b>[Ne]3s<sup>2</sup>3p<sup>4</sup></b> , A is phosphorus: <b>[Ne]3s<sup>2</sup>3p<sup>3</sup></b>  In <b>B</b> , there is <b>interelectronic repulsion between the pair of electrons in the doubly-filled 3p orbital of B</b> . <b>Less energy</b> is required to overcome the <b>weaker electrostatic forces of attraction between the nucleus and the paired valence 3p electron in B</b> compared to the <b>unpaired valence 3p electron in A</b> .								
	(ii)	A strongly acidic solution is formed when the chloride of <b>A</b> reacts with water.								[2]
		Chloride of A undergoes <b>hydrolysis</b> to give <b>white fumes</b> of HCl gas  <b>PCl<sub>3</sub> (l) + 3 H<sub>2</sub>O (l) → H<sub>3</sub>PO<sub>3</sub> (aq) + 3 HCl (aq)</b> Or <b>PCl<sub>5</sub> (l) + 4 H<sub>2</sub>O (l) → H<sub>3</sub>PO<sub>4</sub> (aq) + 5 HCl (aq)</b> <b>pH of solution ≈ 2</b>								
										[Total: 8]

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  
- the reagents and condition for reaction **II** and **III**,

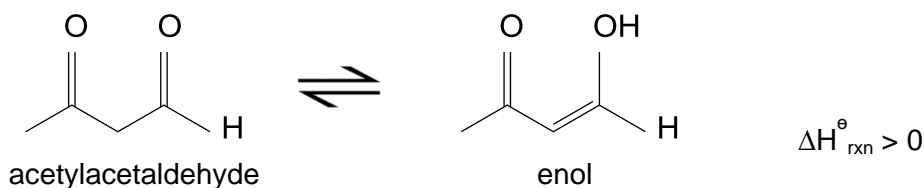
Reaction II:  $\text{Cl}_2$  (g),  $\text{AlCl}_3$       Reaction III: dilute  $\text{HCl}$ , heat

- the type of reaction for reactions **I** and **III**.

Reaction I: Condensation      Reaction III: Acidic Hydrolysis

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.



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

$$K_c = \frac{[\text{enol}]}{[\text{acetylacetaldehyde}]}$$

- (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.

	acetylacetaldehyde	enol
Initial concentration / $\text{mol dm}^{-3}$	1	0
Change in concentration / $\text{mol dm}^{-3}$	-0.76	+0.76
Final concentration / $\text{mol dm}^{-3}$	0.24	0.76

$$K_c = \frac{0.76}{0.24} = 3.17$$

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

The large equilibrium constant indicates that the **equilibrium position lies to the right**. Hence **at equilibrium, most** of the species present is the **enol**.

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

**[6]**

By **Le Chatelier's Principle**, the position of equilibrium shifts to the **right** to **absorb** the excess heat, favouring the **endothermic reaction**. **[enol]** will **increase** while **[acetylacetaldehyde]** will **decrease** until a new equilibrium is reached.

