

52nd INTERNATIONAL CHEMISTRY OLYMPIAD

2020

UK Round One

MARK SCHEME

Although we would encourage students to always quote answers to an appropriate number of significant figures, do not penalise students for significant figure errors. Allow where a student's answers differ slightly from the mark scheme due to the use of rounded/non-rounded data from an earlier part of the question.

In general, 'error carried forward' (referred to as ECF) can be applied. We have tried to indicate where this may happen in the mark scheme.

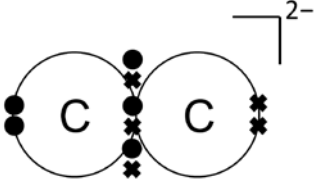
For answers with missing or incorrect units, penalise one mark for the first occurrence in **each** question and write **UNIT** next to it. Do not penalise for subsequent occurrences in the same question.

Organic structures are shown in their skeletal form, but also accept displayed formulae as long as the representation is unambiguous.

State symbols are not required for balanced equations and students should not be penalised if they are absent.

No half marks are to be awarded. One blank tick box has been included per mark available for each part. Please mark by placing a tick in each box if mark is scored.

Question	1	2	3	4	5	6	Total
Marks Available	10	10	17	12	17	20	86

1.	This question is about calcium carbide	Mark
(a)	(i) $\text{CaO} + 3\text{C} \rightarrow \text{CaC}_2 + \text{CO}$ <i>Must be fully correct for mark.</i>	☑
	(ii) <div style="text-align: center;">  </div> <i>Charge must be indicated for mark to be awarded.</i>	☑
(b)	$\text{CaC}_2 + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{C}_2\text{H}_2$ <i>Must be fully correct for mark.</i>	☑
(c)	Moles of $\text{HCl(aq)} = 0.0346 \text{ dm}^3 \times 0.250 \text{ mol dm}^{-3} = 8.65 \times 10^{-3} \text{ mol}$ Moles of Ca(OH)_2 in $20.0 \text{ cm}^3 = 8.65 \times 10^{-3} \text{ mol} / 2 = 4.325 \times 10^{-3} \text{ mol}$ in 20.0 cm^3 Moles of Ca(OH)_2 in $50.0 \text{ cm}^3 = 2.5 \times 4.325 \times 10^{-3} \text{ mol} = 0.0108 \text{ mol}$ <i>(One mark)</i> Moles of $\text{CaC}_2 = 0.0108 \text{ mol}$ $M_r(\text{CaC}_2) = 64.1 \text{ g mol}^{-1}$ Mass of $\text{CaC}_2 = 0.0108 \text{ mol} \times 64.1 \text{ g mol}^{-1} = 0.693 \text{ g}$ Percentage by mass $\text{CaC}_2 = 0.693 \text{ g} / 0.752 \text{ g} = 92.2\%$ <i>(One mark)</i> <i>Correct answer scores both marks regardless of working.</i>	☑ ☑
(d)	2 calcium atoms and 4 carbon atoms. <i>1 mark for each correct answer.</i>	☑ ☑
(e)	Molar volume of $\text{CaC}_2 = 64.1 \text{ g mol}^{-1} / 2.20 \text{ g cm}^{-3} = 29.14 \text{ cm}^3 = 2.914 \times 10^{-5} \text{ m}^3$ <i>One mark for correct molar volume in m^3.</i> Volume of CaC_2 unit cell $= 2 \times 2.914 \times 10^{-5} \text{ m}^3 / 6.02 \times 10^{23} \text{ mol}^{-1}$ $= 9.68 \times 10^{-29} \text{ m}^3 = 96.8 \text{ \AA}^3$ <i>One mark for correct molar volume in m^3 or in \AA^3.</i> Length of side $z = 9.68 \times 10^{-29} \text{ m}^3 / (3.88 \times 10^{-10} \text{ m})^2 = 6.43 \times 10^{-10} \text{ m} = 6.43 \text{ \AA}$ <i>One mark</i> <i>Correct answer scores three marks regardless of working.</i>	☑ ☑ ☑
Total out of 10		10

