

# Markscheme

November 2022

Chemistry

Standard level

Paper 2

14 pages

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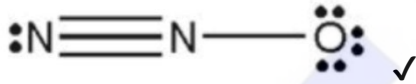
## Subject Details: Chemistry Standard level Paper 2 Markscheme

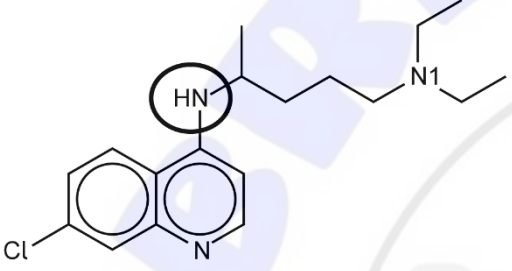
Candidates are required to answer **ALL** questions. Maximum total = [50 marks].

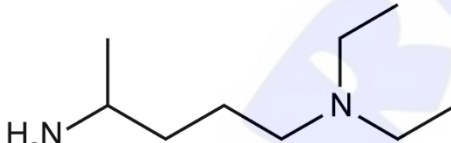
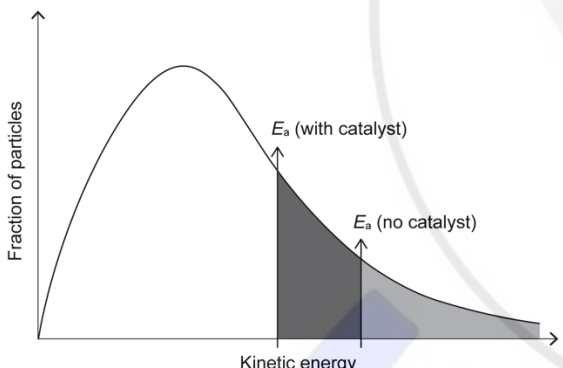
1. Each row in the “Question” column relates to the smallest subpart of the question.
2. The maximum mark for each question subpart is indicated in the “Total” column.
3. Each marking point in the “Answers” column is shown by means of a tick (✓) at the end of the marking point.
4. A question subpart may have more marking points than the total allows. This will be indicated by “**max**” written after the mark in the “Total” column. The related rubric, if necessary, will be outlined in the “Notes” column.
5. An alternative word is indicated in the “Answers” column by a slash (/). Either word can be accepted.
6. An alternative answer is indicated in the “Answers” column by “**OR**”. Either answer can be accepted.
7. An alternative markscheme is indicated in the “Answers” column under heading **ALTERNATIVE 1** etc. Either alternative can be accepted.
8. Words inside chevrons « » in the “Answers” column are not necessary to gain the mark.
9. Words that are underlined are essential for the mark.
10. The order of marking points does not have to be as in the “Answers” column, unless stated otherwise in the “Notes” column.
11. If the candidate’s answer has the same “meaning” or can be clearly interpreted as being of equivalent significance, detail and validity as that in the “Answers” column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect) in the “Notes” column.
12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.
14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the “Notes” column.
15. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the “Notes” column. Similarly, if the formula is specifically asked for, do not award a mark for a correct name unless directed otherwise in the “Notes” column.
16. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the “Notes” column.
17. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the “Notes” column.

Question		Answers	Notes	Total
1.	(a)	$\%N = \frac{2 \times 14.01 \text{ g mol}^{-1}}{(2 \times 14.01 \text{ g mol}^{-1} + 4 \times 1.01 \text{ g mol}^{-1} + 3 \times 16.00 \text{ g mol}^{-1})} \times 100\% \Rightarrow 35.00\% \checkmark$		1
1.	(b)	<p>«Brønsted-Lowry» acid <b>AND</b> can donate a proton/H<sup>+</sup>  <b>OR</b>                      «Brønsted-Lowry» acid <b>AND</b> cannot accept proton/H<sup>+</sup> ✓</p>		1
1	(c)	$\left[ \begin{array}{c} \text{:}\ddot{\text{O}}\text{:} \\   \\ \text{:}\ddot{\text{O}}\text{=N}-\ddot{\text{O}}\text{:} \\ \text{:} \end{array} \right]^{1-} \checkmark$	<p>Negative charge must be included on square bracket or singly-bonded oxygen atom.</p> <p>Accept <math display="block">\begin{array}{c} \text{:}\ddot{\text{O}}\text{:}^- \\   \\ \text{:}\ddot{\text{O}}\text{=N}^+-\ddot{\text{O}}\text{:}^- \end{array}</math></p> <p>Accept any combination of dots/crosses or lines to represent electron pairs.</p>	1
1.	(d)	$\text{pH} = -\log(1.07 \times 10^{-5}) \Rightarrow 4.97 \checkmark$		1

