



## Cambridge International AS & A Level

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CHEMISTRY

9701/41

Paper 4 A Level Structured Questions

May/June 2020

MARK SCHEME

Maximum Mark: 100

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

**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 | <p><u>'List rule' guidance</u> (see examples below)</p> <p>For questions that require <i>n</i> responses (e.g. State <b>two</b> reasons ...):</p> <ul style="list-style-type: none"><li>• The response should be read as continuous prose, even when numbered answer spaces are provided</li><li>• Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i></li><li>• Incorrect responses should not be awarded credit but will still count towards <i>n</i></li><li>• Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should <b>not</b> 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</li><li>• Non-contradictory responses after the first <i>n</i> responses may be ignored even if they include incorrect science.</li></ul> |

**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.

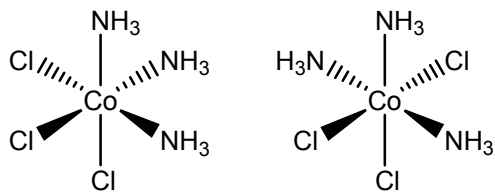
For answers given in standard form, (e.g.  $a \times 10^n$ ) in which the convention of restricting the value of the coefficient ( $a$ ) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

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.

| 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: $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 2\text{OH}^- \rightarrow \text{Co}(\text{OH})_2 + 6\text{H}_2\text{O}$<br><b>OR</b> $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 2\text{OH}^- \rightarrow [\text{Co}(\text{H}_2\text{O})_4(\text{OH})_2] + 2\text{H}_2\text{O}$<br>M3: precipitation/ acid-base<br>M4: blue solution<br>M5: $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 6\text{NH}_3 \rightarrow [\text{Co}(\text{NH}_3)_6]^{2+} + 6\text{H}_2\text{O}$<br>M6: <b>ligand</b> exchange/displacement/substitution/replacement | 6     |
| 1(b)     | <ul style="list-style-type: none"> <li>• solution turns blue → pink</li> <li>• a white ppt. of <math>\text{AgCl}</math> forms</li> <li>• equilibrium shifts to the left / <math>[\text{Cl}^-]</math> decreases</li> </ul> Two correct responses = 1 mark Three correct responses = 2 marks   | 2     |
| 1(c)     |  <p>geometric <b>ALLOW</b> cis-trans<br/>           Two correct responses = 1 mark Three correct responses = 2 marks</p>   | 2     |
| 1(d)(i)  | <b>each nitrogen</b> / the four nitrogen's has a <b>lone pair of electrons</b> (to the metal ion)<br>Two correct responses = 1 mark  | 1     |

| Question | Answer  | Marks |
|----------|---|-------|
| 1(d)(ii) | $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + \text{C}_6\text{H}_{18}\text{N}_4 \rightarrow [\text{Co}(\text{C}_6\text{H}_{18}\text{N}_4)]^{2+} + 6\text{H}_2\text{O}$ <b>OR</b> $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + \text{C}_6\text{H}_{18}\text{N}_4 \rightarrow [\text{Co}(\text{C}_6\text{H}_{18}\text{N}_4)(\text{H}_2\text{O})_2]^{2+} + 4\text{H}_2\text{O}$ | 1     |

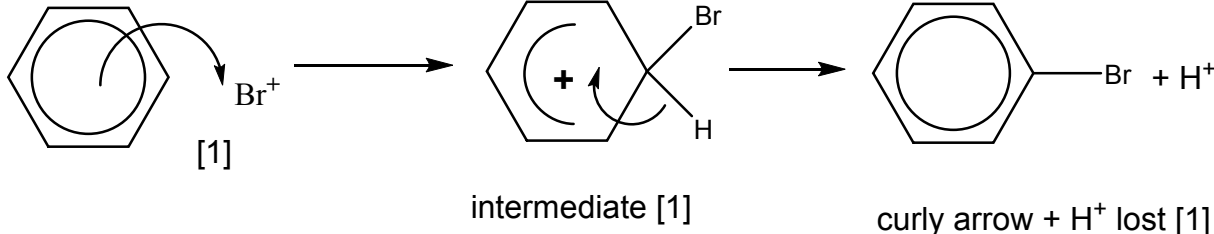
| Question | Answer  | Marks |
|----------|---|-------|
| 2(a)(i)  | <p><b>M1</b> solubility increases down the group</p> <p><b>M2</b> <math>\Delta H_{\text{latt}}</math> and <math>\Delta H_{\text{hyd}}</math> both become less exothermic / less negative</p> <p><b>M3</b> <math>\Delta H_{\text{latt}}</math>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

