



# Cambridge Pre-U

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**CHEMISTRY**

**9791/03**

Paper 3 Part B Written

**For examination from 2020**

MARK SCHEME

Maximum Mark: 100

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**Specimen**

This specimen paper has been updated for assessments from 2020. The specimen questions and mark schemes remain the same. The layout and wording of the front covers have been updated to reflect the new Cambridge International branding and to make instructions clearer for candidates.

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This syllabus is regulated for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document has **8** pages. Blank pages are indicated.

**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:**

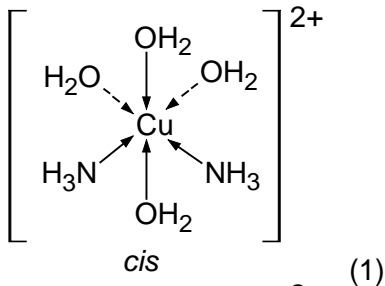
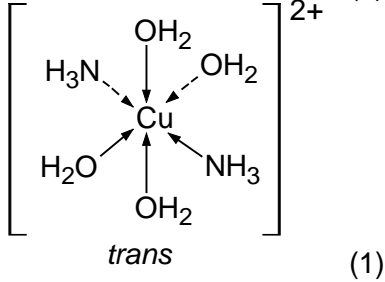
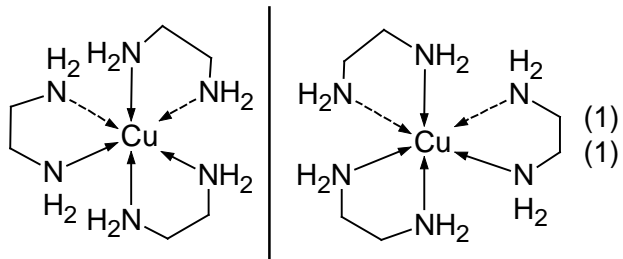
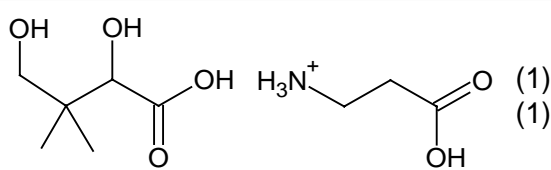
Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

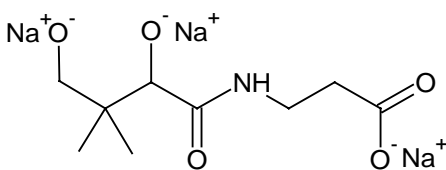
| Question | Answer  | Marks |
|----------|---|-------|
| 1(a)(i)  | Different structural forms of the same element (in the same physical state)   | 1     |
| 1(a)(ii) | Diamond hard due to (equal strength of) covalent bonds in <u>all directions/ tetrahedral</u> (1)<br><br>but graphite soft due to weak (van der Waal's) forces between layers/allowing them to slide over each other (easily) (1)<br>Allow explanation of softness of graphite in terms of air between layers<br><br>Diamond doesn't conduct electricity as no mobile charge carriers, (1)<br>Graphite conducts due to mobile delocalised electrons between layers (1) | 4     |
| 1(b)(i)  | <u>2-D/single sheet</u> of carbon atoms in <u>hexagonal rings</u>   | 1     |
| 1(b)(ii) | <u>weak van der Waals</u> forces between graphene sheets in graphite  | 1     |
| 1(c)     | Carbon (as diamond) is a non-conductor, silicon and/or germanium is/are semi-conductors, tin and/or lead conduct electricity (1)<br>(metals conduct electricity/non-metals are non-conductors)<br><br>Oxide(s) of carbon are simple covalent/molecular<br>AND Silicon dioxide (and germanium oxide) is giant covalent (1)<br><br>Oxides of tin and lead have (increasingly) ionic character (1)   | 3     |
| 1(d)     | Tin(II) less stable than tin(IV)/lead (IV) less stable than lead(II) (1)<br>Lead(II) more stable than tin(II) (1)   | 2     |

