Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/41**

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

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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

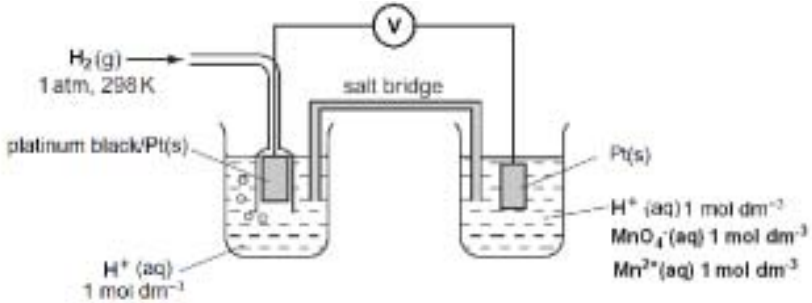
Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

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)	<table><tr><td>the order of reaction with respect to [NO]</td><td>2</td></tr><tr><td>the order of reaction with respect to [O2]</td><td>1</td></tr><tr><td>the overall order of reaction</td><td>3</td></tr></table> **ALL CORRECT** [1]	**1**
1(b)(i)	$k = (1.51 \times 10^{-4}) / (0.003^2 \times 0.00200)$ k = **8389** [1] min 2sf $mol^{-2}\ dm^6\ s^{-1}$ [1]	**2**
1(b)(ii)	$8400 = (6.05 \times 10^{-5}) / (x^2 \times 0.005)$ $x = \sqrt{(6.05 \times 10^{-5}) / (8400 \times 0.005)}$ x = **0.00120** / **1.20** $\times$ **10^{-3}** [1] min 2sf ecf from Q1bi	**1**
1(c)	slow(est) [1]	**1**
1(d)(i)	**correct RDS identified** as step 1 with **only one $S_2O_8^{2-}$** and **one I^-** [1] overall mechanism adds up to chemical equation and no cancellable species on LHS / RHS in each of the equations [1] **M2 DEP** on one $S_2O_8^{2-}$ and one I^- in step 1 e.g. step 1 $S_2O_8^{2-} + I^- \rightarrow SO_4^{2-} + SO_4I^-$ RDS = step 1 step 2 $SO_4I^- + I^- \rightarrow SO_4^{2-} + I_2$	**2**
1(d)(ii)	no. of $t_{1/2}$ = 192 / 48 = 4 $[I^-]$ = 0.0078 / 16 = **4.9×10^{-4}** [1] min 2sf	**1**

Question	Answer	Marks
2(a)(i)	**M1** energy released when 1 mole of an ionic compound is formed [1] **M2** from gaseous ions (under standard conditions) [1]	**2**
2(a)(ii)	Ca^{2+} & O^{2-} have a higher charge / charge density (than Li^+ and F^-) [1]	**1**
2(a)(iii)	MgO –3600 or more negative **AND** BaO –3200 or less negative **BOTH** [1]	**1**
2(b)(i)	$BaO(s) + H_2O(l) \rightarrow Ba(OH)_2(aq)$ [1]	**1**
2(b)(ii)	**M1** (solubility) increases (down the group) [1] **M2** both ΔH_{latt} and ΔH_{hyd} become less exothermic / less negative [1] **M3** ΔH_{latt} changes more / is dominant factor [1] **M4** ΔH_{sol} becomes more negative / more exothermic [1]	**4**
2(c)	**M1:** Use of $2 \times$ –348 (EA F) and +158 (bond energy of F_2) [1] **M2:** Use of +147 (at Mg) and +736 and +1450 (IEs of Mg) [1] **M3:** evaluation and calculation of their answer (–1102 – (147 + 158 + 736 + 1450 – 696)) = **–2897** ($kJ\ mol^{-1}$) [1] ecf	**3**
2(d)(i)	• (energy change) when an / one electron is added to • each atom / ion in one mole of • gaseous atoms / ions mark as • ✓ ✓ [2]	**2**
2(d)(ii)	F has greater nuclear charge / more protons **AND** greater attraction between F atom / nucleus and the electrons • ✓ **BOTH** [1]	**1**

