



National  
Qualifications  
2024

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# **2024 Chemistry**

## **Advanced Higher**

### **Question Paper Finalised Marking Instructions**

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## General marking principles for Advanced Higher Chemistry

*This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in this paper. These principles must be read in conjunction with the detailed marking instructions, which identify the key features required in candidate responses.*

- (a) Marks for each candidate response must **always** be assigned in line with these general marking principles and the detailed marking instructions for this assessment.
- (b) Marking should always be positive. This means that, for each candidate response, marks are accumulated for the demonstration of relevant skills, knowledge and understanding: they are not deducted from a maximum on the basis of errors or omissions.
- (c) If a specific candidate response does not seem to be covered by either the principles or detailed marking instructions, and you are uncertain how to assess it, you must seek guidance from your team leader.
- (d) Where a candidate makes an error at an early stage in a multi stage calculation, credit should normally be given for correct follow on working in subsequent stages, unless the error significantly reduces the complexity of the remaining stages. The same principle should be applied in questions which require several stages of non-mathematical reasoning. The exception to this rule is where the marking instructions for a numerical question assign separate “concept marks” and an “arithmetic mark”. In such situations, the marking instructions will give clear guidance on the assignment of partial marks.
- (e) In many cases, marks can still be awarded for inaccurate or unconventional spelling or vocabulary as long as the meaning of the word(s) is conveyed. For example, responses that include ‘distilling’ for ‘distillation’, or ‘it gets hotter’ for ‘the temperature rises’, should be accepted.
- (f) If a correct answer and a wrong answer are present, it should be treated as a cancelling error and no marks should be given. For example, in response to the question, ‘State the colour seen when blue Fehling’s solution is warmed with an aldehyde’, the answer ‘red green’ gains no marks.  
However, if a correct answer and additional information, which does not conflict, are present, the additional information should be ignored, whether correct or not. For example, in response to a question concerned with melting point, ‘State why the tube should not be made of copper’, the response ‘Copper has a low melting point and is coloured grey’ would **not** be treated as having a cancelling error.
- (g) Full marks are usually awarded for the correct answer to a calculation without working and the partial marks shown in the Detailed Marking Instructions are for use when working is given but the final answer is incorrect. An exception is when candidates are asked to ‘Clearly show your working’, when full marks cannot be awarded for the correct answer without working.

**(h) Significant figures.**

This marking instruction only applies to correct final answers. If the data in a question is given to three significant figures, the final answer should also have three significant figures. However one fewer significant figure and up to two more significant figures is acceptable.

For example if a correct final answer is 8.16 J then 8.2 J, 8.158 J and 8.1576 J would also be acceptable. Answers out with this range would not be acceptable and one mark would not be awarded.

The use of a recurrence dot, eg  $8.16\dot{6}$ , would imply an infinite number of significant figures and would therefore not be acceptable.

This marking instruction must only be applied a maximum of once per paper and cannot be applied if instruction (i) has already been applied in the paper.

**(i) Units**

This marking instruction only applies to correct final answers. In most questions units are not required. However, if the candidate writes units then they must be correct. The symbols L and l are both acceptable for litres.

An incorrect unit would not be acceptable and one mark would not be awarded.

This marking instruction must only be applied a maximum of once per paper and cannot be applied if instruction (h) has already been applied in the paper.

**(j) Intermediate rounding.**

Ideally, calculated intermediate values should not be rounded. However, if the candidate has correctly rounded, the calculated intermediate values can have one significant figure fewer than the data given in the question but no fewer, otherwise full marks may not be awarded and partial marking would apply.

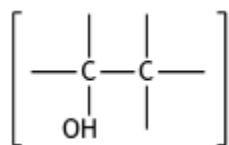
For example, if the data in a question is given to three significant figures, the intermediate value should have no fewer than two significant figures.

**(k) If a structural formula is asked for, CH<sub>3</sub> is acceptable as a methyl group, and CH<sub>3</sub>CH<sub>2</sub> and C<sub>2</sub>H<sub>5</sub> are acceptable as an ethyl group.**

If a name is asked for such as 3-methylhexane, then 3, methyl-hexane would be acceptable, ie ignore incorrect use of commas and dashes.