| Question  | Answer  | Marks |
|-----------|---|-------|
| 2(a)(i)   | $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$   | 1     |
| 2(a)(ii)  | $K_{\text{sp}} = [\text{Ba}^{2+}][\text{SO}_4^{2-}]$  | 1     |
| 2(a)(iii) | $[\text{Ba}^{2+}] = [\text{SO}_4^{2-}]$ so $K_{\text{sp}} = [\text{SO}_4^{2-}]^2 = 1.08 \times 10^{-10}$ (1)<br>so $[\text{SO}_4^{2-}] = \sqrt{1.08 \times 10^{-10}} = \underline{1.04 \times 10^{-5}}$ (mol dm <sup>-3</sup> ) (3 sf) (1)  | 2     |
| 2(a)(iv)  | $250 \text{ mg dm}^{-3} = \frac{0.250}{96} = 2.604 \times 10^{-3} \text{ mol dm}^{-3}$ (1)<br><br>So: $[\text{SO}_4^{2-}]$ in 500 cm <sup>3</sup> after mixing<br>$= 2.604 \times 10^{-3} \times 300/1000 \times \frac{1000}{50}$<br>$= 1.563 \times 10^{-3} \text{ mol dm}^{-3}$ (1)<br><br>so $1.08 \times 10^{-10} = [\text{Ba}^{2+}] \times 1.563 \times 10^{-3}$<br>so $[\text{Ba}^{2+}] = \frac{1.08 \times 10^{-10}}{1.563 \times 10^{-3}} = 6.918 \times 10^{-8} \text{ mol dm}^{-3}$<br>$= [\text{BaCl}_2]$ in 500 cm <sup>3</sup> mixture<br>$\times 5/2 = \underline{1.73 \times 10^{-7}} \text{ mol dm}^{-3}$ in original 200 cm <sup>3</sup> sample of BaCl <sub>2</sub> (1) | 3     |
| 2(b)(i)   | Pt (s) (1)<br>Ag <sup>+</sup> (aq) Ag(s) (1)<br>H <sup>+</sup> (aq) = <u>1</u> mol dm <sup>-3</sup> (1)   | 3     |
| 2(b)(ii)  | [Ag <sup>+</sup> ] will fall so eqm $\text{Ag}^+ + \text{e}^- \rightleftharpoons \text{Ag}$ moves to left (1)<br>$E^\ominus$ falls (below 0.80 V) (1)   | 2     |

| Question  | Answer  | Marks |
|-----------|---|-------|
| 2(b)(iii) | $[\text{Ag}^+] = \frac{1.8 \times 10^{-10}}{2.1} = 8.6 \times 10^{-11} \text{ mol dm}^{-3} \text{ (1)}$ $E = 0.8 - 0.03 \log(1/(8.6 \times 10^{-11})^2) \text{ (1)}$ $= (+) 0.196 \text{ (1)}$ allow 0.20V<br>do not allow 0.2V | 3     |

| Question  | Answer  | Marks |
|-----------|---|-------|
| 3(a)      | 1. Adsorption 2. Reaction 3. Desorption   | 1     |
| 3(b)(i)   | catalyst in same state as reactants   | 1     |
| 3(b)(ii)  | $E_{\text{cell}}^{\ominus} = 2.01 - 0.54 = (+)1.47 \text{ V}$   | 1     |
| 3(b)(iii) | $\Delta_r G^{\ominus} = -nFE^{\ominus}$<br>$= -2 \times 96500 \times 1.47 \text{ (1)}$<br>$= -283710 = \underline{-283.7} \text{ kJ mol}^{-1} \text{ (1)}$<br>allow $-284 \text{ kJ mol}^{-1}$  | 2     |
| 3(b)(iv)  | (Large) negative value indicates favourable reaction/more –ve than –60 suggests completion  | 1     |
| 3(b)(v)   | High activation energy (1)<br>Repulsion between two negative species (1)  | 2     |
| 3(b)(vi)  | $2\text{Fe}^{2+} + \text{S}_2\text{O}_8^{2-} \rightarrow 2\text{Fe}^{3+} + 2\text{SO}_4^{2-} \text{ (1)}$<br>$2\text{I}^- + 2\text{Fe}^{3+} \rightarrow \text{I}_2 + 2\text{Fe}^{2+} \text{ (1)}$<br>Reactions can happen in either order (owtte) (so either $\text{Fe}^{2+}$ or $\text{Fe}^{3+}$ suitable) (1) | 3     |
| 3(c)(i)   | Active site   | 1     |
| 3(c)(ii)  | Movement of a <u>pair</u> of electrons (resulting in formation or breaking of a covalent bond)  | 1     |
| 3(c)(iii) | Lewis base  | 1     |
| 3(c)(iv)  | Low pH = high $[\text{H}^+]$ (1)<br>so $\text{COO}^-$ in ASP would be protonated (and unable to accept $\text{H}^+$ from HIS) (1)   | 2     |
| 3(c)(v)   | Plot of $\ln[\text{chymotrypsin}]$ vs time being <u>straight</u> (confirms agreement with equation and hence first order kinetics) (1)<br>Use of excess alkali means that [alkali] effectively constant (so doesn't affect rate) (1)<br>Allow reference to constant gradient                                    | 2     |
| 3(c)(vi)  | $k = \text{gradient} = \frac{2.14 \times 10^{-5} - 1.14 \times 10^{-5}}{14000 - 2000} \text{ (1)}$<br>$= \frac{1.00 \times 10^{-5}}{12000} = 8.33 \times 10^{-10} \text{ (1)}$<br>Allow $8.25 - 8.33 \times 10^{-10}$<br>Ignore units   | 2     |

