
CHEMISTRY**9701/42**

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.

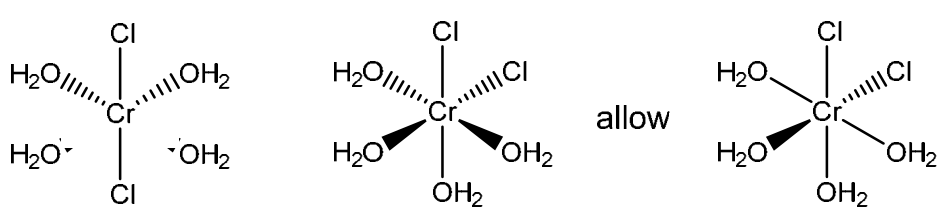
Cambridge will not enter into discussions about these mark schemes.

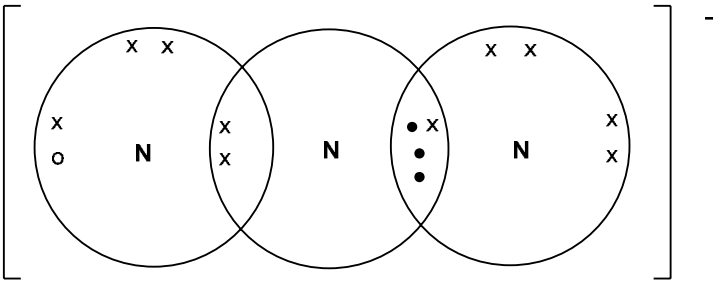
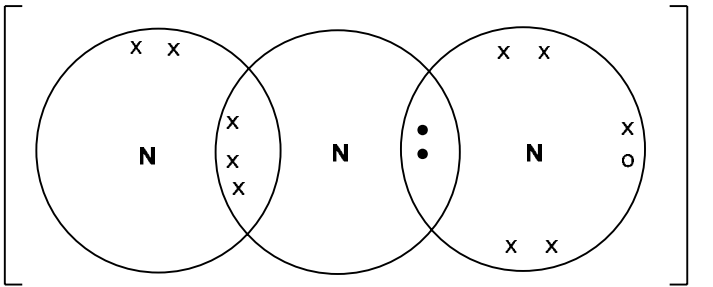
Cambridge is publishing the mark schemes for the October/November 2016 series for most Cambridge IGCSE[®], Cambridge International A and AS Level components and some Cambridge O Level components.

Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9701	42

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"> <thead> <tr> <th></th><th>co-ordination number</th><th>oxidation number</th></tr> </thead> <tbody> <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> </tbody> </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 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 $[\text{Ni}(\text{CN})_2(\text{NH}_3)_2]$ $\begin{array}{ccc} \text{NC} & & \text{NH}_3 \\ & \text{Ni} & \\ \text{H}_3\text{N} & & \text{CN} \end{array}$ or $\begin{array}{ccc} & \text{NC} & \\ & & \\ \text{H}_3\text{N} & -\text{Ni}- & \text{CN} \\ & & \\ & \text{NH}_3 & \end{array}$ or $\begin{array}{ccc} & \text{NH}_3 & \\ & & \\ \text{H}_3\text{N} & -\text{Ni}- & \text{CN} \\ & & \\ & \text{CN} & \end{array}$ square planar or tetrahedral	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 first structure shows a central Cr atom with two Cl atoms (top and bottom), and four OH₂ groups (left, right, front-left, front-right) using wedge and dash notation. The second structure shows a central Cr atom with two Cl atoms (top and right), and four OH₂ groups (left, bottom, front-left, front-right) using wedge and dash notation. The third structure shows a central Cr atom with two Cl atoms (top and back-right), and four OH₂ groups (left, bottom, front-left, front-right) using wedge and dash notation. The word 'allow' is placed between the second and third structures.	1 1 1 3
	Total:	12