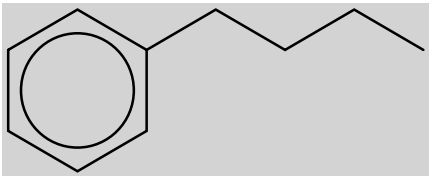
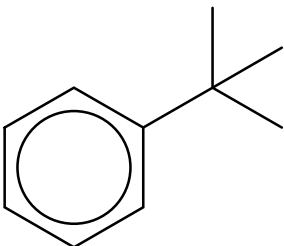
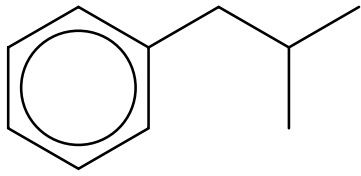
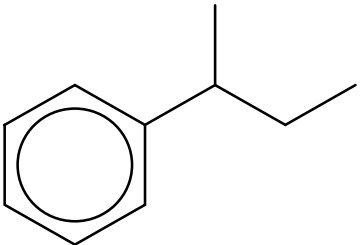
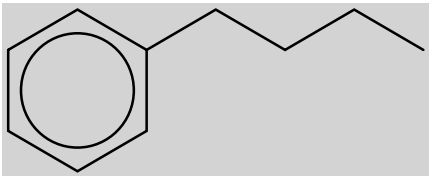
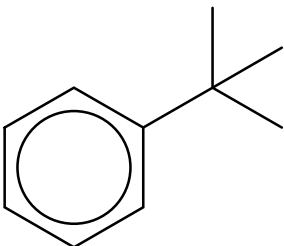
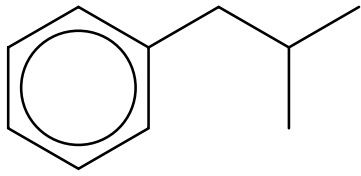
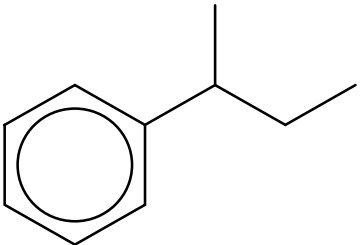
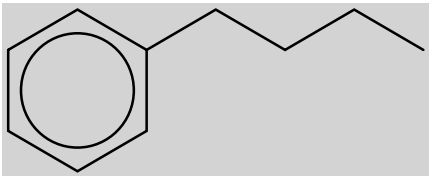
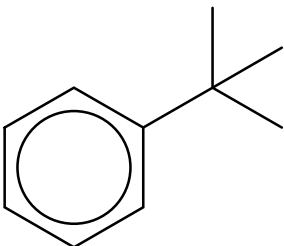
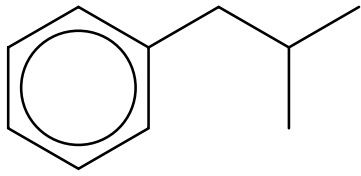
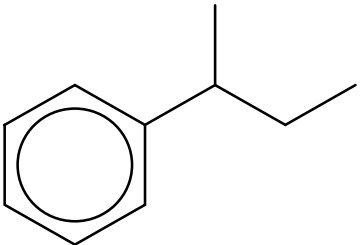
| Question | Answer   | Marks |
|----------|--|-------|
| 3(a)(i)  | $6\text{CO}_2 + 24\text{H}^+ + 24\text{e}^- \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O}$ <p><b>ALLOW</b> <math>6\text{CO}_2 + 12\text{H}^+ + 12\text{e}^- \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 3\text{O}_2</math> for both marks</p> <p><b>ALLOW</b> one mark for an unbalanced equation showing the correct species of either equation</p> | 2     |