**(l) When drawing structural formulae, a mark should only be awarded if the bonds point to the appropriate atoms.**

The example below would be incorrect.

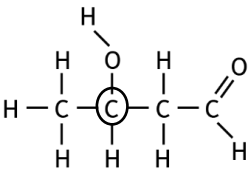


## Marking instructions for each question

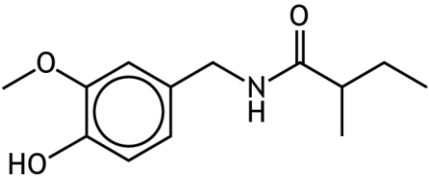
### Section 1

Question	Answer	Mark
1.	D	1
2.	C	1
3.	B	1
4.	B	1
5.	D	1
6.	C	1
7.	B	1
8.	B	1
9.	A	1
10.	D	1
11.	A	1
12.	C	1
13.	A	1
14.	A	1
15.	B	1
16.	D	1
17.	C	1
18.	D	1
19.	B	1
20.	A	1
21.	C	1
22.	D	1
23.	A	1
24.	C	1
25.	A	1

## Section 2

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i)	Second/2	1	
		(ii)	1.15 (1)  $\text{l mol}^{-1}\text{s}^{-1}$ (1)	2	1.1/1.15/1.147/1.1467 are also acceptable answers.  Allow follow through from part (i) for unit.  Allow units in any order .
		(iii)	Step 1 <b>AND</b> Both reactants/particles/species are involved <b>OR</b> $\text{CH}_3\text{CHO}$ and $\text{OH}^-$ are involved <b>OR</b> Step 1 is first order for both reactants <b>OR</b> Step 1 matches the rate equation	1	0 marks awarded for Step 1 with no explanation.  Both molecules are involved would be awarded 0 marks.
	(b)	(i)		1	
		(ii)	Contains <u>equal</u> amounts of both isomers/enantiomers <b>OR</b> It is a racemic mixture	1	A definition of optically inactive is not acceptable.

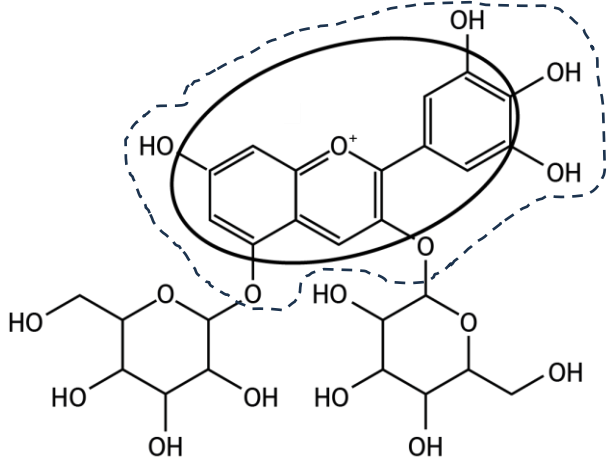
Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	Unreactive (with substances in the chilli peppers) <b>OR</b> Volatile/Low boiling point <b>OR</b> Able to dissolve the capsaicinoid <b>OR</b> Similar polarity to capsaicinoid	1	Answers that imply the chilli pepper will dissolve are not acceptable.
		(ii)	Vacuum <b>OR</b> Under reduced pressure	1	Accept a suitable labelled diagram with pump or vacuum.
	(b)		140000	1	140100/140070 are also acceptable answers.
	(c)	(i)	Agonist	1	
		(ii)	0.0825 (%)	1	0.083/0.08253/0.082529 are also acceptable answers.  Unit is not required but if given must be correct.

