## ANGLO-CHINESE JUNIOR COLLEGE DEPARTMENT OF CHEMISTRY Preliminary Examination

## **CHEMISTRY H2**

9729/03

Paper 3 Free Response

2 September 2019 2 hours

Candidates answer on separate paper.

Additional Materials: Cover Page Answer Paper Insert

## **READ THESE INSTRUCTIONS FIRST**

Write your index number and name, form class and tutorial class 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 one question.

Start each question on a new page of writing paper. Fasten the insert in front of all writing paper at the end of the examination.

A Data Booklet is provided.

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

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.

This document consists of 21 printed pages and 1 blank page.



ANGLO-CHINESE JUNIOR COLLEGE Department of Chemistry

[Turn over

Section A

Answer **all** the questions from this section.

1	(a)	Use of the insert is necessary for this question. Fasten the insert in front of all writing paper at the end of the examination								
		An ior	doalkane. RL is hydrolysed by aqueous sodium hydroxide. The results obtained							
		from [NaOł	from two experiments are plotted on the insert. In each experiment, the overall [NaOH(aq)] remained virtually constant at the value given beside each graph.							
		(i)	(i) Use the graphs on the insert to determine the following. Show all workings clearly.							
			I Use the half-life method to deduce the order of reaction with respect to the iodoalkane.							
			<b>II</b> Use the initial rates method to deduce the order of reaction with respect to sodium hydroxide.							
			III Construct a rate equation for the reaction and use it to calculate a value for the rate constant. Include its units. [7]							
			From working on graph, when $[OH^-] = 0.10$ M, half-life = 58 min OR From working on graph, when $[OH^-] = 0.15$ M, half-life = 39 min [1] $\therefore$ reaction is first order w.r.t. RI. [1]							
		From working on graph, when $[OH^-] = 0.10 \text{ M}$ , initial rate = 0.0100/96 = 0.000104 mol dm <sup>-3</sup> min <sup>-1</sup> & From working on graph, when $[OH^-] = 0.15 \text{ M}$ , initial rate = 0.0100/64 = 0.000156 mol dm <sup>-3</sup> min <sup>-1</sup> [1]								
		rate = $k[RI][OH^-]$ [1] (if S <sub>N</sub> 1, do not award this mark)								
		$k = \frac{0.000104}{[0.010][0.10]} = 0.104 \text{ mol}^{-1} \text{ dm}^3 \text{ min}^{-1} \text{ OR}$ $k = \frac{0.000156}{[0.010][0.15]} = 0.104 \text{ mol}^{-1} \text{ dm}^3 \text{ min}^{-1} [1+1]$								
		Allow ecf if rate equation is rate = k[RI], then $k = \frac{0.000104}{10000000000000000000000000000000$								
			$k = \frac{0.000156}{[0.010]} = 0.0156 \text{ mol}^{-1} \text{ dm}^3 \text{ min}^{-1} [1+1] \text{ (D.N.A. if rate = k[OH^{-}])}$							



