
CHEMISTRY

9701/41

Paper 4 A Level Structured Questions

October/November 2019

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 International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2019 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **14** printed pages.



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PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
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- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

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GENERIC MARKING PRINCIPLE 5:

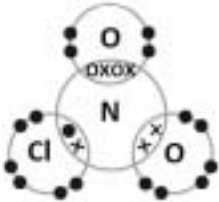
Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

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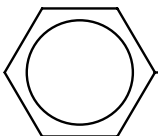
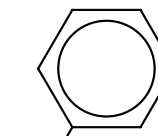
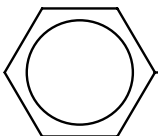
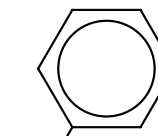
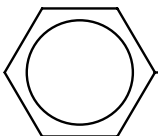
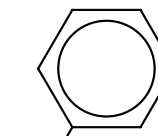
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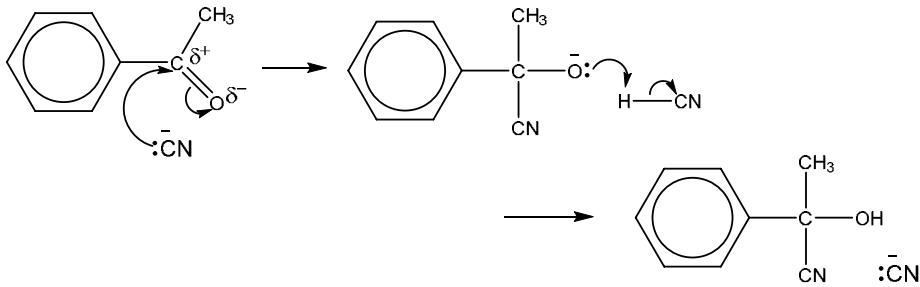
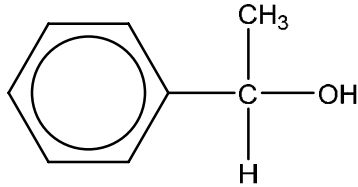
Question	Answer	Marks
1(a)	Platinum / Pt Aluminium / Al BOTH	1
1(b)(i)	M1: use of or quoting a valid Nernst equation $E = E^{\circ} + 0.0590 / z \log [\text{ox}] / [\text{red}]$ OR $E = 0.15 + (0.0590 / 2) \log 2$ M2: $E = (+)0.16$ (0.159) V minimum 2 sig. fig. correct answer scores 2 marks	2
1(b)(ii)	$E_{\text{cell}} = 0.16 - (-1.66) = +1.82 \text{ V}$ minimum 3 sig. fig.	1
1(b)(iii)	$2\text{Al} + 3\text{Sn}^{4+} \rightarrow 2\text{Al}^{3+} + 3\text{Sn}^{2+}$ M1: species M2: balancing	2
1(c)	M1: number of C (= $300\,000 \times 60 \times 60 \times 24$) = 2.59×10^{10} (C) M2: number of F (= $2.592 \times 10^{10} / 9.65 \times 10^4$) = 2.69×10^5 (moles of electrons) M3: moles of Al (= $2.69 \times 10^5 / 3$) = 8.95×10^4 M4: mass of Al (= $8.95 \times 10^4 \times 27$) = 2420 kg correct answer scores 4 marks	4
1(d)	M1: ($\text{Cr}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Cr}$) $E^{\circ} = -0.91$ and ($2\text{H}^{+} + 2\text{e}^{-} \rightleftharpoons \text{H}_2$) $E^{\circ} = 0.00$ seen M2: hydrogen formed instead / hydrogen (ions) easier to reduce / hydrogen has more positive E°	2

Question	Answer	Marks
2(a)	 M1: eight electrons around N atom [N=O, N-O, N-Cl with N-O as dative] M2: all other electrons correct	2
2(b)(i)	(rate =) $k[\text{ClNO}_2][\text{NO}]$	1
2(b)(ii)	$\text{mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$	1
2(b)(iii)	Yes AND number of moles of reactants in overall equation is the same as order in rate equation	1
2(c)(i)	• straight line with a negative gradient • starting at 2.0×10^{-4} • reaches at 1.8×10^{-4} at 0.2 seconds Award 1 mark for two points, award 2 marks for all three points	2
2(c)(ii)	$2 \times 10^{-5} \text{ (mol dm}^{-3}\text{)}$	1
2(c)(iii)	The reaction has reached equilibrium	1

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Question	Answer	Marks
3(a)	a measure / degree of disorder / randomness of a system	1
3(b)	M1: negative – molecules have less energy in the system M2: positive – solid being converted into an aqueous solution M3: negative – gaseous ions being converted into a solid	3
3(c)(i)	(standard) Gibbs free energy <u>change</u>	1
3(c)(ii)	M1: $(\Delta)G = \Delta H - T\Delta S$ M2: description of calculating the minimum value of T for which ΔG is zero / becomes negative OR $T = \Delta H / \Delta S$ [1]	2

