
CHEMISTRY

9701/41

Paper 4 A Level Structured Questions

October/November 2016

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.

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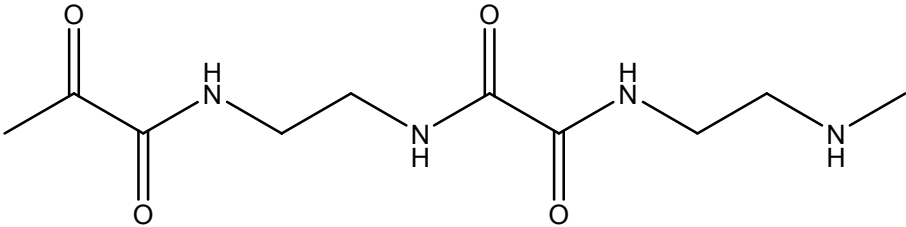
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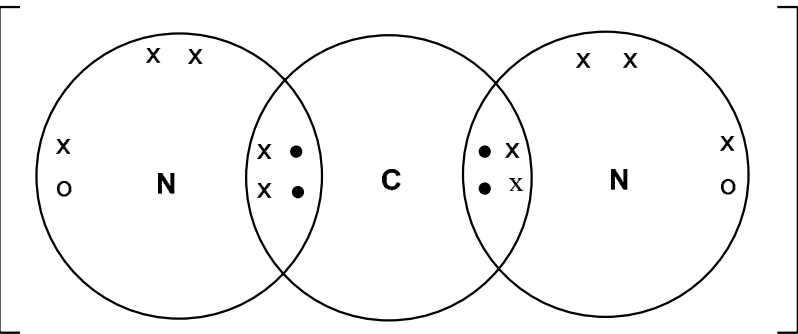
Page 2	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
1(a)	Cu [Ar] 3d ¹⁰ 4s ¹ Cu ²⁺ [Ar] 3d ⁹ (4s ⁰)	1 1 2
1(b)(i)	ligand exchange / replacement / displacement / substitution	1 1
1(b)(ii)	[Cu(H ₂ O) ₆] ²⁺ blue and [CuCl ₄] ²⁻ yellow OR yellow / green OR green / yellow	1 1
1(b)(iii)	tetrahedral	1 1
1(b)(iv)	$K_{\text{stab}} = [\text{CuCl}_4^{2-}] / [\text{Cu}(\text{H}_2\text{O})_6^{2+}][\text{Cl}^-]^4$	1 1
1(c)(i)	a species that contains two lone pairs that (each) form a co-ordinate / dative bond OR are donated (to a metal ion / atom)	1 1 2
1(c)(ii)	equilibrium 2 lies more to the RHS / favours forward reaction more	1 1
1(d)(i)	optical	1 1
1(d)(ii)	3D correct for octahedral one correct structure with 3D second correct with 3D	1 1 1

Page 3	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
		3
1(e)(i)	lone pair receive / accepts a proton / H^+	1 1 2
1(e)(ii)	$H_2NCH_2CH_2NH_2 + 2HCl \rightarrow ClH_3NCH_2CH_2NH_3Cl$ OR $H_2NCH_2CH_2NH_2 + 2H^+ \rightarrow H_3N^+CH_2CH_2N^+H_3$	1 1
1(f)(i)	amide bond, displayed or $-CONH-$ rest of the molecule with continuation bonds 	1 1 2
1(f)(ii)	condensation / addition – elimination	1 1
1(f)(iii)	any named polyalkene / eg polyethene, PVC allow Bakelite or Kevlar	1 1
	Total:	20

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Question	Answer	Mark
2(a)	solid remains	1 1
2(b)	stability increases (down the group) as size / radius of (metal) ion / M²⁺ increases so polarisation / distortion of anion / carbonate ion decreases	1 1 1 3
2(c)(i)		2
2(c)(ii)	$\text{CaCN}_2 + 3\text{H}_2\text{O} \rightarrow \text{CaCO}_3 + 2\text{NH}_3$ CaCO_3 correct equation	1 1 2
	Total:	8

Page 5	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
3(a)(i)	(entropy) increases / is positive and H ₂ / gas is formed	1 1
3(a)(ii)	(entropy) increases / is positive and (KCl (aq)) solution has (free) moving / mobile ions / aqueous ions	1 1
3(a)(iii)	(entropy) decreases / is negative and decrease in gas	1 1
3(b)(i)	$\Delta S^\circ = 26.9 + 214 - 65.7 = (+) 175.2 \text{ (J K}^{-1} \text{ mol}^{-1}\text{)}$ $\Delta G^\circ = 117 - (298 \times 175.2 / 1000)$ OR $\Delta G^\circ = 117\,000 - (298 \times 175.2)$ $\Delta G^\circ = +64.8 \text{ (kJ mol}^{-1}\text{)}$	1 1 1 3
3(b)(ii)	T ΔS is more positive than ΔH / T ΔS increases / –T ΔS more negative and ΔG is negative / decrease / less positive	1 1
3(c)	use of $\Delta G = 0$ or $\frac{T\Delta S}{\Delta H} = 1$ $T = 130 / (316 / 1000) = \mathbf{410 / 411 / 412 / 411.4 \text{ (K)}}$	1 1 2

Page 6	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
3(d)	hydration enthalpy and lattice energy both more endothermic / more positive / less exothermic / less negative (down the group) ΔH_{hyd} decreases more / faster and ΔH_{sol} becomes (more) endothermic / (more) positive / less exothermic / less negative	1 1 2
	Total:	11

Question	Answer	Mark
4(a)	(an element) forming one or more (stable) ions or compounds or oxidation states with partially filled / incomplete d orbitals	1 1
4(b)(i)	A Co(OH)_2 OR $\text{Co(H}_2\text{O)}_4\text{(OH)}_2$ B $[\text{CoCl}_4]^{2-}$ C $[\text{Co(NH}_3)_6]^{2+}$ OR $[\text{Co(NH}_3)_6]^{3+}$ two correct = 1 mark three correct = 2 marks	 2
4(b)(ii)	$[\text{Co(H}_2\text{O)}_6]^{2+}$ pink solution of B blue solution of C brown/yellow/orange	

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Question	Answer	Mark
	two correct = 1 mark three correct = 2 marks	2

