

**GCE**

**Chemistry B**

**H433/02: Scientific literacy in chemistry**

Advanced GCE

**Mark Scheme for November 2020**

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

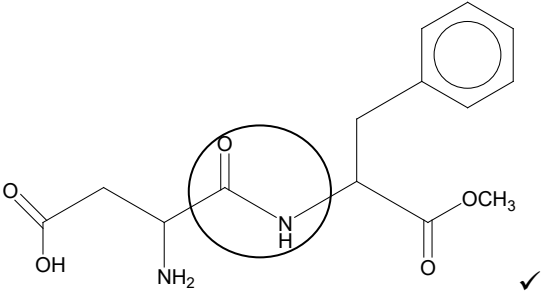
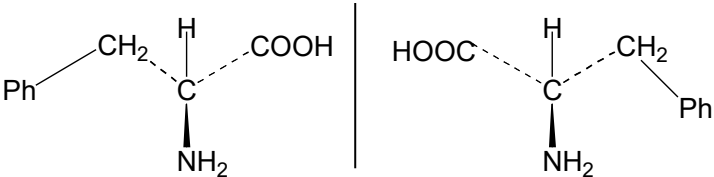
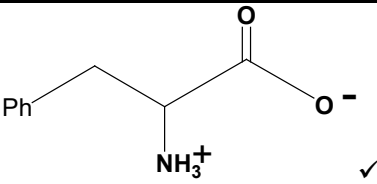
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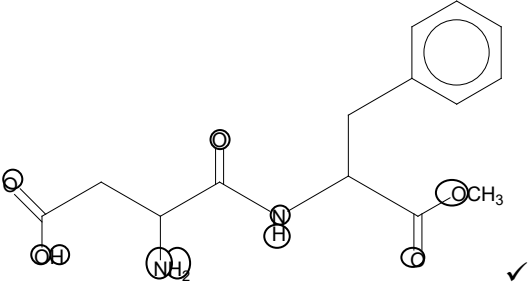
## Annotations

| Annotation  | Meaning                                |
|---|--|
|    | Correct response                       |
|    | Incorrect response                     |
|    | Omission mark                          |
|    | Benefit of doubt given                 |
|    | Contradiction                          |
|    | Rounding error                         |
|    | Error in number of significant figures |
|    | Error carried forward                  |
|    | Level 1                                |
|    | Level 2                                |
|    | Level 3                                |
|  | Benefit of doubt not given             |
|  | Noted but no credit given              |
|  | Ignore                                 |

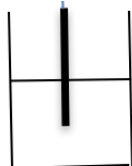
Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

| <b>Annotation</b>   | <b>Meaning</b>   |
|---------------------|--|
| <b>DO NOT ALLOW</b> | Answers which are not worthy of credit                     |
| <b>IGNORE</b>       | Statements which are irrelevant                            |
| <b>ALLOW</b>        | Answers that can be accepted                               |
| ( )                 | Words which are not essential to gain credit               |
| —                   | Underlined words must be present in answer to score a mark |
| <b>ECF</b>          | Error carried forward                                      |
| <b>AW</b>           | Alternative wording  |
| <b>ORA</b>          | Or reverse argument  |

| Question |   |     | Answer   | Mark | AO element | Guidance  |
|----------|---|-----|--|------|------------|---|
| 1        | a |     |   | 1    | 1.1        | <b>ALLOW</b> correct C–N bond circled   |
| 1        | b | i   |  <p>Correct 3D structure around chiral centre ✓<br/>correct mirror image ✓</p> | 2    | 2.1 x 2    | <b>ALLOW</b> any object and correct mirror image scores 1 mark<br><b>ALLOW</b> dotted wedges instead of dotted lines.<br><b>ALLOW</b> wedges for bonds in front of the plane of the paper<br><b>ALLOW</b> two ordinary lines as long as they are <b>not</b> 180° to each other. |
| 1        | b | ii  |    | 1    | 1.1        | <b>DO NOT ALLOW</b> NH <sup>3(+)</sup><br><b>IGNORE</b> extra correct details on skeletal structure   |
| 1        | b | iii | <p>H<sub>2</sub>NCH(COOH)CH<sub>2</sub>COOH also formed ✓<br/>also CH<sub>3</sub>OH ✓<br/>hydrolysis of ester ✓</p>  | 3    | 3.2 x 3    | <b>ALLOW</b> any unambiguous structures<br><b>ALLOW</b> NH <sub>3</sub> <sup>+</sup> in formula of amino acid   |
| 1        | c |     |  | 1    | 1.1        | <b>ALLOW</b> circles round NH <sub>2</sub> , NH and OH rather than the atoms separately<br><b>ALL</b> indicated atoms <b>MUST</b> be circled to score the mark  |