Question	Answer			Marks												
4(a)	M1: CH_3COCl or ethanoyl chloride M2: AlCl_3 catalyst			2												
4(b)	<table><tr><th>reagent</th><th>organic product</th><th>name of mechanism</th></tr><tr><td>Cl</td><td> chlorine atom(s) in side chain only</td><td>free radical substitution</td></tr><tr><td>nitric / sulfuric</td><td> one only $-\text{NO}_2$ group added at 3 position</td><td>electrophilic substitution</td></tr><tr><td>Br</td><td>no reaction with Br_2</td><td></td></tr></table> Award 1 mark for each correct entry to the table [5]			reagent	organic product	name of mechanism	Cl	 chlorine atom(s) in side chain only	free radical substitution	nitric / sulfuric	 one only $-\text{NO}_2$ group added at 3 position	electrophilic substitution	Br	no reaction with Br_2		5
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4(c)(i)	nucleophilic addition			1												

Question	Answer	Marks
4(c)(ii)	 M1 and M2: first structure – award one mark for two points correct, award two marks for four points correct. • correct polarity shown on C=O bond • curly arrow from double bond to O of the C=O • lone pair shown on C of CN⁻ ion • curly arrow from C (on CN⁻ ion) to C of C=O M3: middle structure • correct intermediate AND curly arrow from lone pair on O⁻ to H⁺ or H of H₂O or HCN M4: third structure • correct product AND either CN⁻ reformed (if HCN seen in step 2) OR curly arrow on H-CN bond towards CN in step 2	4
4(d)(i)		1
4(d)(ii)	LiAlH ₄ or NaBH ₄	1
4(d)(iii)	conc H ₂ SO ₄ / conc H ₃ PO ₄ / Al ₂ O ₃	1
4(d)(iv)	6	1

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Question	Answer	Marks
4(d)(v)	• 25–50 • 110–160 • 190–220 Award 1 mark for two points, award 2 marks for three points	2

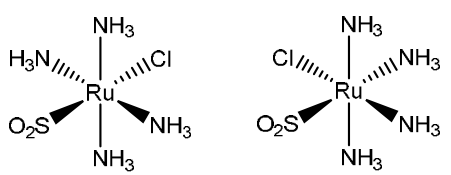
Question	Answer	Marks
5(a)(i)	$K_{sp} = [Ag^+]^2[S^{2-}]$	1
5(a)(ii)	• $[S^{2-}] = 1.16 \times 10^{-17}$ • $[Ag^+] = 2.32 \times 10^{-17}$ • $K_{sp} = \mathbf{6.2(4)} \times 10^{-51}$ minimum 2 sig. fig. correct answer scores 2 marks Award 1 mark for two points, award 2 marks for three points	2
5(a)(iii)	M1: moles $Ag_2S = 1 / 247.9 = 0.00403$ moles [1] 2sf min M2: $1.16 \times 10^{-17} = 0.0040 / V$ so $V = \mathbf{3.5 \times 10^{14}}$ (dm³) [1] 2sf min ecf on M1 correct answer scores 2 marks	2
5(b)(i)	M1: $[H^+] = \sqrt{2.0 \times 10^{-9} \times 0.20}$ $[H^+] = 2.0 \times 10^{-5}$ (1.9976×10^{-5}) M2: pH = 4.7 (4.699) minimum 2 sig. fig. min correct answer scores 2 marks	2

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Question	Answer	Marks
5(b)(ii)	M1: Both equilibria correctly stated moles KOH = $0.005 \times 0.2 = 1 \times 10^{-3}$ moles HOBr(initial) = $0.020 \times 0.2 = 4 \times 10^{-3}$ moles HOBr(eqm) = $4 \times 10^{-3} - 1 \times 10^{-3} = 3 \times 10^{-3}$ moles BrO⁻(eqm) = 1×10^{-3} M2: ratio [OBr⁻]/[HOBr] = 1/3 [H⁺] = $3 \times 2.0 \times 10^{-9} = 6 \times 10^{-9}$ pH = 8.2(2) correct answer scores 2 marks	2

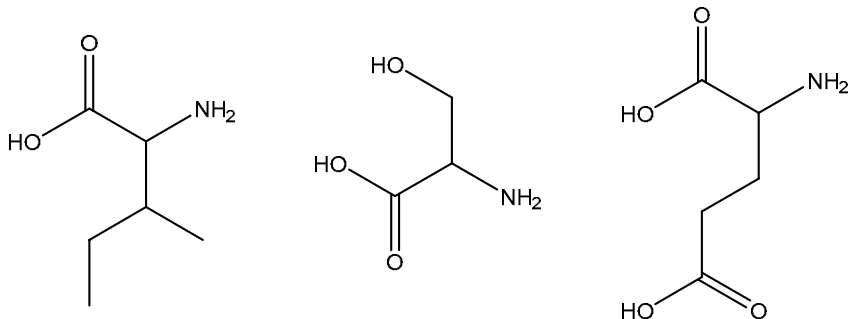
Question	Answer	Marks
6(a)(i)	$\text{Mg(g)} \rightarrow \text{Mg}^{\text{+}}(\text{g}) + \text{e}^{-}$	1
6(a)(ii)	$\text{Sr(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Sr(OH)}_2(\text{aq}) + \text{H}_2(\text{g})$	1
6(a)(iii)	more reactive and easier to ionise down the group OR more reactive and ionisation energies decrease down the group	1
6(b)(i)	brown gas and white solid	1
6(b)(ii)	$2\text{Ca(NO}_3)_2 \rightarrow 2\text{CaO} + 4\text{NO}_2 + \text{O}_2$	1
6(b)(iii)	M1: more stable (down the group) M2: cationic radius increases / charge density of M²⁺ decreases (down the group) M3: NO₃⁻ anion is less polarised / distorted	3