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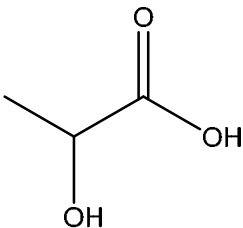
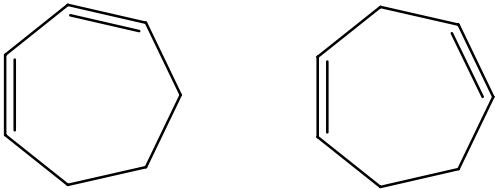
Question	Answer	Mark						
4(c)	(emf / potential / E) of an electrode OR a half-cell compared to / connected to (S)HE which can be called a “hydrogen half-cell” at concentration of 1 mol dm^{-3} and pressure of 1 atm (or in Pa) OR 298 K	1 1 2						
4(d)(i)	<table><tr><td>half-cell</td><td>electrode</td></tr><tr><td>$\text{Co}^{2+} / \text{Co}$</td><td>Co / cobalt</td></tr><tr><td>$\text{Fe}^{3+} / \text{Fe}^{2+}$</td><td>Pt / carbon / graphite</td></tr></table>	half-cell	electrode	$\text{Co}^{2+} / \text{Co}$	Co / cobalt	$\text{Fe}^{3+} / \text{Fe}^{2+}$	Pt / carbon / graphite	1 1
half-cell	electrode							
$\text{Co}^{2+} / \text{Co}$	Co / cobalt							
$\text{Fe}^{3+} / \text{Fe}^{2+}$	Pt / carbon / graphite							
4(d)(ii)	$\text{Co} + 2\text{Fe}^{3+} \rightarrow \text{Co}^{2+} + 2\text{Fe}^{2+}$	1 1						
4(d)(iii)	$E^\ominus_{\text{cell}} = 0.77 - (-0.28) = (+ \text{ or } -) 1.05 \text{ (V)}$	1 1						
4(e)(i)	$E_{\text{electrode}} = -0.28 + (0.059 / 2) \log [0.05] = \textbf{-0.32 / -0.318 (V)}$	1 1						
4(e)(ii)	more positive	1 1						
4(f)	$4\text{Fe}^{3+} + \text{V} + \text{H}_2\text{O} \rightarrow \text{VO}^{2+} + 4\text{Fe}^{2+} + 2\text{H}^+$ VO^{2+} correct equation	1 1						

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Question	Answer	Mark
		2
	Total:	14

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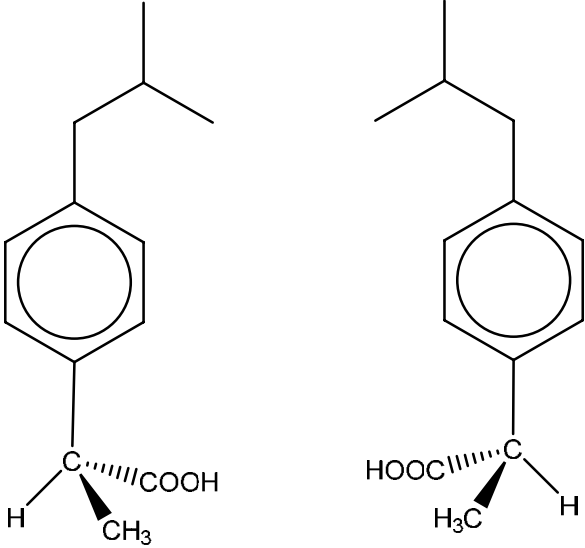
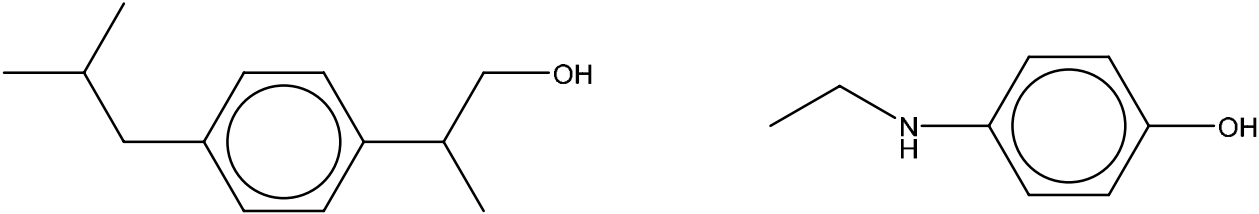
Question	Answer				Mark																
5(a)(i)	(100/22.1)×(0.7/1.1) or $\frac{100 \times 0.7}{22.1 \times 1.1}$ or 2.87/2.88/2.9 3 carbon atoms				1 1 2																
5(a)(ii)	C ₃ H ₆ O ₃				1 1																
5(b)	<table><tr><td>absorption / cm⁻¹</td><td>appearance of the peak</td><td>type of bond</td><td>functional group</td></tr><tr><td>3350</td><td>broad and strong</td><td>OH or O–H</td><td>alcohol / ROH</td></tr><tr><td>2680</td><td>very broad and strong</td><td>OH or O–H</td><td>(carboxylic) acid / CO₂H</td></tr><tr><td>1725</td><td>strong</td><td>C = O</td><td>(carboxylic) acid / CO₂H</td></tr></table>				absorption / cm ⁻¹	appearance of the peak	type of bond	functional group	3350	broad and strong	OH or O–H	alcohol / ROH	2680	very broad and strong	OH or O–H	(carboxylic) acid / CO ₂ H	1725	strong	C = O	(carboxylic) acid / CO ₂ H	2
absorption / cm ⁻¹	appearance of the peak	type of bond	functional group																		
3350	broad and strong	OH or O–H	alcohol / ROH																		
2680	very broad and strong	OH or O–H	(carboxylic) acid / CO ₂ H																		
1725	strong	C = O	(carboxylic) acid / CO ₂ H																		

Question	Answer			Mark
5(c)(i)	δ /ppm	type of proton	relative peak area	
	1.4	–CH ₃ or –CH ₂ or –CH or alkane	3	
	3.9	–OCH or –OCH ₂ or –OCH ₃ or CH or alkyl next to electronegative atom / oxygen	1	
	4.7	–OH or alcohol	1	
	12.9	–OH or –CO ₂ H or carboxylic acid	1	
				4
5(c)(ii)	doublet and 1 / one H / proton on neighbouring OR adjacent carbon			1
				1
5(c)(iii)	4.7 and 12.9 OR –OH and –CO ₂ H			1
				1
5(c)(iv)				1
				1
5(d)(i)				1
	both required for 1 mark			1

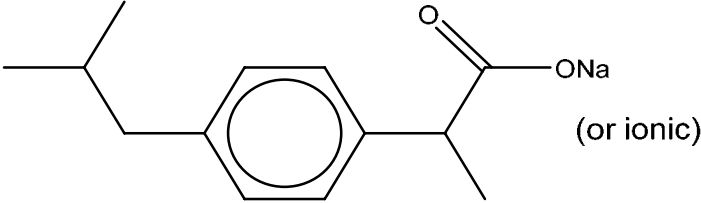
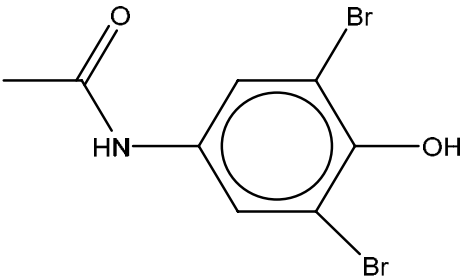
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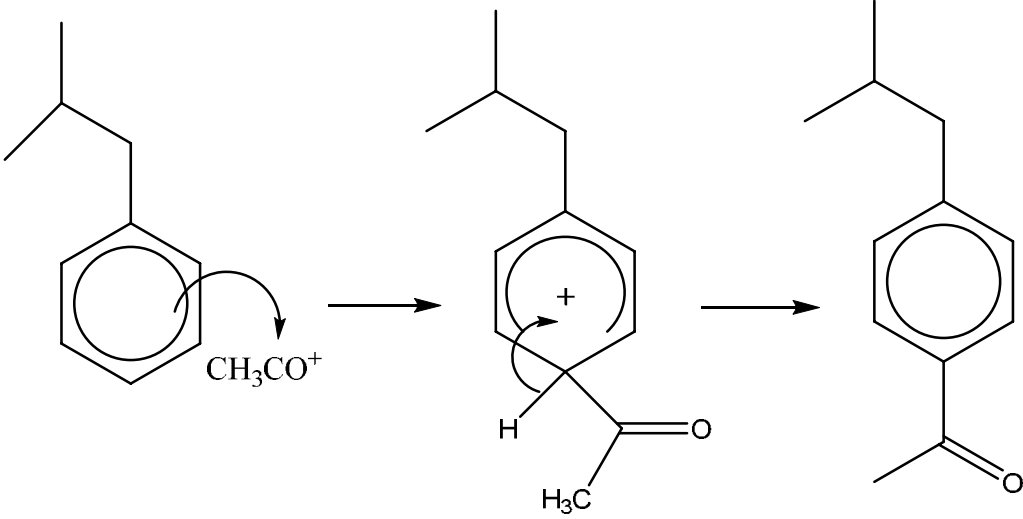
Question	Answer		Mark
5(d)(ii)	isomer	number of peaks	
	P	4	1
	Q	4	1
			2
	Total:		15