| Question | Answer  | Marks |
|----------|---|-------|
| 4(a)     | Any two from:<br>Two C-O bonds broken and (1)<br>Two C-N bonds formed (1)<br>Both cations 2+ so similar enthalpy of hydration (1)   | 2     |
| 4(b)     | Positive value for reaction with 'en' indicates feasible reaction (since $\Delta H$ -ve) (1)<br>Reaction with 'en' more positive than with $\text{NH}_3$ as no. of moles increases (from 2 to 3 while with $\text{NH}_3$ no. of moles remains the same) (1) | 2     |
| 4(c)(i)  | Geometric/ <i>cis-trans</i> / <i>E-Z</i>  | 1     |
| 4(c)(ii) | <br>   | 2     |
| 4(d)(i)  | Optical   | 1     |
| 4(d)(ii) |    | 2     |
| Question | Answer  | Marks |
| 5(a)     | 1° alcohol (1)<br>2° alcohol (1)<br>Secondary/substituted amide (1)<br>Carboxylic acid (1)<br>Allow one mark if unqualified 'alcohol' <b>and</b> 'amide' given  | 4     |
| 5(b)(i)  |    | 2     |

| Question  | Answer   | Marks |
|-----------|--|-------|
| 5(b)(ii)  |  <p>(1) for BOTH 'alcoholic' O<sup>-</sup>Na<sup>+</sup><br/>(1) for 'carboxylic' O<sup>-</sup>Na<sup>+</sup></p>   | 2     |
| 5(c)(i)   | Circle round C attached to –OH, –CONHCH <sub>2</sub> CH <sub>2</sub> COOH, –H and –C(CH <sub>3</sub> ) <sub>2</sub> CH <sub>2</sub> OH   | 1     |
| 5(c)(ii)  | (+) indicates that this enantiomer <u>rotates</u> plane polarised light clockwise (1)<br>R (= <i>rectus</i> ) indicates that, if chiral centre is orientated such that lowest priority group (H) points away (1) then priority of remaining groups decreases in a clockwise direction (–OH, –CONHCH <sub>2</sub> CH <sub>2</sub> COOH, –C(CH <sub>3</sub> ) <sub>2</sub> CH <sub>2</sub> OH) (1) | 3     |
| 5(d)(i)   | [H <sup>+</sup> ] = $\sqrt{3.98 \times 10^{-5} \times 0.2} = 2.82 \times 10^{-3} \text{ mol dm}^{-3}$ (1)<br>pH = $-\log_{10}[\text{H}^+] = -\log_{10} 2.82 \times 10^{-3}$ (1)<br>= 2.55 (1)  | 3     |
| 5(d)(ii)  | -NHCO or N or O (in pantothenic acid) (1)<br>exerts a –I effect (cf propanoic acid) (1)<br>hence O–H in COOH weakened/COO <sup>-</sup> stabilised so dissociation greater (1)  | 3     |
| 5(e)(i)   | Right-hand C in pantothenic acid is carboxylic acid level but in pantothenol is alcohol level (1)<br>Increase in FGL from pantothenol to pantothenic acid corresponds to oxidation (1)   | 2     |
| 5(e)(ii)  | CH <sub>3</sub> COOCH <sub>2</sub> C(CH <sub>3</sub> ) <sub>2</sub> CH(OCOCH <sub>3</sub> )CONH(CH <sub>2</sub> ) <sub>3</sub> OCOCH <sub>3</sub>  | 1     |
| 5(e)(iii) | C <sub>9</sub> H <sub>19</sub> NO <sub>4</sub> + 3 CH <sub>3</sub> COCl → C <sub>15</sub> H <sub>25</sub> NO <sub>7</sub> + 3 HCl<br>(1) for species; (1) for balancing  | 2     |

| Question | Answer  | Marks |
|----------|---|-------|
| 6(a)     | C <sub>11</sub> H <sub>14</sub> O <sub>2</sub>  | 1     |
| 6(b)     | Structural/positional   | 1     |
| 6(c)     | 3-phenylpropylethanoate   | 1     |
| 6(d)     | (Isomer 1)<br>Singlet/integral 5 shows 5 Hs on phenyl group (1)<br><br>Integral 3 as 3Hs shows CH <sub>3</sub> group, (1)<br>triplet as 2Hs on adjacent C (1)<br><br>3 × Integral 2 as 3 CH <sub>2</sub> groups (1)<br>Quartet indicates 3Hs on adjacent C (1)<br><br>Only Isomer 1 has CH <sub>2</sub> adjacent to CH <sub>3</sub> /CH <sub>3</sub> adjacent to CH <sub>2</sub> (1)<br>Allow reference to fact that if isomer 2 then would have 2 singlets | 6     |

