

# Markscheme

May 2022

Chemistry

Standard level

Paper 2

15 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		$2 \text{ Li (s)} + 2 \text{ H}_2\text{O (l)} \rightarrow 2 \text{ LiOH (aq)} + \text{H}_2 \text{ (g)}$ ✓		1
1.	b	i	$n_{\text{Li}} \ll \frac{0.200 \text{ g}}{6.94 \text{ g}} = \gg 0.0288 \ll \text{mol} \gg$ ✓ $\ll n_{\text{LiOH}} = n_{\text{Li}} \gg$ $[\text{LiOH}] \ll = \frac{0.0288 \text{ mol}}{0.5000 \text{ dm}^3} = \gg 0.0576 \ll \text{mol dm}^{-3} \gg$ ✓	Award [2] for correct final answer.	2
1.	b	ii	$\ll n_{\text{H}_2} = \frac{1}{2} \times 0.0288 \text{ mol} = 0.0144 \text{ mol} \gg$ $\ll V = \frac{nRT}{P} = \gg \left( \frac{0.0144 \text{ mol} \times 8.31 \text{ JK}^{-1} \text{ mol}^{-1} \times (22.5 + 273) \text{ K}}{103 \text{ kPa}} \right) \ll \times 10^3 \gg$ ✓ $V = 343 \ll \text{cm}^3 \gg$ ✓	Award [2] for correct final answer. Accept answers in the range 334 – 344 $\text{cm}^3$ . Award [1 max] for 0.343 $\ll \text{cm}^3/\text{dm}^3/\text{m}^3 \gg$ . Award [1 max] for 26.1 $\text{cm}^3$ obtained by using 22.5 K. Award [1 max] for 687 $\text{cm}^3$ obtained by using 0.0288 mol.	2
1.	b	iii	lithium was impure/«partially» oxidized <b>OR</b> gas leaked/ignited ✓	Accept “gas dissolved”.	1 max
1.	c		$\text{H}_2\text{O}$ <b>AND</b> hydrogen gains electrons «to form $\text{H}_2$ » <b>OR</b> $\text{H}_2\text{O}$ <b>AND</b> H oxidation state changed from +1 to 0 ✓	Accept “ $\text{H}_2\text{O}$ <b>AND</b> H/ $\text{H}_2\text{O}$ is reduced”.	1

(continued...)

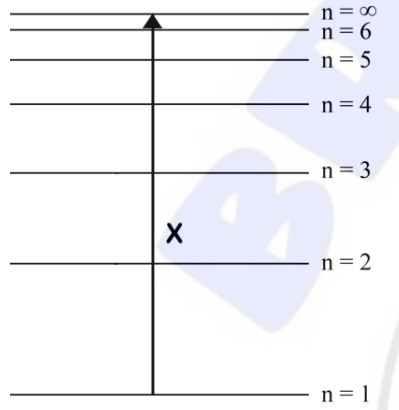
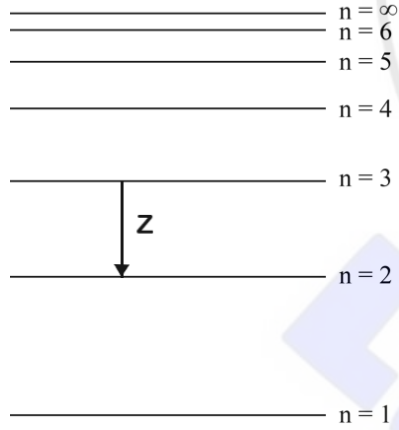
(Question 1 continued)

