

Cambridge International AS & A Level

CHEMISTRY**9701/21**

Paper 2 AS Level Structured Questions

May/June 2024

MARK SCHEME

Maximum Mark: 60

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

This document consists of **12** printed pages.

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These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

PUBLISHED**GENERIC MARKING PRINCIPLE 5:**

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

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Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>'List rule' guidance</u> For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i>. • Incorrect responses should not be awarded credit but will still count towards <i>n</i>. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should not be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first <i>n</i> responses may be ignored even if they include incorrect science.

6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

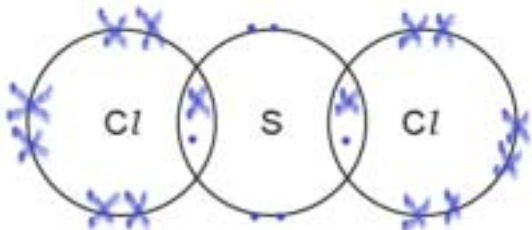
Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

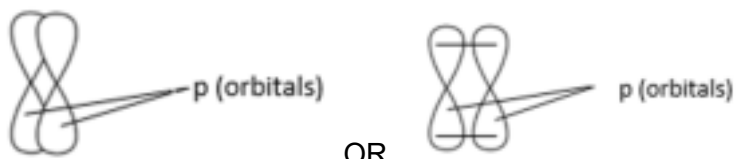
State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

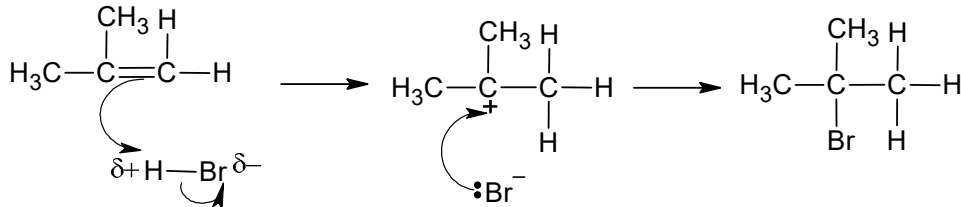
Question	Answer	Marks								
1(a)	<table><tr><td>halogen</td><td>colour at 293 K</td></tr><tr><td>chlorine</td><td>green</td></tr><tr><td>bromine</td><td>brown</td></tr><tr><td>iodine</td><td>(dark) grey</td></tr></table> All three correct for one mark	halogen	colour at 293 K	chlorine	green	bromine	brown	iodine	(dark) grey	1
halogen	colour at 293 K									
chlorine	green									
bromine	brown									
iodine	(dark) grey									
1(b)	M1 (it / volatility) decreases M2 more electrons in molecules M3 (so) increased strength of instantaneous dipole – induced dipole forces (of attraction)	3								
1(c)(i)	$\text{Br}_2 + 2\text{I}^- \rightarrow 2\text{Br}^- + \text{I}_2$	1								
1(c)(ii)	(Br₂ / bromine is an) oxidising agent AND removes electron(s) from iodide (ions) I⁻ OR increases the oxidation number of I⁻ / iodide (ion)	1								
1(d)(i)	NaBr + H₂SO₄ → HBr + NaHSO₄ OR 2NaBr + H₂SO₄ → 2HBr + Na₂SO₄	1								
1(d)(ii)	M1 sodium chloride M2 Cl⁻ is not a strong enough reducing agent to reduce H₂SO₄ M3 Br⁻ & I⁻ are strong enough reducing agents to react (further) with (the S in) H₂SO₄ <i>Alternative M2 and M3</i> M2 ability to behave as reducing agents increases down the group M3 EITHER Cl⁻ is not strong enough to reduce H₂SO₄ OR Br⁻ and I⁻ react (further) with (the S in) H₂SO₄	3								