	(b)	Acetylacetaldehyde can undergo oxidation with potassium dichromate(VI) under heat to form a carboxylic acid.
	(i)	Write two <b>redox</b> half-equations to represent the reaction between acetylacetaldehyde and $\text{Cr}_2\text{O}_7^{2-}$ ions and prove that the overall equation is as follows: $3\text{CH}_3\text{COCH}_2\text{CHO} + \text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ \rightarrow 3\text{CH}_3\text{COCH}_2\text{COOH} + 4\text{H}_2\text{O} + 2\text{Cr}^{3+}$
		$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} \quad \text{---(1)}$ $\text{CH}_3\text{COCH}_2\text{CHO} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{COCH}_2\text{COOH} + 2\text{H}^+ + 2\text{e}^- \quad \text{---(2)}$ <p>To balance the no of e, 3 x (2)</p> $3\text{CH}_3\text{COCH}_2\text{CHO} + 3\text{H}_2\text{O} \rightarrow 3\text{CH}_3\text{COCH}_2\text{COOH} + 6\text{H}^+ + 6\text{e}^-$ <p>Overall equation:</p> $3\text{CH}_3\text{COCH}_2\text{CHO} + \text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ \rightarrow 3\text{CH}_3\text{COCH}_2\text{COOH} + 4\text{H}_2\text{O} + 2\text{Cr}^{3+}$ <p>(shown)</p>
	(ii)	8 cm <sup>3</sup> of liquid acetylacetaldehyde was dissolved in water and made up to 250 cm <sup>3</sup> . 25.0 cm <sup>3</sup> of this solution was titrated with 0.10 mol dm <sup>-3</sup> acidified potassium dichromate(VI). Given that the density of acetylacetaldehyde is 0.956 g cm <sup>-3</sup> , calculate the volume of potassium dichromate(VI) required to complete the titration.
		$n_{\text{acetylacetaldehyde}} \text{ in } 250 \text{ cm}^3 = \frac{8 \times 0.956}{86.0} = 8.893 \times 10^{-2} \text{ mol}$ $n_{\text{acetylacetaldehyde}} \text{ in } 25 \text{ cm}^3 = 8.893 \times 10^{-3} \text{ mol}$ $n_{\text{Cr}_2\text{O}_7^{2-}} = \frac{8.893 \times 10^{-3}}{3} = 2.964 \times 10^{-3} \text{ mol}$ $n_{\text{Cr}_2\text{O}_7^{2-}} = \frac{2.964 \times 10^{-3}}{0.1} = 2.96 \times 10^{-2} \text{ dm}^3 = 29.6 \text{ cm}^3$
	(iii)	Propose a simple chemical test that allows you to confirm the presence of acetylacetaldehyde and state any observations clearly. <span style="float: right;">[6]</span>
		<p>Test: Add a few drops of Tollen's reagent/Fehling's reagent and warm.</p> <p>Observations: A silver mirror/reddish-brown ppt will be observed.</p>
	(c) (i)	Deduce which of the two acids, $\text{CH}_3\text{COCH}_2\text{COOH}$ or $\text{CH}_3\text{COCHClCOOH}$ , has a higher $pK_a$ value.
		<p>The <b>electron-donating R group</b> ( <math>-\text{CH}_3</math> ) <b>intensifies the negative charge on the carboxylate anion</b> hence <b>destabilising the carboxylate anion relative to the acid</b>, hence, <math>\text{CH}_3\text{COCH}_2\text{COOH}</math> is the <b>weaker acid and has a higher <math>pK_a</math></b>.</p> <p><b>The electron-withdrawing chloro group disperses the negative charge on the carboxylate anion</b> hence <b>stabilising the carboxylate anion relative to the acid</b>.</p>

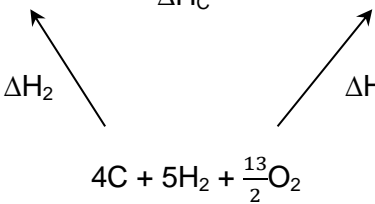
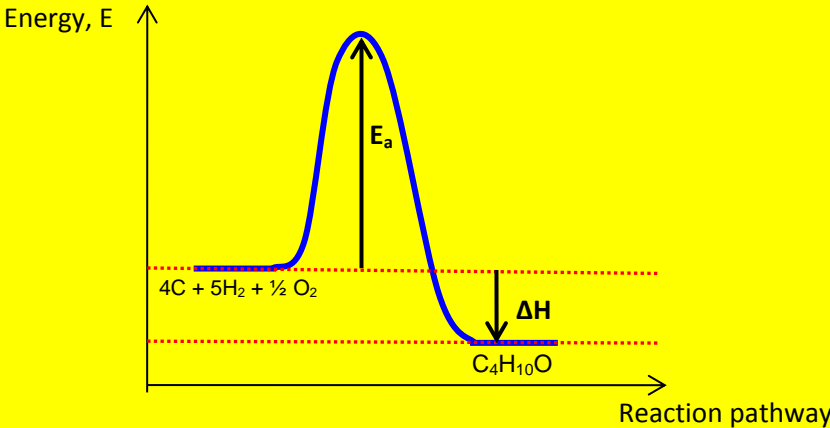
		(ii)	Propose a simple test-tube test which can be achieved in the school laboratory to differentiate $\text{CH}_3\text{COCH}_2\text{COOH}$ from $\text{CH}_3\text{COCHC/COOH}$ . <span style="float: right;">[4]</span>
			Test: Add $\text{NaOH}$ (aq), heat, followed by aqueous $\text{HNO}_3$ then aqueous $\text{AgNO}_3$  Observation: White ppt of $\text{AgCl}$ will be observed for $\text{CH}_2\text{C/COOH}$ but not for $\text{CH}_3\text{COOH}$
			[Total: 16]