Question			Expected response	Max mark	Additional guidance
2.	(d)	(i)	Acid chlorides	1	
		(ii)	Condensation OR Nucleophilic substitution	1	Substitution, on its own, is not an acceptable answer.
		(iii)	 <p>Or any other correct structural formula</p>	1	

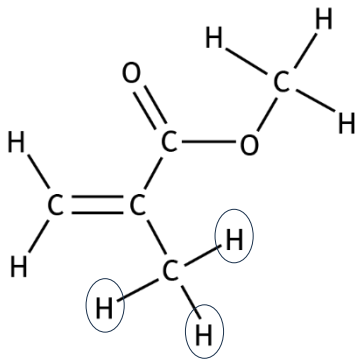
Question			Expected response	Max mark	Additional guidance
3.	(a)	(i)	Electrons in the same box/orbital have opposite/different spin <b>OR</b> Electrons are paired with opposite spins in each box/orbital	1	Answers referring only to the arrows and not electrons are not acceptable.  A definition of the Pauli exclusion principle in terms of quantum numbers without reference to spin is not enough for the mark to be awarded.
		(ii)	5, 0, 0, +½ <b>OR</b> 5, 0, 0, -½	1	Sign must be shown for ½.  Numbers without labels must match the order: n, l, m <sub>l</sub> , m <sub>s</sub>  If the labels have been given, they must be correct.
	(b)	(i)	Electron falls/moves down <b>OR</b> Jumps/moves to lower level	1	Any mention of absorption of light/HOMO and LUMO/d-d transitions is not acceptable.
		(ii)	477 (nm)  <b>Partial marking</b> 1 mark can be awarded for any one of the following:  $c=f\lambda$ and $E = hf$ <b>OR</b> $E = \frac{h c}{\lambda}$ <b>OR</b> Use of the correct equations	2	480/477.0/477.04 are also acceptable answers.  Unit not required but must be correct if given.  A correct answer given in metres only is awarded 1 mark.
	(c)	(i)	2	1	Award 0 marks if a + or - sign is given.
		(ii)	Tetradentate	1	Polydentate is not an acceptable answer.



Question			Expected response	Max mark	Additional guidance
3.	(d)	(i)	<p>Weigh an accurate mass that is close to 2.5 g</p> <p><b>OR</b></p> <p>The exact mass should be known/measured/weighed/given to 2 dp or more and should be close to 2.5 g/desired mass</p> <p><b>OR</b></p> <p>The mass does not need to be exactly 2.5 g/desired mass but it must be accurately measured/known/weighed/given to 2 dp or more</p>	1	
		(ii)	<p>The following 4 points:</p> <ul style="list-style-type: none"> <li>• heat</li> <li>• cool in a desiccator</li> <li>• weigh (crucible/sample)</li> <li>• repeat (heating, cooling and weighing) until there is no further change in mass / constant mass</li> </ul>	2	<p>2 marks awarded for all 4 points 1 mark awarded for 2 or 3 points 0 marks awarded for 1 point</p> <p>Use of a source of heat is acceptable for the first bullet point.</p> <p>Desiccator must be named but the function (prevent absorption of water) is not required.</p> <p>A maximum of 1 mark may be awarded if weighing comes before cooling.</p>
		(iii)	<p>6</p> <p><b>Partial marking</b> 1 mark can be awarded for any one of the following:</p> <p>Mass of both H<sub>2</sub>O (1.09g) and SrCl<sub>2</sub> (1.62 g)</p> <p><b>OR</b></p> <p>mol SrCl<sub>2</sub> = 0.01021</p> <p><b>OR</b></p> <p>mol H<sub>2</sub>O = 0.06056</p> <p><b>OR</b></p> <p>A correct whole number ratio from incorrect number(s) of moles</p>	2	<p>6 with no working would be awarded 0 marks.</p>