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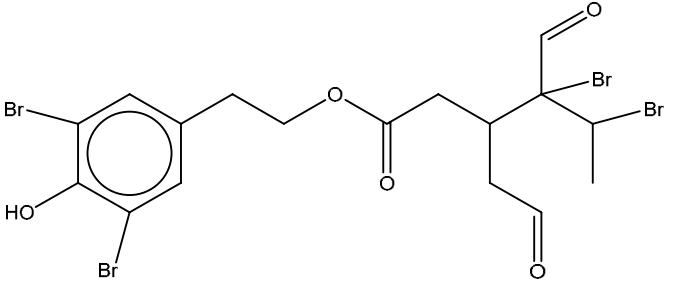
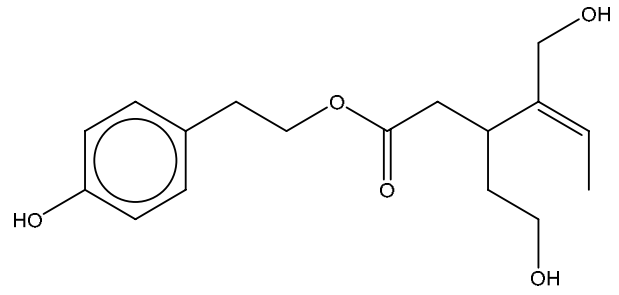
Question	Answer	Marks
3(c)(i)	(entropy is a measure / degree of the) disorder of a system / substance	1 1
3(c)(ii)	$\Delta S^\ddagger = (2 \times 27) + (3 \times 214) - (90) - (3 \times 198)$ OR $696 - 684$ $\Delta S^\ddagger = (+) 12 \text{ (J K}^{-1} \text{ mol}^{-1})$	1 1 2
3(c)(iii)	$\Delta G^\ddagger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

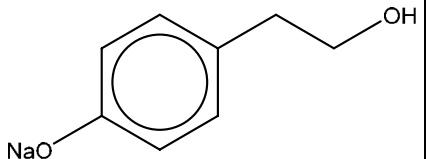
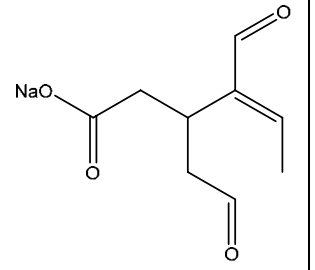
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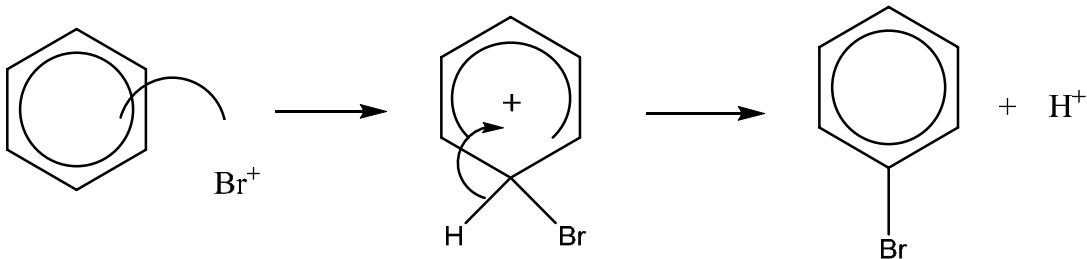
Question	Answer	Marks
4(a)	d orbitals split into lower and upper orbitals light / photon absorbed electron(s) promoted / excited / jumps up to (higher) (d–) orbital or electron(s) moves / jumps (from lower (d–)) to higher (d–) orbital	1 1 1 3
4(b)(i)	$\text{Cu} + 4\text{HNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{NO}_2 + 2\text{H}_2\text{O}$ 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