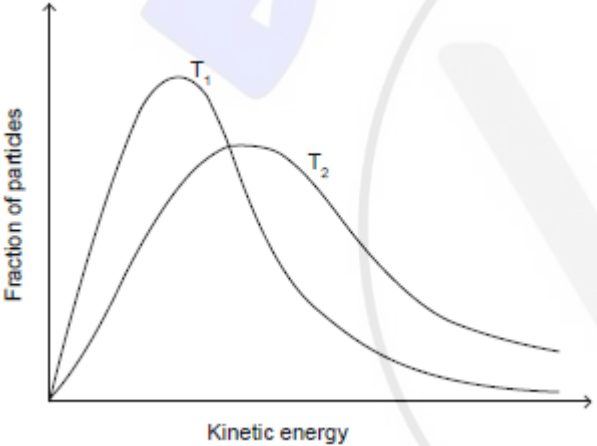
Question		Answers	Notes	Total
1.	d	<i>Any two:</i> temperature of the water increases ✓ lithium melts ✓ pop sound is heard ✓	<i>Accept "lithium/hydrogen catches fire". Do not accept "smoke is observed".</i>	<b>2 max</b>

Question			Answers	Notes	Total
2.	a		increasing number of protons/nuclear charge/ $Z_{\text{eff}}$ ✓  «atomic» radius/size decreases <b>OR</b> same number of energy levels <b>OR</b> similar shielding «by inner electrons» ✓		2
2.	b	i	<i>Any two of:</i> does not represent sub-levels/orbitals ✓ only applies to atoms with one electron/hydrogen ✓ does not explain why only certain energy levels are allowed ✓ the atom is considered to be isolated ✓ does not take into account the interactions between atoms/molecules/external fields ✓ does not consider the number of electrons the energy level can fit ✓ does not consider probability of finding electron at different positions/OWTTE ✓	<i>Do not accept "does not represent distance «from nucleus»".</i>	2 max

(continued...)


(Question 2 continued)

Question			Answers	Notes	Total
2.	b	ii	 <p>upward arrow X <b>AND</b> starting at <math>n = 1</math> extending to <math>n = \infty</math> ✓</p>		1
2.	b	iii	 <p>downward or upward arrow between <math>n = 3</math> and <math>n = 2</math> ✓</p>		1

Question			Answers	Notes	Total
3.	a		<p>increases rate <b>AND</b> lower <math>E_a</math> ✓</p> <p>provides alternative pathway «with lower <math>E_a</math>»  <b>OR</b>                      more/larger fraction of molecules have the «lower» <math>E_a</math> ✓</p>	<p>Accept description of how catalyst lowers <math>E_a</math> for M2 (e.g. “reactants adsorb on surface «of catalyst»”, “reactant bonds weaken «when adsorbed»”, “helps favorable orientation of molecules”).</p>	2
3.	b	i	 <p>both axes correctly labelled ✓</p> <p>peak of <math>T_2</math> curve lower <b>AND</b> to the right of <math>T_1</math> curve ✓</p> <p>lines begin at origin <b>AND</b> correct shape of curves <b>AND</b> <math>T_2</math> must finish above <math>T_1</math> ✓</p>	<p>Accept “probability «density» / number of particles / <math>N</math> / fraction” on y-axis.</p> <p>Accept “kinetic <math>E/KE/E_k</math>” but not just “Energy/<math>E</math>” on x-axis.</p>	3

(continued...)

(Question 3 continued)

Question			Answers	Notes	Total
3.	b	ii	decrease <b>AND</b> equilibrium shifts left / favours reverse reaction ✓ «forward reaction is» exothermic / $\Delta H$ is negative ✓		2
3.	c	i	sulfuric acid/ $H_2SO_4$ ✓	Accept "disulfuric acid/ $H_2S_2O_7$ ".	1
3.	c	ii	fully ionizes/dissociates ✓ proton/ $H^+$ «donor» ✓		2
3.	d	i		Do <b>not</b> accept the delocalised structure. Accept any combination of dots, crosses and lines. Coordinate/dative bond may be represented by an arrow.	1
3.	d	ii	three electron domains repel <b>OR</b> three electron domains as far away as possible ✓  trigonal planar <b>OR</b> «all» angles are $120^\circ$ ✓		2