Question			Expected response	Max mark	Additional guidance
4.	(a)	(i)		1	<p>Solid circle shows the minimum acceptable.</p> <p>Dashed circle shows the maximum acceptable.</p>
		(ii)	Curve with the peak at a maximum between 500-560 nm	1	Spikes and inverse peaks are not acceptable.
	(b)		<p>One (line) represents end on overlap (to form a sigma bond) (1)</p> <p>One (line) represents side on/parallel overlap (to form a pi bond) (1)</p>	2	
	(c)		<p>Different conjugation/ different numbers of carbon atoms in conjugated system/different chromophore (1)</p> <p>Different energy gap between HOMO and LUMO (1)</p> <p><b>OR</b></p> <p>Smaller conjugated system/fewer (carbon) atoms in conjugated system/smaller chromophore (1)</p> <p>Larger energy gap between HOMO and LUMO/shorter wavelength of light absorbed (1)</p> <p><b>OR</b></p> <p>Larger conjugated system/more (carbon) atoms in conjugated system/larger chromophore (1)</p> <p>Smaller energy gap between HOMO and LUMO/longer wavelength of light absorbed (1)</p>	2	<p>Any mention of emission or d-d transitions is not acceptable for the second mark.</p> <p>The second mark for the wavelength of light cannot be awarded unless it matches a statement about the size of the conjugated system/chromophore.</p>

Question			Expected response	Max mark	Additional guidance
5.			<p>This is an open-ended question</p> <p><b>1 mark:</b> The candidate has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. They have made some statement(s) that are relevant to the situation, showing that they have understood at least a little of the chemistry within the context.</p> <p><b>2 marks:</b> The candidate has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. They make some statement(s) that are relevant to the situation, showing that they understand the context.</p> <p><b>3 marks:</b> The maximum available mark would be awarded to a candidate who has demonstrated, at an appropriate level, a good understanding, of the chemistry involved. The candidate shows a good comprehension of the chemistry of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the context. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks.</p>	3	<p><b>Award 0 marks</b> where the candidate has not demonstrated, at an appropriate level, an understanding of the chemistry involved. There is no evidence that they have recognised the area of chemistry involved, or they have not given any statement of a relevant chemistry principle. Award zero marks also if the candidate merely restates the chemistry given in the question.</p>

Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)	Radio (waves/frequency)	1	
		(ii)	TMS/tetramethylsilane	1	A structure on its own is not acceptable.
	(b)	(i)	 <p>Circling any number of the circled hydrogen atoms is acceptable.</p>	1	Circling the methyl group including the carbon atom is awarded 0 marks.
		(ii)	Lack of free rotation/restricted rotation	1	Accept a description of restricted rotation.
		(iii)	5	1	
	(c)		Any correct structural formula for ethyl ethanoate <b>OR</b> methyl propanoate	1	

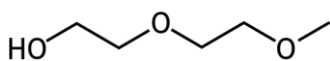
Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>	1	Any order
		(ii)	<p>4.41 (2)</p> <p><b>Partial marking</b> 1 mark can be awarded for any one of the following:</p> <p><math>\text{pH} = \frac{1}{2} \text{pK}_a - \frac{1}{2} \log_{10} c</math></p> <p><b>OR</b></p> <p>Correct substitution into the above equation</p> <p><b>OR</b></p> <p><math>[\text{H}^+] = \sqrt{(\text{K}_a c)}</math></p> <p><b>OR</b></p> <p>Calculating <math>\text{pK}_a = 3.86</math></p> <p><b>OR</b></p> <p>Correctly calculating a pH value from a calculated concentration of hydrogen ions.</p>	2	4.4/4.405/4.4055 are also acceptable answers.
	(b)	(i)	Complexometric (titration)	1	
		(ii)	<p>119 (mg) (2)</p> <p><b>Partial marking</b> 1 mark can be awarded for any one of the following:</p> <p>Moles of Ca in 100 cm<sup>3</sup> = <math>2.98 \times 10^{-3}</math></p> <p><b>OR</b></p> <p>Mass of Ca in 10 cm<sup>3</sup> = 0.0119498 g/11.9498 mg</p> <p><b>OR</b></p> <p>Correctly calculated mass in mg per 100 cm<sup>3</sup> from incorrectly calculated mass of Ca (in g) in 10 cm<sup>3</sup>.</p> <p><b>OR</b></p> <p>Correctly calculated mass in mg per 100 cm<sup>3</sup> from incorrectly calculated moles of Ca.</p>	2	<p>120/119.5/119.50 are also acceptable answers.</p> <p>Award 1 mark for a correct answer given in grams.</p>

