Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/41**

Paper 4 A Level Structured Questions **May/June 2020**

MARK SCHEME

Maximum Mark: 100

Published

Students did not sit exam papers in the June 2020 series due to the Covid-19 global pandemic.

This mark scheme is published to support teachers and students and should be read together with the question paper. It shows the requirements of the exam. The answer column of the mark scheme shows the proposed basis on which Examiners would award marks for this exam. Where appropriate, this column also provides the most likely acceptable alternative responses expected from students. Examiners usually review the mark scheme after they have seen student responses and update the mark scheme if appropriate. In the June series, Examiners were unable to consider the acceptability of alternative responses, as there were no student responses to consider.

Mark schemes should usually be read together with the Principal Examiner Report for Teachers. However, because students did not sit exam papers, there is no Principal Examiner Report for Teachers for the June 2020 series.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the June 2020 series for most Cambridge IGCSE™ and Cambridge International A & 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.

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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 (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.

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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.

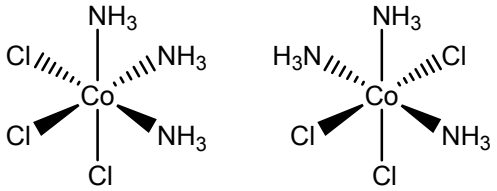
Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

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)(i)	(a molecule or ion) formed by a (central) metal atom / ion surrounded by / bonded to (one or more) ligands	**1**
1(a)(ii)	M1: blue ppt/solid M2: $[Co(H_2O)_6]^{2+} + 2OH^- \rightarrow Co(OH)_2 + 6H_2O$ **OR** $[Co(H_2O)_6]^{2+} + 2OH^- \rightarrow [Co(H_2O)_4(OH)_2] + 2H_2O$ M3: precipitation/ acid-base M4: blue solution M5: $[Co(H_2O)_6]^{2+} + 6NH_3 \rightarrow [Co(NH_3)_6]^{2+} + 6H_2O$ M6: **ligand** exchange/displacement/substitution/replacement	**6**
1(b)	• solution turns blue → pink • a white ppt. of AgC*l* forms • equilibrium shifts to the left / $[Cl^-]$ decreases Two correct responses = 1 mark Three correct responses = 2 marks	**2**
1(c)	 geometric **ALLOW** cis-trans Two correct responses = 1 mark Three correct responses = 2 marks	**2**
1(d)(i)	**each nitrogen** / the four nitrogen's has a **lone pair of electrons** (to the metal ion) Two correct responses = 1 mark	**1**

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Question	Answer	Marks
1(d)(ii)	$[Co(H_2O)_6]^{2+} + C_6H_{18}N_4 \rightarrow [Co(C_6H_{18}N_4)]^{2+} + 6H_2O$ **OR** $[Co(H_2O)_6]^{2+} + C_6H_{18}N_4 \rightarrow [Co(C_6H_{18}N_4)(H_2O)_2]^{2+} + 4H_2O$	**1**

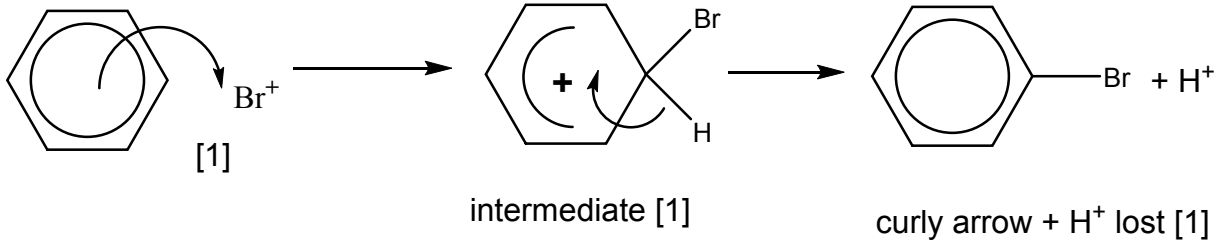
Question	Answer	Marks
2(a)(i)	**M1** solubility increases down the group **M2** ΔH_{latt} and ΔH_{hyd} both become less exothermic / less negative **M3** ΔH_{latt} changes **more** (than ΔH_{hyd} as OH^- being smaller than M^{2+}) **M4** ΔH_{sol} becomes more exothermic / more negative	**4**
2(a)(ii)	**M1** $Mg(OH)_2$ **AND** Mg^{2+} has a smaller ionic radii/ Mg^{2+} has a higher charge density **M2** OH^- ion is polarised/distorted more	**2**