Question	Answer	Marks						
2(a)(i)	hydrolysis	1						
2(a)(ii)	silicon(IV) chloride / silicon tetrachloride ALLOW phosphorus(III) chloride / phosphorus trichloride	1						
2(b)(i)	M1 1 shared pair of electrons between each S-Cl shown as •× M2 6 non-bonding electrons around each Cl shown as × AND 4 non-bonding electrons around S shown as • 	2						
2(b)(ii)	M1 shape non-linear M2 bond angle 103–105(°)	2						
2(c)(i)	<table border="1"><tr><td></td><td>oxidation number in Mg₃N₂</td></tr><tr><td>magnesium</td><td>(+)II / 2(+)</td></tr><tr><td>nitrogen</td><td>–III/ 3 –</td></tr></table> Both correct for one mark		oxidation number in Mg ₃ N ₂	magnesium	(+)II / 2(+)	nitrogen	–III/ 3 –	1
	oxidation number in Mg ₃ N ₂							
magnesium	(+)II / 2(+)							
nitrogen	–III/ 3 –							
2(c)(ii)	Mg ₃ N ₂ + 6H ₂ O → 3Mg(OH) ₂ + 2NH ₃	1						
2(c)(iii)	M1 due to OH [–] (aq) M2 EITHER acid-base reaction of water by ammonia OR dissociation of (some) Mg(OH) ₂	2						
2(d)(i)	BN	1						
2(d)(ii)	graphite	1						

Question	Answer	Marks
3(a)	M1 (if a change in conditions occurs) the equilibrium shifts M2 to minimise the change in conditions	2
3(b)	M1 change in appearance paler red / more yellow / less orange M2 change in relative concentration of $\text{FeSCN}^{2+}(\text{aq})$ lower M3 change in value of the equilibrium constant, K_c lower	3
3(c)(i)	M1 <i>deduce the concentration of SCN^- present in initial mixture</i> $[\text{SCN}^- \text{ eq'm}] = [\text{Fe}^{3+} \text{ eq'm}] = [\text{original } \text{SCN}^-] - [\text{FeSCN}^{2+} \text{ produced}]$ $1.30 \times 10^{-3} + 0.300 \times 10^{-3} = 1.60 \times 10^{-3} \text{ mol dm}^{-3}$ M2 <i>find initial amount of Fe^{3+} initially</i> $M1 \times 25 / 1000 = \text{amount of } \text{Fe}^{3+} \text{ added initially} = 4.00 \times 10^{-5} \text{ (mol)}$	2
3(c)(ii)	M1 value for $K_c = 178$ M2 units = $\text{mol}^{-1} \text{ dm}^3$	2

Question	Answer	Marks												
4(a)	M1 (enthalpy change / energy change) when one mole of a compound / substance is formed M2 from its elements in their standard states	2												
4(b)(i)	<table border="1"> <tr> <td></td><td>equation for reaction</td><td>$\Delta H_{\text{formation}}$</td></tr> <tr> <td>Fe₂O₃</td><td>$2\text{Fe (s)} + \frac{3}{2}\text{O}_2\text{(g)} \rightarrow \text{Fe}_2\text{O}_3\text{(s)}$</td><td>–824.2</td></tr> <tr> <td>CO</td><td>$\text{C (s)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{CO (g)}$</td><td>–110.5</td></tr> <tr> <td>CO₂</td><td>$\text{C (s)} + \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$</td><td>–393.5</td></tr> </table>		equation for reaction	$\Delta H_{\text{formation}}$	Fe ₂ O ₃	$2\text{Fe (s)} + \frac{3}{2}\text{O}_2\text{(g)} \rightarrow \text{Fe}_2\text{O}_3\text{(s)}$	–824.2	CO	$\text{C (s)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{CO (g)}$	–110.5	CO ₂	$\text{C (s)} + \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$	–393.5	2
	equation for reaction	$\Delta H_{\text{formation}}$												
Fe ₂ O ₃	$2\text{Fe (s)} + \frac{3}{2}\text{O}_2\text{(g)} \rightarrow \text{Fe}_2\text{O}_3\text{(s)}$	–824.2												
CO	$\text{C (s)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{CO (g)}$	–110.5												
CO ₂	$\text{C (s)} + \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$	–393.5												
4(b)(ii)	$\Delta H_{\text{reaction}} = -\Delta H_{\text{Fe}_2\text{O}_3} - (3 \times -\Delta H_{\text{CO}}) + (3 \times -\Delta H_{\text{CO}_2})$ $= -(-824.2) - (3 \times -110.5) + (3 \times -393.5)$ $= -24.8 \text{ kJ mol}^{-1}$ - evidence of use of correct expression and / or any rearrangement of only these bond energy values - use correct stoichiometry for these bond energy values only - calculate their expression correctly provided the expression uses only addition / subtraction and all 3 values	2												

