

---

**CHEMISTRY**

**9701/42**

Paper 4 A Level Structured Questions

**May/June 2017**

MARK SCHEME

Maximum Mark: 100

---

**Published**

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2017 series for most Cambridge IGCSE<sup>®</sup>, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

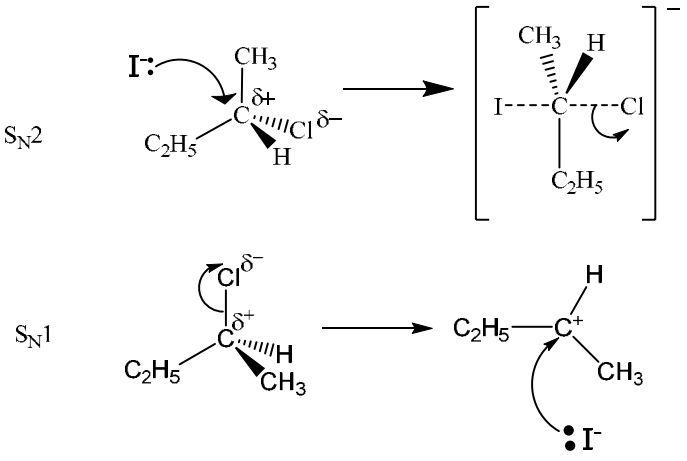
---

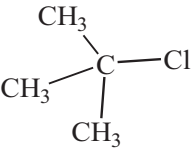
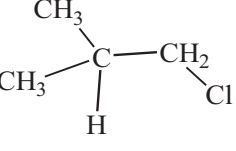
© IGCSE is a registered trademark.

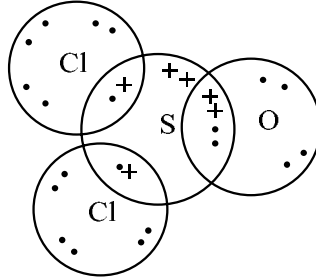
This document consists of **13** printed pages.

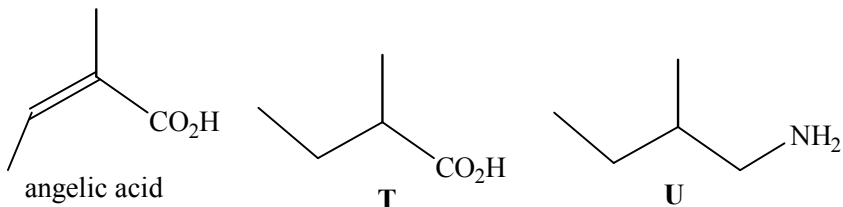
Question	Answer	Marks
1(a)(i)	increases down the group	1
	radius / size of (cat)ion/M <sup>2+</sup> increases	1
	less polarisation / distortion of anion / carbonate <b>ion</b> / CO <sub>3</sub> <sup>2-</sup>	1
1(a)(ii)	Na <sup>+</sup> has smaller ionic charge <b>and</b> larger ionic radii  OR the <b>charge density</b> of the Na <sup>+</sup> is <b>lower</b>	1
1(b)(i)	2KHCO <sub>3</sub> ———→ K <sub>2</sub> CO <sub>3</sub> + CO <sub>2</sub> + H <sub>2</sub> O	1
1(b)(ii)	NaHCO <sub>3</sub> because Na <sup>+</sup> is <b>smaller</b> OR charge density Na <sup>+</sup> is <b>larger</b>	1
1(c)(i)	LE = $\Delta H_f - 2(\Delta H_{at} + IE) - \frac{1}{2}(O=O) - (EA_1 + EA_2)$ = $-361 - 2(89) - 2(418) - 496/2 - (-141+798)$ = <b>-2280</b> (kJ mol <sup>-1</sup> ) correct answer scores [3]	1 1 1
1(c)(ii)	LE of Na <sub>2</sub> O will be <b>more negative</b> AND as Na <sup>(+)</sup> is smaller / larger charge density / smaller radii AND so greater attraction (between the ions) OR (ionic) bonds will be stronger	1
	<b>Total:</b>	<b>10</b>