Question			Expected response	Max mark	Additional guidance
8.	(a)	(i)	$K = \frac{[\text{SO}_2(\text{g})]^2 [\text{O}_2(\text{g})]}{[\text{SO}_3(\text{g})]^2}$	1	Round brackets are not acceptable in the equilibrium expression. State symbols are not required but must be correct if given. Must be a capital K.
		(ii)	0.0386  <b>Partial marking</b> 1 mark can be awarded for any one of the following: $[\text{SO}_3] = 0.450$ <b>OR</b> Correctly calculating a value for K using an incorrect value for $[\text{SO}_3]$	2	0.039/0.03858/0.038580 are also acceptable answers.  A value of K given with a unit is awarded a maximum of 1 mark.  Allow follow through for a correct use of an incorrect expression from part (a).
		(iii)	No effect/same value of K	1	
		(iv)	Reaction is endothermic <b>OR</b> The reverse reaction is exothermic (1)  Equilibrium shifts to the left <b>OR</b> Reverse reaction/reactants favoured <b>OR</b> $[\text{SO}_3]$ increases/more reactant <b>OR</b> $[\text{SO}_2]$ and/or $[\text{O}_2]$ decreases/less product (1)	2	Maximum of 1 mark if the candidate has not identified that $T_2$ is lower than $T_1$ .
	(b)		Greater/stronger repulsion by non-bonding pair(s)/lone pair(s) of electrons in sulfur dioxide	1	Answer must be clear that non-bonding/lone pairs are in sulfur dioxide.

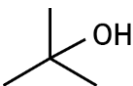
Question			Expected response	Max mark	Additional guidance
9.	(a)		Zinc ion/ $\text{Zn}^{2+}$ ion does not contain an incomplete d subshell.  <b>OR</b> Zinc ion/ $\text{Zn}^{2+}$ ion contains a full d subshell/ $3d^{10}$	1	
	(b)	(i) (A)	The following 4 statements <ul style="list-style-type: none"> <li>dissolving (the solid) in distilled/deionised water (in a beaker)</li> <li>transferring the solutions and rinsings into a volumetric/standard flask</li> <li>making up to the (graduation) mark with distilled/deionised water</li> <li>stoppering and inverting</li> </ul>	2	2 marks awarded for all 4 points 1 mark awarded for 2 or 3 points 0 marks awarded for 1 point  A maximum of 1 mark may be awarded if the solid is washed directly into the flask.  Only one mention of distilled/deionised water is required.  Only one mention of standard/volumetric flask is required.
		(i) (B)	The following 4 statements <ul style="list-style-type: none"> <li>Standard/accurate solutions or solutions of known concentration (are prepared/used).</li> <li>A suitable filter/wavelength</li> <li>Mention of a blank or solvent only measurement.</li> <li>Absorbance/transmittance of each solution is measured.</li> </ul>	2	2 marks awarded for all 4 points 1 mark awarded for 2 or 3 points 0 marks awarded for 1 point  A maximum of 1 mark can be awarded if any absorbance is measured before a filter is selected.
	(b)	(ii)	1.3 (%)  Partial marking  1 mark may be awarded for one of the following  $[\text{MnO}_4^-] = 1.4 \times 10^{-4} \text{ (mol l}^{-1}\text{)}$ <b>OR</b> Correct mass of Mn from $[\text{MnO}_4^-] \times 0.5 \times 54.9$	2	1/1.35/1.348 also acceptable answers.  Unit is not required but if given must be correct.

Question			Expected response	Max mark	Additional guidance
10.	(a)	(i)	-105 (kJ mol <sup>-1</sup> )	1	-110/-105.0 are also acceptable answers.  Unit not required but if given must be correct.
		(ii)	-79.5 (J K <sup>-1</sup> mol <sup>-1</sup> )  Partial marking 1 mark can be awarded for any one of the following: $\Delta G^\circ = -81.3$ (kJ mol <sup>-1</sup> ) <b>OR</b> Correct substitution into $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ <b>OR</b> $\Delta S^\circ = \frac{(\Delta H^\circ - \Delta G^\circ)}{T}$	2	-79.53/-79.530 are also acceptable answers.  Unit not required but if given must be correct.  Allow follow through from (i)  $\Delta S^\circ = -81.3$ is awarded 0 marks
		(iii)	1320 (K) (2)  Partial marking 1 mark can be awarded for any one of the following: $\Delta G = 0$ <b>OR</b> $T = \frac{\Delta H}{\Delta S}$ <b>OR</b> Correct substitution into equation above	2	1300/1321/1320.8 are also acceptable answers.  Follow through applies from a(i) and/or a(ii).  Units not required but must be correct if given.
	(b)		Heterogeneous	1	