Question	Answer	Mark
6(a)	ibuprofen: carboxylic acid / carboxyl paracetamol: phenol and amide any two = 1 mark all three = 2 marks	2
6(b)(i)	(chiral centre is a) carbon OR atom that has four different groups / atoms / species attached to it	1 1

Question	Answer	Mark
6(b)(ii)	 one correct isomer second diagram shows second isomer	1 1 2
6(c)	 with ibuprofen with paracetamol	1 1 2

Page 14	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
6(d)(i)	(reagent D) Na_2CO_3 / any carbonate (reagent E) Cl_2/Br_2	1 1 2
6(d)(ii)	 (or ionic)	1 1
6(d)(iii)		1 1
6(e)(i)	$\text{CH}_3\text{COCl} + \text{AlCl}_3 \rightarrow \text{CH}_3\text{CO}^+ + \text{AlCl}_4^-$	1 1

Question	Answer	Mark
6(e)(ii)	 curly arrow from ring system to CH_3CO^+ correct intermediate curly arrow from C–H bond into ring	1 1 1 3
6(e)(iii)	electrophilic substitution	1 1
	Total:	16

Page 16	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
7(a)	moles of thiosulfate = $0.1 \times 20.8 / 1000 = 2.08 \times 10^{-3}$ moles of ClO^- in 25 cm^3 portion = $2.08 \times 10^{-3} / 2 = 1.04 \times 10^{-3}$ (moles of ClO^- in $250 \text{ cm}^3 = 1.04 \times 10^{-2}$) concentration of $\text{ClO}^- = 1.04 \times 10^{-2} / (10 / 1000) = 1.04 \text{ (mol dm}^{-3}\text{)}$	1 1 1 3
7(b)(i)	starch	1 1
7(b)(ii)	blue OR black to colourless	1 1
7(b)(iii)	towards / close to the end-point of the titration / when the solution goes yellow	1 1
7(c)	moles of $\text{O}_2 = 82 / 24\,000 = 3.42 \times 10^{-3} = \text{moles } \text{ClO}^- \text{ ions}$ concentration of $\text{ClO}^- = 3.42 \times 10^{-3} / (5 / 1000) = 0.68 / 0.683 / 0.684 \text{ (mol dm}^{-3}\text{)}$	1 1 2
7(d)(i)	$K_c = \frac{[\text{C}_3\text{H}_3\text{N}_3\text{O}_3][\text{HClO}_3]^3}{[\text{C}_3\text{Cl}_3\text{N}_3\text{O}_3][\text{H}_2\text{O}]^3}$	1 1
7(d)(ii)	(position of eqm) moves to the right / forward reaction predominates / more HClO made (as $[\text{HClO}]$ decreases) no effect on K_c	1 1 2

Page 17	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
7(d)(iii)	$2\text{HClO} \rightarrow 2\text{HCl} + \text{O}_2$ OR $2\text{HClO} \rightarrow \text{H}_2 + \text{Cl}_2 + \text{O}_2$	1 1
7(e)(i)	addition of acid: $\text{H}^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{CO}_3$ OR $\text{H}^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{O} + \text{CO}_2$ addition of base: $\text{OH}^- + \text{H}_2\text{CO}_3 \rightarrow \text{HCO}_3^- + \text{H}_2\text{O}$ OR $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$ and position of eqm moves to the right OR $\text{OH}^- + \text{HCO}_3^- \rightarrow \text{CO}_3^{2-} + \text{H}_2\text{O}$	1 1 2
7(e)(ii)	$K_a = \frac{[\text{H}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}$ $[\text{H}^+] = (7.94 \times 10^{-7}) \times 1/9.5 = 8.36 \times 10^{-8}$ $\text{pH} = -\log[\text{H}^+] = \mathbf{7.08}$	1 1 2
	Total:	16

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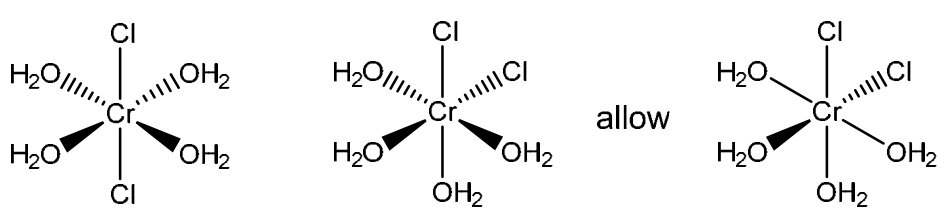
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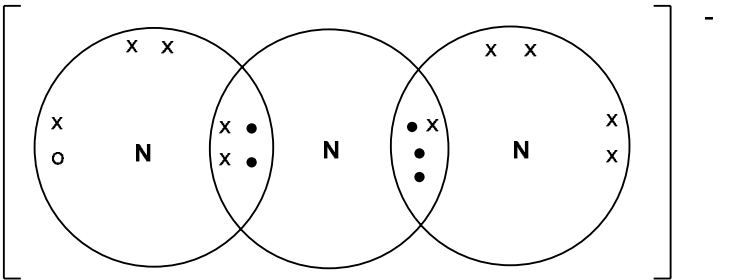
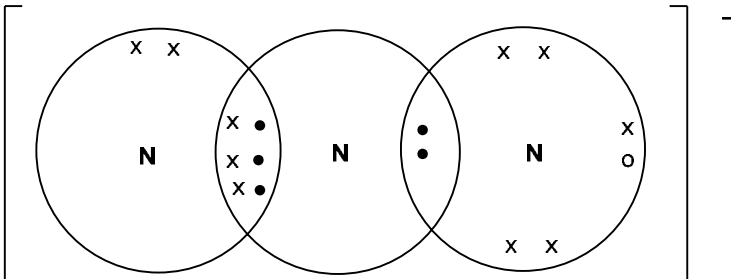
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Question	Answer	Marks									
1(a)	(an element) forming (one or more stable) ions with incomplete d subshell [1]	1 1									
1(b)(i)	<table border="1"> <tr> <td></td><td>co-ordination number</td><td>oxidation number</td></tr> <tr> <td>$[\text{Ni}(\text{CN})_2(\text{NH}_3)_2]$</td><td>4</td><td>+2</td></tr> <tr> <td>$[\text{CrCl}_2(\text{H}_2\text{O})_4]^+$</td><td>6</td><td>+3</td></tr> </table>		co-ordination number	oxidation number	$[\text{Ni}(\text{CN})_2(\text{NH}_3)_2]$	4	+2	$[\text{CrCl}_2(\text{H}_2\text{O})_4]^+$	6	+3	2
	co-ordination number	oxidation number									
$[\text{Ni}(\text{CN})_2(\text{NH}_3)_2]$	4	+2									
$[\text{CrCl}_2(\text{H}_2\text{O})_4]^+$	6	+3									
1(b)(ii)	dative (covalent)/co-ordinate	1 1									
1(b)(iii)	correct diagram of $[\text{Ni}(\text{CN})_2(\text{NH}_3)_2]$ square planar or tetrahedral	1 1 2									
1(c)(i)	(concentrated) hydrochloric acid / soluble chloride ion	1 1									
1(c)(ii)	ligand exchange / substitution	1 1									
1(d)(i)	cis-trans (isomerism) / geometric(al)	1 1									