		$2NI_3(s) \rightarrow N_2(g) + 3I_2(g)$ $\Delta H = -290 \text{ kJ mol}^{-1}$								
	76.5	kJ mol <sup>-1</sup> of energy is needed to convert solid $NI_3$ to gaseous $NI_3$ .								
	Use t the N	Use the above information and relevant information from the <i>Data Booklet</i> to calculate the N–I bond energy. [2]								
		$2NI_3(s) \xrightarrow{-290} N_2(g) + 3I_2(g)$								
		2(+76.5) 2(-944) 3(-151)								
		$ \begin{array}{c} \checkmark \\ 2NI_3(g) \longrightarrow 2N(g) + 6I(g) \\ 6BDE(N-I) \end{array} $								
	–290 BDE(	= $2(+76.5) + 6BDE(N-I) + (-944) + 3(-151)$ N-I) = 159 kJ mol <sup>-1</sup>								
	[1] us [1] ar	sing –290, +76.5, –944 & –151, no need coefficients and sign. Inswer 159, no ECF								
(d)	Alpha particles, ${}_{2}^{4}$ He <sup>2+</sup> are produced from the radioactive decay of certain isotopes. An example of one is from the decay of Americium-241.									
		$^{241}_{95}\text{Am} \rightarrow ^{4}_{2}\text{He}^{2+} + \text{M}$								
	(i) Use the <i>Data Booklet</i> to identify species <b>M</b> that is formed. [1]									
	$^{237}_{93}$ Np <sup>2-</sup> , $^{237}$ Np <sup>2-</sup> minimally, no need for <sub>93</sub> .									
	(ii)	(ii) Calculate the angle of deflection for <b>M</b> in a uniform electric field if the angle of								
		deflection for ${}_{2}^{2}\text{He}^{2^{+}}$ is +7.11°. [1]								
		Angle of deflection, AOD = $k_m^Q$								
		$\frac{AOD_1m_1}{O_1} = \frac{AOD_2m_2}{O_2}$								
		$AOD_{Np}^{2-} = \frac{+7.11 \times 4 \times (-2)}{(+2)237} = -0.12^{\circ} (2 \text{ or } 3 \text{ sf})$								
	Amer the th	icium is often used in smoke detectors as the compound $AmO_2$ and is made from nermal decomposition of americium(III) ethanedioate, $Am_2(C_2O_4)_3$ .								
		$Am_2(C_2O_4)_3 \longrightarrow 2AmO_2 + 4CO + 2CO_2$								
	(iii)	Explain why the thermal decomposition is a redox reaction in terms of oxidation state changes. [2]								
		Am in $Am_2(C_2O_4)_3$ is oxidised from +3 oxidation state to +4 in $AmO_2$ . [1] C in $Am_2(C_2O_4)_3$ is reduced from +3 oxidation state to +2 in CO and oxidised +4 in $CO_2$ . [1]								
		[Total: 20]								



	(ii)	State the type of the reaction in stage 2. [1]							
		Elimination							
	(iii)	nstead of purchasing malononitrile as a starting reagent, it can be made from dichloromethane.							
		Suggest the reagent and conditions needed to convert dichloromethane to malononitrile. [1]							
		KCN (alc), heat under reflux							
	<ul> <li>The following 3-step mechanism illustrates stage 1.</li> <li>Malononitrile is deprotonated by a weak base, R<sub>2</sub>NH to form its conjugate base, (NC)<sub>2</sub>CH<sup>-</sup>.</li> <li>The conjugate base of malononitrile undergoes nucleophilic addition with</li> <li>2-chlorobenzaldehyde to give</li> </ul>								
	•	The conjugate acid of R <sub>2</sub> NH is deprotonated by the intermediate.							
	(iv) Describe the 3-step mechanism illustrated above. Show all charges and relevant lone pairs and show the movement of electron pairs by using curly arrows. $R_2NH$ + $H$ + $CN$ + $R_2NH_2$ + $O$								
		$C_{l} = C_{l} = C_{l$							
		$\begin{array}{c} \textcircled{O}\\ R_2NH\\ H\\ \hline\\ C\\ C\\$							

		Step 1: 2 correct arrows $- [\checkmark]$ $R_2NH_2^+ \& (NC)_2CH^ [\checkmark]$						
		Step 2: 2 correct arrows – [√] δ+ & δ− – [√] slow – [√]						
		Step 3: 2 correct arrows – [√]						
		$6[\sqrt{]} - 3m$ $4[\sqrt{]} - 2m$ $2[\sqrt{]} - 1m$						
	(v)	Suggest another role of the weak base, R <sub>2</sub> NH. [1]						
		Catalyst						
	(vi)	Compare, and explain, the relative acidities of dichloromethane and malononitrile. [2]						
		<u>Malononitrile is more acidic</u> than dichloromethane. The <u>two nitrile groups are more</u> <u>electron withdrawing than the two chloro groups</u> and they <u>stabilise the negative</u> <u>charge on the conjugate base of malononitrile better</u> than dichloromethane.						
	(vii)	Draw the <b>only two</b> organic products formed when 2-chlorobenzalmalononitrile is heated with acidified potassium manganate(VII). [2]						
		$C_1$ $OH$ $O CO_2H$ $CO_2H$						
		Note: Mesoxalic acid product is thermally stable and will not give 3 $CO_2$ . More appropriately, it will be further hydrated in aqueous medium to form dihydroxymalonic acid, $(HO)_2C(CO_2H)_2$ , but we can accept mesoxalic acid as the answer.						
(b)	Durin prom sleep	During World War II, amphetamine pills were issued to the German army as they promoted alertness and self-confidence while reducing pain, hunger and the need for sleep.						
	Study	/ the two methods of synthesis and answer the questions below.						