| Question  | Answer   | Marks |
|-----------|--|-------|
| 3(a)(ii)  | salt bridge (indicated)      voltmeter / V labelled<br>O <sub>2</sub> good delivery system    H <sub>2</sub> good delivery system<br>Pt electrode                      H <sup>+</sup> / HCl / H <sub>2</sub> SO <sub>4</sub> solution labelled (at least once)<br>1 atm                                1 mol dm <sup>-3</sup> quoted<br>Every two correct responses = 1 mark | 4     |
| 3(a)(iii) | $E^{\circ}_{\text{cell}} = (+) 1.23 \text{ V}$ <b>AND</b> positive electrode = O <sub>2</sub> half-cell identified   | 1     |

| Question | Answer   | Marks |
|----------|--|-------|
| 4(a)     | <b>M1</b> phenylmethanamine / <b>U</b> > phenylamine / <b>T</b> > benzamide / <b>S</b> [1]<br>any two from: <ul style="list-style-type: none"> <li>alkyl group is electron donating so lone pair more able to accept a proton</li> <li>lone pair on N overlaps with delocalised system so less able to accept a proton</li> <li>presence of electron-withdrawing oxygen / carbonyl group means lone pair is not available to accept a proton <b>OR</b> amides are neutral</li> </ul> | 3     |
| 4(b)(i)  | reaction 1    LiAlH <sub>4</sub><br>reaction 2    heat NH <sub>3</sub> under pressure/ heat NH <sub>3</sub> in a sealed tube   | 2     |
| 4(b)(ii) | reaction 1    reduction<br>reaction 2    nucleophilic substitution   | 2     |



| Question  | Answer   | Marks |
|-----------|--|-------|
| 5(a)(i)   | The substitution product is stabilised by delocalisation of (6) $\pi$ -electrons<br><b>OR</b><br>The addition product is not stabilised by delocalisation of (6) $\pi$ -electrons [1]  | 1     |
| 5(a)(ii)  |  <ul style="list-style-type: none"> <li>• first curly arrow</li> <li>• intermediate</li> <li>• 2<sup>nd</sup> curly arrow, product <b>and</b> H<sup>+</sup> formed / lost</li> </ul> | 3     |
| 5(a)(iii) | $A/Br_4^- + H^+ \rightarrow A/Br_3 + HBr$  | 1     |
| 5(b)      | lone pair of oxygen is delocalised into the ring<br><br><u>any one from:</u> <ul style="list-style-type: none"> <li>• phenol has a higher electron density in the ring</li> <li>• phenol can polarise/induce a dipole in Br<sub>2</sub></li> </ul>                     | 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)  | <table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="width: 50%; padding: 5px;"> <br/>           number of peaks in carbon-13 NMR = 8         </td> <td style="width: 50%; padding: 5px;"> <br/>           number of peaks in carbon-13 NMR = 6         </td> </tr> <tr> <td style="width: 50%; padding: 5px;"> <br/>           number of peaks in carbon-13 NMR = 7         </td> <td style="width: 50%; padding: 5px;"> <br/>           number of peaks in carbon-13 NMR = 8         </td> </tr> </tbody> </table> <p style="margin-top: 10px;">Two correct organic products = 1 mark<br/>three correct organic products = 2 marks<br/>all products linked correctly to NMR = 2 marks</p> | <br>number of peaks in carbon-13 NMR = 8 | <br>number of peaks in carbon-13 NMR = 6 | <br>number of peaks in carbon-13 NMR = 7 | <br>number of peaks in carbon-13 NMR = 8 | 4 |
| <br>number of peaks in carbon-13 NMR = 8 | <br>number of peaks in carbon-13 NMR = 6  |   |  |   |  |   |
| <br>number of peaks in carbon-13 NMR = 7 | <br>number of peaks in carbon-13 NMR = 8  |   |  |   |  |   |