Question	Answer	Marks
5(a)	(electrostatic) attraction between nuclei of two atoms and shared pair of electrons	1
5(b)(i)	sp^2	1
5(b)(ii)	M1 σ bond – diagram showing how σ bond is made from direct overlap of orbitals i.e.  OR  M2 π bond - diagram showing how π bond is made from sideways overlap of 2$\times$ p– orbitals i.e.  OR 	2
5(c)(i)	EITHER (pair of) electrons in π bond are further away from the nuclei so weaker attraction OR (pair of) electrons in σ bond are closer to the two nuclei so stronger attraction	1

Question	Answer	Marks
5(c)(ii)	 M1 arrow from = of C=C to H of H-Br M2 correct dipole on H-Br AND arrow from H-Br bond to Br M3 correct intermediate AND 2-bromopropane M4 arrow from lone pair on Br⁻ to C⁺ of their intermediate (with +ve or δ+ charge)	4

Question	Answer	Marks
6(a)(i)	(molecules with the) same structural formula (and same molecular formula) with different arrangement of atoms / groups in space	1
6(a)(ii)	M1 number of stereoisomers = 8 M2 reasoning: 2 chiral centres AND 1 C=C (producing a cis-and trans or geometrical pair)	2
6(a)(iii)	C ₁₃ H ₂₀ O ₃	1
6(a)(iv)	ester AND carbonyl / ketone AND C=C (bond) / alkene	1
6(b)(i)	reducing agent for C=O AND C=C	1
6(b)(ii)	sodium borohydride / NaBH ₄	1
6(c)(i)	M1 deduce n = 12 (from Y – 1C (in methanol)) M2 (100 × x) ÷ (1.1 × 100) = 12 (so) x = 13.2	2

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Question	Answer		Marks
6(c)(ii)		observation on addition of 2,4–DNPH	1
	Y	orange precipitate	
	Q	no precipitate	
	Both correct for one mark		
6(c)(iii)	ROH + Na → RNa + 1 / 2H ₂ (0.002 mol Q produced 0.002 mol H ₂ gas so) 2 OH groups M1 answer indicates that OH group(s) in Q react with Na to produce the H ₂ in the ratio 1 mol OH : ½ mol H ₂ M2 uses data to show 2OH groups		2
6(c)(iv)	M1 Y will have absorption / peak / trough between 1670–1740 due to C=O (Q will not) M2 Q will have absorption / peak / trough between 3200–3600 due to O-H (Y will not)		2