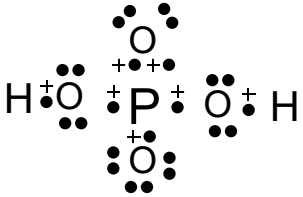
| Question |   |     | Answer   | Mark | AO element               | Guidance  |
|----------|---|-----|--|------|--------------------------|---|
|          |   |     |   |      |                          |   |
| 1        | d |     | Instantaneous (dipole)-induced dipole/id-id ✓  | 1    | 2.5                      | <b>ALLOW</b> Van der Waals or London  |
| 1        | e | i   | place in solvent and allow solvent to rise up paper ✓<br>solvent below level of spot ✓<br>(dry and) use ninhydrin/locating agent/UV (light) ✓<br>more than one spot indicates hydrolysis ✓ | 4    | 1.2<br>3.3<br>1.2<br>3.4 | <b>ALLOW</b> labelled diagrams to score MP1, 2 & 4<br><b>IGNORE</b> use of water as solvent<br><b>ALLOW</b> matching spots from individual amino acids            |
| 1        | e | ii  | enzyme would be denatured /tertiary structure broken down so no reaction (AW)✓   | 1    | 3.1                      |   |
| 1        | e | iii | No difference to rate (AW)✓<br>Aspartame/substrate zero order (when in excess) ✓   | 2    | 3.1 x 2                  | <b>ALLOW</b> initially rate increases AND then becomes constant(AW)<br><b>ALLOW</b> all active sites occupied(AW) when aspartame in excess/at high concentration' |

| Question |   |      | Answer  | Mark | AO element | Guidance  |
|----------|---|------|---|------|------------|---|
| 2        | a | i    | salt bridge ✓<br>filter paper <b>and</b> potassium nitrate (solution) ✓   | 2    | 3.4 x 2    | <b>ALLOW</b> ion bridge<br><b>ALLOW</b> any Gr I /II nitrate solution   |
| 2        | a | ii   | 298 K/ 25°C ✓<br>concentrations of solutions 1 mol dm <sup>-3</sup> ✓   | 2    | 1.2 x 2    |   |
| 2        | b | i    | silver <u>ions</u> / Ag <sup>+</sup> ✓  | 1    | 1.2        |   |
| 2        | b | ii   | From Cu to Ag<br><b>AND</b> Cu electrode potential is more negative/less positive ✓   | 1    | 2.3        | <b>ALLOW</b> Ag electrode is more positive/less negative<br><b>ALLOW</b> Cu is oxidised/loses electrons<br><b>ALLOW</b> Ag <sup>+</sup> ions are reduced/accept electrons |
| 2        | c |      | <b>FIRST CHECK THE ANSWER ON ANSWER LINE</b><br><b>If answer = 6.8 x 10<sup>-7</sup> (mol dm<sup>-3</sup>) award 4 marks</b><br><br>$E^\ominus = 0.46$ ✓<br><br>Rearrange equation: $0.06 \log[\text{Ag}^+] = E - E^\ominus$ ✓<br><br>$\log [\text{Ag}^+] = -6.17$ ✓<br><br>$[\text{Ag}^+] = 6.8 \times 10^{-7} \text{ (mol dm}^{-3}\text{)}$ ✓ | 4    | 2.8 x 4    | <b>ALLOW</b> 1 or more sf (0.06 in equation)<br><b>ALLOW</b> ecf throughout   |
| 2        | d | (i)  | Equation showing that IO <sub>3</sub> <sup>-</sup> reacts with Cu ✓<br><br>$2\text{IO}_3^- + 12\text{H}^+ + 5\text{Cu} \rightarrow \text{I}_2 + 6\text{H}_2\text{O} + 5\text{Cu}^{2+}$ ✓  | 2    | 2.8 x 2    | Mark separately<br><br>Second mark can be scored for reverse equation.<br><b>ALLOW</b> equilibrium sign<br><b>IGNORE</b> state symbols                                    |
| 2        | d | (ii) |   | 2    | 3.3 x 2    |   |