| Question | Answer   | Marks |
|----------|--|-------|
| 6(a)     | <p><b>M1</b> 2-chloropropanoic acid &gt; 3-chloropropanoic acid &gt; propanoic acid [1]</p> <p><b>M2</b> CH<sub>3</sub>CHClCO<sub>2</sub>H / ClCH<sub>2</sub>CH<sub>2</sub>CO<sub>2</sub>H (are more acidic) as they contain an electronegative Cl atom so weaken O-H bond / stabilise carboxylate anion [1]</p> <p><b>M3</b> CH<sub>3</sub>CHClCO<sub>2</sub>H (is more acidic than ClCH<sub>2</sub>CH<sub>2</sub>CO<sub>2</sub>H) as the Cl atom is closer to CO<sub>2</sub>H so weaken O-H bond more / stabilise carboxylate anion more [1]</p> | 3     |

| Question  | Answer  | Marks                                 |                         |                 |        |   |                                       |        |  |                                |        |                                      |                            |   |
|-----------|---|---------------------------------------|-------------------------|-----------------|--------|---|---------------------------------------|--------|--|--------------------------------|--------|--------------------------------------|----------------------------|---|
| 6(b)(i)   | $K_{eq} = 4.07 \times 10^{-3} / 1.78 \times 10^{-4} = 22.9$   | 1                                     |                         |                 |        |   |                                       |        |  |                                |        |                                      |                            |   |
| 6(b)(ii)  | 3 <sup>rd</sup> box ticked [to the right] <b>AND</b> as the $K_{eq}$ is greater than one      ecf on $K_{eq}$   | 1                                     |                         |                 |        |   |                                       |        |  |                                |        |                                      |                            |   |
| 6(b)(iii) | <p><math>pK_a</math> 1.23    <math>HO_2CCO_2H + H_2O \rightleftharpoons HO_2CCO_2^- + H_3O^+</math><br/> <b>OR</b> <math>HO_2CCO_2H \rightleftharpoons HO_2CCO_2^- + H^+</math></p> <p><math>pK_a</math> 4.19    <math>HO_2CCO_2^- + H_2O \rightleftharpoons ^-O_2CCO_2^- + H_3O^+</math><br/> <b>OR</b> <math>HO_2CCO_2^- \rightleftharpoons ^-O_2CCO_2^- + H^+</math></p>   | 2                                     |                         |                 |        |   |                                       |        |  |                                |        |                                      |                            |   |
| 6(b)(iv)  | $pK_a = -\log K_a$  | 1                                     |                         |                 |        |   |                                       |        |  |                                |        |                                      |                            |   |
| 6(c)      | <table border="1"> <thead> <tr> <th></th> <th>reagents and conditions</th> <th>observed change</th> </tr> </thead> <tbody> <tr> <td>test 1</td> <td><b>M1</b> Tollen's reagent, warm<br/><b>OR</b><br/>Fehling's solution, warm</td> <td>silver mirror<br/><br/>(brick)-red ppt.</td> </tr> <tr> <td>test 2</td> <td><b>M2</b> aqueous alkaline iodine<br/><b>OR</b><br/>2,4-DNPH</td> <td>yellow ppt.<br/><br/>orange ppt.</td> </tr> <tr> <td>test 3</td> <td><b>M3</b> acidified <math>MnO_4^-</math>, warm</td> <td>decolourises (and bubbles)</td> </tr> </tbody> </table> <p>Two correct observations = 1 mark<br/>Three correct observations = 2 marks</p> |                                       | reagents and conditions | observed change | test 1 | <b>M1</b> Tollen's reagent, warm<br><b>OR</b><br>Fehling's solution, warm | silver mirror<br><br>(brick)-red ppt. | test 2 | <b>M2</b> aqueous alkaline iodine<br><b>OR</b><br>2,4-DNPH | yellow ppt.<br><br>orange ppt. | test 3 | <b>M3</b> acidified $MnO_4^-$ , warm | decolourises (and bubbles) | 5 |
|           | reagents and conditions   | observed change                       |                         |                 |        |   |                                       |        |  |                                |        |                                      |                            |   |
| test 1    | <b>M1</b> Tollen's reagent, warm<br><b>OR</b><br>Fehling's solution, warm   | silver mirror<br><br>(brick)-red ppt. |                         |                 |        |   |                                       |        |  |                                |        |                                      |                            |   |
| test 2    | <b>M2</b> aqueous alkaline iodine<br><b>OR</b><br>2,4-DNPH  | yellow ppt.<br><br>orange ppt.        |                         |                 |        |   |                                       |        |  |                                |        |                                      |                            |   |
| test 3    | <b>M3</b> acidified $MnO_4^-$ , warm  | decolourises (and bubbles)            |                         |                 |        |   |                                       |        |  |                                |        |                                      |                            |   |

