Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/42**

Paper 4 A Level Structured Questions **October/November 2023**

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 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

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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.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	‘List rule’ guidance For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

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6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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Question	Answer	Marks
1(a)	1 0 [1] 1 2 [1]	**2**
1(b)(i)	The line should start at **1 × 10^{-5}** and decrease to **0.773 × 10^{-5} / 7.73 × 10^{-6}** and be **straight** for 10 s [1]	**1**
1(b)(ii)	its not possible **AND** the concentrations in the rate law are not known [1]	**1**
1(c)	9.24×10^{-7} [1]	**1**
1(d)(i)	630 [1]	**1**
1(d)(ii)	Three halvings taking equal times, these times to agree with their answer to di.[1]	**1**
1(e)(i)	$CH_3COH{=}CH_2 + I_2 \rightarrow CH_3C^+(OH)CH_2I + I^-$ [1]	**1**
1(e)(ii)	step 1 **AND** has (both) substances in rate law.[1]	**1**
1(e)(iii)	$CH_3C^+OHCH_3$ and CH_3COCH_3 **OR** $CH_3C^+(OH)CH_3$ and $CH_3C(OH){=}CH_2$ **OR** $CH_3C^+(OH)CH_2I$ and CH_3COCH_2I [1]	**1**

Question	Answer	Marks
2(a)	resists pH change when small amount of acid or alkali is added [1]	**1**
2(b)(i)	$C_6H_5COOH + NaOH \rightarrow C_6H_5COO^-Na^+ + H_2O$ [1]	**1**
2(b)(ii)	$C_6H_5COO^-Na^+ + HNO_3 \rightarrow C_6H_5COOH + NaNO_3$ [1]	**1**
2(c)	$[H^+] = 7.08 \times 10^{-5}$ [1] $[C_6H_5COOH] = 8.20 \times 10^{-3}$ [1] $[C_6H_5COO^-Na^+] = 7.31 \times 10^{-3}$ [1]	**3**

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Question	Answer	Marks
2(d)	neutralisation is exothermic [1] All of the C_6H_5COOH has reacted **AND** excess KOH 1]	**2**
2(e)(i)	If [X] = $[Mg^{2+}]$ = $[Mg(C_6H_5COO^-)_2]$ $4X^3 = 1.76 \times 10^{-7}$ so $X = 3.53 \times 10^{-3}$ [1] 0.940 g dm^{-3} [1]	**2**
2(e)(ii)	lower than **AND** common ion effect [1]	**1**

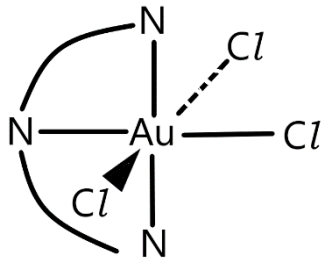
Question	Answer	Marks
3(a)(i)	hydrogen, delivery system, H^+, platinum, [1]	**1**
3(a)(ii)	iron . . . . . hydrogen . . . . . iron [1]	**1**
3(b)(i)	(for specified V^{2+}, V^{3+} or VO^{2+}) $E^\ominus$ is more positive than / above –0.44 **AND** more negative than / below 0.77 V [1]	**1**
3(b)(ii)	V and VO_2^+ [1]	**1**
3(b)(iii)	$V + Fe^{2+} \rightarrow V^{2+} + Fe$ **OR** $VO_2^+ + 2H^+ + Fe^{2+} \rightarrow VO^{2+} + H_2O + Fe^{3+}$ [1]	**1**
3(c)(i)	Nernst: $E = 0.77 + (0.059 / z)\log[ox] / [red]$ [1] 0.947 [1]	**2**
3(c)(ii)	$2Fe^{3+} + Cl^- + 2OH^- \rightarrow 2Fe^{2+} + ClO^- + H_2O$ [1]	**1**
3(d)	$E^\ominus_{cell} = 1.33$ V [1] $\Delta G^\ominus = -nE^\ominus_{cell}F$ [1] –257 [1]	**3**