2.	This question is about hydrogen as a fuel	Mark
(a)	$\Delta H^{\ominus}_r = \Sigma \Delta H^{\ominus}_f (\text{Products}) - \Sigma \Delta H^{\ominus}_f (\text{Reactants})$ $\Delta H^{\ominus}_r = -393.5 \text{ kJ mol}^{-1} - (-74.8 \text{ kJ mol}^{-1} + 2 \times -285.8 \text{ kJ mol}^{-1})$ $= +253 \text{ kJ mol}^{-1}$	<input checked="" type="checkbox"/>
(b)	<p>Reaction 2: $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$</p> <p><i>(Reduction occurs at the cathode). Either "Reaction 2" or the reaction equation gets the mark.</i></p>	<input checked="" type="checkbox"/>
(c)	$\Delta H^{\ominus} = 2 \times 285.8 \text{ kJ mol}^{-1} = +571.6 \text{ kJ mol}^{-1}$ <p><i>Sign must be correct for mark. A negative value scores zero marks.</i></p>	<input checked="" type="checkbox"/>
(d)	$\Delta S^{\ominus} = 2 \times 163.0 \text{ J K}^{-1} \text{ mol}^{-1} = +326.0 \text{ J K}^{-1} \text{ mol}^{-1}$ $\Delta G^{\ominus} = 571.6 \text{ kJ mol}^{-1} - 298 \text{ K} \times 0.326 \text{ kJ K}^{-1} \text{ mol}^{-1} = +474.5 \text{ kJ mol}^{-1} \text{ (one mark)}$ $E^{\ominus} = 474.5 \times 10^3 \text{ J mol}^{-1} / (4 \times 96485 \text{ C mol}^{-1}) = -1.23 \text{ V (one mark)}$ <p><i>Correct final answer scores both marks. One mark for calculation of ΔG^{\ominus} and one mark for calculation of E^{\ominus}.</i></p> <p><i>ECF: Allow ECF from part (c).</i></p>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
(e)	$E^{\ominus} = -1.23 \text{ V}$ <p><i>(the same answer as in part (d) – the other half reaction is the standard hydrogen electrode with $E^{\ominus} = 0.00 \text{ V}$)</i></p> <p><i>ECF: Accept if answer is same as part (d) or answer is -1.13 V if no answer achieved for part (d).</i></p>	<input checked="" type="checkbox"/>
(f)	$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$ $\Delta H^{\ominus}_r = \Sigma \Delta H^{\ominus}_f (\text{Products}) - \Sigma \Delta H^{\ominus}_f (\text{Reactants})$ $\Delta H^{\ominus}_r = 2 \times -285.8 \text{ kJ mol}^{-1} - 393.5 \text{ kJ mol}^{-1} + 74.8 \text{ kJ mol}^{-1} = -890 \text{ kJ mol}^{-1}$	<input checked="" type="checkbox"/>
(g)	$\Delta H^{\ominus}_r = -285.8 \text{ kJ mol}^{-1}$ <p><i>The same reaction as the standard enthalpy change of formation of water, which is given.</i></p> <p><i>This is the only correct answer – no ECF for this part.</i></p>	<input checked="" type="checkbox"/>

(h) relative $M_r(\text{H}_2) = 2$ relative $M_r(\text{CH}_4) = 16$

Ratio = heat released with H_2 / heat released with CH_4

$$= (-285.8 \text{ kJ mol}^{-1} / 2^{1/2}) / (-890.3 \text{ kJ mol}^{-1} / 16^{1/2})$$

$$= 0.908 \text{ or } 0.908 \text{ to } 1 \text{ or } 1 \text{ to } 1.101.$$

ECF: Answer = (answer to part (g) $\times 16^{1/2}$) / (2^{1/2} \times answer to part (f))

Answer with given values = (-352.8 kJ mol⁻¹ / 2^{1/2}) / (-943.2 kJ mol⁻¹ / 16^{1/2})

$$= 1.058$$

Correct final answer scores two marks. This must be the correct way around, i.e. value lower than 1. One mark is given for the inverse ratio of 1.101 or 1.101 to 1. All other values score no marks.



Total out of 10

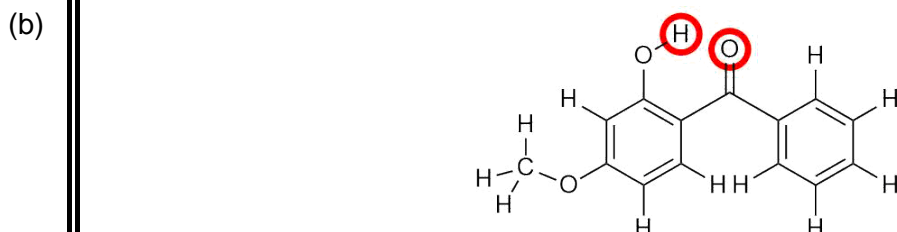
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3. This question is about sun cream