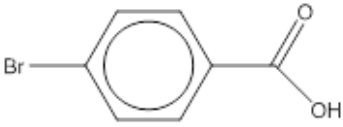
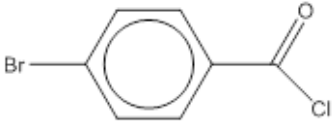
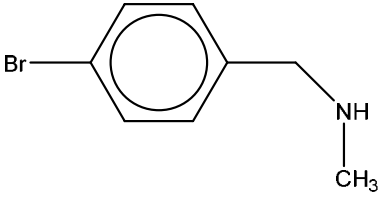
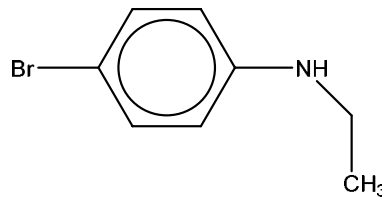
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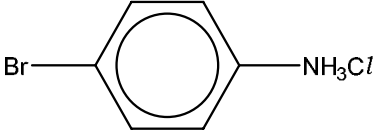
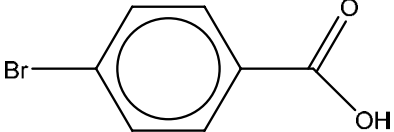
Question	Answer	Marks
5(a)	$K_a = \frac{[\text{HPO}_4^{2-}][\text{H}_3\text{O}^+]}{[\text{H}_2\text{PO}_4^-]}$	1 1
5(b)(i)	a solution that resists changes in pH when small amounts of acid and base / alkali are added	1 1 2
5(b)(ii)	addition of acid: $\text{H}^+ + \text{HPO}_4^{2-} \rightarrow \text{H}_2\text{PO}_4^-$ 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

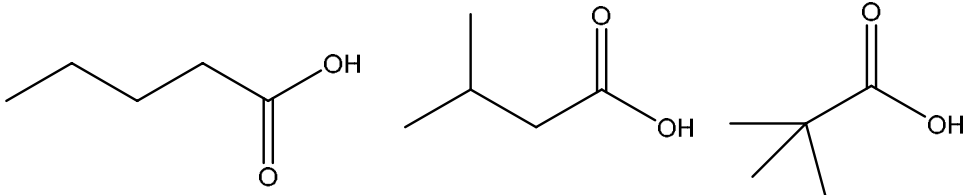
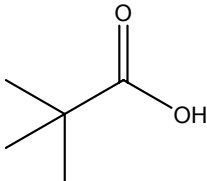
Question	Answer			Marks
6(c)				
	reagent	structure of product(s)	type of reaction	
	excess $\text{Br}_2(\text{aq})$	 addition of bromine to alkene 2×Br substituted in phenol at positions 2 and 6	(electrophilic) substitution or (electrophilic) addition	1 1
	NaBH_4		reduction (allow nucleophilic addition)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

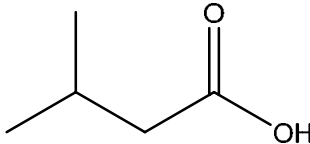
Question	Answer	Marks
	excess hot NaOH(aq)   hydrolysis	1+1
	all three reaction types	1 6
6(d)	mixture of (two) optical/stereo isomers <u>is</u> formed	1 1
	Total:	12

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

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

Question	Answer	Marks
7(e)(i)	 (or ionic) CH_3COOH 1 mark for each correct structure	2
7(e)(ii)		1 1
7(e)(iii)	(precipitate) compound is less polar / more non-polar / non-ionic resulting in less hydrogen bonding to water	1 1
	Total:	20

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
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Question	Answer				Marks																				
8(d)(i)	<table><tr><th>δ/ppm</th><th>type of proton</th><th>number of protons</th><th>splitting</th></tr><tr><td>0.9</td><td>alkane / CH / CH₃</td><td>6</td><td>doublet</td></tr><tr><td>1.6</td><td>alkane / CH</td><td>1</td><td><i>[multiplet]</i></td></tr><tr><td>2.4</td><td>alkyl next to C = O / CH₍₂₎CO / CH</td><td>2</td><td>doublet</td></tr><tr><td>11.5</td><td>OH / CO₂H / carboxylic acid</td><td>1</td><td>singlet</td></tr></table>				δ/ppm	type of proton	number of protons	splitting	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	4
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0.9	alkane / CH / CH ₃	6	doublet																						
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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 1																				
8(e)	CDCl ₃ OR D ₂ O, DMSO, CD ₂ Cl ₂ , CCl ₄				1 1																				
Total					13																				