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.	
		$\text{AlCl}_3 + 6\text{H}_2\text{O} \rightarrow [\text{Al}(\text{H}_2\text{O})_6]^{3+} + 3\text{Cl}^-$ $[\text{Al}(\text{H}_2\text{O})_6]^{3+} \rightleftharpoons [\text{Al}(\text{H}_2\text{O})_5\text{OH}]^{2+} + \text{H}^+$ <p>pH = 3.0</p>	
	(b)	The melting point of aluminium fluoride, aluminium chloride and aluminium oxide is $1291^\circ\text{C}$ , $192^\circ\text{C}$ and $2072^\circ\text{C}$ respectively. Using bonding and structure, explain the differences in their melting points.	
		<p><math>\text{Al}_2\text{O}_3</math> and <math>\text{AlF}_3</math> have <b><u>giant ionic structure</u></b> with <b><u>strong ionic bonds</u></b>.  <math>\text{AlCl}_3</math> has <b><u>simple molecular structure</u></b> with <b><u>weak intermolecular van der waal's forces of attraction</u></b>.</p> <p>Hence <math>\text{AlCl}_3</math> requires the <b><u>least energy</u></b> to overcome the <b><u>weakest intermolecular van der Waal's forces of attraction</u></b>.</p> <p>For <math>\text{Al}_2\text{O}_3</math> and <math>\text{AlF}_3</math>, <math>\Delta H_{\text{latt}} \propto \left  \frac{q^+ q^-}{r^+ + r^-} \right </math></p> <ul style="list-style-type: none"> <li><math>q^+</math>, <math>r^+</math> are the same</li> <li>Anionic charge: <math>\text{O}^{2-} &gt; \text{F}^-</math></li> <li>Anionic size: <math>\text{O}^{2-} &gt; \text{F}^-</math></li> <li>Magnitude of lattice energy: <math>\text{Al}_2\text{O}_3 &gt; \text{AlF}_3</math></li> </ul>	
	(c)	Write chemical equations to show how aluminium oxide reacts separately with hydrochloric acid and sodium hydroxide.	
		<p>Alumium oxide is <b><u>amphoteric</u></b>.  <math>\text{Al}_2\text{O}_3(\text{s}) + 6 \text{HCl}(\text{aq}) \rightarrow 2 \text{AlCl}_3(\text{aq}) + 3 \text{H}_2\text{O}(\text{l})</math>  <math>\text{Al}_2\text{O}_3(\text{s}) + 2 \text{NaOH}(\text{aq}) + 3 \text{H}_2\text{O}(\text{l}) \rightarrow 2 \text{Na}[\text{Al}(\text{OH})_4](\text{aq})</math>  <b>(no need state symbols)</b></p>	
			[Total: 7]

## Section B

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

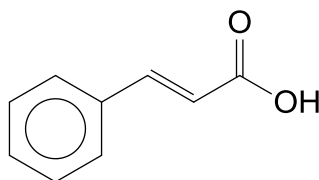
5	2-bromobutane is an isomer of 1-bromobutane. It is an irritant and harmful when ingested.	
(a)	(i)	2-bromobutane reacts with aqueous sodium hydroxide. The product <b>M</b> , C <sub>4</sub> H <sub>10</sub> O, formed is commonly used as fuel, cleaning agent and paint remover. Write a balanced chemical equation showing the production of <b>M</b> and state the type of reaction that has taken place.
		$\text{CH}_3\text{CH}(\text{Br})\text{CH}_2\text{CH}_3 + \text{NaOH} \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3 + \text{NaBr}$ <p>Nucleophilic substitution</p>
	(ii)	<p>Gaseous form of product <b>M</b> can be combusted to carbon dioxide and water according to the following equation.</p> $\text{C}_4\text{H}_{10}\text{O} (\text{g}) + 6\text{O}_2 (\text{g}) \rightarrow 4\text{CO}_2 (\text{g}) + 5\text{H}_2\text{O} (\text{l})$ <p>Using bond energy from the <i>Data Booklet</i>, calculate the enthalpy change of combustion, in kJ mol<sup>-1</sup>. Leave your answer to <b>four</b> significant figures.</p>
		<div style="text-align: center;"> </div> $+ 6 \text{O}=\text{O} \rightarrow 4 \text{O}=\text{C}=\text{O} + 5 \text{H}-\text{O}-\text{H}$ <p> <math>\Delta H = \Sigma \text{BE (reactants)} - \Sigma \text{BE (products)}</math>  <math>= [3\text{BE}(\text{C}-\text{C}) + 9\text{BE}(\text{C}-\text{H}) + \text{BE}(\text{C}-\text{O}) + \text{BE}(\text{O}-\text{H}) + 6\text{BE}(\text{O}=\text{O})]</math>  <math>\quad \quad \quad - [8\text{BE}(\text{C}=\text{O}) + 10\text{BE}(\text{O}-\text{H})]</math>  <math>= [3(350) + 9(410) + 360 + 460 + 6(496)] - [8(740) + 10(460)]</math>  <math>= (1050 + 3690 + 360 + 460 + 2976) - (5920 + 4600)</math>  <math>= 8536 - 10520</math>  <math>= -1984 \text{ kJ mol}^{-1}</math> </p>
	(iii)	Hence, using relevant data from the <i>Data Booklet</i> , determine the mass of the product <b>M</b> required to boil 100 cm <sup>3</sup> of water from 25°C given that the process efficiency is 80%.
		<p>Step (1) Using <math>Q' = mc\Delta T</math>  <math>Q' = 100(4.18)(100-25) = 31350 \text{ J}</math></p> <p>Step (2) Using <math>Q' = (\text{efficiency}/100)Q</math>  <math>31350 = (80/100)Q</math>  <math>Q = 39187.5 \text{ J}</math></p> <p>Step (3) Using <math>\Delta H_c = - (Q/n)</math>  <math>-1984 \times 10^3 = - (39187.5/n)</math>  <math>n = 0.01975 \text{ mol}</math>  <math>\text{mass} = 0.01975 \times 74 = 1.46 \text{ g}</math></p>
		<b>[6]</b>