Question	Answer	Marks
2(a)	Add AgNO <sub>3</sub> Cl <sup>-</sup> gives a white ppt <b>and</b> I <sup>-</sup> gives a yellow ppt.	1
	Add NH <sub>3</sub> (aq); ppt dissolves <b>and</b> ppt is insoluble	1
2(b)(i)	conductivity <b>decreases</b> during the reaction, AND number of Na <sup>+</sup> / I <sup>-</sup> / <b>ions</b> are <b>decreased</b> / used up (from solution)	1
2(b)(ii)	(Equilibrate) solutions at 40 °C / with a water bath (cannot be after mixing)  mix <b>known volumes and</b> start the clock / timing clearly mentioned/implied  measure conductance / conductivity at regular intervals / every measured time [method A] OR measure the time for conductance to go to zero / a specific value / to be constant [method B]  prepare a curve of conductance vs. time [related to method A] OR prepare a curve of conductance vs. concentration [related to method A] OR repeating the experiment at different concentrations [related to method A and B]	3         any 3 points
2(c)(i)	[R-Cl]: rate increases by 5 / 3 when concentration increases by 10 / 6 (5 / 3),	1  so order = 1
	[I <sup>-</sup> ]: rate increases by 5 / 3 when concentration increases by 5 / 3,	1  so order = 1
2(c)(ii)	rate = $k[I^-][CH_3CH_2CHClCH_3]$ AND units of $k = dm^3 mol^{-1} s^{-1}$	1
2(c)(iii)	relative rate = 5 / 5.3	1

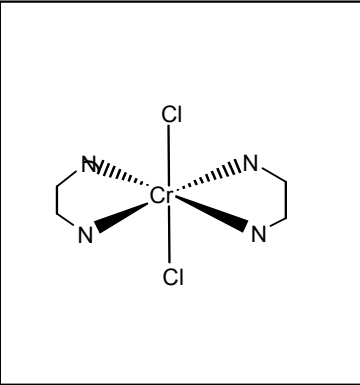
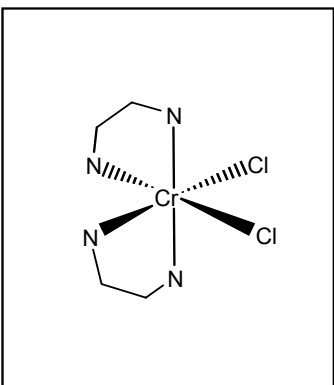
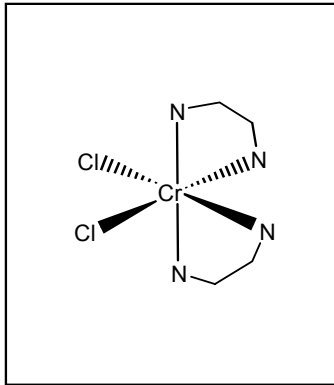
Question	Answer	Marks
2(d)(i)	<p>either S<sub>N</sub>1 or S<sub>N</sub>2 mechanism</p>  <p>S<sub>N</sub>2</p> <p>S<sub>N</sub>1</p> <p>C-Cl dipole AND C-Cl curly arrow</p> <p>intermediate cation OR 5-valent transition state (charge essential)</p> <p>I<sup>-</sup> with lone pair AND other curly arrow</p>	<p></p> <p></p> <p></p> <p><b>1</b></p> <p><b>1</b></p> <p><b>1</b></p>
2(d)(ii)	<p>If S<sub>N</sub>1 in 2(d)(i) <b>mixture of / two</b> optical isomers will be formed, AND the intermediate can be formed by the I<sup>-</sup> approaching from top or bottom plane</p> <p>If S<sub>N</sub>2 in 2(d)(i) <b>one optical isomer</b> AND attack always from fixed direction / opposite side</p>	<b>1</b>

