GradeMax

Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/42**

Paper 4 A Level Structured Questions **March 2020**

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 2020 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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[Turn over

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.

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5 ‘List rule’ guidance (see examples below)

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 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)(i)	forms (one or more stable) ions with partially filled (3)d-subshell	**1**
1(a)(ii)	(Iron) has a higher (melting point) **AND** is denser/higher (density) (than calcium)	**1**
1(a)(iii)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ (4s^0)$	**1**
1(a)(iv)	**M1** d sub-shell splits into two sets of d orbitals of different energy **M2** wavelength / frequency of light absorbed **M3** electron(s) promoted / excited **M4** colour seen is complementary (to colour absorbed)	**4**
1(b)(i)	octahedral	**1**
1(b)(ii)	$[Fe(H_2O)_6]^{2+} + 6CN^- \rightarrow [Fe(CN)_6]^{4-} + 6H_2O$	**1**
1(b)(iii)	$[Fe(CN)_6]^{4-}$ is (+)2 $[Fe(CN)_5NO]^{2-}$ is (+)3	**1**
1(b)(iv)	**M1** forms a single / one dative bond to a (central) metal atom / ion **M2** with lone pair (of electrons)	**2**
1(b)(v)	—	**1**
1(b)(vi)	**M1** d–d energy gap / ΔE is different **M2** different frequency / wavelength of light <u>absorbed</u>	**2**
1(c)(i)	the number of dative bonds formed with/by the (central) metal atom / ion **OR** number of bonds between the ligands and the (central) metal atom / ion	**1**

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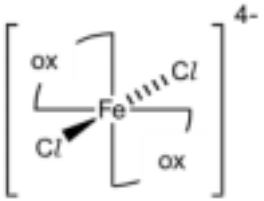
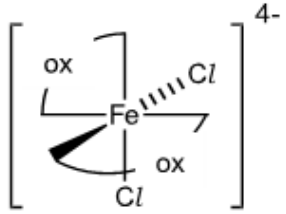
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(c)(ii)</td><td>trans


optical

</td><td>2</td></tr>
<tr><td>1(c)(iii)</td><td><table>
<tr><th>reactant</th><th>observation with $(CO_2H)_2$</th></tr>
<tr><td>warm H^+/MnO_4^-</td><td>decolourised
OR effervescence / bubbling / fizzing</td></tr>
<tr><td>2,4-DNPH</td><td>none / no reaction</td></tr>
<tr><td>warm Tollens' reagent</td><td>none / no reaction</td></tr>
</table></td><td>2</td></tr>
</table>

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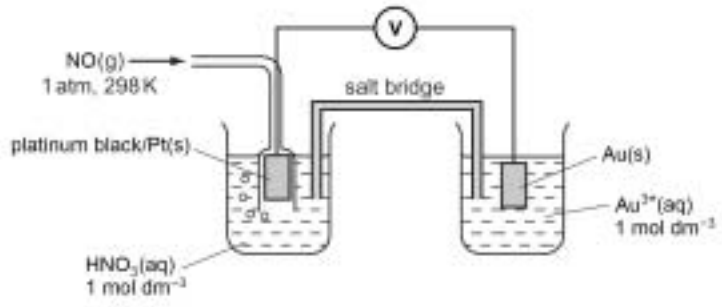
Question	Answer	Marks
2(a)(i)	**M1** (thermal stability) increases (down the group) **M2** size / radius of metal ion/M^{2+} increases **M3** polarisation / distortion of anion / CO_3^{2-} decreases	**3**
2(a)(ii)	**M1** lattice energy **AND** hydration enthalpy become less exothermic **M2** hydration enthalpy / ΔH_{hyd} becomes less exothermic more **M3** enthalpy change of solution / ΔH_{sol} becomes less exothermic / more endothermic	**3**
2(b)(i)	$2Al^{3+} + 3O^{2-} + 3C \rightarrow 2Al + 3CO$	**1**
2(b)(ii)	**M1** $Q = It = 3.5 \times 10^5 \times 3 \times 60^2 = 3.78 \times 10^9$ C **M2** no. of mol e^- = $3.78 \times 10^9 / 96500 = 3.92 \times 10^4$ **M3** mass Al = $27 \times 3.92 \times 10^4 / 3 = 3.5(3) \times 10^5$ g	**3**
2(b)(iii)	$3SiF_4 + 2H_2O \rightarrow 2H_2SiF_6 + SiO_2$	**1**

