Cambridge International AS & A Level

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CHEMISTRY **9701/42**

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.

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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.

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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: 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.

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Question	Answer	Marks
1(a)	Platinum **and** platinum	**1**
1(b)(i)	**M1:** Nernst quoted correctly $E = E^{\ominus} + 0.0590 / z \log [ox] / [red]$ 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:** $Mn^{3+} + 2Br^- \rightarrow Mn^{2+} + Br_2$ **M2:** $2Mn^{3+} + 2Br^- \rightarrow Mn^{2+} + Br_2$	**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:** $Mg^{2+} + 2e^- \rightleftharpoons Mg$ $E^{\ominus} = -2.38$ **and** $2H^+ + 2e^- \rightleftharpoons H_2$ $E^{\ominus} = 0.00$ **M2:** hydrogen produced instead / hydrogen easier to reduce / hydrogen preferentially reduced / hydrogen has more positive $E^{\ominus}$	**2**

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

Question	Answer	Marks
2(c)	**M1:** rate = k[ester][OH^-] **M2:** value of k = 0.206 **M3:** units $mol^{-1}dm^3s^{-1}$	**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:** pK_a = 9.26 Award 2 marks for correct answer	**2**
3(b)(i)	$NH_3 + H^+ \rightarrow NH_4^+$	**1**
3(b)(ii)	$NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ **or** $H^+ + OH^- \rightarrow H_2O$ **and** reference to expression in Q shifting R	**1**
3(c)(i)	quotes $K_w = 1 \times 10^{-14}$ or 1×10^{-1} $[H^+][OH^-]$ $[H^+] = 1 \times 10^{-7}$	**1**
3(c)(ii)	**M1:** $[H^+] = 2.3 \times 10^{-7}$ (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:** $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$ $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ 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**

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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><tr><th>Reagent added to a solution of $CuSO_4(aq)$</th><th>Observations</th><th>Formula of the copper(II) compound or complex ion that is formed</th></tr><tr><td>a few drops of dilute ammonia</td><td>blue ppt</td><td>$Cu(OH)_2$ or $Cu(OH)_2(H_2O)_4$</td></tr><tr><td>an excess of dilute ammonia</td><td>deep blue solution</td><td>$[Cu(NH_3)_4]^{2+}$ or $[Cu(NH_3)_4(H_2O)_2]^{2+}$</td></tr><tr><td>an excess of aqueous sodium hydroxide</td><td>blue ppt</td><td>$Cu(OH)_2$ or $Cu(OH)_2(H_2O)_4$</td></tr><tr><td>an excess of conc HCl.</td><td>green-yellow / yellow-green / yellow</td><td>$[CuCl_4]^{2-}$</td></tr></table> Award 1 mark for each correct observation and formula in a row of the table.	**4**

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:** $2FeSO_4 + Cl_2 \rightarrow Fe_2(SO_4)_2Cl_2$ or $2Fe^{2+} + Cl_2 \rightarrow 2Fe^{3+} + 2Cl^-$	**2**
6(e)(i)	$[[FeCl_4]^-] / [[Fe(H_2O)_6]^{3+}][Cl^-]^4$	**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:** Sn + 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)	$NCCH_2CH_2CN$ / CH_2CNCH_2CN	**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 CO_2H group of hexanoic acid **either** – withdraws charge from OH group **or** is electronegative **and** weakens O–H bond **or** – stabilises resultant anion/negative ion / $–CO_2^-$ group/carboxylate ion • benzene / aromatic / C_6H_5 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 / $–CO_2^-$ 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 CH_3	**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:** $(C_5NH_4)COOH$ or $(C_5NH_5)^+COOH$ **M2:** $(C_5NH_4)COO^-(Na^+)$ or $(C_5NH_4)COONa$	**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 × ?) / 100 **M2:** Ans 5.28 Award 2 marks for correct answer	**2**

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