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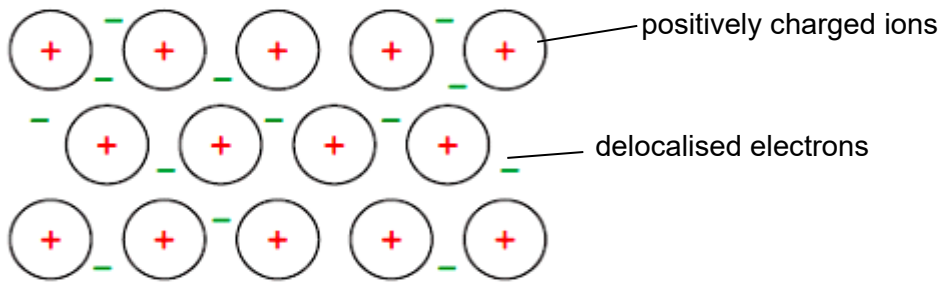
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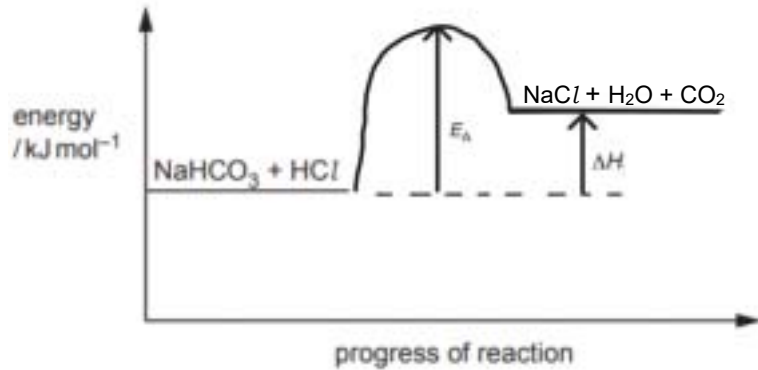
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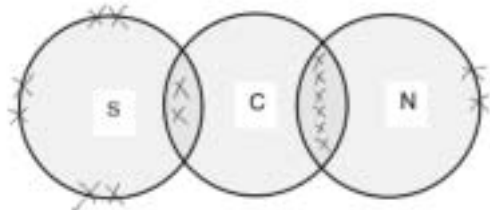
Question	Answer	Marks								
1(a)	<table><tr><td>Mg²⁺</td><td>24</td><td>12</td><td>10</td></tr><tr><td>Al³⁺</td><td>27</td><td>13</td><td>10</td></tr></table> 4 correct = 2 marks 2 or 3 correct = 1 mark 0 or 1 correct = 0 marks	Mg ²⁺	24	12	10	Al ³⁺	27	13	10	2
Mg ²⁺	24	12	10							
Al ³⁺	27	13	10							
1(b)	M1 it / Al³⁺ is smaller (compared to Mg²⁺) M2 greater nuclear attraction for remaining electrons M3 same shielding effect AND greater nuclear charge	3								
1(c)	 labelled diagram shows: - regular arrangement of minimum of 2 × 2 circles containing + for positive ions AND surrounded by (sea of) delocalised electrons	1								
1(d)(i)	large amount of energy required to break bonds in giant covalent structure	1								

Question	Answer	Marks						
1(d)(ii)	M1 all 3 melting points lower than Mg M2 show melting point Cl < P < S	2						
1(e)(i)	<table border="1"> <tbody> <tr> <td>Na</td><td>solid</td><td>10–14</td></tr> <tr> <td>S</td><td>gas</td><td>0–4</td></tr> </tbody> </table> 4 correct = 2 marks 2 or 3 correct = 1 mark 0 or 1 correct = 0 marks	Na	solid	10–14	S	gas	0–4	2
Na	solid	10–14						
S	gas	0–4						
1(e)(ii)	acid–base OR neutralisation	1						
1(e)(iii)	$\text{P}_4\text{O}_{10} + 6\text{H}_2\text{O} \rightarrow 4\text{H}_3\text{PO}_4$	1						
1(f)(i)	reacts with both acids and bases OR shows both acidic and basic behaviour	1						
1(f)(ii)	$\text{Al}(\text{OH})_3 + \text{NaOH} \rightarrow \text{NaAl}(\text{OH})_4$	1						