Question	Answer	Marks
3(a)(i)	Mark as • ✓✓ • voltage of an electrode / half-cell • compared / connected to (S)HE / hydrogen half-cell / electrode • under standard conditions / 1 mol dm^{-3}, 1 atm, 298 K	**2**

Question	Answer	Marks
3(a)(ii)	 Mark as • ✓ • ✓ • ✓ • ✓ • HNO_3(aq) and Au^{3+}(aq) • Au(s) and Pt(s) electrode • voltmeter (or circled V) • salt bridge labelled • NO (g) • a good delivery system for NO • 1M / 1 mol dm^{-3} • 298 K **AND** 1 atm	**4**
3(a)(iii)	$Au^{3+} + NO + 2H_2O \rightarrow Au + NO_3^- + 4H^+$	**1**
3(a)(iv)	+1.50 – 0.96 = + 0.54 (V)	**1**
3(a)(v)	**M1 M2** any two [1] all four [2] • adding conc HNO_3 shifts equilibrium 3 to the right • *E* for (half-equation 3) increases / more positive • adding conc HC*l* shift equilibrium 2 to the left • *E* for (half-equation 2) decreases / less positive **M3** *E*(3) becomes greater than *E*(2)	**3**

Question	Answer	Marks
3(b)(i)	$2AuCl_3 + 3H_2O_2 \rightarrow 2Au + 3O_2 + 6HCl$	1
3(b)(ii)	**M1** 1st order w.r.t. $AuCl_3$ because rate ×2 / doubles when concentration ×2 / doubles **M2** First order $H_2O_2 \times 2$; $AuCl_3 \times 3$ rate × 6 so order = 1 for H_2O_2 **M3** rate = k [$AuCl_3$] [H_2O_2]	3
3(b)(iii)	$k = 1.53 \times 10^{-1} / (0.10 \times 0.50) = 3.06$ $dm^9\ mol^{-2}\ minute^{-1}$	2
3(c)(i)	ΔH_4 = (3 ×) electron affinity of fluorine / F ΔH_6 = (enthalpy change of) formation of AlF_3	2
3(c)(ii)	**M1** $+326 + 1½ \times 158 + 5137 + 3 \times -328 + \Delta H_{latt} = -1504$ **M2** $\Delta H_{latt} = -6220$ (kJ mol^{-1})	2
3(c)(iii)	**M1** lattice energy of ScF_3 should be less exothermic ora **M2** Sc ion / Sc^{3+} larger than Al ion / Al^{3+} **AND** lesser attraction between the ions / ionic bonds are weaker	2
3(d)(i)	$K_{sp} = [Al^{3+}][F^-]^3$	1
3(d)(ii)	$K_{sp} = 6.5 \times 10^{-2} \times (3 \times 6.5 \times 10^{-2})^3 = 4.8 \times 10^{-4}$	1

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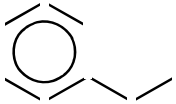
Question	Answer	Marks
4(a)(i)	A = ester B = (2°) amide	**2**
4(a)(ii)	2	**1**
4(b)	 **M1** phenylalanine **M2** protonated amine **M3** (ethanol) CH_3CH_2OH	**3**
4(c)(i)	catalyst / halogen carrier	**1**
4(c)(ii)	**M1** —OH directs to 2,4 **AND** both 2 positions occupied / only position 4 is available **M2** —COOH directs to 3 position **AND** only position 3 is available / 5 is occupied	**2**
4(d)(i)	x = 14.4 / 100 × 100 / 1.1 = 13.1 13 carbon atoms (some working required)	**1**
4(d)(ii)	(250 – 205 = 45, so) CO_2H / C_2H_5O	**1**