| Question                    | Answer  |                                  |   |  | Marks                       |                                |                                  |   |                               |                               |         |                     |                 |  |                          |                 |     |   |                         |   |   |
|-----------------------------|---|----------------------------------|---|--|-----------------------------|--------------------------------|----------------------------------|---|-------------------------------|-------------------------------|---------|---------------------|-----------------|--|--------------------------|-----------------|-----|---|-------------------------|---|---|
| 6(d)                        | <table border="1" data-bbox="338 213 1178 512"> <thead> <tr> <th data-bbox="338 213 607 316">chemical shift (<math>\delta</math>)</th> <th data-bbox="607 213 909 316">environment of the carbon atom</th> <th data-bbox="909 213 1178 316">hybridisation of the carbon atom</th> </tr> </thead> <tbody> <tr> <td data-bbox="338 316 607 381">27</td> <td data-bbox="607 316 909 381"><b>CH<sub>3</sub></b> circled</td> <td data-bbox="909 316 1178 381">sp<sup>3</sup></td> </tr> <tr> <td data-bbox="338 381 607 446">163</td> <td data-bbox="607 381 909 446"><b>COOH</b> circled</td> <td data-bbox="909 381 1178 446">sp<sup>2</sup></td> </tr> <tr> <td data-bbox="338 446 607 512">192</td> <td data-bbox="607 446 909 512"><b>C=O(COOH)</b> circled</td> <td data-bbox="909 446 1178 512">sp<sup>2</sup></td> </tr> </tbody> </table> <p data-bbox="338 544 869 576">Award one mark for each correct column</p>  |                                  |   |  | chemical shift ( $\delta$ ) | environment of the carbon atom | hybridisation of the carbon atom | 27  | <b>CH<sub>3</sub></b> circled | sp <sup>3</sup>               | 163     | <b>COOH</b> circled | sp <sup>2</sup> | 192  | <b>C=O(COOH)</b> circled | sp <sup>2</sup> | 2   |   |                         |   |   |
| chemical shift ( $\delta$ ) | environment of the carbon atom  | hybridisation of the carbon atom |   |  |                             |                                |                                  |   |                               |                               |         |                     |                 |  |                          |                 |     |   |                         |   |   |
| 27                          | <b>CH<sub>3</sub></b> circled   | sp <sup>3</sup>                  |   |  |                             |                                |                                  |   |                               |                               |         |                     |                 |  |                          |                 |     |   |                         |   |   |
| 163                         | <b>COOH</b> circled   | sp <sup>2</sup>                  |   |  |                             |                                |                                  |   |                               |                               |         |                     |                 |  |                          |                 |     |   |                         |   |   |
| 192                         | <b>C=O(COOH)</b> circled  | sp <sup>2</sup>                  |   |  |                             |                                |                                  |   |                               |                               |         |                     |                 |  |                          |                 |     |   |                         |   |   |
| 6(e)                        | <table border="1" data-bbox="338 608 1442 1011"> <thead> <tr> <th data-bbox="338 608 510 710">chemical shift (<math>\delta</math>)</th> <th data-bbox="510 608 891 710">group responsible for the peak</th> <th data-bbox="891 608 1072 710">splitting pattern</th> <th data-bbox="1072 608 1442 710">number of <sup>1</sup>H atoms responsible for the peak</th> </tr> </thead> <tbody> <tr> <td data-bbox="338 710 510 775">1.3</td> <td data-bbox="510 710 891 775">alkane / CH / CH<sub>3</sub></td> <td data-bbox="891 710 1072 775">triplet</td> <td data-bbox="1072 710 1442 775">3</td> </tr> <tr> <td data-bbox="338 775 510 876">2.2</td> <td data-bbox="510 775 891 876">CH<sub>3</sub>CO <b>or</b><br/>alkyl / CH next to C=O</td> <td data-bbox="891 775 1072 876">singlet</td> <td data-bbox="1072 775 1442 876">3</td> </tr> <tr> <td data-bbox="338 876 510 1011">4.0</td> <td data-bbox="510 876 891 1011">CH<sub>2</sub>O <b>or</b><br/>alkyl / CH next to<br/>electronegative atom / C=O</td> <td data-bbox="891 876 1072 1011">quartet /<br/>quadruplet</td> <td data-bbox="1072 876 1442 1011">2</td> </tr> </tbody> </table> <p data-bbox="338 1043 999 1075">Award one mark for every three correct responses.</p> |                                  |   |  | chemical shift ( $\delta$ ) | group responsible for the peak | splitting pattern                | number of <sup>1</sup> H atoms responsible for the peak | 1.3                           | alkane / CH / CH <sub>3</sub> | triplet | 3                   | 2.2             | CH <sub>3</sub> CO <b>or</b><br>alkyl / CH next to C=O | singlet                  | 3               | 4.0 | CH <sub>2</sub> O <b>or</b><br>alkyl / CH next to<br>electronegative atom / C=O | quartet /<br>quadruplet | 2 | 3 |
| chemical shift ( $\delta$ ) | group responsible for the peak  | splitting pattern                | number of <sup>1</sup> H atoms responsible for the peak |  |                             |                                |                                  |   |                               |                               |         |                     |                 |  |                          |                 |     |   |                         |   |   |
| 1.3                         | alkane / CH / CH <sub>3</sub>   | triplet                          | 3   |  |                             |                                |                                  |   |                               |                               |         |                     |                 |  |                          |                 |     |   |                         |   |   |
| 2.2                         | CH <sub>3</sub> CO <b>or</b><br>alkyl / CH next to C=O  | singlet                          | 3   |  |                             |                                |                                  |   |                               |                               |         |                     |                 |  |                          |                 |     |   |                         |   |   |
| 4.0                         | CH <sub>2</sub> O <b>or</b><br>alkyl / CH next to<br>electronegative atom / C=O   | quartet /<br>quadruplet          | 2   |  |                             |                                |                                  |   |                               |                               |         |                     |                 |  |                          |                 |     |   |                         |   |   |
| 6(f)                        | <p data-bbox="338 1114 629 1145">CH <b>AND</b> CH<sub>3</sub> <b>circled</b></p> <p data-bbox="338 1161 869 1193">these protons do not exchange with D<sub>2</sub>O</p> <p data-bbox="338 1193 943 1225"><b>OR</b> OH and NH protons exchange with D<sub>2</sub>O</p>   |                                  |   |  | 2                           |                                |                                  |   |                               |                               |         |                     |                 |  |                          |                 |     |   |                         |   |   |
| 6(g)(i)                     | <p data-bbox="338 1262 555 1294"><math>K_w = [D^+][DO^-]</math></p>   |                                  |   |  | 1                           |                                |                                  |   |                               |                               |         |                     |                 |  |                          |                 |     |   |                         |   |   |
| 6(g)(ii)                    | <p data-bbox="338 1327 808 1359"><b>M1</b> <math>[D^+] = \sqrt{1.35 \times 10^{-15}} = 3.67 \times 10^{-8}</math></p> <p data-bbox="338 1391 898 1423"><b>M2</b> pH = -log [D<sup>+</sup>] = <b>7.4(3)</b>      min 2sf</p>   |                                  |   |  | 2                           |                                |                                  |   |                               |                               |         |                     |                 |  |                          |                 |     |   |                         |   |   |

