Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/42**

Paper 4 A Level Structured Questions **March 2021**

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 March 2021 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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.

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	<u>'List rule' guidance</u> 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.

6	<u>Calculation specific guidance</u> 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	<u>Guidance for chemical equations</u> 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.

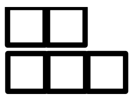
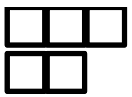
Question	Answer	Marks
1(a)	Co^{2+} = [Ar] $3d^7$ ($4s^0$) Co^{3+} = [Ar] $3d^6$ ($4s^0$)	**1**
1(b)	**M1/2:** Any two of: • Co^{3+} is **reduced** Co^{2+} • oxygen gas/O_2 is evolved • E of Co^{3+} **greater** than E of O_2 **M3:** no change (to $[Co(edta)]^-$) / not feasible **OWTTE**	**3**
1(c)	Any two of VISUAL observations: • condensation on tube / steam evolved • **brown** fumes / brown gas evolved • O_2 formed that relights a glowing splint • (solid) dissolves / turns to liquid	**2**
1(d)	**M1:** cationic radius / ion size increases (down the group) **M2:** less polarisation / distortion of nitrate **ion** / anion / NO_3^-	**2**

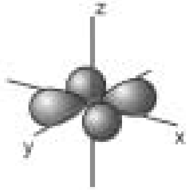
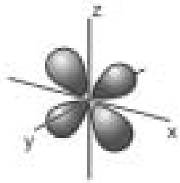
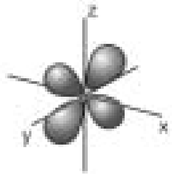
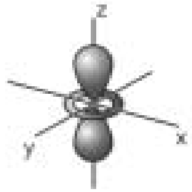
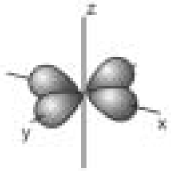
Question	Answer	Marks
2(a)(i)	**M1** the only number extracted: 762, 1560, 496 **M2** correct multiplier, other four numbers used and calculation to the answer $-272 = +416 + ½(496) + 762 + 1560 - 141 + 798 + \Delta H_{lattice}$ $\therefore \Delta H_{lattice}$ = **–3915** (kJ mol^{-1}) ecf	**2**
2(a)(ii)	$20 \times [0.9(+2) + 0.1(+3)] - 2x = 0$ $\therefore$ ***x* = 21**	**1**
2(a)(iii)	• FeO more exothermic/more negative • Fe^{2+} has smaller radius/higher charge density (also same charge) • greater attraction/ stronger ionic bonds (between Fe^{2+} and O^{2-}) **All three for two marks**	**2**

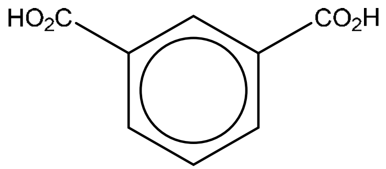
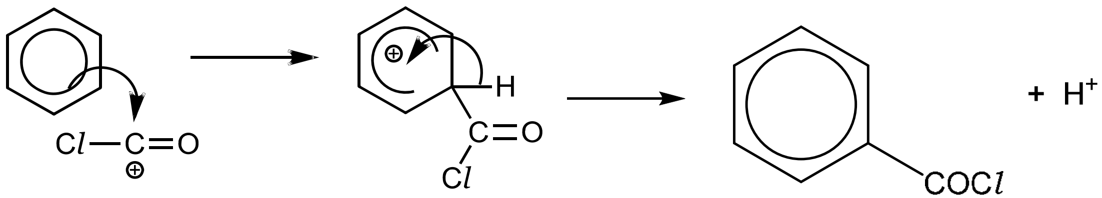
Question	Answer	Marks
2(b)(i)	• Fe^{2+} *reduced* to Fe **OR** oxid no. Fe +2 → 0 • Fe^{2+} *oxidised* to Fe^{3+} (in Fe_3O_4) **OR** oxid no. Fe +2 → +3 **BOTH bullets required**	**1**
2(b)(ii)	$2O^{2-} \rightarrow O_2 + 4e^-$	**1**
2(b)(iii)	**M1:** coulombs and correct use of ÷ 96500 **M2:** correct use of 3 and 8 **M3:** correct use of 55.8 and answer **M1**: $Q = It = 50 \times 6 \times 60^2$ **OR** 1.08×10^6 C **AND** no. of faraday = $1.08 \times 10^6 \div 96500$ **OR** 11.2 / 11.19 mol e^- **M2**: $Fe^{2+} + 2Fe^{3+} + 8e^- \rightarrow 3Fe$ ∴ moles of Fe = 3 / 8 × M1 = 4.20 mol Fe ecf **M3**: mass of Fe = 55.8 × M2 = 234.2 g ecf 3sf min	**3**
2(c)(i)	Any one of: small size / compact, low mass, high voltage **OWTTE**	**1**
2(c)(ii)	Li from +1 to +1 Fe from +3 to +2	**1**
2(c)(iii)	$LiC_6 + FePO_4 \rightarrow LiFePO_4 + 6C$	**1**