Question	Answer	Marks
2(e)(i)	4 peaks	1
2(e)(ii)	 	1 + 1
	number of peaks = 2	number of peaks = 3
<b>Total:</b>		<b>18</b>

Question	Answer	Marks
3(a)		
	four shared pairs: S=O and 2 × S-Cl	1
	all (9) lone pairs	1
3(b)(i)	$\text{NaOH} + \text{HCl} \longrightarrow \text{NaCl} + \text{H}_2\text{O}$	1
	$2\text{NaOH} + \text{SO}_2 \longrightarrow \text{Na}_2\text{SO}_3 + \text{H}_2\text{O}$	1

Question	Answer	Marks
3(b)(ii)	moles (at start) = $0.5 \times 60 / 1000 = 3 \times 10^{-2}$ AND moles (at end) = $0.5 \times 10.8 / 1000 = 5.4 \times 10^{-3}$	1
	moles reacted (= $(30 - 5.4) \times 10^{-3}$ =) $2.5 \times 10^{-2}$ correct ans. scores [2]	1
3(b)(iii)	moles of $\text{RCO}_2\text{H} = 2.46 \times 10^{-2} / 3 = 8.2 - 8.3 \times 10^{-3}$ mole	1
3(b)(iv)	$M_r = 1.00 / (8.2 \times 10^{-3}) = 121.95 (=122)$	1
3(b)(v)	$\text{C}_7\text{H}_6\text{O}_2$ OR $\text{C}_6\text{H}_5\text{CO}_2\text{H}$	1
3(c)(i)	$\text{LiAlH}_4$	1
3(c)(ii)	 <p>angelic acid                      <b>T</b>                      <b>U</b></p>	3
3(c)(iii)	angelic acid:                      geometrical OR cis-trans compound <b>T</b> :                      optical	1
	<b>Total:</b>	<b>14</b>

Question	Answer	Marks
4(a)(i)	$M_r = 52 + 6 \times 18 + 3 \times 35.5 = 266.5$	<b>1</b>
4(a)(ii)	$1.00\text{g} = 1 / 266.5$ <b>OR</b> $3.75 \times 10^{-3}$ moles (of complex in 1g) for <b>A</b> , $n=2$ <b>AND</b> $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl} \cdot 2\text{H}_2\text{O}$ for <b>B</b> , $n=1$ <b>AND</b> $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl} \cdot \text{H}_2\text{O}$ for <b>C</b> , $n=0$ ; <b>AND</b> $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$	<b>2</b>
4(b)(i)	Geometric(al) / cis-trans	<b>1</b>
4(b)(ii)	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <math display="block">\begin{array}{c} \text{CN} \\   \\ \text{R}_3\text{P} - \text{Ni} - \text{PR}_3 \\   \\ \text{CN} \end{array}</math> <p>isomer 1</p> </div> <div style="text-align: center;"> <math display="block">\begin{array}{c} \text{CN} \\   \\ \text{R}_3\text{P} - \text{Ni} - \text{CN} \\   \\ \text{PR}_3 \end{array}</math> <p>isomer 2</p> </div> </div>	<b>1</b>
4(b)(iii)	isomer 2 <b>AND</b> dipoles do not cancel <b>OR</b> $\text{CN}^-$ are on the same side of the molecule	<b>1</b>
	<b>Total:</b>	<b>6</b>