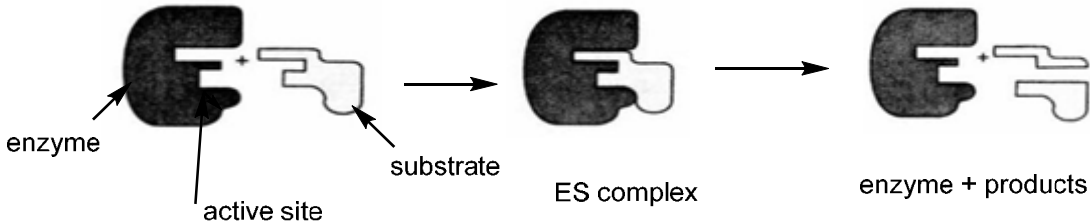
| Question  | Answer  | Marks |
|-----------|---|-------|
| 7(a)(i)   | <b>M1</b> $K_{sp} = [Ag^+]^2[CO_3^{2-}]$<br><b>M2</b> units = mol <sup>3</sup> dm <sup>-9</sup>   | 2     |
| 7(a)(ii)  | $x = \sqrt[3]{6.3 \times 10^{-12}/4} = 1.16 \times 10^{-4}$ (mol dm <sup>-3</sup> )<br>[Ag <sup>+</sup> ] =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

