CAMBRIDGE
International Education

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.

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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.

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	'List rule' guidance For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • 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 ***n*** 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.

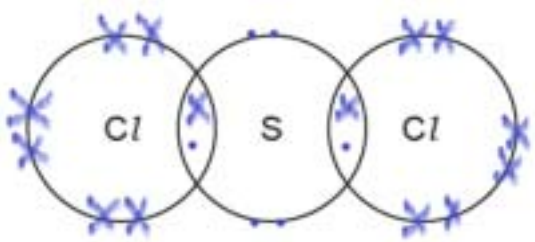
Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

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.

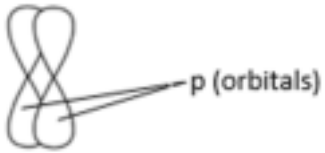
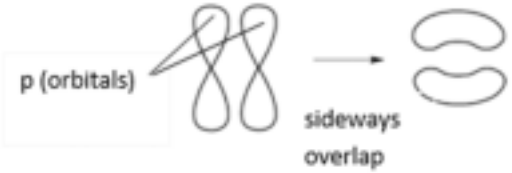
Question	Answer	Marks
1(a)	<table><tr><td>halogen</td><td>colour at 293 K</td></tr><tr><td>chlorine</td><td>green</td></tr><tr><td>bromine</td><td>brown</td></tr><tr><td>iodine</td><td>(dark) grey</td></tr></table> All three correct for one mark	**1**
1(b)	**M1** (it / volatility) decreases **M2** more electrons in molecules **M3** (so) increased strength of instantaneous dipole – induced dipole forces (of attraction)	**3**
1(c)(i)	$Br_2 + 2I^- \rightarrow 2Br^- + I_2$	**1**
1(c)(ii)	(Br_2 / 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)	$NaBr + H_2SO_4 \rightarrow HBr + NaHSO_4$ **OR** $2NaBr + H_2SO_4 \rightarrow 2HBr + Na_2SO_4$	**1**
1(d)(ii)	**M1** sodium chloride **M2** Cl^- is not a strong enough reducing agent to reduce H_2SO_4 **M3** Br^- & I^- are strong enough reducing agents to react (further) with (the S in) H_2SO_4 *Alternative M2 and M3* **M2** ability to behave as reducing agents increases down the group **M3 EITHER** Cl^- is not strong enough to reduce H_2SO_4 **OR** Br^- and I^- react (further) with (the S in) H_2SO_4	**3**

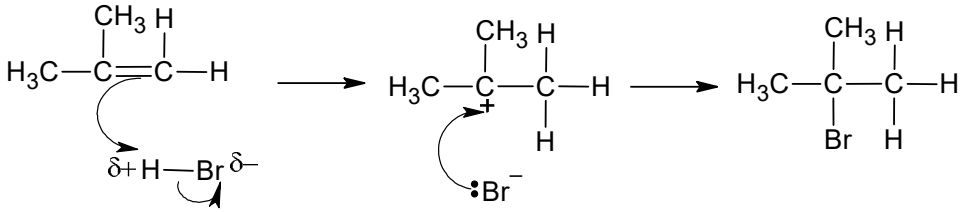
Question	Answer	Marks
2(a)(i)	hydrolysis	**1**
2(a)(ii)	silicon(IV) chloride / silicon tetrachloride **ALLOW** phosphorus(III) chloride / phosphorus trichloride	**1**
2(b)(i)	**M1** 1 shared pair of electrons between each S-C*l* shown as •× **M2** 6 non-bonding electrons around each C*l* shown as × **AND** 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><tr><td></td><td>oxidation number in Mg_3N_2</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	**1**
2(c)(ii)	$Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$	**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 $FeSCN^{2+}(aq)$ lower **M3** change in value of the equilibrium constant, K_c lower	**3**
3(c)(i)	**M1** *deduce the concentration of SCN^- present in initial mixture* [SCN^- eq'm] = [Fe^{3+} eq'm] = [original SCN^-] – [$FeSCN^{2+}$ produced] $1.30 \times 10^{-3} + 0.300 \times 10^{-3} = 1.60 \times 10^{-3}$ mol dm^{-3} **M2** *find initial amount of Fe^{3+} initially* M1 $\times$ 25 / 1000 = amount of Fe^{3+} added initially = 4.00×10^{-5} (mol)	**2**
3(c)(ii)	**M1** value for K_c = 178 **M2** units = mol^{-1} dm^3	**2**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(a)</td><td>M1 (enthalpy change / energy change) when one mole of a compound / substance is formed
M2 from its elements in their standard states</td><td>2</td></tr>
<tr><td>4(b)(i)</td><td>
<table>
<tr><td></td><td>equation for reaction</td><td>$\Delta H_{formation}$</td></tr>
<tr><td>Fe_2O_3</td><td>$2Fe\,(s) + \frac{3}{2}O_2\,(g) \rightarrow Fe_2O_3\,(s)$</td><td>–824.2</td></tr>
<tr><td>CO</td><td>$C\,(s) + \frac{1}{2}O_2\,(g) \rightarrow CO\,(g)$</td><td>–110.5</td></tr>
<tr><td>CO_2</td><td>$C\,(s) + O_2\,(g) \rightarrow CO_2\,(g)$</td><td>–393.5</td></tr>
</table>
</td><td>2</td></tr>
<tr><td>4(b)(ii)</td><td>$\Delta H_{reaction} = -\Delta H_{Fe2O3} - (3 \times -\Delta H_{CO}) + (3 \times -\Delta H_{CO2})$
$= -(-824.2) - (3 \times -110.5) + (3 \times -393.5)$
$= -24.8\ kJ\ mol^{-1}$

• 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</td><td>2</td></tr>
</table>

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× p– orbitals i.e.  OR  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** $(100 \times x) \div (1.1 \times 100) = 12$ (so) $x = 13.2$	**2**

Question	Answer	Marks
6(c)(ii)	<table><tr><td></td><td>observation on addition of 2,4–DNPH</td></tr><tr><td>**Y**</td><td>orange precipitate</td></tr><tr><td>**Q**</td><td>no precipitate</td></tr></table> Both correct for one mark	**1**
6(c)(iii)	ROH + Na → RONa + 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**