Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/42**

Paper 4 A Level Structured Questions **October/November 2022**

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.

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)	(energy change) when one mole of ionic solid is formed from gaseous ions	**1**
1(b)	(–2237 + 193 + 590 + 1150 + (2 × 121) – (2 × 364)) [1] = –790 [1]	**2**
1(c)	–342 **and** Br atom has larger radius	**1**
1(d)(i)	energy change when one mole dissolves in water [1] energy change when one mole of gaseous ions dissolves in water [1]	**2**
1(d)(ii)	(–2237 – 83 + 1650) / 2 [1] = –335 [1]	**2**
1(e)(i)	negative **and** reduction in number of gas molecules	**1**
1(e)(ii)	TΔS becomes more negative [1] less feasible **AND** ΔG becomes positive [1]	**2**

Question	Answer	Marks
2(a)(i)	rate = k[NO][O_3]	**1**
2(a)(ii)	1.66×10^{-8} [1] mol dm^{-3} s^{-1} [1]	**2**
2(a)(iii)	not constant **AND** overall second order / not overall first order	**1**
2(b)(i)	graph is straight line clearly parallel to x-axis	**1**
2(b)(ii)	graph is straight line with negative gradient	**1**

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Question	Answer	Marks
2(b)(iii)	adsorption of reactants onto catalyst surface [1] bonds in reactants weaken [1] reaction occurs followed by desorption of products [1]	**3**
2(b)(iv)	all active sites on catalyst surface are occupied	**1**

Question	Answer	Marks
3(a)(i)	the voltage produced by a half-cell compared with a standard hydrogen electrode [1] 1 mol dm^{-3}, 298 K, 1 atm [1]	**2**
3(a)(ii)	Mg wire and Pt wire [1] voltmeter, salt bridge, complete circuit [1] solutes Mg^{2+} and MnO_4^-, Mn^{2+}, H^+ [1]	**3**
3(a)(iii)	Mg is minus, Pt is plus arrow points towards MnO_4^- / Mn^{2+} half-cell	**1**
3(a)(iv)	3.90 V	**1**
3(a)(v)	$5Mg + 2MnO_4^- + 16H^+ \rightarrow 5Mg^{2+} + 2Mn^{2+} + 8H_2O$	**1**
3(a)(vi)	no change **and** dilution will make Mg^{2+} / Mg potential even more negative	**1**
3(b)	either: $4.75 \times 10^{22} \times 2 \times 1.60 \times 10^{-19}$ = 15 200 C **OR** $2 \times 96\,500 \times (4.75 \times 10^{22}) / 6.02 \times 10^{23}$ = 15 228 C [1] 15 200 / (15 × 60) = 16.9 A **OR** 15 228 / (15 × 60) = 16.9 A [1]	**2**

Question	Answer	Marks
4(a)(i)	$27\ x^4 = 2 \times 10^{-39}$ $x = 9.28 \times 10^{-11}$ mol dm^{-3}	**1**
4(a)(ii)	$[Fe^{3+}][0.02]^3 = 2 \times 10^{-39}$ [1] $[Fe^{3+}] = 2.5 \times 10^{-34}$ [1]	**2**
4(a)(iii)	common ion (effect)	**1**
4(b)(i)	two species that differ by one H^+ ion	**1**
4(b)(ii)	HBrO BrO^- H_3O^+ H_2O	**1**
4(b)(iii)	[acid] = 4×10^{-2} $[H^+]^2 = 8.0 \times 10^{-11}$ [1] pH = 5.05 [1]	**2**
4(b)(iv)	8.70	**1**

Question	Answer	Marks
5(a)	a d-block element that forms one or more stable ions with incomplete d-orbitals	**1**
5(b)(i)	<table><tr><td></td><td>geometry</td><td>CN</td><td>bond angle</td></tr><tr><td>$[Cu(H_2O)_6]^{2+}$</td><td>octahedral</td><td>6</td><td>90 or 180</td></tr><tr><td>$[CuCl_4]^{2-}$</td><td>tetrahedral</td><td>4</td><td>109 to 110</td></tr></table>	**3**
5(b)(ii)	degenerate – of the same energy non-degenerate – not of the same energy / different energy	**1**
5(b)(iii)	different frequency / wavelength / photon absorbed	**1**

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Question	Answer	Marks
5(c)(i)	forms 2 dative / coordinate bonds	**1**
5(c)(ii)	one isomer correct with correct 3D [1] three isomers different with correct 3D [1]	**2**
5(c)(iii)	e.g. 1 and 2 optical [1] e.g. 1 or 2 and 3 cis-trans / geometric [1]	**2**
5(d)	0.0230 moles ethanedioate in whole 100 cm^3 0.00575 moles ethanedioate in 25 cm^3 sample [1] 0.00230 moles of MnO_4^- needed [1] 230 cm^3 [1]	**3**
5(e)	Cu^{2+} is smaller / has a smaller radius / than Ba^{2+} [1] Cu^{2+} polarises / distorts the anion more [1]	**2**