Method 1 NH  $NH_2$ stage 1 stage 2 phenylpropanone amphetamine Method 2 Br  $NH_2$ stage 1 (2-bromopropyl)benzene amphetamine (i) State the reagent used in stage 1 for both methods of synthesis. [1] NH<sub>3</sub> (ii) One would think that Method 2 would give better yield of amphetamine during synthesis since it only involves one stage as compared to two stages in Method 1, but this is not true. Suggests why the yield of amphetamine via Method 2 would be poor. [1] Amphetamine synthesised via Method 2 can react further with more (2-bromopropyl)benzene to undergo polysubstitution/polyalkylation. OWTTE Only half of the product formed via Method 1 was biologically active in the body. (iii) Account for this observation. [2] Amphetamine produced exists as a racemic mixture (idea of 50:50) and only one of the enantiomers possesses the correct configuration to be biologically active. OWTTE (iv) Stage 2 of Method 1 employs the use of platinum metal as a catalyst. State the type of catalysis involved and briefly outline the stages involved in the reaction. [3]

			Heterogeneous catalyst. [1] Diffusion – <u>adsorption – reaction (bond breaking and forming) – desorption</u> – diffusion. [2] OWTTE						
		(v)	Explain why transition metals are useful as catalysts.[1]						
			<u>Variable oxidation state</u> OR ability for substances to <u>adsorb on to/form dative</u> <u>bonds</u> on their surface for reaction. OWTTE.						
	(c)	Cisplatin is an anti-cancer drug containing a platinum centre and appears as a light yellow powder. When cisplatin is dissolved in water and allowed to react with the cyclen <i>ligand</i> , the position of equilibrium lies strongly to the right hand side.							
		$\left \begin{array}{c} NH_{3} \\ I \\ CI \\ CI \\ CI \\ CI \\ CI \\ CI \\ CI$							
		(i)	Define the term <i>ligand</i> . [1]						
			A ligand is a neutral molecule or anion with at least one lone pair of electrons capable of dative bonding to the central metal atom or ion.						
		(ii) Suggest signs for the enthalpy change of reaction and entropy change of reaction for the forward reaction, and comment on the spontaneity of the reaction across different temperatures. [2]							
			Sign for $\Delta H$ is negative and sign for $\Delta S$ is positive. [1] Thus the reaction is spontaneous for all temperatures. [1]						
		(iii)	Explain why transition metal compounds are coloured. [2]						
		In presence of ligands, degenerate d-orbitals split into two energy levels with difference of $\Delta E$ . [ $\checkmark$ ] When white/visible light falls on the complex ion, a particular wavelength of light with energy equal to $\Delta E$ is absorbed [ $\checkmark$ ] by the transition metal ion and the electron is promoted from a lower-energy d-orbital to a higher-energy d-orbital. [ $\checkmark$ ] The colour observed is complementary in colour to the light that is absorbed. [ $\checkmark$ ]							
		<ul> <li>[√] ligands cause degenerate levels to split</li> <li>[√] energy gap absorbs visible wavelength / promote e<sup>-</sup> lower to higher level</li> <li>[√] colour seen is complementary</li> </ul>							
			$3[\sqrt{]} - 2m, 2[\sqrt{]} - 1m$						
$\vdash$			[Total: 25]						