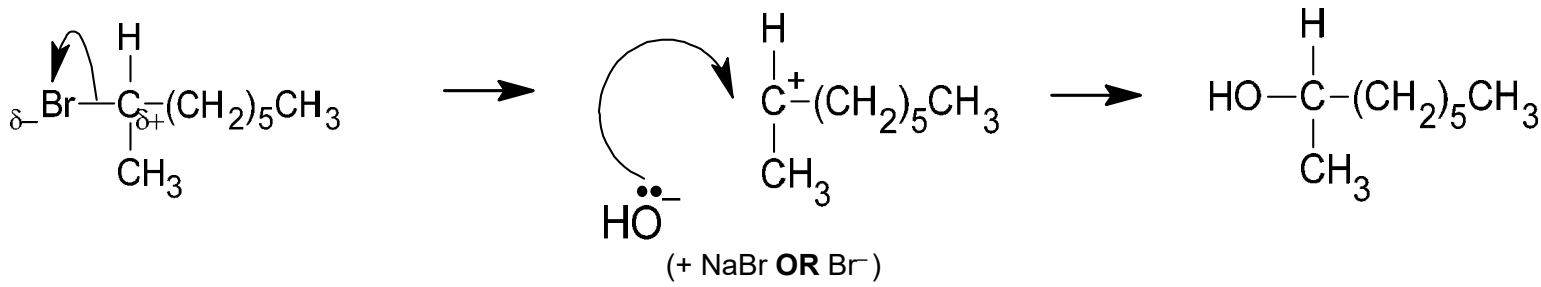
Question	Answer	Marks
2(a)	 <i>All three correct (2 marks) or two correct (1 mark):</i> • profile for endothermic reaction (include 'hump') • arrow representing E_A • arrow representing ΔH OR (+) 27.2	2
2(b)(i)	no more fizzing / effervescence stops	1
2(b)(ii)	M1 calculate Q from $= 50 \times 4.18 \times (26.2 - 19.6) = 1379.4$ M2 Use M1 to find energy change when 1 mol Na_2CO_3 / 2 mol HCl reacts M1 $\div 0.04 = 34485$ M3 express Q as $\Delta H_{(1)}$ in $\text{kJ mol}^{-1} = -(\text{value for M2}) \div 1000$ $= -34.5 \text{ kJ mol}^{-1}$ <i>Alternative method</i> M1 evidence of use $Q = mc\Delta T = 50 \times 4.18 / 1000 \times (26.2 - 19.6) = 1.3794$ M2 Use M1 to find energy change when 1 mol Na_2CO_3 / 2 mol HCl reacts M1 $\div 0.04 = 34.485$ M3 express Q as $\Delta H_{(1)}$ in $\text{kJ mol}^{-1} = -(\text{value for M2})$ (expressed in kJ) $= -34.5 \text{ kJ mol}^{-1}$	3

Question	Answer	Marks
2(b)(iii)	Using answer from 2(b)(ii) $(\Rightarrow) 2\Delta H_2 - (\Delta H_1)$ $(\Rightarrow) 2 \times 27.2 - (2b(ii))$ $2 \times 27.2 - (-34.50) = (+) 88.9 \text{ kJ mol}^{-1}$ All three correct (2 marks) or two correct (1 mark): (27.2) – (–34.5) OR (27.2) – (2b(ii)) 2×27.2 and $1 \times 2b(ii)$ - calculate correctly their expression Using alternative value of $\Delta H_1 = -38.4 \text{ kJ mol}^{-1}$ $\Delta H_r = (+)92.8 \text{ kJ mol}^{-1} = 2 \text{ marks}$	2
2(c)	$\text{Ca}(\text{NO}_3)_2 \rightarrow \text{CaO} + 2\text{NO}_2 + \frac{1}{2}\text{O}_2$ M1 correct formula for calcium nitrate: $\text{Ca}(\text{NO}_3)_2$ M2 correct balanced equation	2

Question	Answer	Marks
3(a)	M1 rates of forward and reverse / backward reactions are equal M2 no change in measurable properties OR concentration of reactants AND products remain constant	2
3(b)(i)	M1 change to appearance of the mixture: (goes) darker red / more red M2 change to relative concentration of $\text{Fe}^{3+}(\text{aq})$: decreases M3 change to the value of equilibrium constant, K_c: constant / none	3

Question	Answer	Marks
3(b)(ii)	Method 1 M1 conc of initial conc of Fe^{3+} and $\text{SCN}^- = 0.0020 \text{ (mol dm}^{-3}\text{)}$ M2 at equilibrium the conc of Fe^{3+} and SCN^- are $(\text{M1} - 0.000423)$ M3 use $0.000423 \div (\text{M1} - 0.000423)^2$ to calculate $K_c = 170(.089)$ M4 units = $\text{mol}^{-1} \text{ dm}^3$ OR $\text{dm}^3 \text{ mol}^{-1}$ Method 2 M1 no mol $\text{FeSCN}^{2+} = 4.23 \times 10^{-4} \times 25 / 1000 = 1.0575 \times 10^{-5}$ M2 no mol Fe^{3+} and SCN^- are $(5 \times 10^{-5} - \text{M1}) = 3.9425 \times 10^{-5}$ M3 $0.000423 \div (\text{M2} \times 1000 / 25)^2 = 170(.089)$ M4 units = $\text{mol}^{-1} \text{ dm}^3$ OR $\text{dm}^3 \text{ mol}^{-1}$	4
3(c)	<i>full electronic configuration of Fe^{3+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$</i>	1
3(d)	 M1 6 electrons between C and N AND 2 electrons between C and S M2 3 lone pairs around S AND none around C AND 1 lone pair around N	2