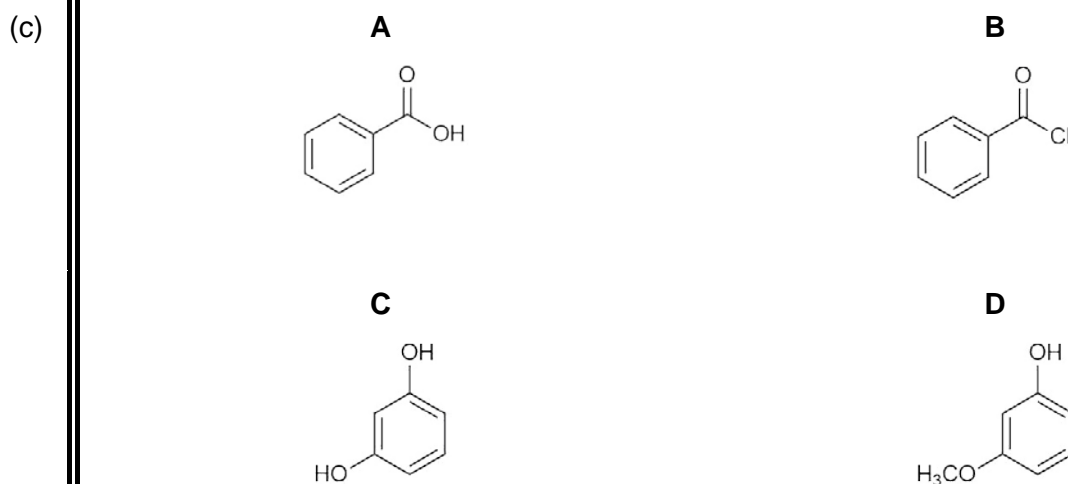
Mark

- | | | | |
|-----|-----------------|----------|--------|
| (a) | ester | aldehyde | ketone |
| | | | ✓ |
| | carboxylic acid | ether | phenol |
| | | ✓ | ✓ |

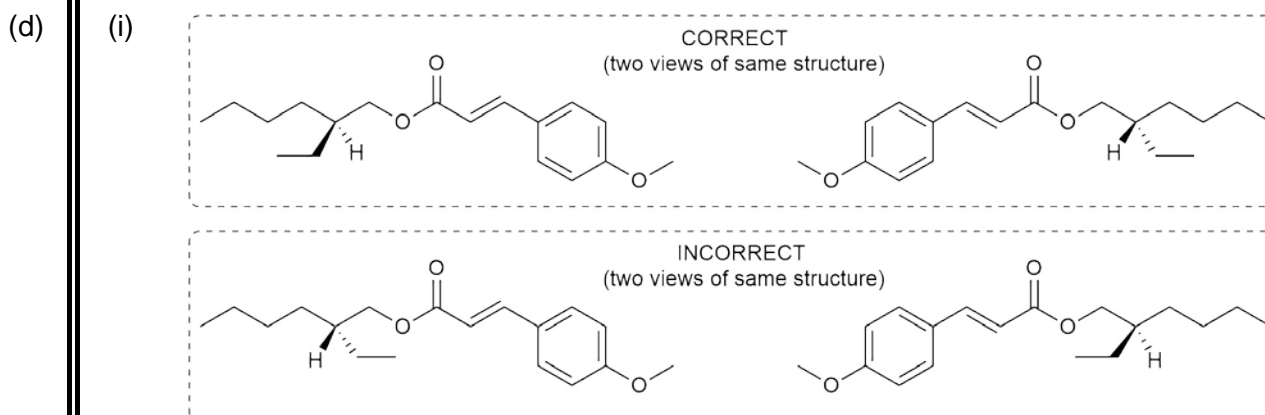
Must all be correct for mark.



Only these two atoms must be circled for the mark.