Page 3	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
1(d)(ii)	one 3D isomer one correct isomer other isomer correct in 3D  The diagram shows three 3D isomers of the complex [CrCl₂(OH₂)₄]. 1. First isomer: Cr center with Cl at top, OH₂ at bottom, H₂O at top-left (wedge), OH₂ at top-right (dash), H₂O at bottom-left (wedge), OH₂ at bottom-right (wedge). 2. Second isomer: Cr center with Cl at top, OH₂ at bottom, H₂O at top-left (wedge), Cl at top-right (dash), H₂O at bottom-left (wedge), OH₂ at bottom-right (wedge). 3. Third isomer: Cr center with Cl at top, OH₂ at bottom, H₂O at top-left (wedge), Cl at top-right (dash), H₂O at bottom-left (wedge), OH₂ at bottom-right (wedge). The word 'allow' is placed between the second and third isomers.	1 1 1 3
	Total:	12

Page 4	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
2(a)	$\text{NaN}_3 \rightarrow \text{Na} + 1.5\text{N}_2$	1 1
2(b)	 all atoms must have 8 outer electrons coding for electrons correct = 16 ($10 \times 5 - 1 \square$) central N must have 8 bonding electrons (inc. 5 • and no non-bonded electrons) allow 	1 1 1 3
2(c)(i)	(energy change) when 1 mole of an (ionic) compound is formed or (energy change) when 1 mole of an <u>ionic</u> solid/lattice/crystal is formed (from) gas (phase) ions / gaseous ions (under standard conditions)	1 1 2
2(c)(ii)	forming an (ionic) bond	1 1

Page 5	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
2(c)(iii)	use of ΔH_{f1} 494 (kJ mol ⁻¹) $\Delta H_f^\circ = +107+494+142-732$ $\Delta H_f^\circ = +11$ (kJ mol ⁻¹)	1 1 1 3
2(c)(iv)	(ionic) radius / size of Na ⁺ is smaller (so stronger attraction to azide ion) OR ionic radius increases down the group	1 1
	Total:	11

Question	Answer	Mark
3(a)	Fe [Ar] 3d ⁶ 4s ² Fe ³⁺ [Ar] 3d ⁵	1 1 2
3(b)(i)	(catalyst is in) the same phase / state as the reactants	1 1
3(b)(ii)	$S_2O_8^{2-} + 2I^- \rightarrow 2SO_4^{2-} + I_2$	1 1
3(b)(iii)	(two) negatively-charged species repel each other	1 1
3(b)(iv)	Equation 1: $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$ Equation 2: $S_2O_8^{2-} + 2Fe^{2+} \rightarrow 2SO_4^{2-} + 2Fe^{3+}$	1 1 2

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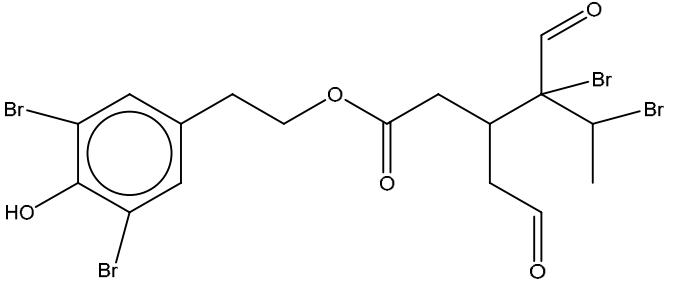
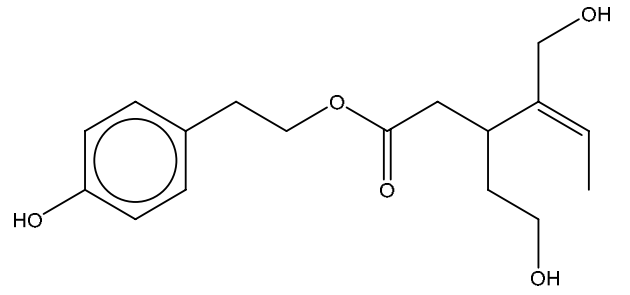
Question	Answer	Marks
3(c)(i)	(entropy is a measure / degree of the) disorder of a system / substance	1 1
3(c)(ii)	$\Delta S^\ominus = (2 \times 27) + (3 \times 214) - (90) - (3 \times 198)$ OR $696 - 684$ $\Delta S^\ominus = (+) 12 \text{ (J K}^{-1} \text{ mol}^{-1}\text{)}$	1 1 2
3(c)(iii)	$\Delta G^\ominus = -43.6 - (298 \times 12 / 1000)$ $\Delta G^\ominus = -47.2 \text{ (kJ mol}^{-1}\text{)}$	1 1 2
3(c)(iv)	high E_a and to speed up the rate	1 1
	Total:	13

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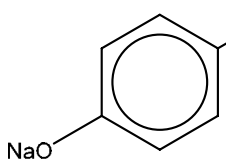
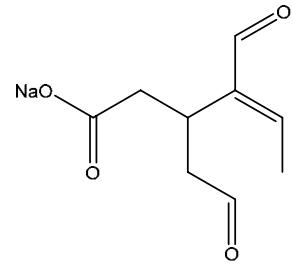
Question	Answer	Marks
4(a)	d orbitals split into lower and upper orbitals light / photon absorbed electron(s) promoted / excited / jumps up to (higher) (d–) orbital or electron(s) moves / jumps (from lower (d–)) to higher (d–) orbital	1 1 1 3
4(b)(i)	$\text{Cu} + 4\text{HNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{NO}_2 + 2\text{H}_2\text{O}$ or ionic $\text{Cu} + 4\text{H}^+ + 2\text{NO}_3^- \rightarrow \text{Cu}^{2+} + 2\text{NO}_2 + 2\text{H}_2\text{O}$ correct species correct balancing	1 1 2
4(b)(ii)	moles $\text{S}_2\text{O}_3^{2-} = 0.1 \times 22.4 / 1000 = \mathbf{2.24 \times 10^{-3}}$ moles of Cu^{2+} in $25 \text{ cm}^3 = \mathbf{2.24 \times 10^{-3}}$ moles of Cu^{2+} in $250 \text{ cm}^3 = 2.24 \times 10^{-2}$ mass of Cu = $2.24 \times 10^{-2} \times 63.5 = 1.4224 \text{ g}$ % Cu = $1.42 / 1.75 \times 100 = \mathbf{81.1}$ or 81.3%	1 1 1 1 4
	Total:	9