Question	Answer	Marks
6(c)	M1: less soluble / decreases (down the group) M2: ΔH_{latt} and ΔH_{hyd} both decrease / less exothermic down the group M3: ΔH_{hyd} decreases by more (than ΔH_{latt}) M4: ΔH_{sol} becomes more endothermic / less exothermic	4

Question	Answer	Marks
7(a)	forms one or more stable ions with incomplete / partially filled d-orbitals / d-subshell	1
7(b)(i)	purple to pale pink / colourless AND orange to green	1
7(b)(ii)	$3\text{Sn}^{2+} + \text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ \rightarrow 3\text{Sn}^{4+} + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	1
7(c)(i)	• six • coordinate bonds / dative bonds / lone pairs donated • to the (central) metal ion award 1 mark for all three points	1
7(c)(ii)	$[\text{Ru}(\text{NH}_3)_4\text{Cl}(\text{SO}_2)]^+$	1
7(c)(iii)	 M1: six correct ligands around Ru, bonds are shown from S of SO_2 M2: 3-D bonds used correctly for octahedral M3: cis and trans isomers shown	3

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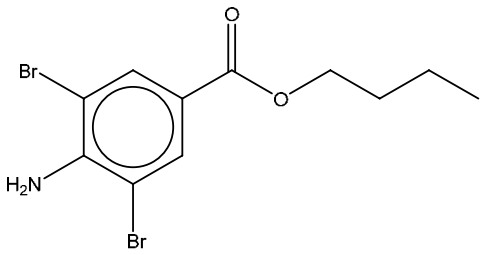
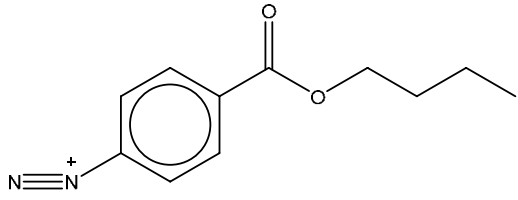
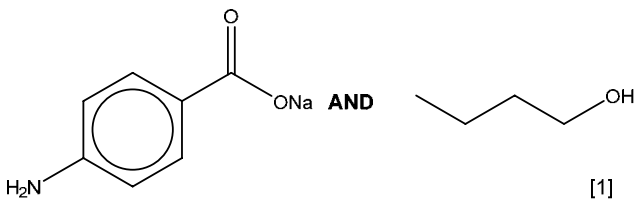
Question	Answer	Marks
7(c)(iv)	cis-trans or geometric(al) [1]	1
7(c)(v)	M1: complexes have two sets of d orbital(s) of different energy OR d-orbitals splits into two sets (of orbitals) M2: visible light absorbed (and complementary colour observed) M3: electron(s) promoted / excited OR electron(s) moves to higher (d–) orbital	3

Question	Answer	Marks
8(a)(i)	any one from: - OH[–] / NaOH; aqueous / dilute; heat under reflux - H⁺ / HCl / H₂SO₄, aqueous / dilute; heat under reflux - protease or named protease; water; T = 30° – 40°C all three points in each bullet [1]	1
8(a)(ii)	 M1: three amino acids in any ionic / non-ionic states [1] M2: three amino acids in the correct ionic state for their conditions [1]	2

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Question	Answer	Marks
8(b)	- permanent dipole-dipole - one group that will have a δ^+ and another with δ^- e.g. CO, NH, COOH, OH BOTH [1] - hydrogen bonds - one group that will have a $H^{\delta+}$, e.g. NH, OH and another with lone pair, e.g. NH, COOH, OH, CONH₂ BOTH [1] - ionic bonding - NH₃⁺ <u>and</u> COO⁻ BOTH [1] ALLOW - London forces - C₄H₉ groups or parts of these alkyl groups	3
8(c)(i)	any structure containing one COOH / COCl <u>and</u> NH ₂ groups in the same molecule [1]	1
8(c)(ii)	HOCH ₂ CH ₂ OH [1] ethan(e)-1,2-diol [1] ecf for diols HO ₂ CCO ₂ H or ClOCCOCl [1] ethan(e)dioic acid or ethan(e)dioyl chloride [1] ecf for diacids / diacyl chlorides	4

Question	Answer	Marks
9(a)(i)	RNH ₂ + H ⁺ → RNH ₃ ⁺ OR RNH ₂ + HCl → RNH ₃ Cl [1]	1
9(a)(ii)	weaker AND lone pair of N delocalised into benzene ring [1]	1