(b)	(i)	<div style="text-align: center;"> <math display="block">\text{C}_4\text{H}_{10}\text{O} + 6\text{O}_2 \xrightarrow{\Delta H_{\text{C}}} 4\text{CO}_2 + 5\text{H}_2\text{O}</math>  </div> <table border="1" style="margin: 10px auto; width: 60%;"> <tr> <th>Compound</th> <th><math>\Delta H_f^\circ / \text{kJ mol}^{-1}</math></th> </tr> <tr> <td><math>\text{CO}_2(\text{g})</math></td> <td>-394</td> </tr> <tr> <td><math>\text{H}_2\text{O}(\text{l})</math></td> <td>-286</td> </tr> </table> <p>Use the energy cycle above, your results from <b>(a)(ii)</b> and the standard enthalpy changes of formation in the table above to calculate the enthalpy change of formation of <math>\text{C}_4\text{H}_{10}\text{O}</math>.</p>	Compound	$\Delta H_f^\circ / \text{kJ mol}^{-1}$	$\text{CO}_2(\text{g})$	-394	$\text{H}_2\text{O}(\text{l})$	-286
Compound	$\Delta H_f^\circ / \text{kJ mol}^{-1}$							
$\text{CO}_2(\text{g})$	-394							
$\text{H}_2\text{O}(\text{l})$	-286							
		<p><math>\Delta H_3</math> is the enthalpy change of formation of <math>\text{C}_4\text{H}_{10}\text{O}</math>  <math>\Delta H_2 = 4 (\Delta H_f^\circ \text{ of } \text{CO}_2) + 5 (\Delta H_f^\circ \text{ of } \text{H}_2\text{O})</math></p> <p>By Hess Law  <math>\Delta H_{\text{C}} + \Delta H_3 = \Delta H_2</math>  <math>-1984 \times 10^3 + \Delta H_3 = 4(-394 \times 10^3) + 5(-286 \times 10^3)</math>  <math>-1984000 + \Delta H_3 = -1576000 - 1430000</math>  <math>\Delta H_3 = -1022 \text{ kJ mol}^{-1}</math></p>						
	(ii)	Using your answer from <b>(b)(i)</b> , construct a reaction pathway diagram for the formation of product <b>M</b> .						
								
		<b>[4]</b>						
(c)		Product <b>M</b> from <b>(a)(i)</b> was reacted with hot concentrated sulfuric acid to form compound <b>Q</b> , <b>R</b> and <b>S</b> . Draw the structural formula of <b>Q</b> , <b>R</b> and <b>S</b> and suggest the different types of isomerism present between them.						
		<div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;"> <math display="block">\begin{array}{c} \text{H} &amp; &amp; \text{H} \\ &amp; \diagdown &amp; / \\ &amp; \text{C} = \text{C} \\ &amp; / &amp; \diagdown \\ \text{H} &amp; &amp; \text{CH}_2\text{CH}_3 \end{array}</math> <p>Compound <b>Q</b></p> </div> <div style="text-align: center;"> <math display="block">\begin{array}{c} \text{H} &amp; &amp; \text{CH}_3 \\ &amp; \diagdown &amp; / \\ &amp; \text{C} = \text{C} \\ &amp; / &amp; \diagdown \\ \text{CH}_3 &amp; &amp; \text{H} \end{array}</math> <p>Compound <b>R</b></p> </div> <div style="text-align: center;"> <math display="block">\begin{array}{c} \text{H} &amp; &amp; \text{H} \\ &amp; \diagdown &amp; / \\ &amp; \text{C} = \text{C} \\ &amp; / &amp; \diagdown \\ \text{CH}_3 &amp; &amp; \text{CH}_3 \end{array}</math> <p>Compound <b>S</b></p> </div> </div> <p>Between <b>Q</b> and <b>R</b> or <b>Q</b> and <b>S</b>: positional isomerism (structural isomerism)</p>						