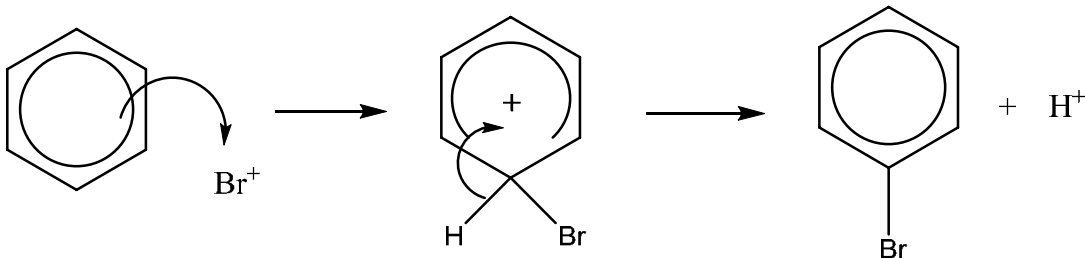
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Question	Answer	Marks
5(a)	$K_a = \frac{[\text{HPO}_4^{2-}][\text{H}_3\text{O}^+]}{[\text{H}_2\text{PO}_4^-]}$	1 1
5(b)(i)	a solution that resists changes in pH when small amounts of acid and base / alkali are added	1 1 2
5(b)(ii)	addition of acid: $\text{H}^+ + \text{HPO}_4^{2-} \rightarrow \text{H}_2\text{PO}_4^-$ OR $\text{H}^+ + \text{H}_2\text{PO}_4^- \rightarrow \text{H}_3\text{PO}_4$ addition of base: $\text{HO}^- + \text{H}_2\text{PO}_4^- \rightarrow \text{HPO}_4^{2-} + \text{H}_2\text{O}$ OR $\text{OH}^- + \text{HPO}_4^{2-} \rightarrow \text{H}_2\text{O} + \text{PO}_4^{3-}$	1 1 2
5(c)	$[\text{H}^+] = 10^{-7.4} = 3.98 \times 10^{-8}$ $[\text{HPO}_4^{2-}]/[\text{H}_2\text{PO}_4^-] = K_a/[\text{H}^+]$ $([\text{HPO}_4^{2-}]/[\text{H}_2\text{PO}_4^-]) = 6.31 \times 10^{-8} / 3.98 \times 10^{-8} = \mathbf{1.58-1.6}$	1 1 1 3
5(d)(i)	$\text{HCl} + \text{H}_2\text{PO}_4^- \rightarrow \text{H}_3\text{PO}_4 + \text{Cl}^-$ OR $\text{H}^+ + \text{H}_2\text{PO}_4^- \rightarrow \text{H}_3\text{PO}_4$ OR $\text{H}_2\text{O} + \text{H}_2\text{PO}_4^- \rightarrow \text{H}_3\text{PO}_4 + \text{OH}^-$	1 1

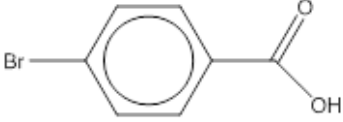
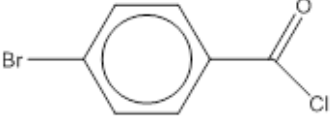
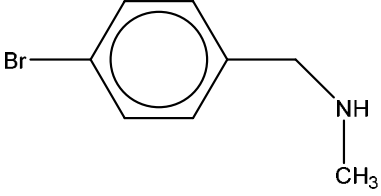
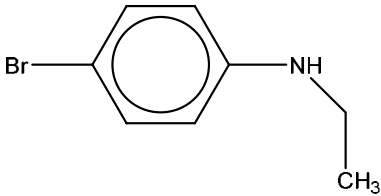
Question	Answer			Marks
6(c)	reagent	structure of product(s)	type of reaction	
	excess $\text{Br}_2(\text{aq})$	 addition of bromine to alkene 2×Br substituted in phenol at positions 2 and 6	(electrophilic) substitution or (electrophilic) addition	1 1
	NaBH_4		reduction (allow nucleophilic addition)	1

Page 11	Mark Scheme	Syllabus	Paper
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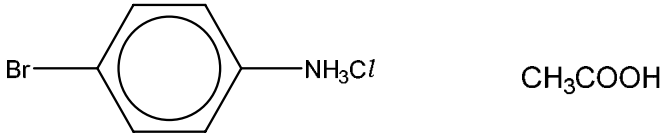
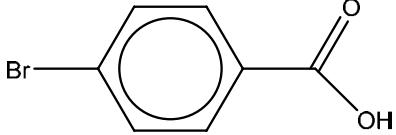
Question	Answer			Marks
	excess hot NaOH(aq) 		hydrolysis	1+1 1 6
6(d)	mixture of (two) optical/stereo isomers <u>are</u> formed			1 1
	Total:			12

Question	Answer	Marks
7(a)(i)	electrophilic substitution	1 1
7(a)(ii)	$(\text{Br}_2 + \text{A}/\text{Br}_3) \rightarrow \text{Br}^+ + \text{A}/\text{Br}_4^-$  curly arrow from ring system to Br^+ correct intermediate curly arrow from C–H bond into ring and loss of H^+	1 1 1 1 4
7(b)	both amide	1 1
7(c)(i)	step 1, A/Br_3 and CH_3Br OR other suitable halogen instead of Br step 2, KMnO_4 or potassium manganate(VII) step 3, conc. H_2SO_4 and conc. HNO_3 step 4. Sn and (conc.) HCl (heat)	1 1 1 1 4

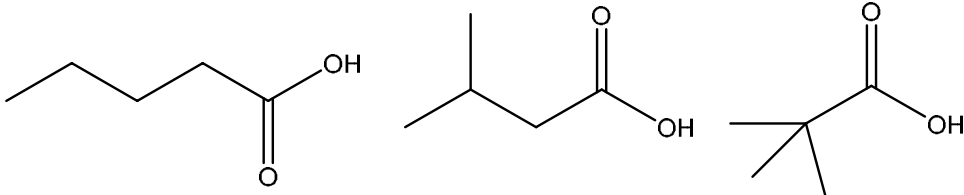
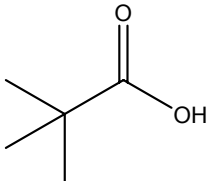
Page 13	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
7(c)(ii)	 R  S  T 1 mark for each correct structure	3
7(d)(i)	  1 mark for each correct structure	2
7(d)(ii)	reduction	1 1

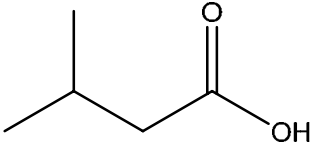
Page 14	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9701	42

Question	Answer	Marks
7(e)(i)	 (or ionic) 1 mark for each correct structure	2
7(e)(ii)		1
7(e)(iii)	(precipitate) compound is less polar / more non-polar / non-ionic resulting in less hydrogen bonding to water	1
	Total:	20