Question	Answer	Marks
9(b)	 [1]  [1]  [1]	3
9(c)(i)	2 [1]	1
9(c)(ii)	CH ₂ next to ester and terminal CH ₃ are circled [1]	1
9(c)(iii)	• one less peak • the lost peak is NH₂ / aryl amine • protons exchange with D OR protons are labile OR valid equation • ✓✓ for two marks [2]	2
9(d)	C ₆ H ₄ NH ₂ ⁺ and CH ₃ CH ₂ CH ₂ CH ₂ ⁺ [1]	1

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Question	Answer	Marks
1(a)	Platinum and platinum	1
1(b)(i)	M1: Nernst quoted correctly $E = E^{\ominus} + 0.0590 / z \log [\text{ox}] / [\text{red}]$ or $E = 1.49 + 0.0590 \log 5$ M2: (+)1.53 V minimum 2 sig. fig. Correct answer scores 2 marks	2
1(b)(ii)	+ / – 0.46 minimum 2 sig. fig.	1
1(b)(iii)	M1: $\text{Mn}^{3+} + 2\text{Br}^- \rightarrow \text{Mn}^{2+} + \text{Br}_2$ M2: $2\text{Mn}^{3+} + 2\text{Br}^- \rightarrow \text{Mn}^{2+} + \text{Br}_2$	2
1(c)	M1: 16200 C M2: 1.0125×10^{23} electrons (use of 1.60×10^{-19}) M3: 0.0802 moles of copper (use of 5.09 and 63.5) M4: 0.1603 moles electrons M5: $L = 6.32 \times 10^{23}$ (correct answer [5]) other approaches acceptable including: M1: 16200 C M2: 1.0125×10^{23} electrons (use of 1.60×10^{-19}) M3: 5.0625×10^{22} copper atoms M4: 0.0802 moles of copper (use of 5.09 and 63.5) M5: $L = 6.32 \times 10^{23}$ (correct answer [5])	5
1(d)	M1: $\text{Mg}^{2+} + 2\text{e}^- \rightleftharpoons \text{Mg}$ $E^{\ominus} = -2.38$ and $2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2$ $E^{\ominus} = 0.00$ M2: hydrogen produced instead / hydrogen easier to reduce / hydrogen preferentially reduced / hydrogen has more positive $E^{\ominus}$	2

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Question	Answer	Marks
2(a)	M1: the time taken for the amount/concentration of a reactant to halve M2: the slowest step	2
2(b)	• Use an excess of CH_3Br • (Several experiments with) different initial $[\text{OH}^-]$ • control / equilibrate temperatures • measure time • find $[\text{OH}^-]$ by sample and titrate or use of pH probe or find $[\text{Br}^-]$ by sample and reference to use of Ag^+. • processing of results – plot graph of $[\text{OH}^-]$ vs rate or evaluate rate is proportional to $[\text{OH}^-]$ numerically Alternative approach: • Use an excess of CH_3Br • One experiment with known initial $[\text{OH}^-]$ • control / equilibrate temperatures • measure time • find $[\text{OH}^-]$ by sample and titrate or use of pH probe or find $[\text{Br}^-]$ by sample and reference to use of Ag^+ and describes how to calculate $[\text{OH}^-]$. • processing of results – plot graph of $[\text{OH}^-]$ vs time and look for constant half-life Award 1 mark for each correctly identified point.	4

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Question	Answer	Marks
2(c)	M1: rate = $k[\text{ester}][\text{OH}^-]$ M2: value of $k = 0.206$ M3: units $\text{mol}^{-1}\text{dm}^3\text{s}^{-1}$	3

Question	Answer	Marks
3(a)(i)	1.3×10^{-5}	1
3(a)(ii)	M1: K_a expression used correctly and $K_a = 5.5(3) \times 10^{-10}$ M2: $\text{p}K_a = 9.26$ Award 2 marks for correct answer	2
3(b)(i)	$\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$	1
3(b)(ii)	$\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$ or $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$ and reference to expression in Q shifting R	1
3(c)(i)	quotes $K_w = 1 \times 10^{-14}$ or 1×10^{-1} $[\text{H}^+][\text{OH}^-]$ $[\text{H}^+] = 1 \times 10^{-7}$	1
3(c)(ii)	M1: $[\text{H}^+] = 2.3 \times 10^{-7}$ (calculator value 2.290867×10^{-7}) and $K_w = [2.3 \times 10^{-7}]^2$ M2: $K_w = 5.2 \times 10^{-14}$ calculator 5.248074×10^{-14} Award 2 marks for correct answer	2

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Question	Answer	Marks
4(a)	M1: correct use of stoichiometry M2: answer + 189	2
4(b)	M1: States or uses correct form of Gibbs equation $\Delta G = \Delta H - T\Delta S$ M2: appreciates / includes $\Delta G = 0$ at temperature required M3: uses 1000 correctly and answer +624(.339) Award 3 marks for correct answer	3
4(c)	negative and decrease in number / amount of gas molecules	1