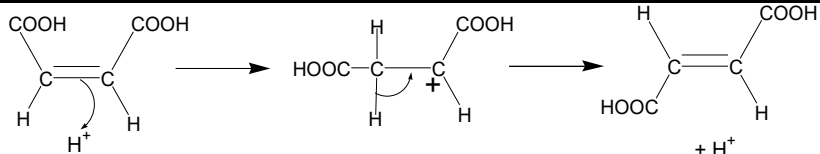


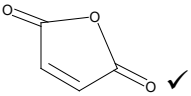
| Question |   |       | Answer   | Mark | AO element | Guidance   |
|----------|---|-------|--|------|------------|--|
|          |   |       | Pt/graphite electrode ✓<br>IO <sub>3</sub> <sup>-</sup> and I <sub>2</sub> and H <sup>+</sup> in solution ✓  |      |            |  |
| 2        | d | (iii) | <b>FIRST CHECK THE ANSWER ON ANSWER LINE</b><br><b>If answer = 0.4 (mol dm<sup>-3</sup>) award 3 marks</b><br><br>[I <sub>2</sub> ] = 0.04 ✓<br><br>√0.04 = 0.2 ✓<br><br>[IO <sub>3</sub> <sup>-</sup> ] = 0.4 (mol dm <sup>-3</sup> ) ✓ | 3    | 2.8 x 3    | 0.28.... (omission of factors of 2) scores 1 mark<br>0.56 and 0.2 score 2 marks<br><b>ALLOW</b> ecf from any statement that begins "[I <sub>2</sub> ] =" |



| Question |   | Answer  | Mark  | AO element | Guidance   |  |
|----------|---|---|---|------------|--|--|
| 3        | a |  <p>ten electrons around P atom / eight electrons around P atom if clear that lone pair from P are used to form a dative covalent bond to one O atom ✓</p> <p>rest correct ✓</p>   | 2   | 2.5 x 2    | <b>IGNORE</b> minus sign<br><b>ALLOW</b> 'extra' electron on single bonded O to be the same symbol or different from the rest of the electrons on that O.<br>Must be clear that only five electrons are from P atom. |  |
| 3        | b | <p>mol P = <math>52 \times 2/142 = 0.73</math> <b>AND</b> mol K = <math>34 \times 2/94.2 = 0.72</math> ✓</p> <p>Ratio is about 1:1 as in <math>\text{KH}_2\text{PO}_4</math> ✓</p>  | 2   | 2.6 x 2    | <b>ALLOW</b> $52/142 = 0.365$ <b>AND</b> $34/94.2 = 0.36$ for MP1  |  |
| 3        | c | i   | $\text{HPO}_4^{2-}$ <b>AND</b> proton acceptor ✓  | 1          | 1.1  |  |
| 3        | c | ii  | 7.2..... ✓  | 1          | 1.2  |  |
| 3        | c | iii   | <p><b>FIRST CHECK THE ANSWER ON ANSWER LINE</b><br/><b>If answer = 5.1.... award 2 marks</b></p> <p><math>[\text{H}^+] (= \sqrt{(6.2 \times 10^{-8} \times 1.0 \times 10^{-3})}) = 7.87 \times 10^{-6} (\text{mol dm}^{-3})</math> ✓</p> <p>pH = 5.1... ✓</p> | 2          | 2.2 x 2  | <b>ALLOW</b> ecf provided ' $[\text{H}^+] =$ ' or ' $\text{H}^+ =$ ' is shown<br><b>AND</b> value is $> 10^{-7}$ and $< 10^{-4}$ |
| 3        | d | <p><math>\text{NH}_4^+ \rightleftharpoons \text{NH}_3 + \text{H}^+</math> <b>OR</b> <math>\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+</math> ✓</p> <p>Acid/ <math>\text{H}^+</math>/ <math>\text{H}_3\text{O}^+</math> (from <math>\text{KH}_2\text{PO}_4</math>) moves equilibrium (position) to left ✓</p> | 2   | 2.7 x 2    | <b>ALLOW</b> equilibrium the other way round (and the corresponding 'right' in MP2)  |  |