Question			Answers	Notes	Total
4.	a	i	<p><math>C_{60}</math> fullerene: «each carbon is» bonded to 3 C <b>AND</b> diamond: bonded to 4 C <b>OR</b>  <math>C_{60}</math> fullerene: delocalized/resonance <b>AND</b> diamond: not delocalized/no resonance <b>OR</b>  <math>C_{60}</math> fullerene: single and double bonds <b>AND</b> diamond: single bonds ✓</p>	<p>Accept "<math>C_{60}</math> fullerene: <math>sp^2</math> <b>AND</b> diamond: <math>sp^3</math>".</p> <p>Accept "<math>C_{60}</math> fullerene: trigonal planar geometry / bond angles between <math>109.5^\circ/109^\circ/108^\circ-120^\circ</math> <b>AND</b> diamond: tetrahedral geometry / bond angle <math>109.5^\circ/109^\circ</math>".</p> <p>Accept "bonds in fullerene are shorter/stronger/have higher bond order".</p>	1
4.	a	ii	<p>diamond giant/network covalent <b>AND</b> sublimes at higher temperature ✓  <math>C_{60}</math> molecular/London/dispersion/intermolecular «forces» ✓</p>	<p>Accept "diamond has strong covalent bonds <b>AND</b> require more energy to break «than intermolecular forces»" for M1.</p>	2
4.	b	i	<p>same general formula / <math>C_nH_{2n+2}</math> ✓  differ by <math>CH_2</math>/common structural unit ✓</p>	<p>Accept "similar chemical properties".</p> <p>Accept "gradation/gradual change in physical properties".</p>	2
4.	b	ii	<p>R: <math>^+C_3H_7</math> ✓</p>		1

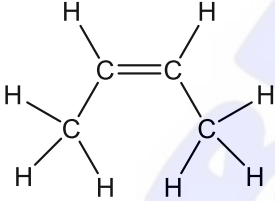
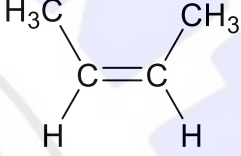
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(Question 4 continued)

Question		Answers	Notes	Total
4.	c	<p><b>ALTERNATIVE 1:</b>  <i>Test:</i>            add bromine «water»/Br<sub>2</sub>(aq) ✓  <i>Result:</i>            «orange/brown/yellow» to colourless/decolourised ✓</p> <p><b>ALTERNATIVE 2:</b>  <i>Test:</i>            add «acidified» KMnO<sub>4</sub> ✓  <i>Result:</i>            «purple» to colourless/decolourised/brown ✓</p> <p><b>ALTERNATIVE 3:</b>  <i>Test:</i>            add iodine /I<sub>2</sub> ✓  <i>Result:</i>            «brown» to colourless/decolourised ✓</p>	<p><i>Do not accept "clear" for M2.</i></p> <p><i>Accept "colour change" for M2.</i></p>	2

(continued...)

(Question 4 continued)

Question			Answers	Notes	Total
4.	d	i		Accept 	1
4.	d	ii	$\text{CH}_3\text{CH}=\text{CHCH}_3 (\text{g}) + \text{HBr} (\text{g}) \rightarrow \text{CH}_3\text{CH}_2\text{CHBrCH}_3 (\text{l})$ <b>OR</b> $\text{C}_4\text{H}_8 (\text{g}) + \text{HBr} (\text{g}) \rightarrow \text{C}_4\text{H}_9\text{Br} (\text{l}) \checkmark$		1
4.	d	iii	«electrophilic» addition/ $\text{E}_\text{A}$ $\checkmark$	Do <b>not</b> accept nucleophilic or free radical addition.	1
4.	d	iv	<b>ALTERNATIVE 1:</b> Any two of: but-2-ene: 2 signals <b>AND</b> product: 4 signals $\checkmark$ but-2-ene: «area ratio» 3:1/6:2 <b>AND</b> product: «area ratio» 3:3:2:1 $\checkmark$ product: «has signal at» 3.5-4.4 ppm «and but-2-ene: does not» $\checkmark$ but-2-ene: «has signal at» 4.5-6.0 ppm «and product: does not» $\checkmark$  <b>ALTERNATIVE 2:</b> but-2-ene: doublet <b>AND</b> quartet/multiplet/4 $\checkmark$ product: doublet <b>AND</b> triplet <b>AND</b> quintet/5/multiplet <b>AND</b> sextet/6/multiplet $\checkmark$	Accept “product «has signal at» 1.3–1.4 ppm «and but-2-ene: does not»”.	2 max