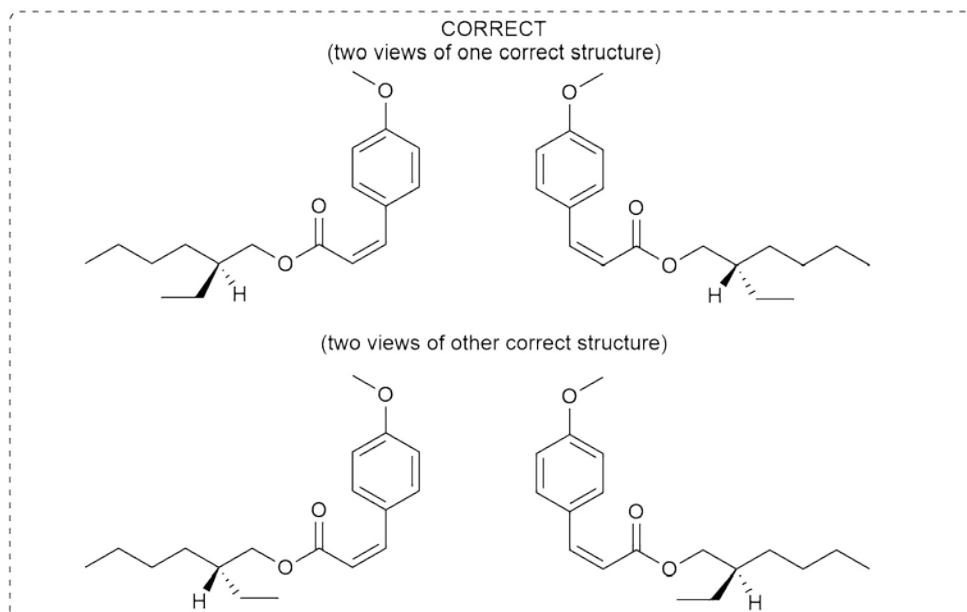


One mark each. No ECF to be awarded as there is sufficient information to work backwards as well as forwards.



Double bond must be unambiguously trans. Stereochemistry of chiral centre must be clearly indicated as of (S) configuration (as drawn in the CORRECT views) and not of (R) configuration (as drawn in the INCORRECT views). Abbreviations are allowed as long as groups are unambiguously defined.

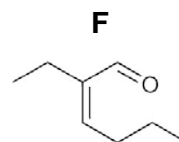
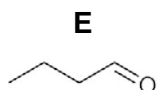
(ii)



Double bond must be unambiguously cis. No marks if trans. Stereochemistry of chiral centre can be either S or R but must be drawn unambiguously. Abbreviations are allowed as long as groups are unambiguously defined.



(e)

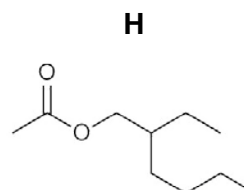
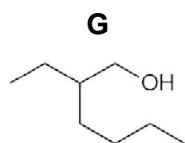


No ECF. Accept both cis and trans isomers or if stereochemistry drawn as undefined.

One mark each.



(f)



*No stereochemistry required. ECF can be awarded only if structure has no alkene or carbonyl functional groups and is consistent with the structure of **F** (having been reduced) or consistent with the structure of **H** (the alcohol to make the ester).*

No ECF. No stereochemistry required.

One mark each.



(g)

The same molecular formula ✓

The same melting points

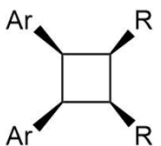
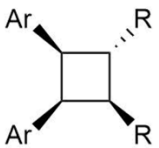
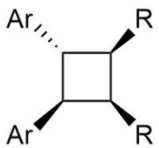
Rotate plane-polarised light in the same direction

If any other answer ticked then no marks.



(h)

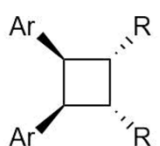
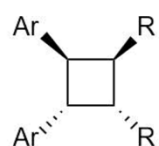
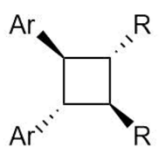
(i)

Substituents on the same face	Truxinates	
Four		
Has enantiomer?	YES	NO
Three		
Has enantiomer?	YES NO	YES NO

All must be correct for mark.



(ii)

Substituents on the same face	Truxinates	
Two		
Has enantiomer?	YES NO	YES NO
Two (continued)		
Has enantiomer?	YES NO	YES NO

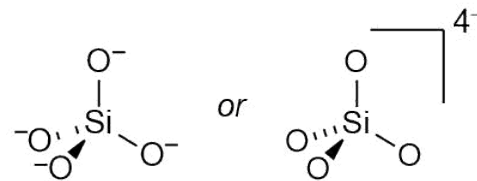
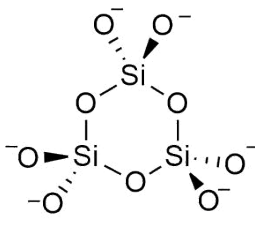
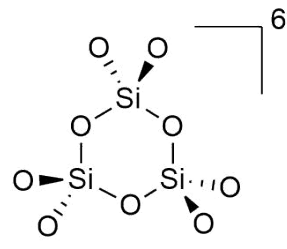
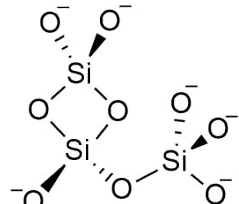
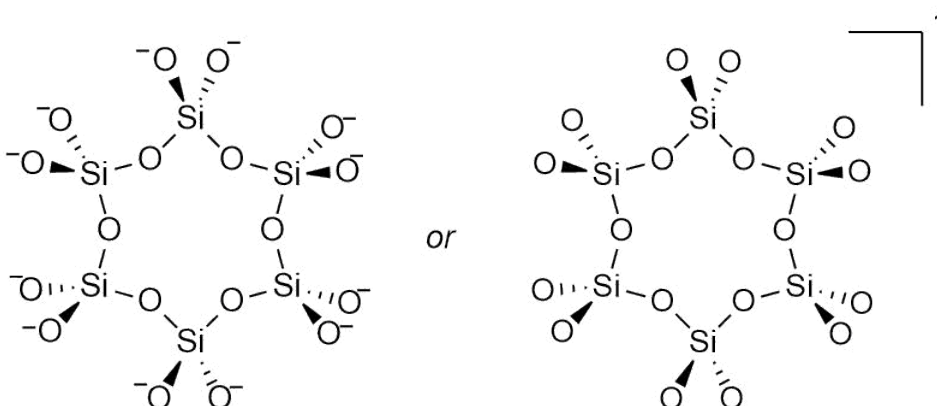
The structures are worth two of the three marks. The structures can be in any order. Three correct structures and one blank box is worth two marks. Two correct structures and two blank boxes is worth one mark. Three correct structures and one incorrect structure or duplicated structure is worth one mark. All other combinations are worth zero marks for this part.