| Question |   |     | Answer   | Mark | AO element | Guidance  |
|----------|---|-----|--|------|------------|---|
| 3        | e |     | <p><b>FIRST CHECK THE ANSWER ON ANSWER LINE</b><br/> <b>If answer = 69 (g) award 4 marks</b></p> <p>Value of <math>[H^+]</math>: <math>3.16 \times 10^{-7}</math> ✓</p> <p>Rearrangement of eqn: <math>[H_2PO_4^-] = [H^+] [HPO_4^{2-}] / K_a</math> ✓</p> <p><math>[H_2PO_4^-] = 3.16 \times 10^{-7} \times 0.1 / 6.2 \times 10^{-8}</math> OR <math>0.51</math> ✓</p> <p>mass <math>KH_2PO_4 = (0.51 \times 136) = 69</math> (g) ✓</p> | 4    | 2.8 x 4    | <p><b>ALLOW</b> 2 or more sf</p> <p><b>ALLOW</b> ecf throughout</p> |
| 3        | f | i   | <p>Equilibrium will move to left (AW) ✓</p> <p><math>[H^+]</math> only restored/unchanged (AW) if <math>[H_2PO_4^-]</math> is large ✓</p>  | 2    | 3.1 x 2    |   |
| 3        | f | ii  | <p>(Student is correct (AW) <b>AND</b>) HCl strong (acid) so all reacts/dissociates/ionises ✓</p>  | 1    | 3.1        |   |
|          | f | iii | <p><b>FIRST CHECK THE ANSWER ON ANSWER LINE</b><br/> <b>If answer = 0.7 award 2 marks</b></p> <p><math>[H^+] (= 0.05 \times 0.01 / 1000) = 5 \times 10^{-7}</math> ✓</p> <p>pH change = <math>7 - 6.3 = 0.7</math> ✓</p>   | 2    | 2.8 x 2    | <b>ALLOW</b> ecf  |

| Question |   |    | Answer   | Mark | AO element | Guidance  |
|----------|---|----|--|------|------------|---|
| 4        | a | i  | (C=C) decolorises bromine water ✓<br>(COOH/acid) will fizz with carbonate/appropriate colour with (named) indicator ✓  | 2    | 1.2 x 2    | ALLOW gas produced turns limewater cloudy(AW) if carbonate test used  |
| 4        | a | ii | <b>FIRST CHECK THE ANSWER ON ANSWER LINE</b><br><b>If answer = 5 (cm<sup>3</sup>) award 3 marks</b><br><br>conc maleic acid = (2.32/116) OR 0.02 (mol dm <sup>-3</sup> ) ✓<br>amt NaOH = 2 x 250 x 0.02/1000 OR 0.01 (mol) ✓<br>vol NaOH = 1000 x 0.01/2 = 5 ✓ | 3    | 2.4 x 3    | 2.5 scores 2 marks<br><br><b>ALLOW</b> ecf<br>Allow wrong answers (after ecf) to 2 or more sig figs.  |
| 4        | b | i  | CHO ✓  | 1    | 1.2        | <b>ALLOW</b> elements in any order  |
|          | b | ii | Z ✓ butenedioic acid ✓   | 2    | 1.1 x 2    | <b>ALLOW</b> 'butendioic acid'  |
|          | c |    | Description of groups being spatially different across C=C ✓<br><br>Lack of free rotation of C=C /groups in a fixed position ✓   | 2    | 1.2 x 2    | <b>ALLOW</b> they are stereoisomers.  |
|          | d |    | Loss of COOH/CO <sub>2</sub> H <b>OR</b> C <sub>3</sub> H <sub>3</sub> O <sub>2</sub> ( <sup>+</sup> )/CHCHCOOH ✓  | 1    | 2.6        |   |
|          | e | i  | <br>one for each arrow ✓✓  | 2    | 2.5 x 2    | One arrow must start) on the double bond and end pointing to H <sup>+</sup> (or to the bond being formed)<br>The other arrow must start and end on the bonds shown.<br>Other arrows are CON |
|          | e | ii | (Electrophilic) Elimination  | 1    | 1.1        |   |