Question			Answers	Notes	Total
1.	(e)	(i)	$q = mc\Delta T = 25.32 \text{ g} \times 4.18 \text{ J g}^{-1}\text{K}^{-1} \times (25.2^\circ\text{C} - 0.8^\circ\text{C}) \Rightarrow 2580 \text{ «J» } \checkmark$	Do <b>not</b> accept a negative value.	1
1.	(e)	(ii)	$2.58 \times 10^3 \text{ J} \times \frac{1 \text{ kJ}}{1000 \text{ J}} \times \frac{1 \text{ mol}}{25.69 \text{ kJ}} \Rightarrow 0.100 \text{ «mol» } \checkmark$ $0.100 \text{ mol} \times 80.06 \text{ g mol}^{-1} \Rightarrow 8.01 \text{ «g» } \checkmark$	Award <b>[2]</b> for the correct final answer. Accept range of 8.00 – 8.10 «g». If $3.11 \times 10^3 \text{ J}$ used then answer is 9.69 «g».	2
1.	(e)	(iii)	$\text{fractional / \% uncertainty in } \Delta T \Rightarrow \frac{0.4}{24.4} / 0.02 / 2\% \checkmark$ $\text{fractional / \% uncertainty in } m \Rightarrow \frac{0.01}{25.32} / 0.0004 / 0.04\% \checkmark$ <p><b>OR</b></p> fractional / \% uncertainty in $m$ is much smaller than uncertainty in $\Delta T \checkmark$ $2\% \times 8.01 \text{ g} \Rightarrow 0.2 \text{ «g» } \checkmark$	Award <b>[3]</b> for correct final answer. Accept range of 0.1 g – 0.2 «g». If 6.55 g used then the answer is 0.1 «g».	3
1.	(e)	(iv)	$\% \text{ error} = \left  \frac{9.50 \text{ g} - 8.01 \text{ g}}{9.50 \text{ g}} \right  \times 100 \% \Rightarrow 15.7\% \checkmark$	Accept range 14.7 – 15.8«%». If 6.55 g used then answer is 31.1«%».	1
1.	(f)	(i)	$\text{NH}_4\text{NO}_3(\text{s}) \rightarrow \text{N}_2\text{O}(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \checkmark$		1

Question			Answers	Notes	Total
1.	(f)	(ii)	$\llcorner 5.00 \text{ g} \div 80.06 \text{ g mol}^{-1} \Rightarrow 0.0625 \text{ mol} \llcorner \text{NH}_4\text{NO}_3 \gg \checkmark$ $\llcorner 1:1 \text{ mol ratio} \gg$ $\llcorner 0.0625 \text{ mol N}_2\text{O} \times \frac{22.7 \text{ dm}^3}{\text{mol}} \Rightarrow 1.42 \llcorner \text{dm}^3 \gg \checkmark$	Award [2] for correct final answer. Accept range 1.36 – 1.43 «dm <sup>3</sup> ». Accept calculations based on PV=nRT.	2
1.	(f)	(iii)	$2 \times -285.8 \llcorner \text{kJ mol}^{-1} \gg \checkmark$ $\llcorner 1 \text{ mol} (82 \text{ kJ mol}^{-1}) + 2 \text{ mol} (-285.8 \text{ kJ mol}^{-1}) - 1 \text{ mol} (-366 \text{ kJ mol}^{-1}) \Rightarrow -124 \llcorner \text{kJ} \gg \checkmark$	Award [2] for correct final answer.	2
1.	(f)	(iv)	Lewis structure:  Shape: linear $\checkmark$	Accept $\begin{array}{c} \text{:N=N=O:} \\ \text{:} \end{array}$ OR $\begin{array}{c} \text{:N-N=O} \\ \text{:} \end{array}$ Only award M2 if the shape corresponds to that expected for the Lewis structure given.	2

Question		Answers	Notes	Total
2.	(a)	 ✓		1
2.	(b)	seven/7 ✓		1
2.	(c)	«bond in ring is» shorter <b>AND</b> more electrons are shared <b>OR</b> «bond in ring is» shorter <b>AND</b> partial double/multiple bonding/bond order 1.5 ✓		1
2.	(d)	nitrogen <b>AND</b> larger number of protons/nuclear charge/ $Z_{\text{eff}}$ <b>OR</b> nitrogen <b>AND</b> smaller «atomic» radius ✓	Accept nitrogen <b>AND</b> further along period.	1

Question			Answers	Notes	Total
2.	(e)	(i)	 <p>primary amine/-NH<sub>2</sub> ✓ rest of structure ✓</p>	Do not penalize using "N1".	2
2.	(e)	(ii)	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$ / $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$ <b>OR</b> $[\text{Ar}]4s^1 3d^{10}$ / $[\text{Ar}]3d^{10} 4s^1$ ✓		1
2.	(e)	(iii)	 <p>both <math>E_a</math> values marked <b>AND</b> left one labelled catalysed ✓</p>		1
2.	(e)	(iv)	increases rate <b>AND</b> there is a greater area under the curve past activation energy <b>OR</b> increases rate <b>AND</b> greater proportion of/more molecules have «kinetic» $E \geq E_a$ «(cat) than $E_a$ (uncat)» ✓	Do not award a mark for general statements about catalysts such as "provides alternative pathway" or "lowers $E_a$ ".	1