		Calculate the time needed to react all of the coated 5,10-dihydrophenazine to completely darken a window panel, given that a constant current of 0.150 A is supplied. [4]								
		$M_{\rm r}$ of 5,10-dihydrophenazine = 182.0 [1]								
	$n_{5,10\text{-dihydrophenazine}} = \frac{0.0300}{182.0} = 0.000165 \text{ mol}$ $n_e = 0.000165 \text{ x } 2 = 0.000330 \text{ mol [1]} \text{ (allow ecf from (iv))}$									
		Q = n <sub>e</sub> F = 0.000330 x 96500 = 31.8 C [1]								
		Q = It t = Q/I = $31.8/0.150 = 212 \text{ s} [1]$								
(b)	lt is n partic	nandatory for all aircrafts to provide an inflatable life vest for every passenger. One cular model of life vests uses a rapid inflation system of compressed $CO_2$ in a canister.								
	A stu amou	dent read that the canisters typically pack 11.0 g of $CO_2$ and commented that the int of $CO_2$ present will inflate a life vest fully to 6.00 dm <sup>3</sup> in capacity.								
	(i)	Show how the student obtained 6.00 dm <sup>3</sup> as the capacity of the life vest and state the assumption made in the calculation. [2]								
		Vol. $CO_2 = \frac{11.0}{44.0} \text{ mol x } 24.0 \text{ dm}^3 \text{ mol}^{-1} = 6.00 \text{ dm}^3 \text{ [1]}$								
		Assumption is that the life vest was inflated at r.t.p. conditions (1 atm, 293 K). [1]								
		Don't penalise 3sf.								
	(ii) State two assumptions of the ideal gas law which allowed the student to make the calculations. [2]									
		1. Volume occupied by particles is negligible compared to the volume of space around them.								
		<ol> <li>Negligible intermolecular forces exist between the particles.</li> <li>Collisions are elastic and of negligible duration. (3 choose 2)</li> </ol>								
(c)	Pass	engers on planes often find that they are more drawn to <i>umami</i> -rich flavours as the tand salty tastes are dulled due to changes in altitude.								
	Monosodium glutamate (MSG) is one compound responsible for providing <i>umami</i>									
	The p $K_a$ values associated with glutamic acid are 2.19, 4.25 and 9.67.									
	Q Q									
		но он								
		NH <sub>2</sub>								
	(i)	Draw the structure of dutamic acid at pH 1 and assign the three $nK_{\rm c}$ values [2]								
	(7)									



Section B Answer one question from this section.

4	(a)	The thermal decomposition reactions for calcium ethanoate and calcium methanoate are given as follows:									
		Ca(H	$Ca(HCOO)_2 \rightarrow CaCO_3 + HCHO$								
		Ca(C	$Ca(CH_{2}COO)_{2} \rightarrow CaCO_{2} + CH_{2}COCH_{2}$								
		Pred	lict the organic product other than propanone and methanal when a mixture	a of							
		calci	um methanoate and calcium ethanoate undergoes thermal decomposition.	[1]							
		CH₃C	СНО [1]								
	(b)	The f	following Ellingham diagram shows the variation of Gibbs free energy change vote the thermal decomposition of calcium carbonate.	vith							
			150								
			100								
			50								
			-50								
			-100								
			300 500 700 900 1100 1300 1500 1700 <b>Temperature / K</b>								
-		(i)	(i) State the range of temperatures where solid calcium carbonate would decompose								
			T > 1100 Kelvin or T ≥ 1000 K (where $\Delta G < 0$ kJ mol <sup>-1</sup> ), cancel upper bound.								
		(ii)	Calculate the entropy change of the reaction.	[1]							
			Gradient of Line = $-\Delta S$								
		$[115 - (-80)] \div (400 - 1600) = -\Delta S$									
		$\Delta S = +0.1625 \text{ kJ mol}^{-1} \text{ K}^{-1} = +163 \text{ J mol}^{-1} \text{ K}^{-1} \text{ (3sf)}$									
		(iii)	Hence, calculate the enthalpy change of the reaction.	[1]							
			$\Delta G = \Delta H - T\Delta S$ 0 = $\Delta H - (1100)(+163)$ [Choose any data point.]								
			$\Delta H = +179,300 \text{ J mol}^{-1} = +179 \text{ kJ mol}^{-1} (3\text{sf})$								