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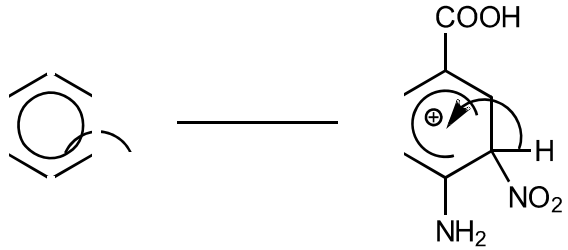
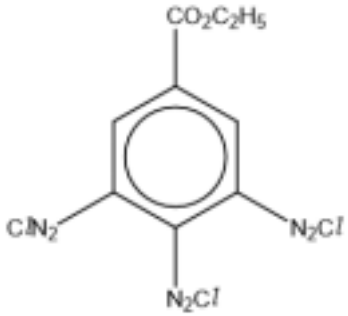
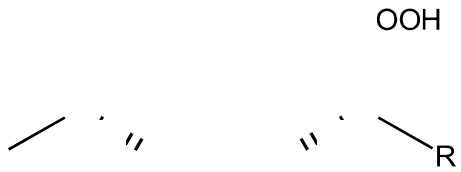
Question	Answer	Marks
5(a)	**M1** COOH is more acidic than phenol **AND** because the O-H bond in acid is weaker **OR** carboxylate ion is more stable **M2** O-H bond weakened / loses proton more easily **AND** by negative inductive effect of C=O / due to electronegative C=O **OR** carboxylate ion / anion is more stable **AND** due to delocalisation of minus charge by C=O / 2O	**2**
5(b)(i)	**M1** a solution which resists changes in pH / controls pH / keeps pH within a small range **M2** when small amounts of H^+ or OH^- are added	**2**
5(b)(ii)	**M1** no. of mol of gallic acid = 2.04 ÷ 170.0 **OR** 0.012(0) mol **M2** $[H^+] = K_a[HA] / [A^-] = 3.89 \times 10^{-5} \times 0.012/0.250 \div 0.0600$ $= 3.89 \times 10^{-5} \times (0.048 \div 0.0600) \quad = 3.112 \times 10^{-5}$ **M3** $pH = -\log_{10} (3.112 \times 10^{-5}) = 4.5(1)$ min 2sf	**3**
5(b)(iii)	**M1** $C_7H_6O_5 + OH^- \rightarrow C_7H_5O_5^- + H_2O$ **OR** $H^+ + OH^- \rightarrow H_2O$ **AND** $C_7H_6O_5 \rightarrow C_7H_5O_5^- + H^+$ **M2** $C_7H_5O_5^- + H^+ \rightarrow C_7H_6O_5$	**2**
5(c)(i)	$HNO_3 + 2H_2SO_4 \rightarrow H_3O^+ + NO_2^+ + 2HSO_4^-$ **OR** $HNO_3 + H_2SO_4 \rightarrow H_2O + NO_2^+ + HSO_4^-$	**1**
5(c)(ii)	 **M1** curly arrow from ring to N of NO_2^+ **M2** correct intermediate **AND** curly arrow from C—H back to ring	**2**

Question	Answer	Marks
5(c)(iii)	electrophilic substitution	1
5(c)(iv)	**M1** Sn and HCl **M2** heat and concentrated (dependent on metal (Fe / Sn) and acid seen for M1)	2
5(c)(v)	 **M1** 1 × diazonium salt with ester group unchanged **M2** 3 × diazonium salt (to match formula)	2
5(c)(vi)	warm / T ⩾ 30 °C **AND** H_2O / named aqueous acid	1
5(d)(i)	5	1
5(d)(ii)	**M1** only one peak **M2** singlet at δ 6.0–9.0 ppm **OR** **M1** singlet(s) only **M2** only one peak at δ 6.0–9.0 ppm	2

Question	Answer	Marks
6(a)(i)	$(CH_3)_2CHCHNH_2COOH + 4[H] \rightarrow (CH_3)_2CHCHNH_2CH_2OH + H_2O$ **OR** $C_5H_{11}NO_2 + 4[H] \rightarrow C_5H_{13}NO + H_2O$	**1**
6(a)(ii)	lithium aluminium hydride / $LiAlH_4$ (in dry ether)	**1**
6(a)(iii)	nucleophilic substitution	**1**
6(b)	 **M1** one peptide link fully displayed (but not contradicted by the other peptide link) **M2** rest of structure correct	**2**
6(c)(i)	**M1** optical isomerism **M2**  	**2**
6(c)(ii)		**1**

Question	Answer	Marks
6(c)(iii)	$K_{stab} = \dfrac{[Ni(H_2O)_2Val_2]}{[Ni(H_2O)_6^{2+}][Val^-]^2}$	**1**
6(c)(iv)	equilibrium lies (well) to the right / towards the products **AND** (Z) is stable / more stable (than $[Ni(H_2O)_6]^{2+}$ in the presence of Val^-)	**1**
6(c)(v)	bidentate	**1**