		Between R and S: cis-trans isomerism
		[4]
(d)	The experimental results obtained from two experiments between 2-bromobutane and aqueous sodium hydroxide were plotted on the graph below.	
	<p><b>Graph of [2-bromobutane] / mol dm<sup>-3</sup> vs time / min</b></p>	
(i)	Use the graph to determine the order of reaction with respect to bromoalkane and sodium hydroxide. Justify your answer in each case.	
	<p><b>To find order of reaction wrt RBr</b>          From the graph, when <math>[\text{OH}^-] = 0.15 \text{ mol dm}^{-3}</math>, <u>half-life is constant at 75 mins.</u>          Hence, the <u>order of reaction w.r.t RBr is 1.</u></p> <p><b>To find order of reaction wrt NaOH</b>          Let <math>g_1</math> and <math>g_2</math> be the gradients of the graph at <math>t = 0</math> when <math>[\text{OH}^-] = 0.10 \text{ mol dm}^{-3}</math> and <math>0.15 \text{ mol dm}^{-3}</math> respectively.  <b>From the graphs, Initial rate for <math>[\text{OH}^-] = 0.10 \text{ mol dm}^{-3}</math></b>          initial rate = <math>-(g_1)</math>  <math>= -(0.0079 - 0.0100) / (40 - 0)</math>  <math>= 5.25 \times 10^{-5} \text{ mol dm}^{-3} \text{ min}^{-1}</math>  <b>From the graphs, Initial rate for <math>[\text{OH}^-] = 0.15 \text{ mol dm}^{-3}</math></b>          initial rate<sub>2</sub> = <math>-(g_2)</math>  <math>= -(0.0068 - 0.0100) / (40 - 0)</math>  <math>= 8.00 \times 10^{-5} \text{ mol dm}^{-3} \text{ min}^{-1}</math></p> <p>Thus, when <math>[\text{OH}^-]</math> is increased 1.5 times (from <math>0.10 \text{ mol dm}^{-3}</math> to <math>0.15 \text{ mol dm}^{-3}</math>)</p>	

			$\text{dm}^{-3})$ while keeping $[\text{RBr}]$ constant, the <b>rate is increased</b> $\frac{8.00 \times 10^{-5}}{5.25 \times 10^{-5}} = 1.5$ <b>times [1]</b> Hence, order of reaction with respect to $\text{OH}^- = 1$
		(ii)	Determine the rate constant for this reaction and state its units.
			Rate = $k [\text{RBr}] [\text{OH}^-]$ $5.25 \times 10^{-5} = k \times 0.010 \times 0.10$ $k = 0.0525 \text{ mol}^{-1} \text{ dm}^3 \text{ min}^{-1}$
			[6]
			[Total: 20]

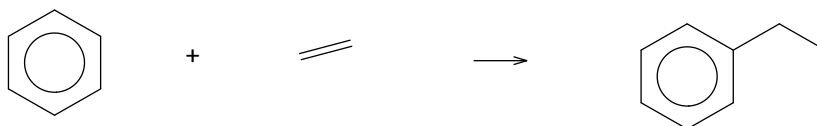
- 6 Styrene is the precursor in the production of useful plastic material polystyrene. The first synthetic pathway used for the preparation of styrene involves cinnamic acid as its main reagent. This method was eventually ceased due to its high production cost and low solubility of cinnamic acid in organic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



**Cinnamic acid**

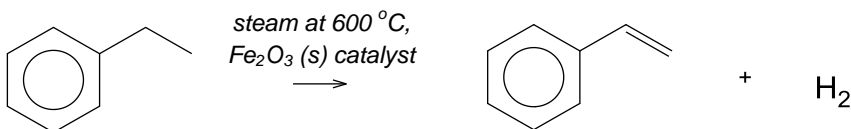
Currently, more than 99% of styrene is produced from ethylbenzene. In **Stage 1**, benzene combines with ethene in an acid-catalysed chemical reaction as shown below.

**Stage 1:**



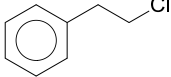
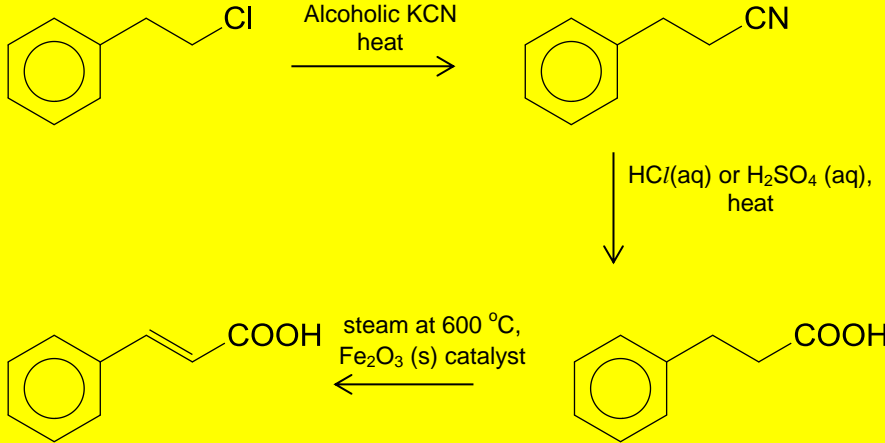
Next, gaseous ethylene is mixed in high-temperature steam and passed over a solid iron (III) oxide catalyst bed to produce styrene:

**Stage 2:**

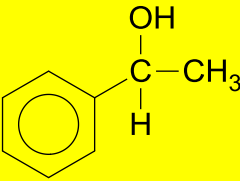
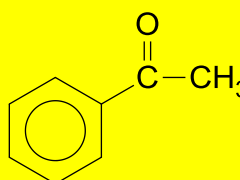
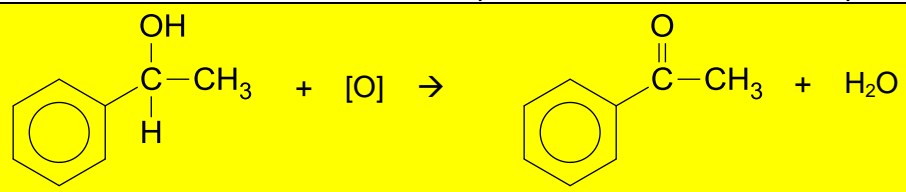
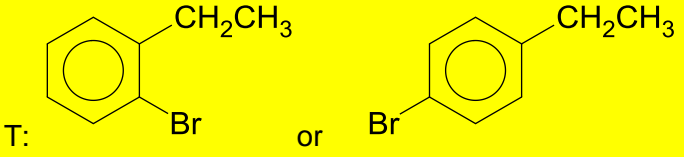
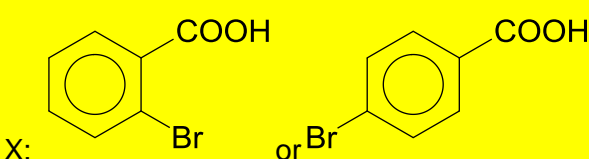


**Styrene**

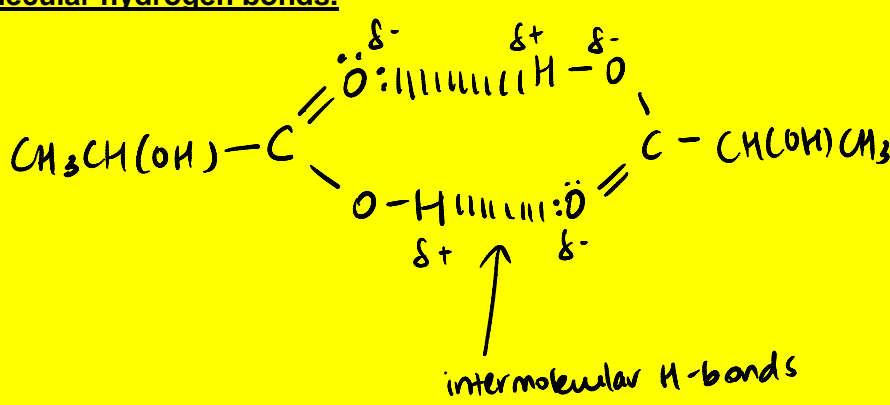
(a)	(i)	State the types of reaction undergone in <b>Stage 1</b> and <b>Stage 2</b> .
		Stage 1: electrophilic substitution Stage 2: elimination
	(ii)	Using the concept of hybridisation, suggest if styrene is a planar molecule.

			All the carbons are <b><u>sp<sup>2</sup> hybridised</u></b> and the shape is <b><u>trigonal planar</u></b> about each carbon. Styrene is <b><u>planar</u></b> .
		(iii)	Using bonding and structure, explain why cinnamic acid is not soluble in organic solvent.
			Both cinnamic acid and organic solvents are simple molecular compounds. However, the <b><u>weak intermolecular van der Waals' forces present in organic solvents is unable to overcome the stronger intermolecular hydrogen bonds</u></b> in cinnamic acid.
		(iv)	<p>Cinnamic acid can be synthesized in three steps, whereby one of the steps involves the reagents and conditions in <b>Stage 2</b>.</p> <p>Propose this synthetic pathway with the use of (chloroethyl)benzene,</p>  <p>as the starting material.</p>
			