Question			Answers	Notes	Total
3.	(a)		$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ <b>OR</b> $[Ar] 3d^6 \checkmark$		1
3.	(b)		$\frac{(63 \times 69) + (65 \times 31)}{100}$ <b>OR</b> $65x + (1 - x)63 = 63.62$ <b>AND</b> $x = 0.31 / 31\% \checkmark$ <b>AND</b> $1 - x = 0.69 / 69\% \checkmark$		1
3.	(c)	(i)	<p>all 4 species correctly labelled <math>\checkmark</math>                      arrow showing electron flow from anode to cathode in the external circuit <math>\checkmark</math></p>	Accept any soluble salt of copper(II) for $Cu^{2+}$ and any soluble salt of iron(II) for $Fe^{2+}$ .  Do <b>not</b> apply ECF for M2.	2
3.	(c)	(ii)	$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^- \checkmark$	Accept equilibrium arrow.  Do <b>not</b> award ECF for $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ .	1

Question			Answers	Notes	Total
3.	(c)	(iii)	«keep» each half-cell/electrolyte «electrically» neutral ✓	<p>Accept balance charges/ions.</p> <p>Accept allow ion flow «between cells».</p>	1
3.	(c)	(iv)	<p><math>\text{NO}_3^-</math> to anode/Fe/left ✓</p> <p><math>\text{K}^+</math> «and <math>\text{Fe}^{2+}</math>» to cathode/Cu/right ✓</p>	<p>Accept other specific anions in addition to nitrate for M1.</p> <p>Award <b>[1 max]</b> for “anions/negative ions to anode <b>AND</b> cations/positive ions to cathode”.</p>	2

Question			Answers	Notes	Total
4.	(a)	(i)	<p>Structure:</p> <p>ester functional group ✓ rest of structure ✓</p> <p>Empirical Formula: C<sub>3</sub>H<sub>5</sub>O ✓</p>	Accept condensed/skeletal formula.	3
4.	(a)	(ii)	<p>dilute adds «excess» water <b>OR</b> water is a product ✓</p> <p>shift left <b>AND</b> decreases yield ✓</p>		2

Question			Answers	Notes	Total
4.	(a)	(iii)	<p><b>A</b> has hydrogen bonding/bonds «and dipole-dipole and London/dispersion forces»  <b>AND B</b> has dipole-dipole «and London/dispersion forces»</p> <p><b>OR</b></p> <p><b>A</b> has hydrogen bonding/bonds <b>AND B</b> does not ✓</p> <p>intermolecular forces are weaker in <b>B</b></p> <p><b>OR</b></p> <p>hydrogen bonding/bonds stronger «than dipole-dipole» ✓</p>		2
4.	(b)		brown/orange/red/yellow to colourless ✓	<i>Do not accept clear for colourless.</i>	1

Question		Answers	Notes	Total
5.	(a)	$\llcorner 0.40\% \times 500.0g = \gg 2.0 \llcorner \text{g} \llcorner \checkmark$  $\llcorner 2.0g \times \frac{1 \text{ mol } S}{32.07g} = 0.062 \text{ mol of } S \llcorner = 0.062 \llcorner \text{mol of } SO_2 \llcorner \checkmark$	Award [2] for correct final answer.  Accept 0.063 «mol».	2
5.	(b)	$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$  <b>OR</b>  $SO_2(g) + \frac{1}{2}O_2(g) \rightarrow SO_3(g)$ <b>AND</b> $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$  <b>OR</b>  $SO_2(g) + \frac{1}{2}O_2(g) + H_2O(l) \rightarrow H_2SO_4(aq) \checkmark$	Accept ionized forms of acids.	1
5.	(c)	Any two of: depth/volume «of solution» $\checkmark$  colour/darkness/thickness/size/background of mark $\checkmark$  intensity of lighting in the lab $\checkmark$	Accept same size flask.  Accept position of observation/person observing.  Accept same equipment/apparatus.  Do <b>not</b> accept catalyst/particle size/pressure/time.	2 max

Question		Answers	Notes	Total
5.	(d)	<p>Any <b>two</b> of:</p> <p>remove sulfur from coal ✓</p> <p>add lime during combustion ✓</p> <p>not allow sulfur oxides to be released into the environment ✓</p> <p>reduce proportion/percentage of energy/power produced by «the combustion of» coal ✓</p>	<p>Accept any valid method to wash coal and remove sulfur content for M1.</p> <p>Accept any valid combustion/post-combustion method to remove sulfur oxides.</p> <p>Accept any suggestion that would reduce the amount of coal that is burnt or would reduce the damage caused.</p> <p>Do <b>not</b> accept answers that only reduce production of SO<sub>2</sub>/CO<sub>2</sub> from other fuels.</p> <p>Accept “improve efficiency of energy production from coal”.</p> <p>Accept “use coal of lower sulfur content” <b>OR</b> “cleaner coal”.</p>	2 max