Question	Answer	Marks
3(a)	(anode =) oxygen / O_2 **AND** (cathode =) hydrogen/H_2 **BOTH** [1]	**1**
3(b)	**M1:** Q = $1.5 \times 60 \times 60 \times 4.5$ = 24300 (C) [1] **M2:** no. of F / moles of e^- = 24300 / 96500 = 0.25(1813) [1] ecf **M3:** volume of Cl_2 = $24 \times 0.252 / 2$ = **3.02** dm^3 [1] ecf min 2sf **M4:** mass of Na = 0.252×23 = **5.79** (5.7917) g Na [1] ecf min 2sf	**4**
3(c)(i)	 • MnO_4^-, H^+, Mn^{2+} in same beaker **AND** H^+ in other beaker • both electrodes Pt(s) (**ALLOW** graphite) • one solute clearly identified as 1M / 1 mol dm^{-3} • 298 K **OR** 1 atm • voltmeter / potentiometer labelled (or circled V) • salt bridge labelled (must touch the solution) • a good delivery system for H_2(g) • H_2(g) mark as two correct points = 1 mark [4]	**4**

Question	Answer	Marks
3(c)(ii)	F_2 **OR** $S_2O_8^{2-}$ **OR** H_2O_2 **OR** $HOCl$ **OR** Co^{3+} **OR** Pb^{4+} [1] $2Mn^{2+} + 8H_2O + 5F_2 \rightarrow 2MnO_4^- + 16H^+ + 10F^-$[1] **OR** $2Mn^{2+} + 5S_2O_8^{2-} + 8H_2O \rightarrow 2MnO_4^- + 16H^+ + 10SO_4^{2-}$ **OR** $Mn^{2+} + 4H_2O + 5Co^{3+} \rightarrow MnO_4^- + 8H^+ + 5Co^{2+}$ **OR** $2Mn^{2+} + 8H_2O + 5Pb^{4+} \rightarrow 2MnO_4^- + 16H^+ + 5Pb^{2+}$ **OR** $2Mn^{2+} + 5H_2O_2 \rightarrow 2MnO_4^- + 6H^+ + 2H_2O$ **OR** $2Mn^{2+} + 10HOCl \rightarrow 2MnO_4^- + 6H^+ + 5Cl_2 + 2H_2O$	**2**

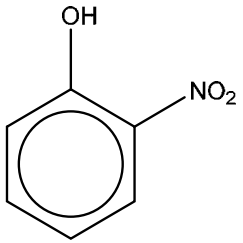
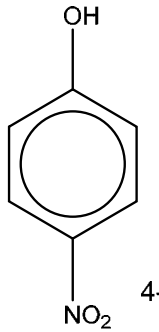
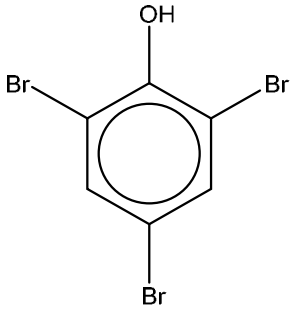
Question	Answer	Marks
4(a)(i)	(pH =) $-\log[H^+]$ OR $-\lg[H^+]$ [1] (K_w =) $[H^+][OH^-]$ [1]	**2**
4(a)(ii)	$[H^+] = 1 \times 10^{-14} / 0.027 = 3.7037 \times 10^{-13}$ pH = $-\log(3.7037 \times 10^{-13})$= **12.4** [1] min 3sf	**1**
4(b)	$[H^+] = \sqrt{3.72 \times 10^{-8} \times 0.010} = 1.9287 \times 10^{-5}$ pH = $-\log(1.9287 \times 10^{-5})$= **4.7** [1] min 2sf	**1**
4(c)(i)	K_{pc} = (0.935 / 50) / (0.065 / 50) K_{pc} = **14.4** (14.38) [1] min 3sf	**1**
4(c)(ii)	**M1:** 14.4 = ((0.935 – x) / 50) / (x / 100) [1] ecf from **4(c)(i)** **M2:** x = **0.114** g [1] min 2sf ecf from M1	**2**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>5(a)(i)</td><td>Kstab = $[(Cu(NH_3)_4)^{2+}] / [(Cu(H_2O)_6)^{2+}] [NH_3]^4$ [1]</td><td>1</td></tr>
<tr><td>5(a)(ii)</td><td>deep / dark / royal blue [1]</td><td>1</td></tr>
<tr><td>5(b)</td><td>$[Cu(NH_3)_4]^{2+} + 2H_2O \rightarrow Cu(OH)_2 + 2NH_4^+ + 2NH_3$ [1]
OR $[Cu(NH_3)_4]^{2+} + 2H_2O \rightarrow Cu(OH)_2 + 2H^+ + 4NH_3$</td><td>1</td></tr>
<tr><td>5(c)</td><td>$Cu(OH)_2 + 4HCl \rightarrow [CuCl_4]^{2-} + 2H_2O + 2H^+$
OR $Cu(OH)_2 + 4Cl^- + 2H^+ \rightarrow [CuCl_4]^{2-} + 2H_2O$