Question	Answer	Marks
4(a)	Three-dimensional stereoisomers of $\text{CH}_3(\text{CH}_2)_5\text{CHBrCH}_3$ M1 correct representation of left-hand answer as 3d structure of one of the enantiomers of $\text{CH}_3(\text{CH}_2)_5\text{CHBrCH}_3$ M2 correct representation of 3d structure of the second enantiomer of $\text{CH}_3(\text{CH}_2)_5\text{CHBrCH}_3$	2

Question	Answer	Marks
4(b)	 (+ NaBr OR Br⁻) M1 correct dipole ($\delta^+ \text{C} - \text{Br}^{\delta-}$) AND curly arrow from bond of C—Br to Br (or just beyond) M2 correct intermediate ALLOW R for $-(\text{CH}_2)_5\text{CH}_3$ M3 curly arrow from lone pair on OH⁻ to the C of intermediate (or suitable position where C—OH bond is made) <i>If SN2 mechanism shown:</i> Apply SN2 mechanism mark scheme only if mechanism shows OH / NaOH species attacking the reactant and no OH M1 correct dipole ($\delta^+ \text{C} - \text{Br}^{\delta-}$) AND curly arrow from bond of C—Br to Br of reactant (or just beyond) NOT M2 M3 curly arrow from lone pair on :OH⁻ to the appropriate C of the reactant	3

Question	Answer				Marks				
4(c)	Chemical test	observation with 2-bromooctane	observation with octan-2-ol	observation with $\text{CH}_3(\text{CH}_2)_5\text{CHCH}_2$	3				
	Br_2 in the dark	✗		orange / brown to colourless					
	PCl_5		steamy fumes	✗					
	$\text{AgNO}_3(\text{aq})$	cream precipitate OR off white precipitate	✗						
	6 correct answers = 3 marks 4 or 5 correct answers = 2 marks 2 or 3 correct answers = 1 mark 0 or 1 correct answer = 0 marks								
4(d)(i)	elimination				1				
4(d)(ii)	NaOH / sodium hydroxide in ethanol				1				
4(e)(i)	<table><tr><td></td><td>0</td><td>2</td><td>6</td></tr></table>		0	2	6				2
	0	2	6						
3 correct answers = 2 marks 2 correct answers = 1 mark 0 or 1 correct answers = 0 marks									

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Question	Answer	Marks
4(e)(ii)	M1 presence of a π bond M2 limited rotation of C=C bond M3 EITHER two different groups on each / both double bonded carbon atoms OR two different atoms on each / both double bonded carbon atom OR one H / atom and one alkyl group on each / both double bonded carbon atom	3

Cambridge International AS & A Level

CHEMISTRY**9701/23**

Paper 2 AS Level Structured Questions

May/June 2024**MARK SCHEME**Maximum Mark: 60

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

This document consists of **11** printed pages.

PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

PUBLISHED**GENERIC MARKING PRINCIPLE 5:**

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>'List rule' guidance</u> For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i>. • Incorrect responses should not be awarded credit but will still count towards <i>n</i>. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should not be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first <i>n</i> responses may be ignored even if they include incorrect science.