The YES/NO for enantiomers are worth one of the three marks. Must all be correct for the mark. Every structure they have drawn must have the correct YES/NO for that structure. (NB Any structure with a plane of symmetry or a centre of inversion does not have an enantiomer and so is a NO, others are YES). This means ECF is being awarded for the chirality mark, i.e. if the YES/NO are consistent for every structure they have drawn they get the mark.



Total out of 17

17

4.	This question is about silicon oxides	Mark
(a)	(i) CO_2	<input checked="" type="checkbox"/>
	(ii) <div style="text-align: center;">  </div> <p><i>A total charge of 4- or four individual charges of 1- must be indicated for mark to be awarded.</i></p> <p><i>(X = Na₄SiO₄ – This is not needed for the mark).</i></p>	<input checked="" type="checkbox"/>
	(iii) $\text{SiO}_2 + 2\text{Na}_2\text{CO}_3 \rightarrow \text{Na}_4\text{SiO}_4 + 2\text{CO}_2$ <i>Must be fully correct for mark.</i>	<input checked="" type="checkbox"/>
	(b) $\text{CaSiO}_3 + 2\text{HCl} + 10\text{H}_2\text{O} \rightarrow \text{SiO}_2 \cdot 11\text{H}_2\text{O} + \text{CaCl}_2$ <i>Must be fully correct for mark.</i>	<input checked="" type="checkbox"/>
	(c) 4	<input checked="" type="checkbox"/>
	(d) (i) <div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center;">  </div> <div style="margin: 0 20px;">or</div> <div style="text-align: center;">  </div> <div style="border: 1px dashed black; padding: 5px; margin-left: 20px;"> <p>An alternative structure that deserves credit as satisfies rules</p>  </div> </div> <p><i>The overall charge must be indicated as 6- or the sum of individual charges must be equal to 6-. 3D shape is not important. Credit can be given for alternative answers as long as formula is correct, overall charge is correct, and has only Si–O bonds and no Si=O double bonds, Si–Si bonds or O–O bonds drawn. An example of an alternative (incorrect) structure which should be credited is shown.</i></p>	<input checked="" type="checkbox"/>
	(ii) <div style="text-align: center;">  </div> <p><i>The overall charge must be indicated as 12- or the sum of individual charges must be equal to 12-. 3D shape is not important. Credit can be given for alternative answers as long as formula is correct, overall charge is correct, and has only Si–O bonds and no Si=O double bonds, Si–Si bonds or O–O bonds drawn.</i></p>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>

(e) From overall formula need to remove $3 \times \text{Mg}^{2+}$ and $2 \times \text{OH}^-$

This leaves $[\text{Si}_4\text{O}_{10}]^{4-}$

The overall charge must be indicated for the mark.



(f) Mineral

$$20.32 \text{ g} / 24.305 \text{ g mol}^{-1} = 0.836 \text{ mol Mg} = n \text{ Mg}$$

$$28.18 \text{ g} / 28.035 \text{ g mol}^{-1} = 1.003 \text{ mol Si} = n \text{ Si} \quad (\text{One mark for both})$$

Talc has ratio of 3 Mg to 4 Si

Chrysotile has 3 Mg to 2 Si.

Mineral with x talc and $(1 - x)$ chrysotile has ratio 3 Mg to $2(1+x)$ Si

$$\text{So } n \text{ Si} / n \text{ Mg} = 2(1 + x) / 3 \quad (\text{One mark})$$

$$n \text{ Si} / n \text{ Mg} = 1.003 / 0.836 = 2(1 + x) / 3$$

$$x = 0.8$$

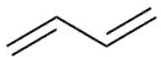
so 80% talc (One mark)

Correct final answer with working scores three marks. Exact steps may vary. First mark can be awarded for correct calculation of the number of moles of both Mg and Si. Second mark can be awarded for a correct ratio in terms of x and $1-x$ (can be either way around). Third mark is only for correct answer as a percentage.