| Question |     | Answer  | Mark | AO element     | Guidance   |
|----------|-----|---|------|----------------|--|
| e        | iii | No, either of the Hs on the left C (of carbocation) could leave<br>✓<br>some <sup>2</sup> H/D would be incorporated ✓   | 2    | 3.2 x 2        |  |
| f        |     |    | 1    | 2.1            |  |
| g        | i   | Atom economies (98/170) = 58% <b>AND</b> (98/222) = 44% ✓<br><br>Identifies butane/reaction 1 should be used because it has the larger atom economy/produces less waste ✓                 | 2    | 2.6<br><br>3.1 | <b>ALLOW</b> 0.58 <b>AND</b> 0.44  |
| g        | ii  | Benzene toxic/ more expensive/butane more available from cracking /doesn't produce CO <sub>2</sub> (ORA for reaction 2) ✓   | 1    | 3.1            | <b>ALLOW</b> ecf from (g)(i) eg butane more flammable                        |
| g        | iii | <b>FIRST CHECK THE ANSWER ON ANSWER LINE</b><br><b>If answer = 61 (kg) award 2 marks</b><br><br>amt butane = 15000/24 = 625 mol ✓<br><br>mass maleic anh = 625 x 98/1000 = 61(kg) (2sf) ✓ | 2    | 2.8 x 2        | 61.3 or 61.2 score 1<br><br>Correct use of gas equation can score both marks |

| Question |    | Answer  | Mark | AO element         | Guidance   |
|----------|----|---|------|--------------------|--|
|          | h* | <p><i>Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.</i></p> <p><b>Level 3 (5 – 6 marks)</b><br/>Correct structure/identity deduced and <b>detailed</b> evidence related to the structure is provided from <b>each</b> spectrum.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p><b>Level 2 (3 – 4 marks)</b><br/>Correct structure/identity deduced with <b>detailed</b> evidence from at least one spectrum.<br/><b>OR</b><br/>Structure/identity attempted with some correct evidence from a minimum of two spectra.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p><b>Level 1 (1 – 2 marks)</b><br/>Correct structure/identity deduced with no relevant evidence.<br/><b>OR</b><br/>Structure/identity not given or incorrect, but some correct evidence from at least one spectrum.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p><b>0 marks</b><br/>No response or nothing of value</p> | 6    | 3.1 x 4<br>3.2 x 2 | <p><b>Indicative scientific points may include:</b></p> <p><b>AO3.1 Analysis:</b><br/><b>IR:</b></p> <ul style="list-style-type: none"> <li>• C=O at 1700</li> <li>• Broad OH 2500-3300</li> <li>• COOH</li> </ul> <p><b>HNMR:</b></p> <ul style="list-style-type: none"> <li>• Three H environments</li> <li>• 1.2: Hs on C connected to C-H</li> <li>• 2.3: H on C connected to Cs with many Hs</li> <li>• 11.8 H in COOH</li> </ul> <p><b>CNMR:</b></p> <ul style="list-style-type: none"> <li>• Three C environments</li> <li>• two Cs in same environment</li> <li>• one C=O (at 183ish)</li> <li>• two C-C</li> </ul> <p><b>AO3.2 Evaluation:</b><br/>Compound A identified as 2-methylpropanoic acid<br/>Structure <math>\text{CH}_3\text{CH}(\text{CH}_3)\text{COOH}</math><br/>presented in any unambiguous way</p> |