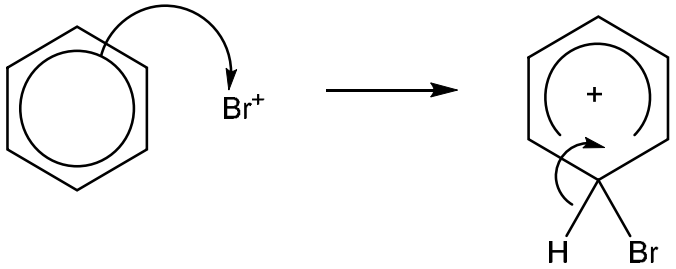
$[CuCl_4]^{2-}$ complex including charge [1]
rest of equation fully correct [1]</td><td>2</td></tr>
<tr><td>5(d)</td><td><table><tr><td></td><td>Y</td><td>Z</td></tr><tr><td>colour of complex</td><td>yellow</td><td>blue / pale blue</td></tr><tr><td>geometry of complex</td><td>tetrahedral</td><td>octahedral</td></tr><tr><td>formula of complex</td><td></td><td>$[Cu(H_2O)_6]^{2+}$</td></tr></table>
one mark for any <u>three</u> cells [1] • • ✓
two marks for all five cells [2] • • ✓ • ✓</td><td>2</td></tr>
<tr><td>5(e)</td><td>M1: d orbitals splits into two sets of energy levels of different energy [1]
M2: wavelength / frequency / light / photon / hν absorbed [1]
M3: electron(s) promoted / excited [1]
M4: colour seen is complementary (to colour absorbed) [1]
M5: d–d energy gap / ΔE is different for Y and Z
AND so different frequency / wavelength of light <u>absorbed</u> • ✓ [1]</td><td>5</td></tr>
</table>

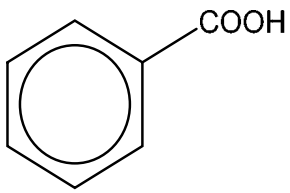
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Question	Answer	Marks
6(a)(i)	(a species) that donates <u>one</u> lone pair [1] to form a dative / coordinate to a central metal atom / metal ion [1]	**2**
6(a)(ii)	$[Ag(S_2O_3)_2]^{3-}$ [1]	**1**
6(b)(i)	$[Ag(S_2O_3)_2]^{3-} + 2CN^- \rightarrow [Ag(CN)_2]^- + 2S_2O_3^{2-}$ [1] **OR** $Ag(S_2O_3)_2]^{3-} + 2NaCN \rightarrow [Ag(CN)_2]^- + Na_2S_2O_3 + S_2O_3^{2-}$	**1**
6(b)(ii)	**Q** is more stable / has a larger K_{stab} than **P** [1]	**1**
6(b)(iii)	**ligand** exchange / displacement / substitution	**1**
6(c)(i)	 both correct [1]	**1**
6(c)(ii)	**square planar** [1]	**1**
6(c)(iii)	cis-trans **OR** geometric(al) [1]	**1**

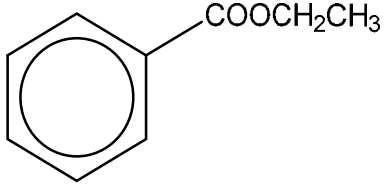
Question	Answer	Marks
7(a)	**M1:** HNO_2 **OR** $NaNO_2$ + HCl [1] **M2:** T ⩾ 10 °C / warm **AND** water [1]	**2**
7(b)	 2-nitrophenol  4-nitrophenol 2 × [1]	**2**
7(c)(i)	 2,4,6-tribromophenol ✓ ✓ [2]	**2**
7(c)(ii)	bromine is decolourised **AND** white precipitate is formed **BOTH** [1]	**1**
7(d)	$C_6H_5OH + NaOH \rightarrow C_6H_5ONa + H_2O$ [1] **ALLOW** any equation for phenol acting as an acid	**1**