Total out of 12

12

5.	This question is about colourful compounds	Mark
(a)		☑
(b)	(i) $\Delta E = 6.626 \times 10^{-34} \text{ m}^2 \text{ kg s}^{-1} \times 2.998 \times 10^8 \text{ m s}^{-1} / 210 \times 10^{-9} \text{ m}$ $= 9.46 \times 10^{-19} \text{ J}$ or $9.46 \times 10^{-19} \text{ m}^2 \text{ kg s}^{-2}$	☑
	(ii) $L^2 = \frac{(2n + 1)h^2}{8m_e\Delta E}$ $n = 2$ (One mark) $L^2 = 5 \times (6.626 \times 10^{-34} \text{ m}^2 \text{ kg s}^{-1})^2 / (8 \times 9.109 \times 10^{-31} \text{ kg} \times 9.46 \times 10^{-19} \text{ m}^2 \text{ kg s}^{-2})$ $= 3.1844 \times 10^{-19} \text{ m}^2$ $L = 5.64 \times 10^{-10} \text{ m}$ $= 5.64 \text{ \AA}$ (One mark) <i>Correct answer in \AA scores both marks. First mark can be awarded for explicit statement of $n = 2$. Do not award second mark if answer is only in m and not in \AA.</i> <i>ECF: Answer = $(5.49 \times 10^{-9} / \text{answer to part (i)}^{1/2}) \text{ \AA}$</i>	☑ ☑
(c)	(i) $\varepsilon = \lambda / d^2$ $= 5714 \text{ \AA} / (2 \times 2.052 \text{ \AA})^2$ $\varepsilon = 339.3 \text{ \AA}^{-1}$ <i>No mark if given in different units.</i>	☑
	(ii) $d^2 = \lambda / \varepsilon$ $d^2 = 5687 \text{ \AA} / 339.3 \text{ \AA}^{-1}$ $d^2 = 16.7609 \text{ \AA}^2$ $d = 4.094 \text{ \AA}$ N–Zn bond = 2.047 \AA <i>No mark if given in different units.</i>	☑
	(iii) $\lambda = \varepsilon d^2$ $\lambda = 339.3 \text{ \AA}^{-1} \times (4.112 \text{ \AA})^2$ $\lambda = 573.7 \text{ nm}$ <i>No mark if given in different units.</i>	☑

(d)

$$k_{1(493K)} = A \exp\left(-\frac{E_a}{RT_{(493K)}}\right)$$

$$k_{1(393K)} = A \exp\left(-\frac{E_a}{RT_{(393K)}}\right)$$

$$\frac{k_{1(493K)}}{k_{1(393K)}} = \exp\frac{E_a}{R}\left(-\frac{1}{T_{(493K)}} + \frac{1}{T_{(393K)}}\right) \text{ One mark}$$

$$\ln\left(\frac{k_{1(493K)}}{k_{1(393K)}}\right) = \frac{E_a}{R}\left(-\frac{1}{T_{(493K)}} + \frac{1}{T_{(393K)}}\right) \text{ One mark}$$

$$E_a = \frac{R \ln\left(\frac{k_{1(493K)}}{k_{1(393K)}}\right)}{\left(-\frac{1}{T_{(493K)}} + \frac{1}{T_{(393K)}}\right)}$$

$$E_a = \frac{8.314 \text{ J K}^{-1} \text{ mol}^{-1} \ln\left(\frac{3.31 \times 10^{12} \text{ s}^{-1}}{1.32 \times 10^{12} \text{ s}^{-1}}\right)}{\left(-\frac{1}{493 \text{ K}} + \frac{1}{393 \text{ K}}\right)}$$

$$E_a = 14.8 \text{ kJ mol}^{-1} \text{ One mark}$$

Correct final answer with working scores full marks. One mark can be awarded for method if they have an expression where A has been removed. Second mark can be awarded if a logarithm has subsequently been taken. Third mark is for final answer.