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

| Question  | Answer   | Marks |
|-----------|--|-------|
| 8(b)(iii) | <p><b>M1</b> moles <math>\text{NH}_3(\text{initial}) = 0.25 \times 0.80 = 0.200</math> <b>AND</b><br/>moles <math>\text{HCl} = 0.20 \times 0.20 = 0.040</math> (= moles <math>\text{NH}_4^+_{\text{eqm}}</math>)</p> <p><b>M2</b> moles <math>\text{NH}_3(\text{eqm}) = 0.20 - 0.04 = 0.160</math><br/> <math>[\text{H}^+] = (5.6 \times 10^{-10} \times 0.04)/(0.16) = 1.4 \times 10^{-10}</math> (mol <math>\text{dm}^{-3}</math>) ecf on M1</p> <p><b>M3</b> <math>\text{pH} = -\log(1.4 \times 10^{-10}) = 9.85</math> ecf on M2 min 2sf</p> | 3     |

| Question  | Answer  | Marks |
|-----------|---|-------|
| 9(a)      | <p><b>M1</b> data seen <math>\text{H}_2\text{O}_2/\text{H}_2\text{O} +1.77\text{V}</math> and <math>\text{MnO}_2/\text{Mn}^{2+} +1.23\text{V}</math> and <math>\text{O}_2/\text{H}_2\text{O}_2 +0.68\text{V}</math><br/> <b>OR</b> <math>E_{\text{cell}} = 0.55\text{V}</math> (first step) <b>and</b> <math>0.54\text{V}</math> (second step)</p> <p><b>M2</b> <math>\text{MnO}_2 + \text{H}_2\text{O}_2 + 2\text{H}^+ \rightarrow \text{Mn}^{2+} + \text{O}_2 + 2\text{H}_2\text{O}</math></p> <p><b>M3</b> <math>\text{Mn}^{2+} + \text{H}_2\text{O}_2 \rightarrow \text{MnO}_2 + 2\text{H}^+</math></p> | 3     |
| 9(b)      | rate = $2.0 \times 10^{-6} \times 0.75 = 1.5 \times 10^{-6}$  | 1     |
| 9(c)(i)   | slowest step in overall reaction  | 1     |
| 9(c)(ii)  | <p><math>\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{I}^- \rightarrow \text{I}_2 + 2\text{H}_2\text{O}</math></p> <p><b>OR</b> <math>\text{H}_2\text{O}_2 + 2\text{HI} \rightarrow \text{I}_2 + 2\text{H}_2\text{O}</math></p>  | 1     |
| 9(c)(iii) | $\text{H}_2\text{O}_2 = 1$ <b>AND</b> $\text{I}^- = 1$ <b>AND</b> $\text{H}^+ = 0$  | 1     |

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

| Question | Answer   | Marks |
|----------|--|-------|
| 10(c)    | <p>diagrams</p>  <p>M1 (can be in words or diagram) substrate shape is complementary to active site</p> <p>M2 (can be in words or diagram) the substrate bind / bonds / fits into the active site</p> <p>M3 (can be in words or diagram) products are released</p> <p>M4 (words) lower <math>E_A</math> / bonds weakened (in substrate) Any three points</p> | 3     |