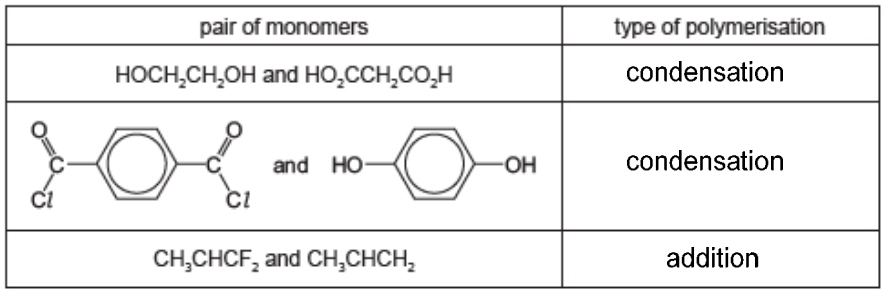
Question	Answer	Marks
7(e)	phenol>water>ethanol [1] • (phenol:) lone pair on oxygen is delocalised into the benzene ring • (ethanol:) positive inductive effect / electron donating effect of alkyl / ethyl group • correct statement about stabilisation of anion/ conjugate base **OR** weakening of O-H bonds once *in the context of phenol / ethanol* • correct statement about ease of proton/H^+ donation *in the context of phenol / ethanol* [2] Two correct statements = 1 mark	**3**

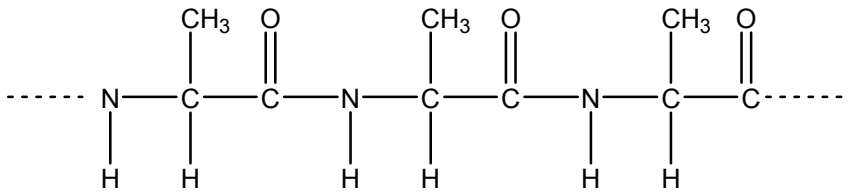
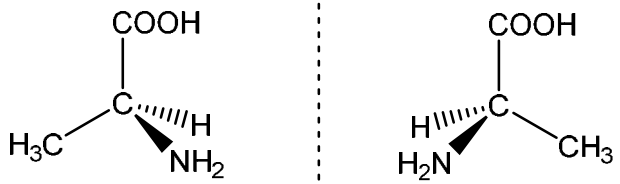
Question	Answer	Marks
8(a)(i)	HBr / hydrogen bromide [1]	**1**
8(a)(ii)	 **M1** curly arrow to Br^+ **AND** curly arrow from C–H bond as shown [1] **M2** correct intermediate [1]	**2**
8(a)(iii)	**electrophilic substitution** [1]	**1**
8(b)(i)	reagent: chloroethane / bromoethane / iodoethane **OR** formula [1] catalyst: $FeCl_3$ / $AlCl_3$ etc. [1]	**2**

Question	Answer	Marks
8(b)(ii)	 [1] **ALLOW** C_6H_5COONa	**1**
8(b)(iii)	step 3 = $LiAlH_4$ [1] step 4 = Pt **AND** H_2 [1]	**2**
8(b)(iv)	5 / five [1]	**1**

Question	Answer	Marks
9(a)	(because $CDCl_3$ / it) does not give a peak [1] **OR** because $CHCl_3$ does give a peak	**1**
9(b)	as a **standard / reference** for (chemical shift measurements) [1]	**1**
9(c)	ester [1]	**1**
9(d)(i)	• (δ = 1.4) triple**t** • (δ = 1.4) two H on neighbouring C atom • (δ = 4.3) quarte**t** / quadruple**t** • (δ = 4.3) three H on neighbouring C atom mark as • ✓ • ✓ [2]	**2**
9(d)(ii)	aryl group / arene / phenyl [1]	**1**

Question	Answer	Marks
9(d)(iii)	 **OR** $C_6H_5CO_2C_2H_5$ [1]	**1**
9(e)	$CH_3CH_2^+$ / $C_2H_5^+$ [1] $C_6H_5^+$ [1]	**2**

Question	Answer	Marks
10(a)	 **ALL** correct [1]	**1**

Question	Answer	Marks
10(b)(i)	 • amide links displayed correct (NHCO **OR** CONH) • three monomers of Ala only • one repeat unit correctly identified • continuation bonds (with a polypeptide involving Ala only) mark as • ✓ ✓ ✓ [3]	**3**
10(b)(ii)	 3D, tetrahedral, both isomers of 2-aminopropanoic acid [1] optical [1]	**2**
10(c)(i)	**epoxy resin** [1] **ALLOW** Super Glues	**1**
10(c)(ii)	compound with two amine groups per molecule, amine groups must not be on the same carbon atom [1] e.g. $H_2NCH_2CH_2NH_2$	**1**