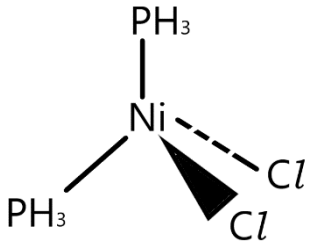
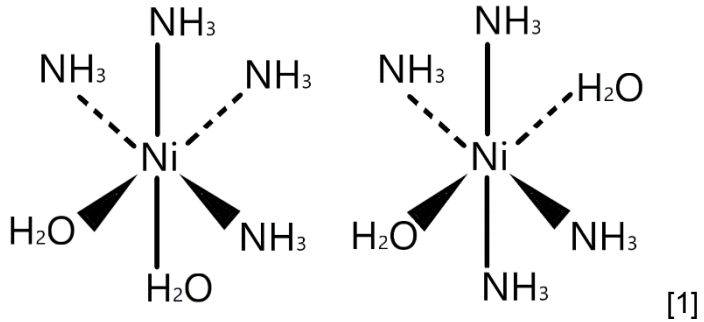
Question	Answer	Marks
3(e)	$0.64 \times 17 \times 60 = 653 / 652.8$ Coulombs [1] $652.8 \div 1.6\text{x}10^{-19} = 4.08 \times 10^{21}$ (number of electrons) $4.08 \times 10^{21} \div 2 = 2.04 \times 10^{21}$ (number of atoms Fe) [1] $0.185 \div 55.8 = 3.31 \times 10^{-3}$ (number of moles Fe atoms $2.04 \times 10^{21} \div 3.31 \times 10^{-3} = L = 6.153 \times 10^{23}$ [1]	**3**
3(f)(i)	$\Delta S = -179$ [1] $\Delta G = \Delta H - T\Delta S$ [1] –74.7 [1]	**3**
3(f)(ii)	less **AND** ΔG becomes more positive [1]	**1**

Question	Answer	Marks
4(a)	equilibrium constant for the formation of a complex in a solvent **/** from its constituents [1]	**1**
4(b)	$+2$ **AND** $+3$ [1]	**1**
4(c)	Six [1]	**1**
4(d)	$[Fe(EDTA)]^-$ **AND** largest K_{stab} [1]	**1**
4(e)	$[[CuEDTA]^{2-}] \div ([[Cu(H_2O)_6]^{2+}] \times [EDTA^{2-}]) = 6.31 \times 10^{19}$ [1] 0.095 [1]	**2**
4(f)	different ΔE **OR** different energy gap between d-orbitals [1] absorption of different wavelength **OR** absorption of different frequency [1]	**2**

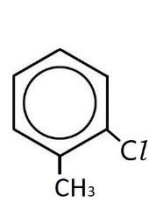
Question	Answer	Marks
5(a)	$MgC_2O_4 \rightarrow MgO + CO_2 + CO$ [1]	**1**

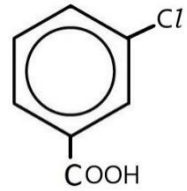
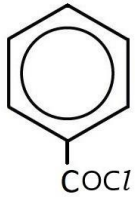
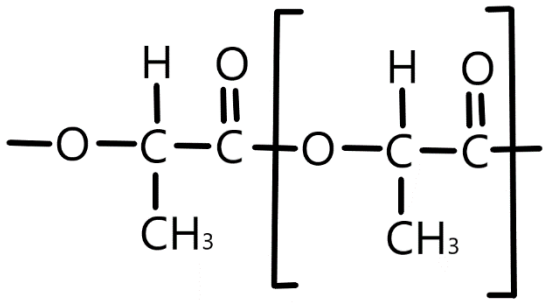
Question	Answer	Marks
5(b)	magnesium ethanedioate decomposes at lower T because Mg^{2+} has smaller radius than Ca^{2+} [1] so anion is more polarised by Mg^{2+} [1]	**2**
5(c)	$(27.05 \div 1000) \times 0.02 = 5.41 \times 10^{-5}$ moles MnO_4^- [1] $5.41 \times 10^{-5} \times 5/2 = 1.3525 \times 10^{-4}$ moles $C_2O_4^{2-}$ [1] 0.00338 mol dm^{-3} [1]	**3**

Question	Answer	Marks
6(a)(i)	donates one lp to metal atom or ion [1]	**1**
6(a)(ii)	metal atom or ion bonded to one or more ligands [1]	**1**
6(a)(iii)	has vacant d-orbitals which are energetically accessible [1]	**1**
6(b)(i)	octahedral square planar octahedral [1]	**1**
6(b(ii)	$[Au(dien)(H_2O)_2Cl]^{2+} + 2Cl^- \rightarrow [Au(dien)Cl_3] + 2H_2O$ [1] **OR** $[Au(dien)Cl_3] + 2H_2O \rightarrow [Au(dien)(H_2O)_2Cl]^{2+} + 2Cl^-$	**1**
6(b)(iii)	 [1]	