		(v)	Describe a simple chemical test to distinguish cinnamic acid and styrene. State any observations clearly.
			<p>Test: <b><u>Add Na<sub>2</sub>CO<sub>3</sub> (aq) or add PCl<sub>5</sub>(s)</u></b></p> <p>Observations:  <b><u>Cinnamic acid</u></b> will produce <b><u>effervescence which produces white ppt in calcium hydroxide solution. No effervescence was observed for styrene.</u></b></p> <p>Or</p> <p><b><u>Cinnamic acid</u></b> will produce <b><u>white fumes</u></b> which turn moist blue litmus paper red. <b><u>No white fumes produced by styrene.</u></b></p>

	(vi)	Using an appropriate sketch of the Boltzmann distribution curve, explain how the use of iron (III) oxide affects the rate of reaction in <b>Stage 2</b> .
		<p>Fraction of particles with energy, <math>E</math></p> <p>No. of particles with <math>E \geq E_a</math> for <b>uncatalysed</b> reaction</p> <p>No. of particles with <math>E \geq E_{a(\text{cat})}</math> for <b>catalysed</b> reaction</p> <p>Energy, <math>E</math></p> <p><math>E_a'</math> (catalysed)      <math>E_a</math> (uncatalysed)</p> <p>When a catalyst is present,</p> <ul style="list-style-type: none"> <li>• <u>activation energy</u> is <u>lowered</u></li> <li>• <u>more reactant particles with energy <math>\geq E_a'</math> (catalysed)</u></li> <li>• <u>more effective collisions</u></li> <li>• Since rate of reaction is proportional to the frequency of effective collisions, <u>rate</u> of reaction <u>increases</u></li> </ul>
		<b>[12]</b>
	(b)	<p>Ethylbenzene is treated with bromine under different conditions to form two isomeric bromides, <b>T</b> and <b>U</b>.</p> <ul style="list-style-type: none"> <li>• When <b>T</b> undergoes reflux with acidified potassium manganate (VII), <b>X</b> with a molecular formula <math>\text{C}_7\text{H}_5\text{BrO}_2</math> is formed.</li> <li>• <b>U</b> reacts with hot alcoholic sodium hydroxide to give styrene, <math>\text{C}_6\text{H}_5\text{CH}=\text{CH}_2</math>.</li> </ul> <p><b>U</b> was subjected to further reaction via a 2-step reaction pathway.</p> $\text{U} \xrightarrow{\text{Step I}} \text{V} \xrightarrow{\text{Step II}} \text{W}$ <ul style="list-style-type: none"> <li>• Both <b>V</b> and <b>W</b> produces a pale yellow precipitate with warmed with alkaline aqueous iodine.</li> <li>• <b>W</b> reacts with 2,4-dinitrophenylhydrazine to give an orange precipitate but does not react with Fehling's solution.</li> </ul>
	(b) (i)	Explain why <b>W</b> reacts with 2,4-dinitrophenylhydrazine but does not react with Fehling's solution.
		<b>W</b> contains a <u>ketone functional group</u> but not an aldehyde functional group.
	(ii)	State the reagents and conditions for Step I and II, and hence suggest the structural formulae of <b>V</b> and <b>W</b> .
		Step I: <u><b>NaOH (aq), heat</b></u>

			<p>Step II: <b><math>K_2Cr_2O_7</math>, dilute <math>H_2SO_4</math>, heat</b></p> <p><i>*<math>KMnO_4</math> is not accepted as it results in side chain [O]</i></p> <p>V: </p> <p>W: </p>
		(iii)	Hence, write a balanced chemical equation for the reaction in step II.
			
		(iv)	Draw the structures of T and X.
			<p>T: </p> <p>X: </p>
			Total: [20]