Question			Expected response	Max mark	Additional guidance
10.	(c)		Addition <b>OR</b> Hydration <b>OR</b> Oxidation <b>OR</b> Hydrolysis	1	
	(d)			1	
	(e)		$\text{N}(\text{CH}_2\text{CH}_2\text{OH})_3$ <b>OR</b> $\text{C}_6\text{H}_{15}\text{NO}_3$ (any order) <b>OR</b> A correct structural formula	1	

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	0.31 (g)  <b>Partial marking</b> 1 mark can be awarded for any one of the following:  GFM of KHP = 204.1g <b>OR</b> A mass calculated using an incorrectly calculated GFM	2	0.3/0.306/0.3062 are also acceptable answers.  Unit not required but must be correct if given.
		(ii)	Indicator should have a range/ change colour/ $pK_{in}$ within the vertical part of the curve <b>OR</b> Indicator should have a range/ change colour/ $pK_{in}$ between 6 and 10	1	
		(iii)	Each sample could have a different mass.	1	
	(b)	(i)	Some of the mass weighed out will be impurities <b>OR</b> Not all the mass weighed out will be KHP <b>OR</b> More is needed to get the correct mass/moles of KHP	1	
		(ii)	1250 (ppm)	1	1300/1254/1254.1 are also acceptable answers.  Unit not required but must be correct if given.

Question			Expected response	Max mark	Additional guidance
12.	(a)		(2-)methylpropan-1-ol	1	
	(b)	(i)	$\text{H}^+/\text{H}_2\text{O}$ <b>OR</b> $\text{H}^+(\text{aq})$ <b>OR</b> $\text{H}_3\text{O}^+$ <b>OR</b> Aqueous acid/named aqueous acid <b>OR</b> Dilute acid/named dilute acid	1	Concentrated acid on its own is not acceptable.
		(ii)	 <b>OR</b> Any other correct structural formula for methylpropan-2-ol	1	
		(iii)	Less stable carbocation/intermediate formed (in methylpropan-1-ol/X) <b>OR</b> More stable carbocation/intermediate formed in major product/isomer of X/ methylpropan-2-ol	1	
	(c)	(i)	Bond breaks and each atom retains one electron from the bond <b>OR</b> Bond breaks evenly <b>OR</b> Diagram with correct half headed curly arrows showing a bond breaking	1	The answer must refer to bond breaking.  Any mention of ions is not acceptable.
		(ii)	Mixture of products formed <b>OR</b> Side reactions	1	

Question			Expected response	Max mark	Additional guidance
12.	(d)		<p>This is an open-ended question</p> <p><b>1 mark:</b> The candidate has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. They have made some statement(s) that are relevant to the situation, showing that they have understood at least a little of the chemistry within the context.</p> <p><b>2 marks:</b> The candidate has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. They make some statement(s) that are relevant to the situation, showing that they understand the context.</p> <p><b>3 marks:</b> The maximum available mark would be awarded to a candidate who has demonstrated, at an appropriate level, a good understanding, of the chemistry involved. The candidate shows a good comprehension of the chemistry of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the context. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks.</p>	3	<p><b>Award 0 marks</b> where the candidate has not demonstrated, at an appropriate level, an understanding of the chemistry involved. There is no evidence that they have recognised the area of chemistry involved, or they have not given any statement of a relevant chemistry principle. Award zero marks also if the candidate merely restates the chemistry given in the question.</p>

[END OF MARKING INSTRUCTIONS]