Question	Answer	Marks
5(a)	M1: Mg – white flame and Sr – red flame M2: white solid product once	2
5(b)(i)	M1: $2\text{Ca(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{CaO(s)}$ $\text{CaCO}_3\text{(s)} \rightarrow \text{CaO(s)} + \text{CO}_2\text{(g)}$ all substances, balanced M2: all state symbols	2
5(b)(ii)	neutralises acid / raises pH	1
5(b)(iii)	M1: ΔH_{lat} and ΔH_{hyd} decrease down group M2: ΔH_{lat} decreases / changes more M3: ΔH_{sol} becomes more exo / more –ve / less endo / less +ve	3

Question	Answer	Marks
5(c)	- no change (for hydroxide) / colourless solution - white (for sulfate) - precipitate (for sulfate) Award 1 mark for two points, award 2 marks for all three points	2
5(d)	M1: stability increases / higher T needed for decompose M2: larger ionic radius M3: harder to distort / polarise anion / carbonate ion or harder to polarise / weaken C–O or C=O bond.	3

Question	Answer	Marks															
6(a)	donates one pair of electrons / forms one coordinate bond	1															
6(b)	<table border="1"> <thead> <tr> <th>Reagent added to a solution of CuSO₄(aq)</th><th>Observations</th><th>Formula of the copper(II) compound or complex ion that is formed</th></tr> </thead> <tbody> <tr> <td>a few drops of dilute ammonia</td><td>blue ppt</td><td>Cu(OH)₂ or Cu(OH)₂(H₂O)₄</td></tr> <tr> <td>an excess of dilute ammonia</td><td>deep blue solution</td><td>[Cu(NH₃)₄]²⁺ or [Cu(NH₃)₄(H₂O)₂]²⁺</td></tr> <tr> <td>an excess of aqueous sodium hydroxide</td><td>blue ppt</td><td>Cu(OH)₂ or Cu(OH)₂(H₂O)₄</td></tr> <tr> <td>an excess of conc HCl.</td><td>green-yellow / yellow-green / yellow</td><td>[CuCl₄]²⁻</td></tr> </tbody> </table> Award 1 mark for each correct observation and formula in a row of the table.	Reagent added to a solution of CuSO ₄ (aq)	Observations	Formula of the copper(II) compound or complex ion that is formed	a few drops of dilute ammonia	blue ppt	Cu(OH) ₂ or Cu(OH) ₂ (H ₂ O) ₄	an excess of dilute ammonia	deep blue solution	[Cu(NH ₃) ₄] ²⁺ or [Cu(NH ₃) ₄ (H ₂ O) ₂] ²⁺	an excess of aqueous sodium hydroxide	blue ppt	Cu(OH) ₂ or Cu(OH) ₂ (H ₂ O) ₄	an excess of conc HCl.	green-yellow / yellow-green / yellow	[CuCl ₄] ²⁻	4
Reagent added to a solution of CuSO ₄ (aq)	Observations	Formula of the copper(II) compound or complex ion that is formed															
a few drops of dilute ammonia	blue ppt	Cu(OH) ₂ or Cu(OH) ₂ (H ₂ O) ₄															
an excess of dilute ammonia	deep blue solution	[Cu(NH ₃) ₄] ²⁺ or [Cu(NH ₃) ₄ (H ₂ O) ₂] ²⁺															
an excess of aqueous sodium hydroxide	blue ppt	Cu(OH) ₂ or Cu(OH) ₂ (H ₂ O) ₄															
an excess of conc HCl.	green-yellow / yellow-green / yellow	[CuCl ₄] ²⁻															

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Question	Answer	Marks
6(c)	- ligand exchange - magnitude of d-orbital splitting changes / ΔE for d-orbitals changes / energy gap between d-orbitals changes - change in colour / frequency / wavelength of light absorbed - electrons are promoted/excited to higher d Award 1 mark for two points, award 2 marks for three points, award 3 marks for all four points	3
6(d)	M1: $E^\ominus$ values 1.36 and 0.77 quoted M2: $2\text{FeSO}_4 + \text{Cl}_2 \rightarrow \text{Fe}_2(\text{SO}_4)_2\text{Cl}_2$ or $2\text{Fe}^{2+} + \text{Cl}_2 \rightarrow 2\text{Fe}^{3+} + 2\text{Cl}^-$	2
6(e)(i)	$[\text{FeCl}_4]^- / [[\text{Fe}(\text{H}_2\text{O})_6]^{3+}][\text{Cl}^-]^4$	1
6(e)(ii)	0.078(125)	1

Question	Answer	Marks
7(a)(i)	- two or more repeat units - correct orientation of groups on all four rings and rings correct - trailing bonds shown - amide links all correct Award 1 mark for two points, award 2 marks for all four points	2
7(a)(ii)	polyamide and condensation	1
7(a)(iii)	yes and can be hydrolysed	1
7(a)(iv)	PCl_3 or PCl_5 or SOCl_2	1
7(a)(v)	M1: conc nitric acid + conc sulfuric acid M2: $\text{Sn} + \text{HCl}$	2

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Question	Answer	Marks
7(b)(i)	M1: sequence / order of amino acids M2: α -helix or β -sheet M3: folding of chain or 3-D shape	3
7(b)(ii)	covalent bonds / peptide bonds / amide bonds	1
7(b)(iii)	M1: hydrogen bonds M2: between C=O and N–H	2