Question	Answer	Marks
5(a)(i)	<i>bidentate</i> : (a species that) forms <b>two</b> dative bonds / donates <b>two</b> lone pairs	1
	<i>ligand</i> : a species that uses a <b>lone pair</b> to form a <b>dative</b> bond to a <b>metal atom / metal ion</b>	1
5(a)(ii)	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; padding: 10px; text-align: center;">  </div> <div style="border: 1px solid black; padding: 10px; text-align: center;">  </div> <div style="border: 1px solid black; padding: 10px; text-align: center;">  </div> </div> <p style="text-align: right; margin-top: 20px;">each structure [1] x 3</p>	3
5(b)(i)	$K_{\text{stab1}} = [\text{Cu}(\text{NH}_3)_4^{2+}] / [\text{Cu}^{2+}][\text{NH}_3]^4$	1
	$K_{\text{stab2}} = [\text{Cu}(\text{en})_2^{2+}] / [\text{Cu}^{2+}][\text{en}]^2$	1
	$\text{mol}^{-4} \text{dm}^{12}$ AND $\text{mol}^{-2} \text{dm}^6$	1
5(b)(ii)	$K_{\text{eq3}} = K_{\text{stab2}} / K_{\text{stab1}}$	1
5(b)(iii)	$K_{\text{eq3}} = K_{\text{stab2}} / K_{\text{stab1}} = 4.4(2) \times 10^6$	1
	$\text{mol}^2 \text{dm}^{-6}$	1
5(c)(i)	$(\Delta S_{\text{eq1}}$ is negative as) <b>more / 5</b> moles of reactants are forming (one mole of) the complex OR $(\Delta S_{\text{eq2}}$ is positive as) <b>fewer / 3</b> moles of reactants are forming (one mole of) the complex	1
5(c)(ii)	$\Delta G_{\text{eq2}} = -100 - 298 \times 40 / 1000$ OR $\Delta G = \Delta H - T\Delta S$ $= -112$ or $-111.9$ ( $\text{kJ mol}^{-1}$ ) correct answer [2]	2 1 1

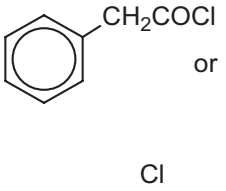
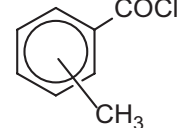
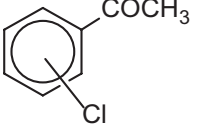
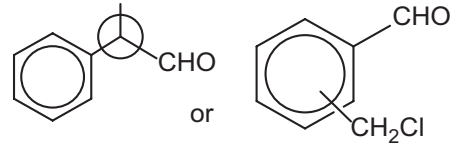
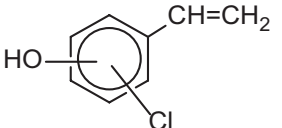
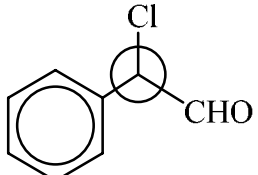


Question	Answer	Marks
5(c)(iii)	Since ( $\Delta G_{\text{eq}2}$ ) is <b>more</b> negative (than $\Delta G_{\text{eq}1}$ ) AND equilibrium 2 is more feasible	1
5(c)(iv)	$\Delta H_{(3)} = -8 \text{ (kJ mol}^{-1}\text{)}$	1
5(c)(v)	<b>ligand</b> exchange / replacement / substitution / displacement	1
	<b>Total:</b>	<b>17</b>