(c)	Dolo to so	mite consists of CaCO <sub>3</sub> and MgCO <sub>3</sub> with the formula CaMg(CO <sub>3</sub> ) <sub>2</sub> . It can be added if or marine aquarium as a pH buffer.								
	(i)	Write a balanced equation for the action of heat on dolomite.[1]								
		$CaMg(CO_3)_2 \rightarrow CaO + MgO + 2CO_2$								
	(ii)	Each carbonate is heated separately.								
		Predict and explain the difference in the thermal decomposition temperatures of the two carbonates. [3]								
		MgCO <sub>3</sub> has lower thermal decomposition temperature than CaCO <sub>3</sub> . [1]								
		Mg <sup>2+</sup> is smaller than Ca <sup>2+</sup> . Mg <sup>2+</sup> has greater charge density (and hence greater polarising power) than Ca <sup>2+</sup> . [1]								
		$Mg^{2+}$ polarised the $CO_3^{2-}$ ion to a greater extent compared to $Ca^{2+}$ . The C–O bond is weakened more. Less energy is needed to break it. [1]								
		Hence MgCO <sub>3</sub> has lower thermal decomposition temperature.								
	(iii)	Explain why Li <sub>2</sub> CO <sub>3</sub> decomposes in a similar way compared to these two carbonates. [1]								
		Li <sup>+</sup> is smaller than Mg <sup>2+</sup> , though Li <sup>+</sup> has smaller charge than Mg <sup>2+</sup> . Li <sup>+</sup> has the similar charge density (and hence similar polarising power) as Mg <sup>2+</sup> . [1]								
(d)	(i)	Predict and explain the difference in melting points of calcium oxide and magnesium oxide								
		<i>Lattice Energy</i> $\propto \left  \frac{Q_+Q}{r_+ + r} \right $ [2]								
		Mg <sup>2+</sup> is smaller [ $$ ] than Ca <sup>2+</sup> . The electrostatic attraction between Mg <sup>2+</sup> and O <sup>2-</sup> is stronger [ $$ ] than that between Ca <sup>2+</sup> and O <sup>2-</sup> . More energy is required to separate the Mg <sup>2+</sup> and O <sup>2-</sup> ions. <b>Two</b> [ $$ ]: [1]								
		Hence MgO has higher melting point and boiling point than CaO. [1]								
	(ii)	In power plant or trash incineration plant, large quantities of sulfur dioxide gas are produced. Calcium oxide can be used to remove sulfur dioxide from these exhaust gases in a process called flue-gas desulfurisation.								
		$CaO+SO_2\toCaSO_3$								
		State the type of reaction for the above reaction. [1]								
		Acid-Base [1]								
(e)	Benzoic acid is an important precursor for the industrial synthesis of many other organic substances. Its salts are also used as food preservatives									