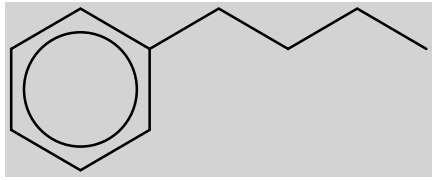
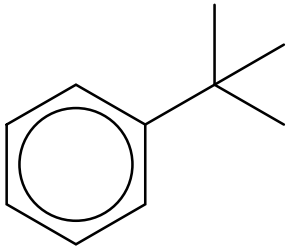
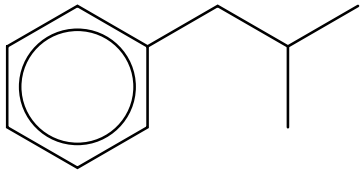
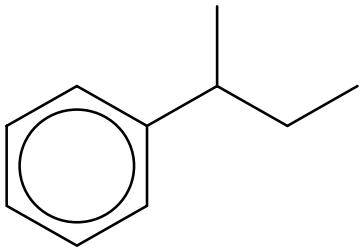
Question	Answer	Marks
3(a)(i)	$6CO_2 + 24H^+ + 24e^- \rightarrow C_6H_{12}O_6 + 6H_2O$ **ALLOW** $6CO_2 + 12H^+ + 12e^- \rightarrow C_6H_{12}O_6 + 3O_2$ for both marks **ALLOW** one mark for an unbalanced equation showing the correct species of either equation	**2**

Question	Answer	Marks
3(a)(ii)	salt bridge (indicated) voltmeter / V labelled O_2 good delivery system H_2 good delivery system Pt electrode H^+ / HCl / H_2SO_4 solution labelled (at least once) 1 atm 1 mol dm^{-3} quoted Every two correct responses = 1 mark	**4**
3(a)(iii)	$E^{\ominus}_{cell}$ = (+) 1.23 V **AND** positive electrode = O_2 half-cell identified	**1**

Question	Answer	Marks
4(a)	**M1** phenylmethanamine / **U** > phenylamine / **T** > benzamide / **S** [1] any two from: • alkyl group is electron donating so lone pair more able to accept a proton • lone pair on N overlaps with delocalised system so less able to accept a proton • presence of electron-withdrawing oxygen / carbonyl group means lone pair is not available to accept a proton **OR** amides are neutral	**3**
4(b)(i)	reaction 1 $LiAlH_4$ reaction 2 heat NH_3 under pressure/ heat NH_3 in a sealed tube	**2**
4(b)(ii)	reaction 1 reduction reaction 2 nucleophilic substitution	**2**

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Question	Answer	Marks
5(a)(i)	The substitution product is stabilised by delocalisation of (6)π-electrons **OR** The addition product is not stabilised by delocalisation of (6)π-electrons [1]	**1**
5(a)(ii)	 [1] intermediate [1] curly arrow + H^+ lost [1] • first curly arrow • intermediate • 2nd curly arrow, product **and** H^+ formed / lost	**3**
5(a)(iii)	$AlBr_4^- + H^+ \rightarrow AlBr_3 + HBr$	**1**
5(b)	lone pair of oxygen is delocalised into the ring <u>any one from:</u> • phenol has a higher electron density in the ring • phenol can polarise/induce a dipole in Br_2	**2**
5(c)(i)	$CH_3CH_2CH^+CH_3$ $(CH_3)_2CHCH_2^+$ $(CH_3)_3C^+$ Each correct structure = 1 mark	**3**

Question	Answer	Marks
5(c)(ii)	 number of peaks in carbon-13 NMR = 8  number of peaks in carbon-13 NMR = 6  number of peaks in carbon-13 NMR = 7  number of peaks in carbon-13 NMR = 8 Two correct organic products = 1 mark three correct organic products = 2 marks all products linked correctly to NMR = 2 marks	**4**