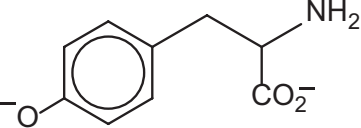
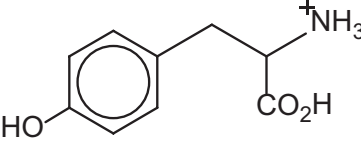
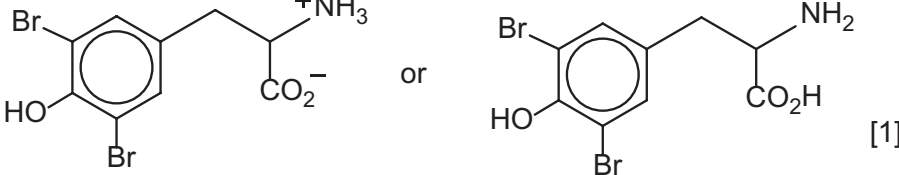
Question	Answer	Marks
6(a)(i)	the lower / smaller the $pK_a$ , the stronger the acid	1
6(a)(ii)	$pK_a = -\log(K_a)$ or $pK_a = -\lg(K_a)$ or $K_a = 10^{-pka}$	1
6(a)(iii)	(stronger than ethanoic acid because) Cl is electron-withdrawing	1
	and so stabilises the $\text{RCO}_2^-$ anion / conjugate base or weakens O-H bond (so $\text{H}^+$ is more easily released)	1
6(b)(i)	$\text{NH}_3^+\text{CH}_2\text{CO}_2^- \longrightarrow \text{NH}_2\text{CH}_2\text{CO}_2^- + \text{H}^+$ OR $\text{NH}_3^+\text{CH}_2\text{CO}_2^- + \text{H}_2\text{O} \longrightarrow \text{NH}_2\text{CH}_2\text{CO}_2^- + \text{H}_3\text{O}^+$	1
6(b)(ii)	$K_a = 10^{-9.87} = 1.35 \times 10^{-10}$ $[\text{H}^+] = \sqrt{K_a \cdot c} = 3.67 \times 10^{-6}$	1
	pH = <b>5.4</b> (5.43–5.44) min 2sf	1

Question	Answer	Marks
6(b)(iii)	curve starts at 5.4 and continuous	1
	vertical portion (end point) at vol added = 10.0 cm <sup>3</sup>	1
	finishes at pH = 12.5 at 20 cm <sup>3</sup> (and does not increase in pH)	1
	<b>Total:</b>	<b>10</b>

Question	Answer				Marks
7(a)	<b>W</b>	<b>X</b>	<b>Y</b>	<b>Z</b>	<b>5</b>
	acyl chloride / COCl	methyl ketone / CH <sub>3</sub> CO group aryl chloride	aldehyde / CHO chloro(alkane) / RCl	Alkene / C=C phenol / C <sub>6</sub> H <sub>5</sub> OH aryl chloride	
0–1 [0]; 2 [1]; 3 [2]; 4 [3]; 5 [4]; 6–8 [5]					

Question	Answer	Marks
7(b)(i)	<p>W  or </p> <p>X </p>	1 + 1
7(b)(i)	<p>Y </p> <p>Z </p>	1 + 1
7(b)(ii)	<p>Y </p> <p>OR any chiral atom correctly labelled</p>	1
<b>Total:</b>		<b>10</b>

Question	Answer	Marks
8(a)(i)	step 1 electrophilic substitution	ignore acylation
	step 2 nucleophilic addition	
8(a)(ii)	hydrolysis	

Question	Answer	Marks
8(a)(iii)	step 1 $ClCH_2CHO$ (allow Br, I for Cl)	1
	$AlCl_3$	1
	step 2 $HCN + NaCN$	1
	step 3 heat in $H_3O^+$ / heat $H^+(aq)$	1
	step 5 $NH_3$ under pressure (+ heat) or heat $NH_3$ in a sealed tube	1
8(a)(iv)	with $NaOH(aq)$  [2]	1 + 1
	with $HCl(aq)$  [1]	1
	with $Br_2(aq)$  [1]	1
8(b)(i)	P is tyr	1
	tyr is 2- AND it is small / has a small Mr	1

Question	Answer	Marks
8(b)(ii)	<i>(dipeptide / phe-tyr) 2-</i> is about double the $M_r$ / mass of <i>(phe) 1</i>  OR mass / charge ratios are about the same for each (for dipeptide / phe-tyr and phe)	<b>1</b>
	<b>Total:</b>	<b>15</b>