5	(a)	(i)	A compound <b>X</b> consists only of carbon, hydrogen and oxygen. During the complet combustion of 4 g of the compound, 8 g of carbon dioxide and 3.273 g of wate were produced.							
			Determine the empirical formula of the compound $X$ .							
				C	Н	0	7			
			Mass / gram	(8)(12.0/44.0) = 2.182	(3.273)(2/18.0) = 0.3637	4 – 2.182 – 0.3637 = 1.454				
			Amount / mole	0.1818	0.3637	0.09088				
			Simplest Ratio	2	4	1				
			Empirical Formula: C2H4O         [1]         Table [1]							
		(ii)	Another 4 g sample of compound <b>X</b> was vaporised at 160 $^{\circ}$ C and 101 kPa, and found to occupy a volume of 1620 cm <sup>3</sup> .							
			Determine the relat	ive molecular ma	ass of this compo	und.	[1]			
			PV = nRT (101,000)(1620 ÷ 10 <sup>-6</sup> ) = (8.31)(160+273)(4 ÷ Mr) Mr = 88.0							
		(iii)	Hence determine the molecular formula of compound <b>X</b> . Show your working clearly. [1]							
			$(M_{\rm r} \text{ of } C_2 H_4 O) \ge n = 88.0$ n = 2							
			Molecular Formula of X is $C_4H_8O_2$ .							
	(b)	Butan aroma	oic acid is used in the preparation of various esters. These esters have pleasant as or tastes. As a consequence, they are used as food and perfume additives.							
		(i)	Biological methods have been developed to produce methane from waste organic matter using bacteria.							
			Based on the changes in oxidation numbers of carbon, construct a balanced equation for the disproportionation of <b>aqueous</b> butanoic acid to produce methane and carbon dioxide only. [1]							
			$2CH_3CH_2CH_2COOH + 2H_2O \rightarrow 5CH_4 + 3CO_2$							
		(ii)	Given the following	data,						
			• Enthalpy change of computation of but angle acid is $-2194 \text{ k} \text{ J} \text{ mal}^{-1}$							
			<ul> <li>Enthalpy change of combustion of methane is -890 kJ mol<sup>-1</sup>.</li> </ul>							
			Calculate the enthalpy change for the reaction in <b>(b)(i)</b> for <b>liquid</b> butanoic acid instead of aqueous butanoic acid. [1]							
			$2CH_{3}CH_{2}CH_{2}COOH \Delta H^{\circ}_{r} = (2)(-2184) -$	$H(I) + 2H_2O(I) \rightarrow (5)(-890) = +82$	5CH₄(g)+ 3CO₂(g 2 kJ mol⁻¹	(1				

	(iii)	Given that								
		$CH_{3}CH_{2}CH_{2}COOH(I) \rightarrow CH_{3}CH_{2}CH_{2}COOH(aq) \qquad \Delta H^{e}_{soln} = -16.7 \text{ kJ mol}^{-1}$								
		Use you answer in (b)(ii) to calculate the enthalpy change of reaction in (b)(i). [2]								
		$2CH_{3}CH_{2}CH_{2}COOH(aq) + 2H_{2}O(I) \xrightarrow{\Delta H^{e}_{r}} 5CH_{4}(g) + 3CO_{2}(g)$								
		(-16.7)(2) +82								
		2CH <sub>3</sub> CH <sub>2</sub> COOH(I) + 2H <sub>2</sub> O(I) [1] cycle								
		By Hess's Law,								
		$\Delta H_r^{e} = -(-16.7)(2) + (+82) = +115 \text{ kJ mol}^{-1} (3\text{sf})$ [1]								
	(iv)	Butanoic acid boils at 117.7 °C. During boiling, the liquid phase is at equilibrium with the gas phase.								
		Calculate the entropy change of vaporisation of butanoic acid, given that the enthalpy change of vaporisation of butanoic acid is $+52.0 \text{ kJ mol}^{-1}$ . [1]								
		At boiling, $\Delta G_{vap} = 0$ $\Delta H_{vap} - T\Delta S_{vap} = 0$ $\Delta S_{vap} = \Delta H_{vap} \div T = +52,000 \div (117.7 + 273) = +133 \text{ J mol}^{-1} \text{ K}^{-1}$								
	(v)	Trouton's Rule states that the entropy change of vaporisation of many liquids, such as benzene and propanone, is about +88 J mol <sup><math>-1</math></sup> K <sup><math>-1</math></sup> .								
		Compare and explain the calculated result in <b>(b)(iv)</b> in relation to Trouton's Rule. [1]								
		$\Delta S^{e}_{vap}$ (butanoic acid) is more positive than +85 J mol <sup>-1</sup> K <sup>-1</sup> , as hydrogen bonds between butanoic acid molecules reduces its entropy in the liquid state.								
(c)	Polyb intere	utylene succinate (PBS) is a polyester used in packaging. It is receiving renewed st due to increased demand for biodegradable polymers.								
		Polybutylene succinate								
	Hydro	lysis of PBS produces two monomers <b>E</b> and <b>F</b> .								
	E can	be reduced to <b>F</b> .								
	When mang	an organic compound <b>D</b> , $C_{10}H_{18}O_2$ is heated with acidified potassium anate (VII), two products, <b>E</b> , $C_4H_6O_4$ and <b>G</b> , $C_6H_{12}O$ are formed.								