Question	Answer	Marks
6(a)(i)	<table><tr><td>blue or pink</td><td>s / solid</td></tr><tr><td>blue</td><td>aq / aqueous</td></tr></table> two cells correct [1] two more cells correct [1]	**2**
6(a)(ii)	$[Co(H_2O)_6]^{2+} + 2OH^- \rightarrow Co(OH)_2 + 6H_2O$ **or** $[Co(H_2O)_6]^{2+} + 2OH^- \rightarrow Co(H_2O)_4(OH)_2 + 2H_2O$	**1**
6(a)(iii)	$[Co(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CoCl_4]^{2-} + 6H_2O$	**1**
6(b)(i)	the equilibrium constant for the formation of a complex ion in a solvent **OR** the equilibrium constant for the formation of a complex ion from its constituent ions	**1**

Question	Answer	Marks
6(b)(ii)	$K_{stab} = [[Co(NH_3)_6]^{2+}] / [[Co(H_2O)_6]^{2+}][NH_3]^6$ **or** $[[Co(NH_3)_6]^{2+}] / [Co^{2+}][NH_3]^6$	**1**
6(b)(iii)	$mol^{-6}\ dm^{18}$	**1**
6(b)(iv)	7.86×10^{-5}	**1**

Question	Answer	Marks
7(a)	**C** > **A** > **B** [1] chlorine and C=O are electronegative / withdraw charge **and** this causes greatest weakening of O–H bond or greatest stabilisation of the anion [1] 2nd oxygen / C=O is electronegative / withdraws charge **and** this weakens O–H bond or stabilises anion [1]	**3**
7(b)(i)	chloromethane aluminium chloride	**1**
7(b)(ii)	$CH_3Cl + AlCl_3 \rightarrow AlCl_4^- + CH_3^+$	**1**
7(b)(iii)	curly arrow from within benzene to CH_3^+ [1] positively charged intermediate [1] curly arrow from C–H bond into ring, $C_6H_5CH_3$, H^+ [1]	**3**
7(b)(iv)	hot alkaline $KMnO_4$ [1] $C_6H_5CH_3 + 3[O] \rightarrow C_6H_5CO_2H + H_2O$ **OR** $C_6H_5CH_3 + 3[O] + OH^- \rightarrow C_6H_5CO_2^- + 2H_2O$ [1]	**2**
7(b)(v)	2 or 4-nitromethylbenzene and 3-nitrobenzoic acid	**1**
7(c)(i)	HNO_2, T between 0° and 10°C	**1**
7(c)(ii)	warm / T>10°C **and** H_2O	**1**

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Question	Answer	Marks
7(c)(iii)	$CH_3C_6H_4–N=N–C_6H_3(CH_3)OH$ [1] T between 0° and 10°C **and** NaOH(aq) [1]	**2**

Question	Answer	Marks
8(a)	C* marked on CH of T and nowhere else	**1**
8(b)(i)	R – $C_6H_5CH_2COCH_2CH_3$ [1] 3.7 is $C_6H_5\mathbf{CH_2}COCH_2CH_3$ 2.5 is $C_6H_5CH_2CO\mathbf{CH_2}CH_3$ 1.0 is $C_6H_5CH_2COCH_2\mathbf{CH_3}$ [1]	**2**
8(b)(ii)	singlet **and** no H on neighbouring C	**1**
8(c)(i)	P and T	**1**
8(c)(ii)	P	**1**
8(d)	$CDCl_3$ or CCl_4	**1**
8(e)	no difference **and** no protons that exchange with D	**1**
8(f)	6 5 [1] 4 3 [1]	**2**

Question	Answer	Marks
9(a)	pH 7 $^{+}H_3N(CH_2)_4CHNH_2COOH$ pH 9.47 $^{+}H_3N(CH_2)_4CHNH_2COO^{-}$ [1] pH 12 $H_2N(CH_2)_4CHNH_2COO^{-}$ [1]	**2**
9(b)	D ethanoyl chloride [1] E correct phenyl ester [1] F correct amide [1]	**3**
9(c)	Br substitutes at both 2 and 6 positions [1] both phenol and COOH groups deprotonated [1] NO_2 substitutes at one or both of 2 and 6 positions [1]	**3**
9(d)(i)	distance travelled by amino acid divided by distance travelled by solvent [1]	**1**
9(d)(ii)	tyr is more soluble in the solvent used **or** lys is more attracted to the stationary phase used	**1**

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