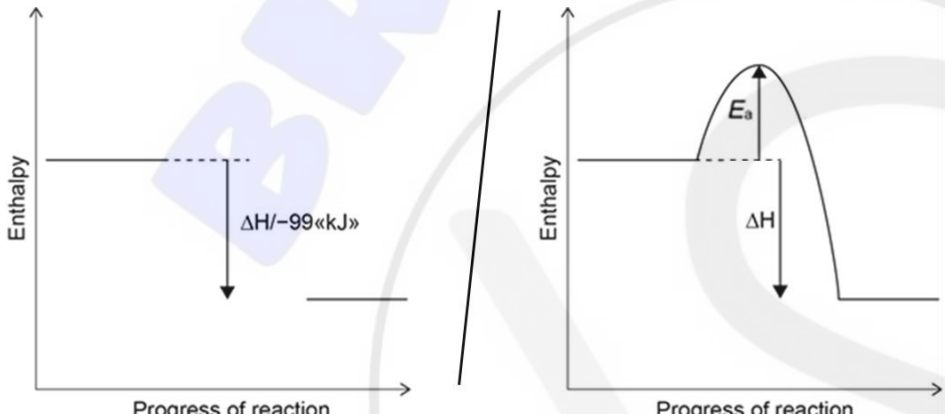
(Question 4 continued)

(continued...)

Question			Answers	Notes	Total
4.	e	i	bond breaking: $\text{C-H} + \text{Cl-Cl} / 414 \text{ «kJ mol}^{-1}\text{»} + 242 \text{ «kJ mol}^{-1}\text{»} / 656 \text{ «kJ»}$ <b>OR</b> bond breaking: $4\text{C-H} + \text{Cl-Cl} / 4 \times 414 \text{ «kJ mol}^{-1}\text{»} + 242 \text{ «kJ mol}^{-1}\text{»} / 1898 \text{ «kJ»} \checkmark$  bond forming: $\text{C-Cl} + \text{H-Cl} / 324 \text{ kJ mol}^{-1} + 431 \text{ kJ mol}^{-1} / 755 \text{ «kJ»}$ <b>OR</b> bond forming: $3\text{C-H} + \text{C-Cl} + \text{H-Cl} / 3 \times 414 \text{ «kJ mol}^{-1}\text{»} + 324 \text{ «kJ mol}^{-1}\text{»} + 431 \text{ kJ mol}^{-1} / 1997 \text{ «kJ»} \checkmark$  $\text{«}\Delta\text{H} = \text{bond breaking} - \text{bond forming} = 656 \text{ kJ} - 755 \text{ kJ} = -99 \text{ «kJ»} \checkmark$	Award <b>[3]</b> for correct final answer.  Award <b>[2 max]</b> for 99 «kJ».	3

(continued...)

(Question 4 continued)

Question			Answers	Notes	Total
4.	e	ii	 <p>reactants at higher enthalpy than products ✓</p> <p><math>\Delta H/-99 \text{ «kJ»}</math> labelled on arrow from reactants to products</p> <p><b>OR</b></p> <p>activation energy/<math>E_a</math> labelled on arrow from reactant to top of energy profile ✓</p>	<p>Accept a double headed arrow between reactants and products labelled as <math>\Delta H</math> for M2.</p>	2

Question		Answers	Notes	Total
5.	a	Cathode (negative electrode): $\text{Zn}^{2+} + 2\text{e}^{-} \rightarrow \text{Zn}(\text{l})$ ✓  Anode (positive electrode): $2\text{Cl}^{-} \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^{-}$ <b>OR</b> $\text{Cl}^{-} \rightarrow \frac{1}{2} \text{Cl}_2(\text{g}) + \text{e}^{-}$ ✓		2
5.	b	$\text{ZnCl}_2(\text{l}) \rightarrow \text{Zn}(\text{l}) + \text{Cl}_2(\text{g})$  balanced equation ✓ correct state symbols ✓	Accept ionic equation.	2