Question	Answer	Marks
6(a)	**M1** 2-chloropropanoic acid > 3-chloropropanoic acid > propanoic acid [1] **M2** $CH_3CHCl CO_2H$ / $ClCH_2CH_2CO_2H$ (are more acidic) as they contain an electronegative C*l* atom so weaken O-H bond / stabilise carboxylate anion [1] **M3** $CH_3CHCl CO_2H$ (is more acidic than $ClCH_2CH_2CO_2H$) as the C*l* atom is closer to CO_2H so weaken O-H bond more / stabilise carboxylate anion more [1]	**3**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>6(b)(i)</td><td>K_{eq} = 4.07x10^{-3}/1.78x10^{-4} = 22.9</td><td>1</td></tr>
<tr><td>6(b)(ii)</td><td>3rd box ticked [to the right] AND as the K_{eq} is greater than one ecf on K_{eq}</td><td>1</td></tr>
<tr><td>6(b)(iii)</td><td>pK_a 1.23 $HO_2CCO_2H + H_2O \rightleftharpoons HO_2CCO_2^- + H_3O^+$
OR $HO_2CCO_2H \rightleftharpoons HO_2CCO_2^- + H^+$

pK_a 4.19 $HO_2CCO_2^- + H_2O \rightleftharpoons {}^-O_2CCO_2^- + H_3O^+$
OR $HO_2CCO_2^- \rightleftharpoons {}^-O_2CCO_2^- + H^+$</td><td>2</td></tr>
<tr><td>6(b)(iv)</td><td>pK_a = – logK_a</td><td>1</td></tr>
<tr><td>6(c)</td><td>
<table>
<tr><th></th><th>reagents and conditions</th><th>observed change</th></tr>
<tr><td>test 1</td><td>M1 Tollen’s reagent, warm
OR
Fehling’s solution, warm</td><td>silver mirror

(brick)-red ppt.</td></tr>
<tr><td>test 2</td><td>M2 aqueous alkaline iodine
OR
2,4-DNPH</td><td>yellow ppt.

orange ppt.</td></tr>
<tr><td>test 3</td><td>M3 acidified MnO_4^- , warm</td><td>decolourises (and bubbles)</td></tr>
</table>
Two correct observations = 1 mark
Three correct observations = 2 marks
</td><td>5</td></tr>
</table>

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>6(d)</td><td>
<table>
<tr><td>chemical shift (δ)</td><td>environment of the carbon atom</td><td>hybridisation of the carbon atom</td></tr>
<tr><td>27</td><td>**C**H_3 circled</td><td>sp^3</td></tr>
<tr><td>163</td><td>**C**OOH circled</td><td>sp^2</td></tr>
<tr><td>192</td><td>**C**=O(COOH) circled</td><td>sp^2</td></tr>
</table>
Award one mark for each correct column</td><td>**2**</td></tr>
<tr><td>6(e)</td><td>
<table>
<tr><td>chemical shift (δ)</td><td>group responsible for the peak</td><td>splitting pattern</td><td>number of ^1H atoms responsible for the peak</td></tr>
<tr><td>1.3</td><td>alkane / CH / CH_3</td><td>triplet</td><td>3</td></tr>
<tr><td>2.2</td><td>CH_3CO **or** alkyl / CH next to C=O</td><td>singlet</td><td>3</td></tr>
<tr><td>4.0</td><td>CH_2O **or** alkyl / CH next to electronegative atom / C=O</td><td>quartet / quadruplet</td><td>2</td></tr>
</table>
Award one mark for every three correct responses.</td><td>**3**</td></tr>
<tr><td>6(f)</td><td>CH **AND** CH_3 **circled**
these protons do not exchange with D_2O
OR OH and NH protons exchange with D_2O</td><td>**2**</td></tr>
<tr><td>6(g)(i)</td><td>K_w = $[D^+][DO^-]$</td><td>**1**</td></tr>
<tr><td>6(g)(ii)</td><td>**M1** $[D^+] = \sqrt{1.35 \times 10^{-15}} = 3.67 \times 10^{-8}$
M2 pH = -log $[D^+]$ = **7.4**(3) min 2sf</td><td>**2**</td></tr>
</table>