Question	Answer	Marks
8(a)	bromine / Br ₂ and uv / light / heat	1
8(b)	1,1-dibromoethane	1
8(c)	NCCH ₂ CH ₂ CN / CH ₂ CNCH ₂ CN	1
8(d)	M1: KCN / NaCN / CN [–] M2: boil/heat/reflux and ethanol as solvent	2
8(e)(i)	acidified manganate(VII) or dichromate(VI)	1
8(e)(ii)	carbon dioxide and water	1

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Question	Answer	Marks
8(f)	M1: most acidic: hexanoic acid > phenol > hexan-1-ol :least acidic - the other O atom in CO₂H group of hexanoic acid either - withdraws charge from OH group or is electronegative and weakens O–H bond or - stabilises resultant anion/negative ion / –CO₂[–] group/carboxylate ion - benzene / aromatic / C₆H₅ ring in phenol <u>delocalises</u> either - lone pair on O atom and weakens O–H bond or - lone pair on resultant anion/negative ion / phenoxide ion this stabilises resultant anion negative ion / –CO₂[–] group/carboxylate ion - the alkyl group in hexan-1-ol donates electrons this strengthens O–H bond Award 1 mark for each bullet point identified.	3
8(g)(i)	M1: δ12.7 is COOH M2: δ3.3 is CH and δ1.1 is CH₃	2
8(g)(ii)	quadruplet / quartet 3 H / protons on neighbouring / adjacent carbon / carbons / C	1
8(g)(iii)	2 (butanedioic acid) and 3 (methylpropanedioic acid)	1

Question	Answer	Marks
9(a)(i)	10	1
9(a)(ii)	120	1
9(b)(i)	correct acid chloride	1
9(b)(ii)	NH ₃ or ammonia	1

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Question	Answer	Marks
9(c)	M1: $(\text{C}_5\text{NH}_4)\text{COOH}$ or $(\text{C}_5\text{NH}_5)^+\text{COOH}$ M2: $(\text{C}_5\text{NH}_4)\text{COO}^-(\text{Na}^+)$ or $(\text{C}_5\text{NH}_4)\text{COONa}$	2
9(d)(i)	LiAlH_4	1
9(d)(ii)	M1: most basic: X > phenylamine > nicotinamide :least basic M2: LP in X cannot be delocalised M3: LP in phenylamine <u>delocalised</u> over the benzene ring or LP in amide <u>delocalised</u> (more effectively) by C=O	3
9(e)	M1: $M + 1 / M = (1.1 \times ?) / 100$ M2: Ans 5.28 Award 2 marks for correct answer	2

CHEMISTRY

9701/43

Paper 4 A Level Structured Questions

October/November 2019

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 International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2019 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **14** printed pages.



Cambridge Assessment
International Education

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

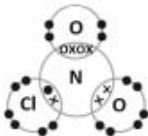
PUBLISHED**GENERIC MARKING PRINCIPLE 5:**

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

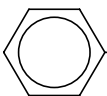
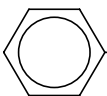
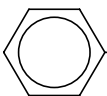
Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Question	Answer	Marks
1(a)	Platinum / Pt Aluminium / Al BOTH	1
1(b)(i)	M1: use of or quoting a valid Nernst equation $E = E^\ominus + 0.0590 / z \log [\text{ox}] / [\text{red}]$ OR $E = 0.15 + (0.0590 / 2) \log 2$ M2: $E = (+)0.16$ (0.159) V minimum 2 sig. fig. correct answer scores 2 marks	2
1(b)(ii)	$E_{\text{cell}} = 0.16 - (-1.66) = \mathbf{+1.82 \text{ V}}$ minimum 3 sig. fig.	1
1(b)(iii)	$2\text{Al} + 3\text{Sn}^{4+} \rightarrow 2\text{Al}^{3+} + 3\text{Sn}^{2+}$ M1: species M2: balancing	2
1(c)	M1: number of C (= $300\,000 \times 60 \times 60 \times 24$) = 2.59×10^{10} (C) M2: number of F (= $2.592 \times 10^{10} / 9.65 \times 10^4$) = 2.69×10^5 (moles of electrons) M3: moles of Al (= $2.69 \times 10^5 / 3$) = 8.95×10^4 M4: mass of Al (= $8.95 \times 10^4 \times 27$) = 2420 kg correct answer scores 4 marks	4
1(d)	M1: ($\text{Cr}^{2+} + 2\text{e}^- \rightleftharpoons \text{Cr}$) $E^\ominus = -0.91$ and ($2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2$) $E^\ominus = 0.00$ seen M2: hydrogen formed instead / hydrogen (ions) easier to reduce / hydrogen has more positive $E^\ominus$	2

Question	Answer	Marks
2(a)	 M1: eight electrons around N atom [N=O, N-O, N-Cl with N-O as dative] M2: all other electrons correct	2
2(b)(i)	(rate =) $k[\text{ClNO}_2][\text{NO}]$	1
2(b)(ii)	$\text{mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$	1
2(b)(iii)	Yes AND number of moles of reactants in overall equation is the same as order in rate equation	1
2(c)(i)	• straight line with a negative gradient • starting at 2.0×10^{-4} • reaches at 1.8×10^{-4} at 0.2 seconds Award 1 mark for two points, award 2 marks for all three points	2
2(c)(ii)	$2 \times 10^{-5} (\text{mol dm}^{-3})$	1
2(c)(iii)	The reaction has reached equilibrium	1