(e)

$$-2\alpha + \beta T = -\alpha\left(2 - \frac{\alpha RT}{E_a}\right)$$

$$-2\alpha + \beta T = -2\alpha + \frac{\alpha^2 RT}{E_a}$$

$$\beta = \frac{\alpha^2 R}{E_a}$$

One mark

$$T\left(\frac{\beta}{\gamma}\right)^{\frac{1}{2}} = \left(\frac{2E_a}{\mu}\right)^{\frac{1}{2}} \frac{\alpha RT}{E_a}$$

$$T\left(\frac{\beta}{\gamma}\right)^{\frac{1}{2}} = T\left(\frac{2E_a}{\mu}\right)^{\frac{1}{2}} \left(\frac{\alpha^2 R^2}{E_a^2}\right)^{\frac{1}{2}}$$

$$\left(\frac{\beta}{\gamma}\right)^{\frac{1}{2}} = \left(\frac{\alpha^2 R}{E_a}\right)^{\frac{1}{2}} \left(\frac{2E_a R}{\mu E_a}\right)^{\frac{1}{2}}$$

$$\left(\frac{\beta}{\gamma}\right)^{\frac{1}{2}} = (\beta)^{\frac{1}{2}} \left(\frac{2R}{\mu}\right)^{\frac{1}{2}}$$

$$\gamma = \frac{\mu}{2R}$$

Two marks. No partial credit for γ .



$$(f) \quad \ln\left(\frac{k_{2(83\text{ K})}}{T_{(83\text{ K})}}\right) = \beta T_{(83\text{ K})} + i - \left(\ln\left(\frac{k_{2(61\text{ K})}}{T_{(61\text{ K})}}\right) = \beta T_{(61\text{ K})} + i\right)$$

$$\ln\left(\frac{k_{2(83\text{ K})}}{T_{(83\text{ K})}}\right) - \ln\left(\frac{k_{2(61\text{ K})}}{T_{(61\text{ K})}}\right) = \beta T_{(83\text{ K})} - \beta T_{(61\text{ K})}$$

One mark

$$\ln\left(\frac{k_{2(83\text{ K})}T_{(61\text{ K})}}{T_{(83\text{ K})}k_{2(61\text{ K})}}\right) = \beta(T_{(83\text{ K})} - T_{(61\text{ K})})$$

$$\beta = \frac{\ln\left(\frac{k_{2(83\text{ K})}T_{(61\text{ K})}}{T_{(83\text{ K})}k_{2(61\text{ K})}}\right)}{(T_{(83\text{ K})} - T_{(61\text{ K})})}$$

One mark

$$\beta = \frac{\ln\left(\frac{8.74 \times 10^{10} \text{ s}^{-1} \times 61\text{ K}}{83\text{ K} \times 6.23 \times 10^{10} \text{ s}^{-1}}\right)}{(83\text{ K} - 61\text{ K})}$$

$$\beta = 1.389 \times 10^{-3} \text{ K}^{-1} \quad \text{One mark}$$

Correct final answer with working scores full marks regardless of method. First mark awarded for expression where the constant i has been removed. Second mark for correct algebraic expression where β is the subject. Third mark is for correct final answer with units.



$$(g) \quad \beta = \frac{\alpha^2 R}{E_a}$$

$$E_a = \frac{\alpha^2 R}{\beta}$$

$$E_a = \frac{2.235^2 \times 8.314 \text{ J K}^{-1} \text{ mol}^{-1}}{1.389 \times 10^{-3} \text{ K}^{-1}}$$

$$E_a = 2.235^2 \times 8.314 \text{ J K}^{-1} \text{ mol}^{-1} / 1.389 \times 10^{-3} \text{ K}^{-1}$$

$$E_a = 29.9 \text{ kJ mol}^{-1}$$

ECF: Allow ECF from part (f). Answer = (0.0415 / answer to (f)) kJ mol⁻¹

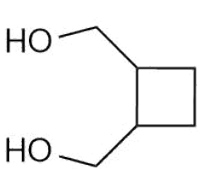
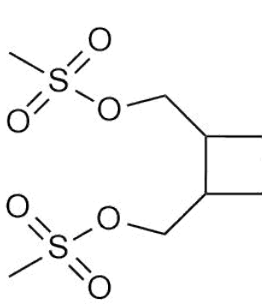
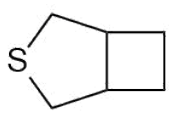
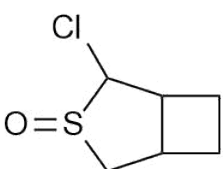
Answer with given value = 43.9 kJ mol⁻¹

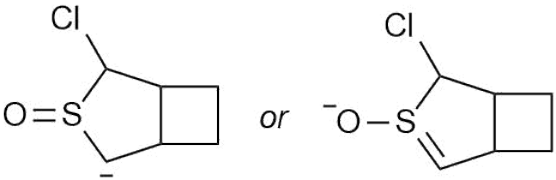
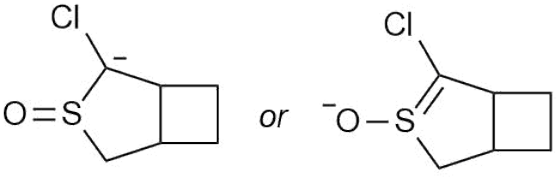
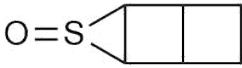
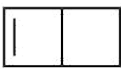