| Question |   |     | Answer  | Mark | AO element | Guidance |
|----------|---|-----|---|------|------------|----------|
| 5        | a | i   | Two Cls/chlorines/two Cl-/ chloride ligands are each -1 ✓                                   | 1    | 1.1        |          |
| 5        | a | ii  | 5d <sup>8</sup> ✓   | 1    | 1.1        |          |
| 5        | a | iii | Yes, it has an ion with an incomplete d subshell (in a compound) ✓                          | 1    | 1.1        |          |
| 5        | b |     | <p>correct identification ✓</p> <p>full structural (with O<sup>-</sup> for first two) ✓</p> | 2    | 1.1 x 2    |          |
| 5        | c | i   | guanine ✓   | 1    | 1.1        |          |
| 5        | c | ii  | hydrogen (bond) ✓   | 1    | 2.1        |          |
| 5        | c | iii | (dative) covalent/ co-ordinate (bond) ✓<br>(lone) pair on nitrogen donated to Pt ✓          | 2    | 2.1 x 2    |          |
| 5        | d | i   | octahedral ✓  | 1    | 2.1        |          |
|          |   | ii  | 6 ✓   | 1    | 2.1        |          |

| Question |    |     | Answer  | Mark | AO element        | Guidance   |
|----------|----|-----|---|------|-------------------|--|
| 5        | d  | iii | <p>Satraplatin also has ethanoate/ester/C=O groups/(4) O atoms (in addition to NH<sub>3</sub> groups that cisplatin also has) ✓</p> <p>(These form more) H-bonds with water(ORA for cisplatin) ✓</p> <p>and (more than) compensate for 'insoluble' (AW) ring <b>OR</b> H-bonds broken in water ✓</p>  | 3    | 3.1 x 3           | Oxygen MOLECULES is CON  |
| 5        | e* |     | <p><i>Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.</i></p> <p><b>Level 3 (5 – 6 marks)</b><br/>Considers disadvantages of cisplatin, with most examples of both toxicity <b>and</b> cell resistance.<br/><b>AND</b><br/>Identifies most examples of how new drugs attempt to overcome the disadvantages of cisplatin.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p><b>Level 2 (3 – 4 marks)</b><br/>Considers disadvantages of cisplatin, with some examples of both toxicity and cell resistance.<br/><b>OR</b><br/>Gives a detailed treatment of either toxicity OR cell resistance</p> <p><b>AND</b><br/>Attempts to provide examples of the ways new drugs attempt to overcome the disadvantages of cisplatin.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> | 6    | 3.1 x 3<br>3.2x 3 | <p><b>Indicative scientific points include:</b></p> <p><b>Disadvantages:</b></p> <p><b>toxicity</b></p> <ul style="list-style-type: none"> <li>damaging to the kidneys/ gastrointestinal tract / nervous system.</li> <li>targets all cells</li> <li>difficulty of administration</li> </ul> <p><b>cell resistance</b></p> <ul style="list-style-type: none"> <li>influx slower/method of entry slowed/prevented</li> <li>efflux faster/method of exit accelerated</li> <li>removed before it can act on DNA</li> <li>improved cell repair mechanism</li> <li>cancer cells evolve</li> <li>improved methods of DNA repair</li> </ul> <p><b>New Drugs attempting to overcome disadvantages</b></p> <ul style="list-style-type: none"> <li>carboplatin less toxic</li> <li>satraplatin/picoplatin different structure and overcame resistance</li> <li>formulae of some of above</li> <li>bulky group in picoplatin helps overcome resistance</li> <li>satraplatin soluble/ administered orally</li> </ul> |

| Question | Answer   | Mark | AO element | Guidance |
|----------|--|------|------------|----------|
|          | <p><b>Level 1 (1 – 2 marks)</b><br/>           Considers disadvantages of cisplatin, with examples of toxicity OR cell resistance.<br/> <b>OR</b><br/>           Attempts to provide examples of the ways new drugs attempt to overcome the disadvantages of cisplatin</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant and correct.</i></p> <p><b>0 marks</b><br/>           No response or nothing of value</p> |      |            |          |



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