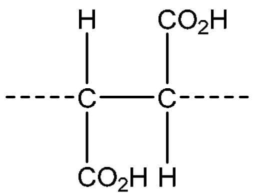
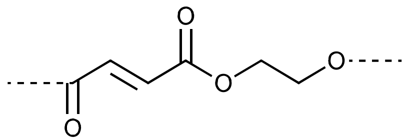
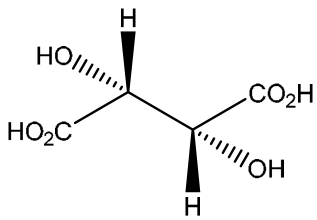
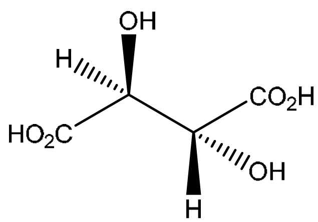
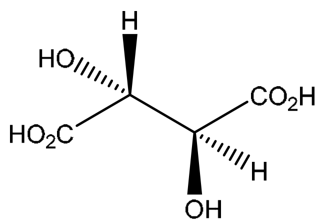
Question	Answer	Marks
3(a)	3 bonding-pair centres and one lone pair (on iodine)	**1**
3(b)	$3I_2 + 6NaOH \rightarrow NaIO_3 + 5NaI + 3H_2O$	**1**

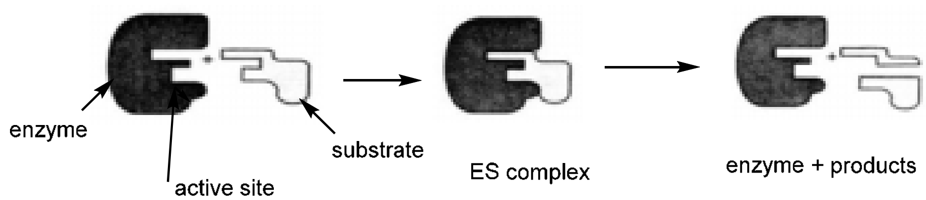
Question	Answer	Marks
3(c)(i)	**M1:** $E^{\ominus}_{cell}$ for IO_3^- / H_2O_2 = –0.68 + 1.19 = +0.51 (∴ feasible) **M2:** $E^{\ominus}_{cell}$ for H_2O_2 / I_2 = +1.77 – 1.19 = +0.58 (∴ feasible) **M3:** $5H_2O_2 + I_2 \rightarrow 4H_2O + 2IO_3^- + 2H^+$	**3**
3(c)(ii)	$2H_2O_2 \rightarrow 2H_2O + O_2$	**1**
3(d)(i)	**M1:** first order w.r.t. H_2O_2 **AND** change in conc. × 1.5 gives increase rate × 1.5 (expts 3 / 4) **M2:** first order w.r.t. IO_3^- **AND** change in conc. × 2 gives increase rate × 2 (as reaction first order w.r.t. H_2O_2) (expts 1 / 3) **M3:** zeroth order w.r.t. H^+ **AND** change in conc. has no effect on rate (expts 1 / 3 / 4 and 2)	**3**
3(d)(ii)	rate = $k[H_2O_2][IO_3^-]$ ecf	**1**
3(d)(iii)	**M1:** $k = 8.82 \times 10^{-5} \div (0.150 \times 0.140) = 4.20 \times 10^{-3}$ min 2sf ecf **M2:** $mol^{-1}\,dm^3\,s^{-1}$ ecf	**2**
3(e)(i)	$K_{sp} = [Pb^{2+}][IO_3^-]^2$	**1**
3(e)(ii)	**M1:** $3.69 \times 10^{-13} = x(2x)^2$ **OR** $x = \sqrt[3]{(3.69 \times 10^{-13} \div 4)}$ **M2:** = $4.5(2) \times 10^{-5}$ ($mol\,dm^{-3}$) min 2sf ecf	**2**
3(f)(i)	**M1:** ΔS = ½(192) + ½(205) + ½(261) + 2(70) – 42 **M2:** (+)427 ($J\,K^{-1}\,mol^{-1}$) ecf	**2**
3(f)(ii)	ΔG (always) negative because • $\Delta H < 0$ / negative **OR** exothermic **<u>AND</u>** • $\Delta S > 0$ / positive **OR** $-T\Delta S < 0$ for all T	**1**