| Question            | Answer  | Marks               |  |   |  |                   |                  |                   |     |                     |                     |                     |  |      |      |      |  |   |   |   |  |          |
|---------------------|---|---------------------|--|---|--|-------------------|------------------|-------------------|-----|---------------------|---------------------|---------------------|--|------|------|------|--|---|---|---|--|----------|
| 6(e)(i)             | <table style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;">C</td> <td style="text-align: center;">H</td> <td style="text-align: center;">O</td> <td></td> </tr> <tr> <td style="text-align: center;"><math>\frac{48.6}{12}</math></td> <td style="text-align: center;"><math>\frac{8.11}{1}</math></td> <td style="text-align: center;"><math>\frac{43.2}{16}</math></td> <td style="text-align: center;">(1)</td> </tr> <tr> <td style="text-align: center;"><math>\frac{4.05}{2.70}</math></td> <td style="text-align: center;"><math>\frac{8.11}{2.70}</math></td> <td style="text-align: center;"><math>\frac{2.70}{2.70}</math></td> <td></td> </tr> <tr> <td style="text-align: center;">1.50</td> <td style="text-align: center;">3.00</td> <td style="text-align: center;">1.00</td> <td></td> </tr> <tr> <td style="text-align: center;">3</td> <td style="text-align: center;">6</td> <td style="text-align: center;">2</td> <td style="text-align: center;">hence C<sub>3</sub>H<sub>6</sub>O<sub>2</sub> (1)</td> </tr> </table> | C                   | H  | O |  | $\frac{48.6}{12}$ | $\frac{8.11}{1}$ | $\frac{43.2}{16}$ | (1) | $\frac{4.05}{2.70}$ | $\frac{8.11}{2.70}$ | $\frac{2.70}{2.70}$ |  | 1.50 | 3.00 | 1.00 |  | 3 | 6 | 2 | hence C <sub>3</sub> H <sub>6</sub> O <sub>2</sub> (1) | <b>2</b> |
| C                   | H   | O                   |  |   |  |                   |                  |                   |     |                     |                     |                     |  |      |      |      |  |   |   |   |  |          |
| $\frac{48.6}{12}$   | $\frac{8.11}{1}$  | $\frac{43.2}{16}$   | (1)  |   |  |                   |                  |                   |     |                     |                     |                     |  |      |      |      |  |   |   |   |  |          |
| $\frac{4.05}{2.70}$ | $\frac{8.11}{2.70}$   | $\frac{2.70}{2.70}$ |  |   |  |                   |                  |                   |     |                     |                     |                     |  |      |      |      |  |   |   |   |  |          |
| 1.50                | 3.00  | 1.00                |  |   |  |                   |                  |                   |     |                     |                     |                     |  |      |      |      |  |   |   |   |  |          |
| 3                   | 6   | 2                   | hence C <sub>3</sub> H <sub>6</sub> O <sub>2</sub> (1) |   |  |                   |                  |                   |     |                     |                     |                     |  |      |      |      |  |   |   |   |  |          |
| 6(e)(ii)            | From Mass Spec RFM = 74 EFM = 74<br>EFM = RFM so Empirical Formula = Molecular Formula  | <b>1</b>            |  |   |  |                   |                  |                   |     |                     |                     |                     |  |      |      |      |  |   |   |   |  |          |
| 6(e)(iii)           | COOH <sup>+</sup><br>(1) for charge; (1) for formula<br>Allow one mark for '+' if m/z = 45  | <b>2</b>            |  |   |  |                   |                  |                   |     |                     |                     |                     |  |      |      |      |  |   |   |   |  |          |
| 6(e)(iv)            | Due to carbon-13 isotope (1)<br>At approx 1% of abundance of carbon-12 isotope (1)  | <b>2</b>            |  |   |  |                   |                  |                   |     |                     |                     |                     |  |      |      |      |  |   |   |   |  |          |
| 6(f)(i)             | C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> CH <sub>2</sub> OH (1)<br>Broad peak around 3300 cm <sup>-1</sup> indicates O–H group (1)   | <b>2</b>            |  |   |  |                   |                  |                   |     |                     |                     |                     |  |      |      |      |  |   |   |   |  |          |
| 6(f)(ii)            | Will also have very broad peak around 2500–3300 cm <sup>-1</sup> due to O–H group (1)<br>In addition will have strong peak around 1640–1750 due to C=O (1)  | <b>2</b>            |  |   |  |                   |                  |                   |     |                     |                     |                     |  |      |      |      |  |   |   |   |  |          |

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