Page 15	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9701	42

Question	Answer	Marks												
8(a)	$102 \times 0.314 = 32$ (32.028) ($102 - 32 = 70$) and $(12 \times 5) + (1 \times 10) = 70$ OR F contains $\text{CO}_2\text{H} = 45$ so $102 - 45 = 57$ so C_4H_9	1 1												
8(b)(i)	 2 correct = 1 mark 3 correct = 2 marks	2												
8(b)(ii)	2-methyl butanoic acid	1 1												
8(c)(i)		1 1												
8(c)(ii)	<table border="1"> <thead> <tr> <th>δ/ppm</th><th>environment of the carbon atom</th><th>hybridisation of the carbon atom</th></tr> </thead> <tbody> <tr> <td>27</td><td>alkyl / CH_3</td><td>sp^3</td></tr> <tr> <td>41</td><td>next to carboxyl / $(\text{CH}_3)_3\text{C}$</td><td>sp^3</td></tr> <tr> <td>179</td><td>carboxyl / CO_2H</td><td>sp^2</td></tr> </tbody> </table>	δ/ppm	environment of the carbon atom	hybridisation of the carbon atom	27	alkyl / CH_3	sp^3	41	next to carboxyl / $(\text{CH}_3)_3\text{C}$	sp^3	179	carboxyl / CO_2H	sp^2	2
δ/ppm	environment of the carbon atom	hybridisation of the carbon atom												
27	alkyl / CH_3	sp^3												
41	next to carboxyl / $(\text{CH}_3)_3\text{C}$	sp^3												
179	carboxyl / CO_2H	sp^2												

Page 16	Mark Scheme	Syllabus	Paper
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Question	Answer				Marks
8(d)(i)	δ/ppm	type of proton	number of protons	splitting	4
	0.9	alkane / CH / CH ₃	6	doublet	
	1.6	alkane / CH	1	<i>[multiplet]</i>	
	2.4	alkyl next to C = O / CH ₍₂₎ CO / CH	2	doublet	
	11.5	OH / CO ₂ H / carboxylic acid	1	singlet	
8(d)(ii)					1
8(e)	CDCl ₃ OR D ₂ O, DMSO, CD ₂ Cl ₂ , CCl ₄				1
	Total				13

CHEMISTRY

9701/43

Paper 4 A Level Structured Questions

October/November 2016

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.

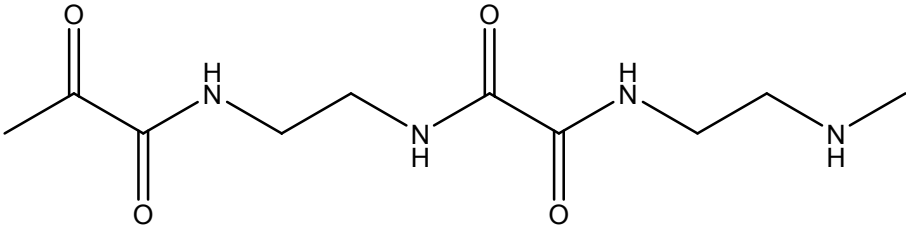
Cambridge is publishing the mark schemes for the October/November 2016 series for most Cambridge IGCSE[®], Cambridge International A and AS Level components and some Cambridge O Level components.



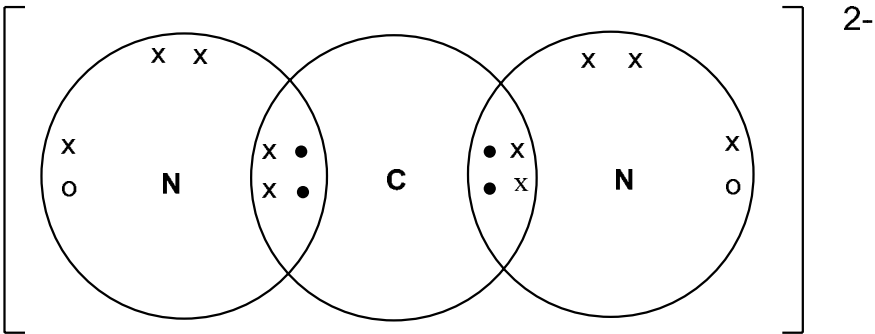
Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9701	43

Question	Answer	Mark
1(a)	Cu [Ar] 3d ¹⁰ 4s ¹ Cu ²⁺ [Ar] 3d ⁹ (4s ⁰)	1 1 2
1(b)(i)	ligand exchange / replacement / displacement / substitution	1 1
1(b)(ii)	[Cu(H ₂ O) ₆] ²⁺ blue and [CuCl ₄] ²⁻ yellow OR yellow / green OR green / yellow	1 1
1(b)(iii)	tetrahedral	1 1
1(b)(iv)	$K_{\text{stab}} = [\text{CuCl}_4^{2-}] / [\text{Cu}(\text{H}_2\text{O})_6^{2+}][\text{Cl}^-]^4$	1 1
1(c)(i)	a species that contains two lone pairs that (each) form a co-ordinate / dative bond OR are donated (to a metal ion / atom)	1 1 2
1(c)(ii)	equilibrium 2 lies more to the RHS / favours forward reaction more	1 1
1(d)(i)	optical	1 1
1(d)(ii)	3D correct for octahedral one correct structure with 3D second correct with 3D	1 1 1

Page 3	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
		3
1(e)(i)	lone pair receive / accepts a proton / H^+	1 1 2
1(e)(ii)	$H_2NCH_2CH_2NH_2 + 2HCl \rightarrow ClH_3NCH_2CH_2NH_3Cl$ OR $H_2NCH_2CH_2NH_2 + 2H^+ \rightarrow H_3N^+CH_2CH_2N^+H_3$	1 1
1(f)(i)	amide bond, displayed or $-CONH-$ rest of the molecule with continuation bonds 	1 1 2
1(f)(ii)	condensation / addition – elimination	1 1
1(f)(iii)	any named polyalkene / eg polyethene, PVC allow Bakelite or Kevlar	1 1
	Total:	20

Page 4	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
2(a)	solid remains	1 1
2(b)	stability increases (down the group) as size / radius of (metal) ion / M²⁺ increases so polarisation / distortion of anion / carbonate ion decreases	1 1 1 3
2(c)(i)		2
2(c)(ii)	$\text{CaCN}_2 + 3\text{H}_2\text{O} \rightarrow \text{CaCO}_3 + 2\text{NH}_3$ CaCO_3 correct equation	1 1 2
	Total:	8

Page 5	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
3(a)(i)	(entropy) increases / is positive and H ₂ / gas is formed	1 1
3(a)(ii)	(entropy) increases / is positive and (KCl (aq)) solution has (free) moving / mobile ions / aqueous ions	1 1
3(a)(iii)	(entropy) decreases / is negative and decrease in gas	1 1
3(b)(i)	$\Delta S^\circ = 26.9 + 214 - 65.7 = (+) 175.2 \text{ (J K}^{-1} \text{ mol}^{-1}\text{)}$ $\Delta G^\circ = 117 - (298 \times 175.2 / 1000)$ OR $\Delta G^\circ = 117\,000 - (298 \times 175.2)$ $\Delta G^\circ = +64.8 \text{ (kJ mol}^{-1}\text{)}$	1 1 1 3
3(b)(ii)	TΔS is more positive than ΔH / TΔS increases / –TΔS more negative and ΔG is negative / decrease / less positive	1 1
3(c)	use of ΔG = 0 or $\frac{T\Delta S}{\Delta H} = 1$ $T = 130 / (316 / 1000) = \mathbf{410 / 411 / 412 / 411.4 \text{ (K)}}$	1 1 2

