# Cambridge International AS & A Level

**CHEMISTRY** **9701/43**

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.

This document consists of **15** printed pages.

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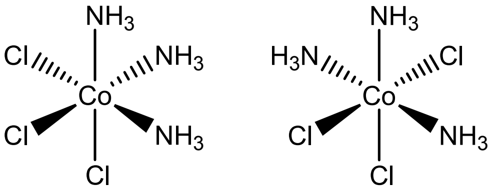
| Question | Answer | Marks |
|---|---|---|
| 1(a)(i) | (a molecule or ion) formed by a (central) metal atom / ion surrounded by / bonded to (one or more) ligands | **1** |
| 1(a)(ii) | M1: blue ppt/solid<br>M2: $[Co(H_2O)_6]^{2+} + 2OH^- \rightarrow Co(OH)_2 + 6H_2O$<br>**OR** $[Co(H_2O)_6]^{2+} + 2OH^-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

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

| Question | Answer | Marks |
|---|---|---|
| 2(a)(i) | **M1** solubility increases down the group<br>**M2** $\Delta H_{latt}$ and $\Delta H_{hyd}$ both become less exothermic / less negative<br>**M3** $\Delta H_{latt}$ changes **more** (than $\Delta H_{hyd}$ as $OH^–$ being smaller than $M^{2+}$)<br>**M4** $\Delta H_{sol}$ 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<br>**M2** $OH^-$ ion is polarised/distorted more | **2** |

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

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| **Question** | **Answer** | **Marks** |
|---|---|---|
| 3(a)(ii) | salt bridge (indicated)   voltmeter / V labelled<br>$O_2$ good delivery system   $H_2$ good delivery system<br>Pt electrode   $H^+$ / HCl / $H_2SO_4$ solution labelled (at least once)<br>1 atm   1 mol dm$^{-3}$ quoted<br>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]<br>any two from:<br>• alkyl group is electron donating so lone pair more able to accept a proton<br>• lone pair on N overlaps with delocalised system so less able to accept a proton<br>• 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   $LiAlH_4$<br>reaction 2   heat $NH_3$ under pressure/ heat $NH_3$ in a sealed tube | **2** |
| 4(b)(ii) | reaction 1   reduction<br>reaction 2   nucleophilic substitution | **2** |

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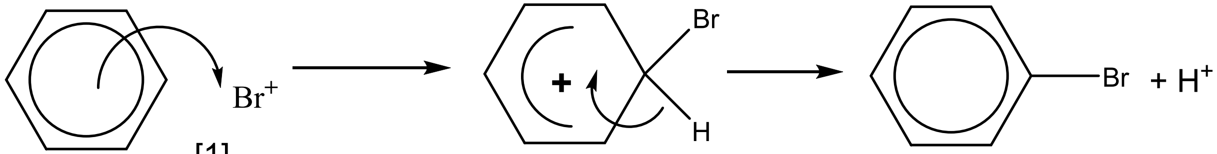
| Question | Answer | Marks |
|---|---|---|
| 5(a)(i) | The substitution product is stabilised by delocalisation of (6)$\pi$-electrons<br>**OR**<br>The addition product is not stabilised by delocalisation of (6)$\pi$-electrons [1] | 1 |
| 5(a)(ii) |  <br>[1]<br>intermediate [1]<br>curly arrow + $H^+$ lost [1]<br>- first curly arrow<br>- intermediate<br>- 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<br><br>any one from:<br>- phenol has a higher electron density in the ring<br>- 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 |

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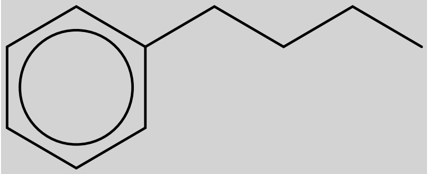
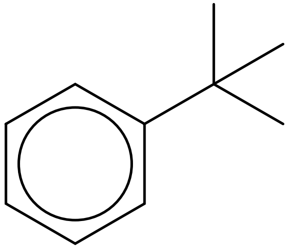
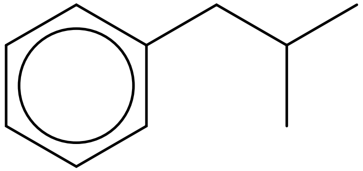
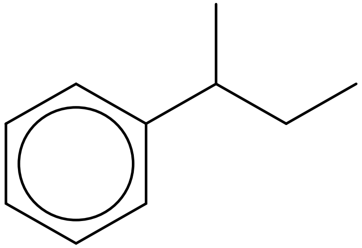
| Question | Answer | Marks |
|---|---|---|
| 5(c)(ii) | <br>number of peaks in carbon-13 NMR = 8<br><br>number of peaks in carbon-13 NMR = 6<br><br>number of peaks in carbon-13 NMR = 7<br><br>number of peaks in carbon-13 NMR = 8<br>Two correct organic products = 1 mark<br>three correct organic products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