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Question	Answer	Marks
3(a)	a measure / degree of disorder / randomness of a system	1
3(b)	M1: negative – molecules have less energy in the system M2: positive – solid being converted into an aqueous solution M3: negative – gaseous ions being converted into a solid	3
3(c)(i)	(standard) Gibbs free energy <u>change</u>	1
3(c)(ii)	M1: $(\Delta)G = \Delta H - T\Delta S$ M2: description of calculating the minimum value of T for which ΔG is zero / becomes negative OR $T = \Delta H / \Delta S$ [1]	2

Question	Answer			Marks												
4(a)	M1: CH_3COCl or ethanoyl chloride M2: AlCl_3 catalyst			2												
4(b)	<table><tr><th>reagent</th><th>organic product</th><th>name of mechanism</th></tr><tr><td>Cl</td><td> chlorine atom(s) in side chain only</td><td>free radical substitution</td></tr><tr><td>nitric / sulfuric</td><td> one only $-\text{NO}_2$ group added at 3 position</td><td>electrophilic substitution</td></tr><tr><td>Br</td><td>no reaction with Br_2</td><td></td></tr></table> Award 1 mark for each correct entry to the table [5]			reagent	organic product	name of mechanism	Cl	 chlorine atom(s) in side chain only	free radical substitution	nitric / sulfuric	 one only $-\text{NO}_2$ group added at 3 position	electrophilic substitution	Br	no reaction with Br_2		5
reagent	organic product	name of mechanism														
Cl	 chlorine atom(s) in side chain only	free radical substitution														
nitric / sulfuric	 one only $-\text{NO}_2$ group added at 3 position	electrophilic substitution														
Br	no reaction with Br_2															
4(c)(i)	nucleophilic addition			1												

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Question	Answer	Marks
4(c)(ii)	M1 and M2: first structure – award one mark for two points correct, award two marks for four points correct. • correct polarity shown on C=O bond • curly arrow from double bond to O of the C=O • lone pair shown on C of CN⁻ ion • curly arrow from C (on CN⁻ ion) to C of C=O M3: middle structure • correct intermediate AND curly arrow from lone pair on O⁻ to H⁺ or H of H₂O or HCN M4: third structure • correct product AND either CN⁻ reformed (if HCN seen in step 2) OR curly arrow on H-CN bond towards CN in step 2	4
4(d)(i)		1
4(d)(ii)	LiAlH ₄ or NaBH ₄	1
4(d)(iii)	conc H ₂ SO ₄ / conc H ₃ PO ₄ / Al ₂ O ₃	1
4(d)(iv)	6	1

Question	Answer	Marks
4(d)(v)	• 25–50 • 110–160 • 190–220 Award 1 mark for two points, award 2 marks for three points	2

Question	Answer	Marks
5(a)(i)	$K_{sp} = [Ag^+]^2[S^{2-}]$	1
5(a)(ii)	• $[S^{2-}] = 1.16 \times 10^{-17}$ • $[Ag^+] = 2.32 \times 10^{-17}$ • $K_{sp} = 6.2(4) \times 10^{-51}$ minimum 2 sig. fig. correct answer scores 2 marks Award 1 mark for two points, award 2 marks for three points	2
5(a)(iii)	M1: moles $Ag_2S = 1 / 247.9 = 0.00403$ moles [1] 2sf min M2: $1.16 \times 10^{-17} = 0.0040 / V$ so $V = 3.5 \times 10^{14} (dm^3)$ [1] 2sf min ecf on M1 correct answer scores 2 marks	2
5(b)(i)	M1: $[H^+] = \sqrt{2.0 \times 10^{-9} \times 0.20}$ $[H^+] = 2.0 \times 10^{-5} (1.9976 \times 10^{-5})$ M2: pH = 4.7 (4.699) minimum 2 sig. fig. min correct answer scores 2 marks	2

Question	Answer	Marks
5(b)(ii)	M1: Both equilibria correctly stated moles KOH = $0.005 \times 0.2 = 1 \times 10^{-3}$ moles HOBr(initial) = $0.020 \times 0.2 = 4 \times 10^{-3}$ moles HOBr(eqm) = $4 \times 10^{-3} - 1 \times 10^{-3} = 3 \times 10^{-3}$ moles BrO⁻(eqm) = 1×10^{-3} M2: ratio [OBr⁻]/[HOBr] = 1/3 [H⁺] = $3 \times 2.0 \times 10^{-9} = 6 \times 10^{-9}$ pH = 8.2(2) correct answer scores 2 marks	2