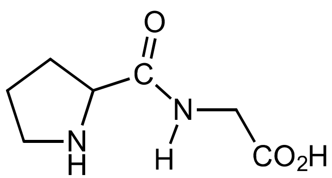
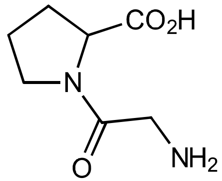
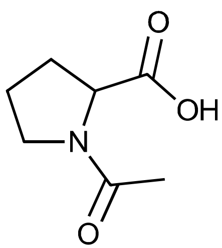
Question	Answer	Marks
4(a)	(element that forms one or more stable) ions with incomplete/ partially filled 3d-orbitals/d-subshell	**1**
4(b)(i)	O_h  **AND** T_d 	**1**

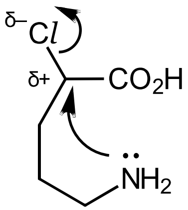
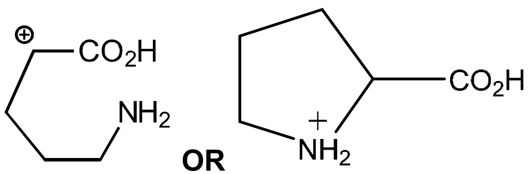
Question	Answer	Marks
4(b)(ii)	**M1:** *lower energy level (in between axes)*  **OR**  **OR**  **M2:** *higher energy level (on the axes)*  **OR** 	**2**
4(c)(i)	Circles round both N atoms and all four O^-	**1**
4(c)(ii)	**M1:** (d–d) energy gap / ΔE is different **M2:** different frequency / wavelength (of light) absorbed	**2**
4(c)(iii)	ligand exchange / substitution / displacement / replacement	**1**
4(c)(iv)	$K_{stab} = \dfrac{\left[Fe(edds)^{-}\right]}{\left[Fe(H_2O)_6{}^{3+}\right]\left[edds^{4-}\right]}$	**1**
4(c)(v)	$[Fe(edta)]^-$ is more stable as it has the higher K_{stab}	**1**
4(c)(vi)	$K_c = \dfrac{K_{stab}(edta)}{K_{stab}(edds)} = \dfrac{1.26\times10^{25}}{3.98\times10^{20}} = 3.17 \times 10^4$ **(31658)** min 2sf	**1**

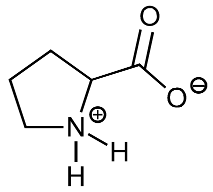
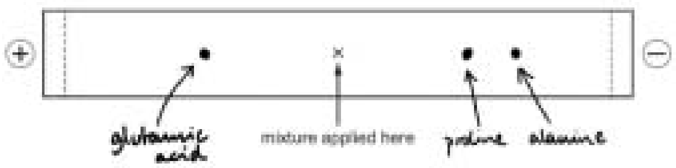
Question	Answer	Marks
5(a)(i)	**M1:** (cisplatin) can bond / bind with DNA / (nitrogenous) base A, T, C, G etc. **M2:** which prevents replication (of the DNA / strand) **OR** prevents cell division / prevents mitosis **OR** prevents transcription (and formation of mRNA)	**2**
5(a)(ii)	square planar	**1**
5(a)(iii)	the distance between two coordinating oxygens is too small to bond trans **OR** atoms in a bidentate ligand can only bond 90° not 180°	**1**
5(a)(iv)	+4	**1**
5(b)(i)	 **L**	**1**
5(b)(ii)	**M1:** heat / reflux with acidified / alkaline KMnO4 (then acidify) **M2:** PCl_5 **OR** $SOCl_2$ / (heat with) PCl_3	**2**
5(b)(iii)	$C_8H_6O_4 + 2PCl_5 \rightarrow C_8H_4O_2Cl_2 + 2POCl_3 + 2HCl$ **OR** $C_8H_6O_4 + 2SOCl_2 \rightarrow C_8H_4O_2Cl_2 + 2SO_2 + 2HCl$ **OR** $3C_8H_6O_4 + 2PCl_3 \rightarrow 3\ C_8H_4O_2Cl_2 + 2H_3PO_3$	**1**
5(b)(iv)	 **M1:** curly arrow from inside hexagon to C of electrophile **M2:** correct intermediate **M3:** curly arrow from C—H bond **AND** formation/loss of H^+	**3**