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Question	Answer	Marks
7(a)(i)	**M1** $K_{sp} = [Ag^+]^2[CO_3^{2-}]$ **M2** units = $mol^3\ dm^{-9}$	**2**
7(a)(ii)	$x = \sqrt[3]{6.3 \times 10^{-12}/4} = 1.16 \times 10^{-4}$ (mol dm^{-3}) $[Ag^+] = 1.16 \times 10^{-4} \times 2 =$ **2.33×10^{-4}** (mol dm^{-3}) min 2sf	**1**
7(a)(iii)	$6.3 \times 10^{-12} = [0.05]^2[CO_3^{2-}]$ $[CO_3^{2-}] =$ **2.52×10^{-9}** (mol dm^{-3}) min 2sf	**1**
7(a)(iv)	**M1** $E = E^\ominus + 0.059\log[Ag^+]$ **M2** $E = 0.80 + 0.059\log(1.2 \times 10^{-4}) =$ **0.57** V ecf from **(a)(ii)** min 2sf	**2**
7(b)(i)	$\Delta S^\ominus = 72.7 + 56.5 - 96.2 =$ **+33.0** J K^{-1} mol^{-1}	**1**
7(b)(ii)	**M1** $\Delta G = \Delta H^\ominus - T\Delta S^\ominus$ **M2** $\Delta G = (65.5) - (298 \times 0.033) =$ **+55.7** kJ mol^{-1} min 3sf **M3** ΔG = positive so not feasible/spontaneous	**3**

Question	Answer	Marks
8(a)	**M1** a solution that resists changes in pH **M2** when small amounts of acid and alkali are added to it	**2**
8(b)(i)	$K_a = \dfrac{[NH_3][H^+]}{[NH_4^+]}$	**1**
8(b)(ii)	**M1** $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ **M2** $NH_3 + H_3O^+ \rightarrow NH_4^+ + H_2O$	**2**

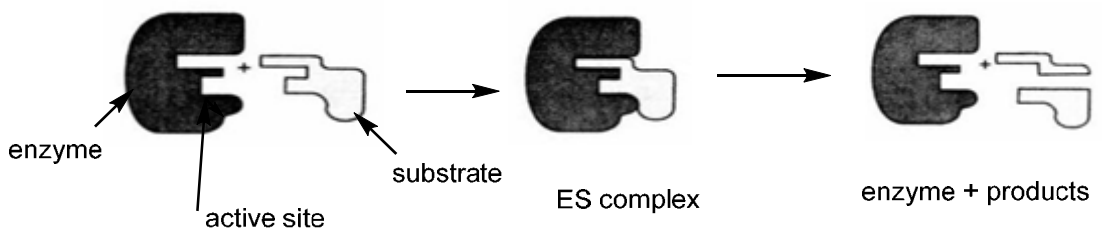
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Question	Answer	Marks
8(b)(iii)	**M1** moles NH_3(initial) = 0.25 x 0.80 = 0.200 **AND** moles HCl = 0.20 x 0.20 = 0.040 (= moles $NH_4^+{}_{eqm}$) **M2** moles $NH_{3(eqm)}$ = 0.20 – 0.04 = 0.160 $[H^+]$ = (5.6 x10^{-10} x 0.04)/(0.16) = 1.4 x 10^{-10} (mol dm^{-3}) ecf on M1 **M3** pH = -log(1.4 x 10^{-10}) = **9.85** ecf on M2 min 2sf	**3**

Question	Answer	Marks
9(a)	**M1** data seen H_2O_2/H_2O +1.77V and MnO_2/Mn^{2+} +1.23 V and O_2/H_2O_2 +0.68 V **OR** E_{cell}= 0.55 V (first step) **and** 0.54 V (second step) **M2** $MnO_2 + H_2O_2 + 2H^+ \rightarrow Mn^{2+} + O_2 + 2H_2O$ **M3** $Mn^{2+} + H_2O_2 \rightarrow MnO_2 + 2H^+$	**3**
9(b)	rate = 2.0 x 10^{-6} x 0.75 = **1.5 x 10^{-6}**	**1**
9(c)(i)	slowest step in overall reaction	**1**
9(c)(ii)	$H_2O_2 + 2H^+ + 2I^- \rightarrow I_2 + 2H_2O$ **OR** $H_2O_2 + 2HI \rightarrow I_2 + 2H_2O$	**1**
9(c)(iii)	H_2O_2 = 1 **AND** I^- = 1 **AND** H^+ = 0	**1**

Question	Answer	Marks
10(a)	+4 **and** any of +1, +2, +3	**1**
10(b)	close similarity of energy of the 4s and 3d sub-shells	**1**

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Question	Answer	Marks
10(c)	diagrams  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 M4 (words) lower E_A / bonds weakened (in substrate) Any three points	**3**

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