Question	Answer	Marks
6(b)(iv)	 [1]	**1**
6(b)(v)	$[Rh(en)_2Cl_2]^+$ **AND** optical **AND** cis / trans **OR** geometric [1]	**1**
6(b)(vi)	 [1] cis/trans **OR** geometric [1]	**2**

Question	Answer	Marks
7(a)	$CH_3Cl + AlCl_3$ [1] hot alkaline) MnO_4^- [1]	**2**

Question	Answer	Marks
7(b)	4, 110-160, 1, 25-50 either order [1] 4, 110-160, 1, 160-185 either order [1]	**2**
7(c)(i)	Mark J and K together.  either  or J or K [1]  J or K [1] for the ring substituted product – $AlCl_3$ [1] for the side-chain substituted product – uv [1]	**4**

Question	Answer	Marks
7(c)(ii)	 L [1]  M [1] PCl_3 + heat **OR** $SOCl_2$ **OR** PCl_5 [1]	**3**
8(a)(i)	 diagram has trailing bonds, two or more monomer residues **AND** either repeat unit correct **OR** ester linkage correct [1] diagram fully correct [1]	**2**

Question	Answer	Marks
8(a)(ii)	condensation **AND** ester [1]	**1**
8(a)(iii)	it is biodegradable because it can hydrolyse [1]	**1**
8(b)(i)	d values: 12, 4.4 [1] 5.0, 1.6 [1] splitting patterns: singlet, quartet / quadruplet, singlet, doublet [1]	**3**
8(b)(ii)	TMS / tetramethylsilane [1]	**1**
8(b)(iii)	$CDCl_3$ will not give an absorption / peak **OR** $CHCl_3$ will give an absorption / peak [1]	**1**
8(c)(i)	time between injection and detection [1]	**1**
8(c)(ii)	an unreactive gas **AND** a non-polar liquid [1]	**1**
8(c)(iii)	area of peak divided by total area of all peaks × 100% [1]	**1**

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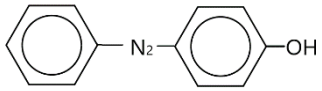
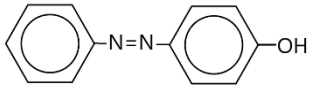
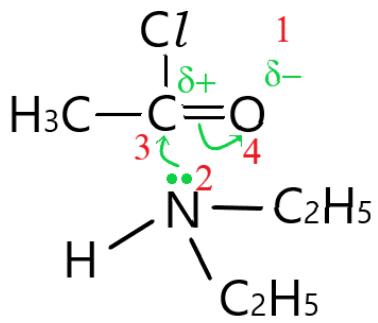
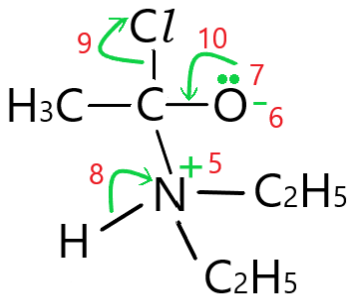
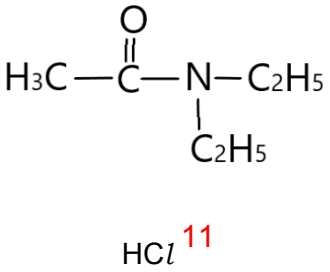
Question	Answer	Marks
9(a)	chloroethane and ethylamine [1] heat, pressure, ethanol [1] N-ethyl ethanamide $CH_3CONHC_2H_5$ [1] $LiAlH_4$ [1] Other syntheses that work also got credit /	**4**
9(b)	phenylamine, ammonia, diethylamine [1] • Availability of lone pair on N to receive H^+ • phenylamine – LP, delocalised / overlaps into ring [1] • diethylamine – ethyl are electron donating [1] Two bullet points for one mark, three bullet points for two marks.	**3**
9(c)	  Q or [1] N_2 or N=N circled **AND** dye / colouring[1]	**2**

Question	Answer	Marks
9(d)(i)	box one:  box two:  box three: 	
	box one: 1 dipole on C=O 2 LP on N of amine [1] 3 CA from N of amine to C of acyl chloride 4 CA from = to O of acyl chloride [1] box two: 5 + on what was N of amine and nowhere else 6 – on what was O of acyl chloride and nowhere else 7 LP on what was O of acyl chloride [1] 8 CA from N-H bond to what was N of amine 9 CA from C-C*l* bond to what was C*l* of acyl chloride 10 CA from (LP on) O to reform C=O [1] box three: 11 HC*l*	**4**
9(d)(ii)	Addition-elimination	**1**