**G** produces a yellow precipitate on warming with iodine in aqueous sodium hydroxide, and rotates the plane of polarised light. Upon gentle heating, E produces a neutral compound H, C<sub>4</sub>H<sub>4</sub>O<sub>3</sub>, which does not react with sodium metal or give a precipitate with 2,4-dinitrophenylhydrazine. Suggest structures for **D** to **H**, and explain the observations described above. [7]  $CH_3CH_2-C$  H  $CH_2CH_2COOH$  G:  $CH_3CH_2-C$   $CH_3$   $CH_3CH_2-C$   $CH_3$ D : ·CH<sub>2</sub>CH<sub>2</sub>· E : Н: HO **F** : HO—CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>-OH Structures: [1] each. Total = [5] Information Type of Reaction Deduction **D**,  $C_{10}H_{18}O_2$  is heated Strong Oxidation D has trisubstituted alkene: with acidified potassium manganate (VII), two products, **E**,  $C_4H_6O_4$  and **G**,  $C_6H_{12}O$  are formed. **G** produces a yellow Mild Oxidation 0 precipitate on heating  $H_3C$ with iodine in aqueous **G** has this: sodium hydroxide. G rotates the plane of G has chiral carbon.  $\sqrt{}$ polarised light. Upon gentle heating, E Dehydration **H** is not carboxylic acid, alcohol, produces a neutral ketone, or aldehyde. compound **H**,  $C_4H_4O_3$ , OR  $\sqrt{}$ which does not react with **H** is anhydride. sodium metal or give a precipitate with 2,4dinitrophenylhydrazine. **Deduction:** 4 ticks: [2]; 2 or 3 ticks: [1]; 1 tick : [0]

(d)	Male form	eic acid and fumaric a nulae, but with very diffe	cid are two ison erent physical pr	mers with the operties.	same molecu	ular and structu	Jral
			ноос	соон =с	ноос	=cH	
			н́	н	н́	соон	
			maleic	acid	<u>fumar</u>	<u>ric acid</u>	
		melting point / °C	13	0	2	87	
		o <i>K</i> a₁	1.9	9	3	.0	-
		o <i>K</i> a <sub>2</sub>	6.5	5	4	5	
	(i)	Give two reasons t fumaric acid.	o explain why	maleic acid I	has a lower n	nelting point th	חמר [2]
		Maleic acid has intra COOH groups. It has	a-molecular hydr s less inter-mole	ogen bonds o cular hydroge	lue to close pro en bonds. <b>[1]</b>	oximity of its tw	'0 —
		Maleic acid has lower packing efficiency of molecules in the solid state. [1] The molecules are further apart. There will be weaker forces of attraction between molecules.					The een
		Hence less energy n melting point.	needed to separa	ate the molec	ules. Maleic ac	cid has lower	
	(ii)	Explain why maleic a	acid has a lower	<sup>·</sup> p <i>K</i> a₁ value tł	nan fumaric ac	id.	[1]
		H hy	/drogen bond		он		
			- 0	0=0		4	
		c=c	Н	F		c==0	
		Carboxylate ion of N	laleic acid	Carbox	ylate ion of Fu	maric acid	
		Due to close proxim can be formed in the hydrogen bond is no	ity of the two –( e carboxylate io t possible in the	COOH groups n of maleic ac carboxylate i	s, intra-molecul cid [ $$ ]. But su on of fumaric a	lar hydrogen bo ch intra-molecu acid.	ond ular
		This ion of maleic a fumaric acid. Hence	acid is more sta pKa₁ value of m	ble $[]$ and naleic acid is $\mathbb{R}$	nore readily fo ower than that	ormed than that of fumaric acid	t of I.
		Two [√] : 1 mark					
	<u> </u>					[Total:	201