6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

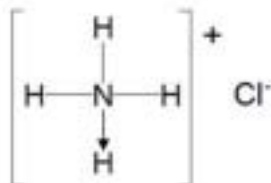
State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

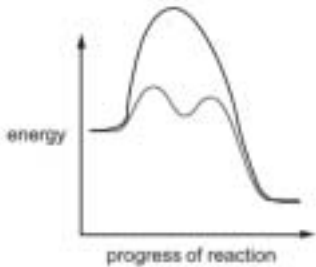
Question	Answer	Marks									
1(a)(i)	M1 (N ₂ molecules /molecule(s) of N ₂) have a strong triple (covalent) bond M2 (N ₂ molecules /molecule(s) of N ₂) are non-polar	2									
1(a)(ii)	<table border="1"> <tr> <td></td><td>σ bond</td><td>π bond</td></tr> <tr> <td>no of bonds</td><td>1</td><td>2</td></tr> <tr> <td>how orbitals overlap</td><td>direct (orbital overlap)</td><td>sideways (overlap of adjacent p orbitals)</td></tr> </table>		σ bond	π bond	no of bonds	1	2	how orbitals overlap	direct (orbital overlap)	sideways (overlap of adjacent p orbitals)	4
	σ bond	π bond									
no of bonds	1	2									
how orbitals overlap	direct (orbital overlap)	sideways (overlap of adjacent p orbitals)									
1(b)(i)	(+)III	1									
1(b)(ii)	number of outer / valence electrons	1									
1(c)(i)	both states shown as solid	1									
1(c)(ii)	M1 <i>correctly balanced equation for aluminium oxide</i> $\text{Al}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \rightarrow 2\text{NaAl}(\text{OH})_4$ M2 <i>correctly balanced equation for P₄O₁₀ and an excess of NaOH</i> $\text{P}_4\text{O}_{10} + 12\text{NaOH} \rightarrow 4\text{Na}_3\text{PO}_4 + 6\text{H}_2\text{O}$	2									
1(d)(i)	(+)IV	1									
1(d)(ii)	thermal decomposition	1									

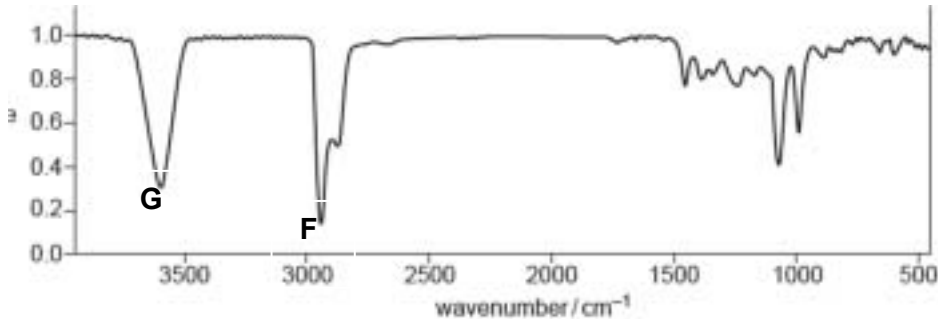
Question	Answer	Marks
2(a)	58% / no change / stays the same AND catalysts don't affect yield / iron is a catalyst	1
2(b)(i)	less yield (in C than A) AND (as) exothermic (forward reaction)	1
2(b)(ii)	(increase in temperature / energy from A to C (so)) M1 more collisions with particles that have $E > E_a$ AND increase frequency of effective collisions M2 (initial) rate (of the forward reaction) increases	2
2(c)(i)	M1 $K_p = (p\text{NH}_3)^2 / (p\text{N}_2)(p\text{H}_2)^3$ M2 atm^{-2}	2
2(c)(ii)	M1 correct amount N_2 at equilibrium = $1 - 1.16 / 2 = 0.42$ AND correct amount H_2 at equilibrium = $3.0 - (1.16 \times 3 / 2) = 1.26$ M2 express amount of ammonia as a mol fraction in terms of total amount of $\text{N}_2 + \text{H}_2 + \text{NH}_3$ at equilibrium = $1.16 / (\text{N}_2 + \text{H}_2 + 1.16) = 0.408$ OR 0.41	2
2(c)(iii)	$0.625 \times 1000 = 625$ (atm)	1
2(d)(i)	M1 catalyst M2 2 equations to show the catalytic activity of NO_2 in formation of SO_3 from SO_2 $\text{SO}_2 + \text{NO}_2 \rightarrow \text{NO} + \text{SO}_3$ $2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$ M3 describe production of H_2SO_4 from SO_3 and water (can be shown in an equation). SO_3 then reacts with (rain)water / moisture / water vapour to make sulfuric acid / H_2SO_4 OR $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$	3
2(d)(ii)	M1 unburned hydrocarbons combine with NO and / NO_2 M2 to form PAN / peroxyac(et)yl nitrate	2