| Question | Answer | Marks |
|---|---|---|
| 6(a) | **M1** 2-chloropropanoic acid > 3-chloropropanoic acid > propanoic acid [1]<br>**M2** $CH_3CHClCO_2H$ / $ClCH_2CH_2CO_2H$ (are more acidic) as they contain an electronegative Cl atom so weaken O-H bond / stabilise carboxylate anion [1]<br>**M3** $CH_3CHClCO_2H$ (is more acidic than $ClCH_2CH_2CO_2H$) as the Cl atom is closer to $CO_2H$ so weaken O-H bond more / stabilise carboxylate anion more [1] | **3** |

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| Question | Answer | Marks |
|---|---|---|
| 6(b)(i) | $K_{eq} = 4.07\text{x}10^{-3}/1.78\text{x}10^{-4} =$ **22.9** | 1 |
| 6(b)(ii) | 3rd box ticked [to the right] **AND** as the $K_{eq}$ is greater than one ecf on $K_{eq}$ | 1 |
| 6(b)(iii) | p$K_a$ 1.23 $HO_2CCO_2H + H_2O \rightleftharpoons HO_2CCO_2^- + H_3O^+$<br>**OR** $HO_2CCO_2H \rightleftharpoons HO_2CCO_2^- + H^+$<br>p$K_a$ 4.19 $HO_2CCO_2^- + H_2O \rightleftharpoons {}^-O_2CCO_2^- + H_3O^+$<br>**OR** $HO_2CCO_2^- \rightleftharpoons {}^-O_2CCO_2^- + H^+$ | 2 |
| 6(b)(iv) | p$K_a$ = – log$K_a$ | 1 |
| 6(c) | see table below<br>Two correct observations = 1 mark<br>Three correct observations = 2 marks | 5 |

6(c)

| | reagents and conditions | observed change |
|---|---|---|
| test 1 | **M1** Tollen's reagent, warm<br>**OR**<br>Fehling's solution, warm | silver mirror<br>(brick)-red ppt. |
| test 2 | **M2** aqueous alkaline iodine<br>**OR**<br>2,4-DNPH | yellow ppt.<br>orange ppt. |
| test 3 | **M3** acidified $MnO_4^-$ , warm | decolourises (and bubbles) |

Two correct observations = 1 mark
Three correct observations = 2 marks

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

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

| Question | Answer | Marks |
|---|---|---|
| 8(a) | **M1** a solution that resists changes in pH<br>**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** $NH_4^+ + OH- \rightarrow NH_3 + H_2O$<br>**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**<br>moles HC$l$ = 0.20 x 0.20 = 0.040 (= moles $NH_4^+{}_{eqm}$)<br><br>**M2** moles $NH_{3(eqm)}$ = 0.20 – 0.04 = 0.160<br>$[H^+]$ = (5.6 x$10^{-10}$ x 0.04)/(0.16) = 1.4 x $10^{-10}$ (mol $dm^{-3}$) ecf on M1<br><br>**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<br>**OR** $E_{cell}$= 0.55 V (first step) **and** 0.54 V (second step)<br><br>**M2** $MnO_2 + H_2O_2 + 2H^+ \rightarrow Mn^{2+} + O_2 + 2H_2O$<br><br>**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) | $H_2O_2 + 2H^+ + 2I^- \rightarrow I_2 + 2H_2O$<br><br>**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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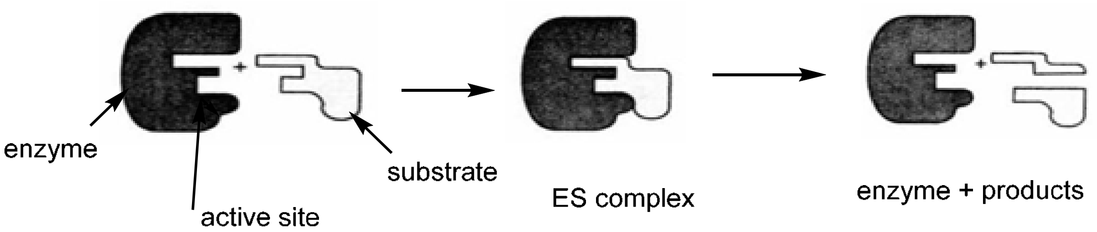
| Question | Answer | Marks |
|---|---|---|
| 10(c) | diagrams<br><br> <br>M1 (can be in words or diagram) substrate shape is complementary to active site<br>M2 (can be in words or diagram) the substrate bind / bonds / fits into the active site<br>M3 (can be in words or diagram) products are released<br>M4 (words) lower $E_A$ / bonds weakened (in substrate) Any three points | **3** |