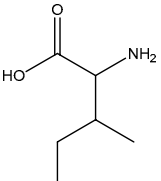
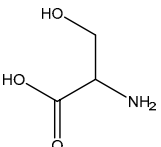
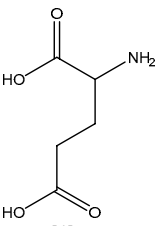
Question	Answer	Marks
6(a)(i)	$\text{Mg(g)} \rightarrow \text{Mg}^{\text{+}}(\text{g}) + \text{e}^{-}$	1
6(a)(ii)	$\text{Sr(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Sr(OH)}_2(\text{aq}) + \text{H}_2(\text{g})$	1
6(a)(iii)	more reactive and easier to ionise down the group OR more reactive and ionisation energies decrease down the group	1
6(b)(i)	brown gas and white solid	1
6(b)(ii)	$2\text{Ca(NO}_3)_2 \rightarrow 2\text{CaO} + 4\text{NO}_2 + \text{O}_2$	1
6(b)(iii)	M1: more stable (down the group) M2: cationic radius increases / charge density of M²⁺ decreases (down the group) M3: NO₃⁻ anion is less polarised / distorted	3

Question	Answer	Marks
6(c)	M1: less soluble / decreases (down the group) M2: ΔH_{latt} and ΔH_{hyd} both decrease / less exothermic down the group M3: ΔH_{hyd} decreases by more (than ΔH_{latt}) M4: ΔH_{sol} becomes more endothermic / less exothermic	4

Question	Answer	Marks
7(a)	forms one or more stable ions with incomplete / partially filled d-orbitals / d-subshell	1
7(b)(i)	purple to pale pink / colourless AND orange to green	1
7(b)(ii)	$3\text{Sn}^{2+} + \text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ \rightarrow 3\text{Sn}^{4+} + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	1
7(c)(i)	• six • coordinate bonds / dative bonds / lone pairs donated • to the (central) metal ion award 1 mark for all three points	1
7(c)(ii)	$[\text{Ru}(\text{NH}_3)_4\text{Cl}(\text{SO}_2)]^+$	1
7(c)(iii)	M1: six correct ligands around Ru, bonds are shown from S of SO_2 M2: 3-D bonds used correctly for octahedral M3: cis and trans isomers shown	3

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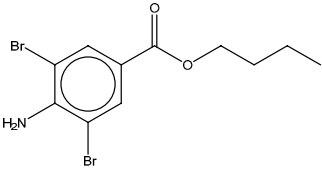
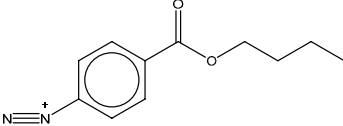
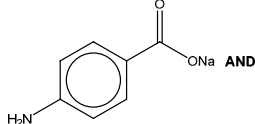
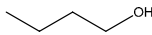
Question	Answer	Marks
7(c)(iv)	cis-trans or geometric(al) [1]	1
7(c)(v)	M1: complexes have two sets of d orbital(s) of different energy OR d-orbitals splits into two sets (of orbitals) M2: visible light absorbed (and complementary colour observed) M3: electron(s) promoted / excited OR electron(s) moves to higher (d–) orbital	3

Question	Answer	Marks
8(a)(i)	any one from: - OH[–] / NaOH; aqueous / dilute; heat under reflux - H⁺ / HCl / H₂SO₄, aqueous / dilute; heat under reflux - protease or named protease; water; T = 30° – 40°C all three points in each bullet [1]	1
8(a)(ii)	   M1: three amino acids in any ionic / non-ionic states [1] M2: three amino acids in the correct ionic state for their conditions [1]	2

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Question	Answer	Marks
8(b)	- permanent dipole-dipole - one group that will have a δ^+ and another with δ^- e.g. CO, NH, COOH, OH BOTH [1] - hydrogen bonds - one group that will have a $H^{\delta+}$, e.g. NH, OH and another with lone pair, e.g. NH, COOH, OH, CONH₂ BOTH [1] - ionic bonding - NH₃⁺ and COO⁻ BOTH [1] ALLOW - London forces - C₆H₉ groups or parts of these alkyl groups	3
8(c)(i)	any structure containing one COOH / COCl and NH ₂ groups in the same molecule [1]	1
8(c)(ii)	HOCH ₂ CH ₂ OH [1] ethan(e)-1,2-diol [1] ecf for diols HO ₂ CCO ₂ H or ClOCCOCl [1] ethan(e)dioic acid or ethan(e)dioyl chloride [1] ecf for diacids / diacyl chlorides	4

Question	Answer	Marks
9(a)(i)	RNH ₂ + H ⁺ → RNH ₃ ⁺ OR RNH ₂ + HCl → RNH ₃ Cl [1]	1
9(a)(ii)	weaker AND lone pair of N delocalised into benzene ring [1]	1

Question	Answer	Marks
9(b)	 [1]  [1]  AND  [1]	3
9(c)(i)	2 [1]	1
9(c)(ii)	CH ₂ next to ester and terminal CH ₃ are circled [1]	1
9(c)(iii)	- one less peak - the lost peak is NH₂ / aryl amine - protons exchange with D OR protons are labile OR valid equation ✓✓ for two marks [2]	2
9(d)	C ₆ H ₄ NH ₂ ⁺ and CH ₃ CH ₂ CH ₂ CH ₂ ⁺ [1]	1