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Question	Answer	Marks
3(a)	$\text{H}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$ M1 correct equation only M2 correct state symbols based on this equation	2
3(b)	$\Delta H = -(-1264) - (2 \times -46) + (2 \times -134) + (3 \times -286) = (+)230 \text{ kJ mol}^{-1}$ M1 correct expression in terms of all 4 enthalpy changes of formation AND correct stoichiometry (as described in given equation) M2 correct calculation based on figures given	2
3(c)(i)	giant (molecular and) covalent	1
3(c)(ii)	M1 give correct expression or calculate mol B compared to mol C $78.26 / 10.8 (= 7.246 / 7.25 \text{ mol B})$ AND $21.74 / 12 (=1.81(2) \text{ mol C})$ M2 Find B : C ratio AND use this to state empirical formula $7.246 \text{ to } 7.25 / 1.817 \text{ to } 1.82 = 3.99 \text{ to } 3.98 \text{ mol B} : 1 \text{ mol C}$ (so) B_4C OR CB_4	2

Question	Answer	Marks
4(a)	 OR Correct representation or label showing M1 (ionic bond between) NH_4^+ and Cl^- AND 4 N—H covalent bonds OR 4 shared pairs of electrons in NH_4 M2 1 N—H coordinate bond OR arrow on bond/line in correct direction or only 1 bonding pair using the same symbol for electrons¹	2
4(b)(i)	acid–base reaction	1
4(b)(ii)	$\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$	1
4(c)(i)	nucleophile	1
4(c)(ii)	OH^- (more reactive because) negatively charged species more attracted to halogenoalkane and / or $\text{C}^{\delta+}$ and / or intermediate and / or C^+ OR NH_3 (more reactive because) N electrons less tightly held OR N is more able to donate (lp) electrons (to make the covalent bond) OR N is less electronegative ORA	1

Question	Answer	Marks
4(d)	 M1 same start energy and finishing energy AND single hump M2 transition state / activation energy shown in answer is higher than both transition state energies shown in reaction profile (as the reaction is slower)	2
4(e)(i)	M1 dipole and correct arrow on C—Br of 2-bromobutane M2 lone pair on NH₃ attacking C(+) of the intermediate drawn M3 curly arrow showing bond between N—H breaking and pointing towards the N	3
4(e)(ii)	NH ₄ Br / ammonium bromide	1
4(e)(iii)	butan-2-amine OR butyl-2-amine	1
4(f)(i)		1
4(f)(ii)	M1 2-bromo-2-methylpropane AND more stable carbocation / C⁺ M2 alkyl groups have an inductive effect (of alkyl groups) AND 2-bromo-2-methylpropane has more / most alkyl groups attached (to C⁺) / carbocation contains more alkyl groups	2

Question	Answer	Marks
5(a)	cold dilute KMnO_4 OR cold dilute potassium manganate(VII)	1
5(b)(i)	step 1 Br_2 (in the dark) step 2 NaOH(aq) + heat	2
5(b)(ii)	electrophilic addition	1
5(c)	 M1 peak shown around 2850–2950 labelled F AND (corresponds to) C—H M2 peak shown around 3200–3600 labelled G AND (corresponds to) O—H (in hydroxy(l) / alcohol)	2
5(d)(i)	W =	1
5(d)(ii)	NH_4Cl	1
5(d)(iii)	$\text{C}_8\text{H}_{12}\text{O}_4 + 8[\text{H}] \rightarrow \text{C}_8\text{H}_{16}\text{O}_2 + 2\text{H}_2\text{O}$	1
5(d)(iv)	LiAlH_4	1