Allow ECF from part (e) only if dimensionality is correct in expression for E_a

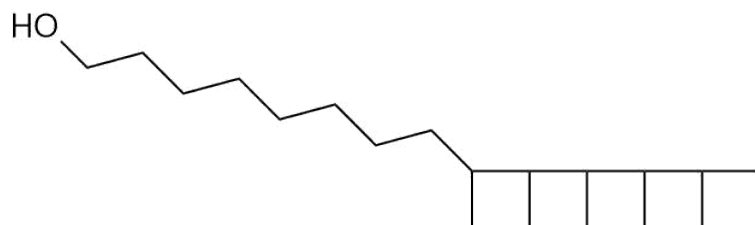


Total out of 17

17

6.	This question is about anammox and ladderanes.			Mark
(a)	(i) nitrogen gas 0	ammonium ion -3		<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
	<i>Both must be correct for mark.</i>			
	(ii) nitrite ion (NO ₂ ⁻) +3	hydrazine (NH ₂ NH ₂) -2	hydroxylamine (NH ₂ OH) -1	
<i>All three correct two marks. Two correct one mark. One or zero correct no marks.</i>				
(b)	(i) NO ₂ ⁻ + 4e ⁻ + 5H ⁺ → NH ₂ OH + H ₂ O <i>Must be fully correct for mark</i> <i>Also accept NO₂⁻ + 4e⁻ + 6H⁺ → [NH₃OH]⁺ + H₂O</i>			<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
	(ii) NH ₄ ⁺ + NH ₂ OH → NH ₂ NH ₂ + H ₂ O + H ⁺ or NH ₄ ⁺ + NH ₂ OH → NH ₂ NH ₂ + H ₃ O ⁺ or NH ₄ ⁺ + NH ₂ OH → [NH ₂ NH ₃] ⁺ + H ₂ O <i>Must be fully correct for mark</i> <i>Also accept analogous equations if hydroxylamine is protonated</i>			
(iii) NH ₂ NH ₂ → N ₂ + 4e ⁻ + 4H ⁺ or [NH ₂ NH ₃] ⁺ → N ₂ + 4e ⁻ + 5H ⁺ <i>Must be fully correct for mark</i>				<input checked="" type="checkbox"/>
(c)	NO ₂ ⁻ + NH ₄ ⁺ → N ₂ + 2H ₂ O <i>Must be fully correct for mark</i>			<input checked="" type="checkbox"/>
(d)	<p style="text-align: center;">A</p>  <p><i>One mark. No stereochemistry required.</i></p>	<p style="text-align: center;">B</p>  <p><i>One mark. No stereochemistry required. ECF is allowed based on A only if their structure of B is consistent with molecular formula.</i></p>		<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
	<p style="text-align: center;">C</p>  <p><i>One mark. No stereochemistry required. No ECF as can work backwards.</i></p>	<p style="text-align: center;">D</p>  <p><i>One mark. No stereochemistry required. No ECF.</i></p>		

<p style="text-align: center;">Anion E⁻</p>  <p><i>No stereochemistry required. Either of these above is worth two marks.</i></p>  <p><i>Either of these incorrect structures above can be given one mark as the student has correctly realised the acidic carbon is next to sulfur. ECF: Maximum ECF score here is one mark as there is information to work forwards and backwards. ECF one mark only awarded if chlorine is in same place as on structure D and anion is on carbon next to sulfur.</i></p>	<p style="text-align: center;">F</p>  <p><i>One mark. No stereochemistry required. No ECF as can work backwards.</i></p>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
<p style="text-align: center;">G</p>  <p><i>One mark. No stereochemistry required. No ECF as sufficient new information.</i></p>	<p style="text-align: center;">X</p> <p style="text-align: center;">S=O</p> <p><i>One mark. No ECF as sufficient new information.</i></p>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
<p style="text-align: center;">H</p>  <p><i>One mark. No stereochemistry required. No ECF as sufficient new information.</i></p>	<p style="text-align: center;">I</p>  <p><i>One mark. No stereochemistry required. ECF can be awarded from H only if their structure of I has the correct number of signals in the ¹³C NMR and is consistent with an elimination from their incorrect structure of H.</i></p>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
<p style="text-align: center;">J</p>  <p><i>One mark. No stereochemistry required. No ECF as sufficient new information. Accept if double bond drawn explicitly as cis or trans.</i></p>		<input checked="" type="checkbox"/>



One mark. No stereochemistry required. Must have exactly and unambiguously eight carbon atoms in the side chain to score the mark.



Total out of 20

20