Page 6	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
3(d)	hydration enthalpy and lattice energy both more endothermic / more positive / less exothermic / less negative (down the group) ΔH_{hyd} decreases more / faster and ΔH_{sol} becomes (more) endothermic / (more) positive / less exothermic / less negative	1 1 2
	Total:	11

Question	Answer	Mark
4(a)	(an element) forming one or more (stable) ions or compounds or oxidation states with partially filled / incomplete d orbitals	1 1
4(b)(i)	A Co(OH)_2 OR $\text{Co(H}_2\text{O)}_4\text{(OH)}_2$ B $[\text{CoCl}_4]^{2-}$ C $[\text{Co(NH}_3)_6]^{2+}$ OR $[\text{Co(NH}_3)_6]^{3+}$ two correct = 1 mark three correct = 2 marks	 2
4(b)(ii)	$[\text{Co(H}_2\text{O)}_6]^{2+}$ pink solution of B blue solution of C brown/yellow/orange	

Page 7	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
	two correct = 1 mark three correct = 2 marks	2

Page 8	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark						
4(c)	(emf / potential / E) of an electrode OR a half-cell compared to / connected to (S)HE which can be called a “hydrogen half-cell” at concentration of 1 mol dm^{-3} and pressure of 1 atm (or in Pa) OR 298 K	1 1 2						
4(d)(i)	<table><tr><td>half-cell</td><td>electrode</td></tr><tr><td>$\text{Co}^{2+} / \text{Co}$</td><td>Co / cobalt</td></tr><tr><td>$\text{Fe}^{3+} / \text{Fe}^{2+}$</td><td>Pt / carbon / graphite</td></tr></table>	half-cell	electrode	$\text{Co}^{2+} / \text{Co}$	Co / cobalt	$\text{Fe}^{3+} / \text{Fe}^{2+}$	Pt / carbon / graphite	1 1
half-cell	electrode							
$\text{Co}^{2+} / \text{Co}$	Co / cobalt							
$\text{Fe}^{3+} / \text{Fe}^{2+}$	Pt / carbon / graphite							
4(d)(ii)	$\text{Co} + 2\text{Fe}^{3+} \rightarrow \text{Co}^{2+} + 2\text{Fe}^{2+}$	1 1						
4(d)(iii)	$E^\ominus_{\text{cell}} = 0.77 - (-0.28) = (+ \text{ or } -) 1.05 \text{ (V)}$	1 1						
4(e)(i)	$E_{\text{electrode}} = -0.28 + (0.059 / 2) \log [0.05] = \textbf{-0.32 / -0.318 (V)}$	1 1						
4(e)(ii)	more positive	1 1						
4(f)	$4\text{Fe}^{3+} + \text{V} + \text{H}_2\text{O} \rightarrow \text{VO}^{2+} + 4\text{Fe}^{2+} + 2\text{H}^+$ VO^{2+} correct equation	1 1						

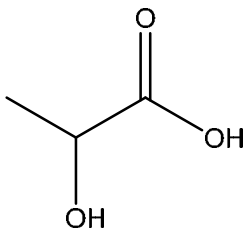
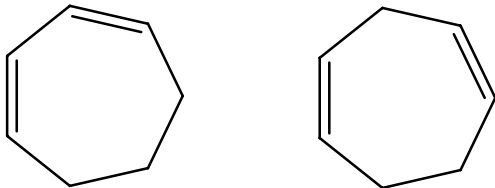
Page 9	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
		2
	Total:	14

Page 10	Mark Scheme	Syllabus	Paper
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Question	Answer				Mark																
5(a)(i)	(100/22.1)×(0.7/1.1) or $\frac{100 \times 0.7}{22.1 \times 1.1}$ or 2.87/2.88/2.9 3 carbon atoms				1 1 2																
5(a)(ii)	C ₃ H ₆ O ₃				1 1																
5(b)	<table><tr><td>absorption / cm⁻¹</td><td>appearance of the peak</td><td>type of bond</td><td>functional group</td></tr><tr><td>3350</td><td>broad and strong</td><td>OH or O–H</td><td>alcohol / ROH</td></tr><tr><td>2680</td><td>very broad and strong</td><td>OH or O–H</td><td>(carboxylic) acid / CO₂H</td></tr><tr><td>1725</td><td>strong</td><td>C = O</td><td>(carboxylic) acid / CO₂H</td></tr></table>				absorption / cm ⁻¹	appearance of the peak	type of bond	functional group	3350	broad and strong	OH or O–H	alcohol / ROH	2680	very broad and strong	OH or O–H	(carboxylic) acid / CO ₂ H	1725	strong	C = O	(carboxylic) acid / CO ₂ H	2
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1725	strong	C = O	(carboxylic) acid / CO ₂ H																		

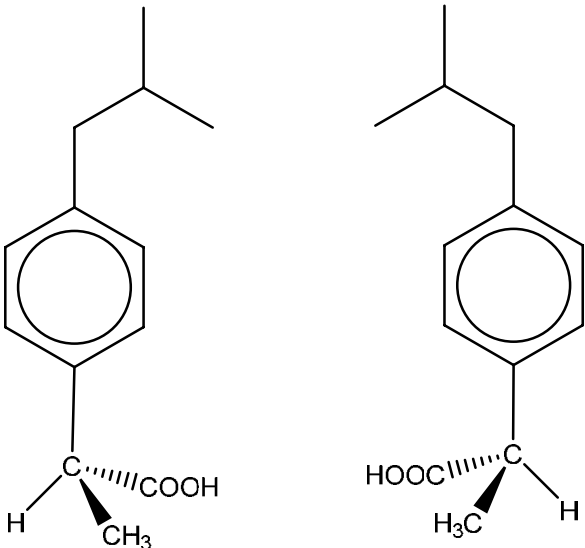
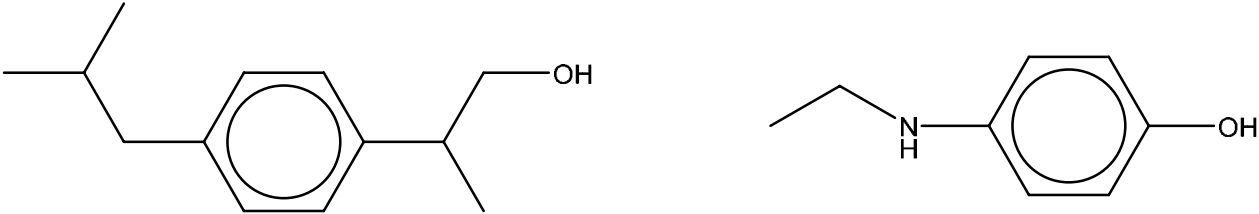
Page 11	Mark Scheme	Syllabus	Paper
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Question	Answer			Mark
5(c)(i)	δ /ppm	type of proton	relative peak area	4
	1.4	$-\text{CH}_3$ or $-\text{CH}_2$ or $-\text{CH}$ or alkane	3	
	3.9	$-\text{OCH}$ or $-\text{OCH}_2$ or $-\text{OCH}_3$ or CH or alkyl next to electronegative atom/oxygen	1	
	4.7	$-\text{OH}$ or alcohol	1	
	12.9	$-\text{OH}$ or $-\text{CO}_2\text{H}$ or carboxylic acid	1	
5(c)(ii)	doublet and 1/one H/proton on neighbouring OR adjacent carbon			1
5(c)(iii)	4.7 and 12.9 OR $-\text{OH}$ and $-\text{CO}_2\text{H}$			1
5(c)(iv)				1
5(d)(i)	 both required for 1 mark			1