Question	Answer	Marks
6(a)	CO_2 and H_2O / in words	**1**
6(b)(i)	 if more than one unit drawn **ALLOW** one repeat unit identified	**1**
6(b)(ii)	 **M1:** presence of an ester group from the diol and COOH **OR** presence of an ester group from the fumaric acid and OH **M2:** rest of repeat unit including 'dangling' bonds	**2**
6(b)(iii)	C—C bonds are non-polar / polyalkenes cannot be hydrolysed **OR** polyesters / they can be broken down by hydrolysis	**1**
6(c)	 **AND**  **OR** 	**2**

Question	Answer	Marks
6(d)	 **M1:** (can be in words or diagram) substrate shape is **complementary** to active site **M2:** (can be in words or diagram) the substrate bind / bonds / fits (into the active site) **M3:** (can be in words or diagram) products are released	**3**

Question	Answer	Marks
7(a)(i)	 **OR**  **M1:** peptide link shown **M2:** rest of Pro–Gly correct	**2**
7(a)(ii)	condensation **ALLOW** substitution / addition–elimination	**1**
7(a)(iii)	there is no H attached to the N	**1**
7(b)(i)	($C_4H_7NHCO_2H$ +) NaOH → $C_4H_7NHCO_2Na$ + H_2O	**1**
7(b)(ii)	 skeletal only	**1**

Question	Answer	Marks
7(b)(iii)	$LiAlH_4$	**1**
7(c)(i)	$CH_2(CO_2C_2H_5)_2$: ● (di)ester CH_2=CHCN: ● alkene ● nitrile/cyanide All three correct for two marks	**2**
7(c)(ii)	addition	**1**
7(c)(iii)	H_2 / Ni **OR** H_2 / Pt **OR** H_2 / Pd	**1**
7(c)(iv)	condensation / (nucleophilic) substitution / elimination	**1**
7(c)(v)	ethanol / C_2H_5OH / CH_3CH_2OH	**1**
7(c)(vi)	 **M1/2:** All four correct: • lone pair on NH_2 • curly arrow from N: to C of C—C*l* • correct dipole on C—C*l* • curly arrow from C—C*l* to C*l* **M3:** intermediate = 	**3**
7(c)(vii)	Asterisk on *$CHCO_2H$	**1**

Question	Answer	Marks
7(d)	9	**1**
7(e)(i)	**M1:**  **M2:** proton / H^+ transferred from carboxylic acid to amine	**2**
7(e)(ii)	 **M1:** glutamic acid towards + end (from the diagram) **M2:** proline and alanine towards – end (from the diagram) **M3:** Glu moves towards positive (pole) as negatively charged / contains a COO^- **OR** Pro/Ala move towards negative (pole) as positively charged / contains a NH_2^+ / contains a NH_3^+ **M4:** Ala moves farther than Pro because of lower M_r / size (with positive charge) ORA	**4**
7(f)	**M1:** initial amount of $C_4H_9N_2O_4SNa$ = 3.50 / 204.1 **OR** 0.0171(48) mol **AND** amount of HCl added = 0.200 × 50.0 / 1000 **OR** 0.0100 mol **M2:** equilibrium amount of $C_4H_9N_2O_4SNa$ = 0.0171(48) – 0.0100 **OR** 0.0071(48) mol **AND** equilibrium amount of ACES = 0.0100 mol ecf **M3:** $K_a = 10^{-6.88} = 1.32 \times 10^{-7}$ (mol dm^{-3}) $[H^+] = (1.32 \times 10^{-7})0.01 / 0.0071(48) = 1.86 \times 10^{-7}$ **OR** 1.8465×10^{-7} ecf **M4**: pH = $-\log(1.86 \times 10^{-7})$ = 6.73 3sf min ecf	**4**