7	(a)	Lactic acid is a monoprotic acid with the formula $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$ ( $M_r = 90.0$ ) 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)	<p>The percentage of lactic acid in food product can be calculated using the following formula.</p> $\% \text{Lactic acid} = \frac{\text{volume of alkali (dm}^3\text{)} \times \text{concentration of alkali (mol dm}^{-3}\text{)} \times 9}{\text{weight of sample (g)}}$ <p>Using the formula, calculate the percentage of lactic acid present in a sample of 20 g yogurt dissolved in 20 <math>\text{cm}^3</math> of distilled water which required 25.0 <math>\text{cm}^3</math> of 0.500 <math>\text{mol dm}^{-3}</math> of sodium hydroxide for complete neutralisation. Leave your answer to 4 significant figures</p> <p><i>Teacher Reference: International Journal of Basic and Applied Sciences IJBAS-IJENS Vol: 12 No:01</i>  <a href="http://www.ijens.org/vol_12_i_01/124901-8585-ijbas-ijens.pdf">http://www.ijens.org/vol_12_i_01/124901-8585-ijbas-ijens.pdf</a></p>
			$\% \text{Lactic acid} = \frac{\frac{25}{1000} \times 0.5 \times 9}{20} = \mathbf{0.005625 \%}$
		(ii)	Using your answer in (a)(i), prove that the concentration of the lactic acid in the yogurt is about $6.00 \times 10^{-4} \text{ mol dm}^{-3}$ .
			<p>Mass of lactic acid in yogurt = <math>\frac{0.005625}{100} \times 20 = 0.001125 \text{ g}</math></p> <p>[lactic acid] in yogurt in <math>\text{g dm}^{-3} = \frac{0.001125}{\frac{20}{1000}} = 0.05625 \text{ g dm}^{-3}</math></p> <p>[lactic acid] in yogurt in <math>\text{mol dm}^{-3} = 0.05625/90.0 = \mathbf{6.25 \times 10^{-4} \text{ mol dm}^{-3}}</math></p>
		(iii)	Given that the pH of the yogurt is 4.72, justify why lactic acid is classified as a weak acid.
			<p><math>[\text{H}^+] = 10^{-4.72} = 1.91 \times 10^{-4} \text{ mol dm}^{-3}</math></p> <p>Since <math>[\text{H}^+]</math> is smaller than <math>[\text{Acid}]</math>, lactic acid is a weak acid.</p>

		(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.
			<p>Component of buffer solution: <math>\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}</math> and <math>\text{CH}_3\text{CH}(\text{OH})\text{COO}^-\text{Na}^+</math></p> <p>When small amount of <math>\text{H}^+</math> is added:  <math>\text{CH}_3\text{CH}(\text{OH})\text{COO}^- + \text{H}^+ \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}</math></p> <p>When small amount of <math>\text{OH}^-</math> is added  <math>\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H} + \text{OH}^- \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{COO}^- + \text{H}_2\text{O}</math></p> <p>Thus pH of the solution remains fairly constant.</p>
		(v)	Calculate the pH of the solution when an <b>additional</b> $30\text{ cm}^3$ of sodium hydroxide was added to the sample of the yogurt mentioned in (a)(i).
			<p><math>30\text{ cm}^3</math> of additional sodium hydroxide will be in excess.</p> <p>Total volume now = <math>30\text{ cm}^3 + 25\text{ cm}^3 + 20\text{ cm}^3 = 75\text{ cm}^3</math></p> <p>Amount of excess NaOH = <math>(30/1000) \times 0.500 = 0.0150\text{ mol}</math></p> <p><math>[\text{NaOH}] = [\text{OH}^-] = (0.015)/(75/1000) = \mathbf{0.200\text{ mol dm}^{-3}}</math></p> <p><math>\text{pOH} = -\lg 0.2 = 0.699</math></p> <p><math>\text{pH} = 14 - 0.699 = \mathbf{13.3\text{ [A1]}}</math></p>
		(vi)	With an aid of a diagram, explain why lactic acid has an apparent relative molecular mass of 180.0 in an organic solvent.
			<p>Each acid molecule pairs up to form a <b>cyclic</b> (closed ring) <b>dimer</b> via <u>intermolecular hydrogen bonds</u>.</p> 
			<b>[11]</b>
	(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 equation in your answer.
		(i)	Lactic acid reacts with ethanol in the presence of hot concentrated sulfuric acid to form two organic products.
			Esterification

			$\text{CH}_3\text{CH}(\text{OH})\text{COOH} + \text{CH}_3\text{CH}_2\text{OH} \rightleftharpoons \text{CH}_3\text{CH}(\text{OH})\text{COOCH}_2\text{CH}_3 + \text{H}_2\text{O}$ <p>Elimination  <math display="block">\text{CH}_3\text{CH}(\text{OH})\text{COOH} \rightarrow \text{CH}_2=\text{CHCOOH} + \text{H}_2\text{O}</math></p>
		(ii)	Lactic acid reacts with lithium aluminium hydride in dry ether to form compound <b>Z</b> .
			<p>Reduction  <math display="block">\text{CH}_3\text{CH}(\text{OH})\text{COOH} + 2[\text{H}] \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{CH}_2(\text{OH})</math></p>
			<b>[6]</b>
	(c)	(i)	Compound <b>Z</b> from (b)(ii) can be formed from an alkene. Name the alkene and suggest the reagent and conditions required for the reaction.
			<p>Propene  Cold alkaline <math>\text{KMnO}_4</math></p>
		(ii)	Suggest reagent and conditions on how the alkene mentioned in (c)(i) can be converted into a saturated hydrocarbon.
			$\text{H}_2$ (g), Nickel Catalyst, heat or $\text{H}_2$ (g), Platinum Catalyst, r.t.p.
			<b>[3]</b>
			<b>[Total: 20]</b>

END OF PAPER