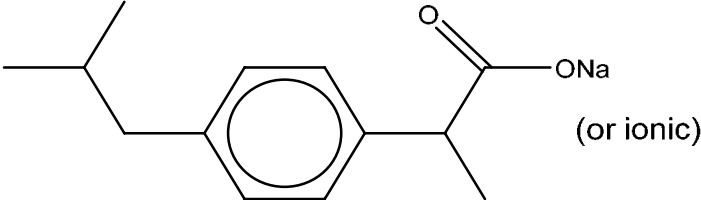
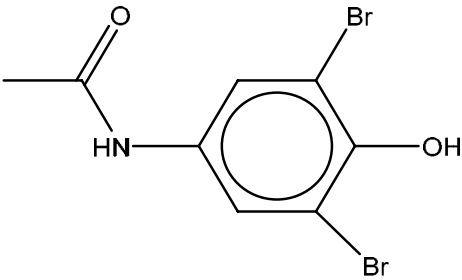
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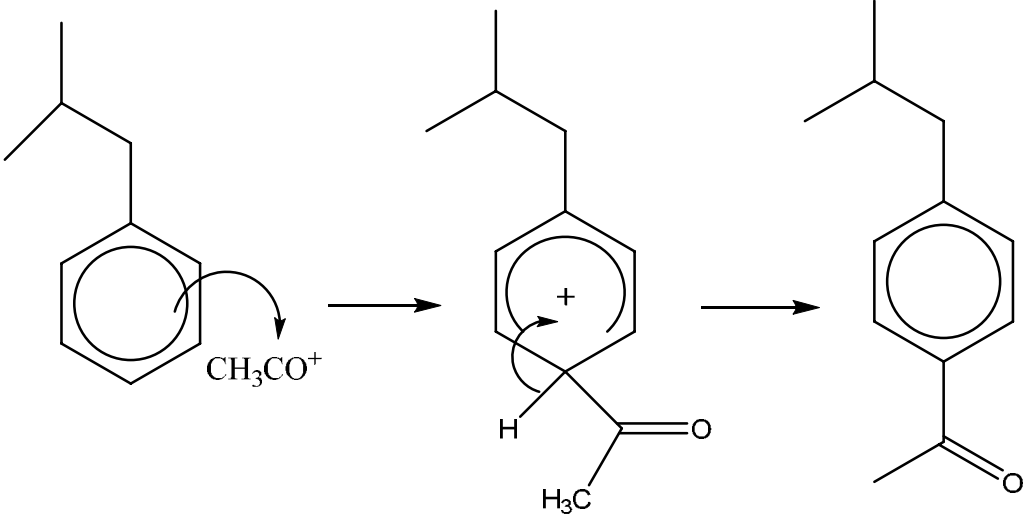
Question	Answer		Mark
5(d)(ii)	isomer	number of peaks	
	P	4	1
	Q	4	1
			2
	Total:		15

Question	Answer	Mark
6(a)	ibuprofen: carboxylic acid / carboxyl paracetamol: phenol and amide any two = 1 mark all three = 2 marks	2
6(b)(i)	(chiral centre is a) carbon OR atom that has four different groups / atoms / species attached to it	1 1

Question	Answer	Mark
6(b)(ii)	 one correct isomer second diagram shows second isomer	1 1 2
6(c)	 with ibuprofen with paracetamol	1 1 2

Page 14	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
6(d)(i)	(reagent D) Na_2CO_3 / any carbonate (reagent E) Cl_2/Br_2	1 1 2
6(d)(ii)	 (or ionic)	1 1
6(d)(iii)		1 1
6(e)(i)	$\text{CH}_3\text{COCl} + \text{AlCl}_3 \rightarrow \text{CH}_3\text{CO}^+ + \text{AlCl}_4^-$	1 1

Question	Answer	Mark
6(e)(ii)	 curly arrow from ring system to CH_3CO^+ correct intermediate curly arrow from C–H bond into ring	1 1 1 3
6(e)(iii)	electrophilic substitution	1 1
	Total:	16

Page 16	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
7(a)	moles of thiosulfate = $0.1 \times 20.8 / 1000 = 2.08 \times 10^{-3}$ moles of ClO^- in 25 cm^3 portion = $2.08 \times 10^{-3} / 2 = 1.04 \times 10^{-3}$ (moles of ClO^- in $250 \text{ cm}^3 = 1.04 \times 10^{-2}$) concentration of $\text{ClO}^- = 1.04 \times 10^{-2} / (10 / 1000) = 1.04 \text{ (mol dm}^{-3}\text{)}$	1 1 1 3
7(b)(i)	starch	1 1
7(b)(ii)	blue OR black to colourless	1 1
7(b)(iii)	towards / close to the end-point of the titration / when the solution goes yellow	1 1
7(c)	moles of $\text{O}_2 = 82 / 24\,000 = 3.42 \times 10^{-3} = \text{moles } \text{ClO}^- \text{ ions}$ concentration of $\text{ClO}^- = 3.42 \times 10^{-3} / (5 / 1000) = 0.68 / 0.683 / 0.684 \text{ (mol dm}^{-3}\text{)}$	1 1 2
7(d)(i)	$K_c = \frac{[\text{C}_3\text{H}_3\text{N}_3\text{O}_3][\text{HClO}_3]^3}{[\text{C}_3\text{Cl}_3\text{N}_3\text{O}_3][\text{H}_2\text{O}]^3}$	1 1
7(d)(ii)	(position of eqm) moves to the right / forward reaction predominates / more HClO made (as $[\text{HClO}]$ decreases) no effect on K_c	1 1 2

Page 17	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
7(d)(iii)	$2\text{HClO} \rightarrow 2\text{HCl} + \text{O}_2$ OR $2\text{HClO} \rightarrow \text{H}_2 + \text{Cl}_2 + \text{O}_2$	1 1
7(e)(i)	addition of acid: $\text{H}^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{CO}_3$ OR $\text{H}^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{O} + \text{CO}_2$ addition of base: $\text{OH}^- + \text{H}_2\text{CO}_3 \rightarrow \text{HCO}_3^- + \text{H}_2\text{O}$ OR $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$ and position of eqm moves to the right OR $\text{OH}^- + \text{HCO}_3^- \rightarrow \text{CO}_3^{2-} + \text{H}_2\text{O}$	1 1 2
7(e)(ii)	$K_a = \frac{[\text{H}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}$ $[\text{H}^+] = (7.94 \times 10^{-7}) \times 1/9.5 = 8.36 \times 10^{-8}$ $\text{pH} = -\log[\text{H}^+] = \mathbf{7.08}$	1 1 2
	Total:	16