Cambridge Assessment
International Education

Cambridge International AS & A Level

CHEMISTRY **9701/22**

Paper 2 AS Level Structured Questions **May/June 2022**

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 2022 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 **14** printed pages.

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 descriptors 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.

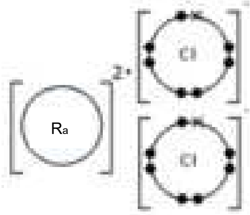
Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

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)	**M1** *comment explaining high melting point of Mg in terms of* many strong metallic bonds **OR** many strong (electrostatic) attractions between cations and delocalised electrons **OR** strong bonds in giant metallic structure. **M2** *comment explaining electrical conductivity of Mg in terms of movement of delocalised electrons* delocalised electrons can move through the structure	2
1(b)(i)	<table><tr><td>species</td><td>magnesium in Mg_3N_2</td><td>nitrogen in Mg_3N_2</td></tr><tr><td>oxidation number</td><td>2(+) / (+)II</td><td>3– / –III</td></tr></table>	1
1(b)(ii)	• redox • Mg loses electrons / Mg increases ox no / Mg is oxidised • N gains electrons / N reduces ox no / N is reduced	1
1(b)(iii)	**M1** (enthalpy change / energy change) when one mole of a compound / substance is formed **M2** from its elements in their standard states	2
1(b)(iv)	**M1** *correct method to find amount Mg_3N_2 formed in reaction* 3.645 ÷ 24.3 mol Mg produces 0.15 ÷ 3 mol of Mg_3N_2 **OR** 0.05 mol of Mg_3N_2 **M2** *use* **M1** *in correct expression to find energy released by 1 mol Mg_3N_2* 23.05 ÷ **M1** **OR** 23.05 ÷ mol Mg_3N_2 **OR** 23 050 ÷ **M1** **OR** 23 050 ÷ Mg_3N_2 **M3** *calculate value from* **M2** *expression correctly* ΔH = –(M2) = –461(.0) kJ mol^{-1} **OR** –461 000 J mol^{-1}	3

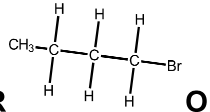
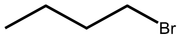
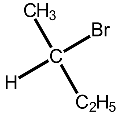
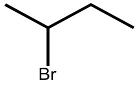
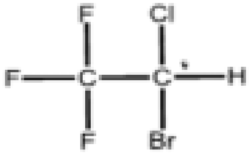
Question	Answer	Marks
2(a)	giant ionic	**1**
2(b)	Ra^{2+} and 2 x Cl^{-} 0 electrons surrounding 2Ra **AND** 8 electrons surrounding Cl 	**1**
2(c)(i)	$Ra + 2H_2O \rightarrow Ra(OH)_2 + H_2$	**1**
2(c)(ii)	Ra – more bubbles per unit time **OR** With Ra solid disappears more quickly **OR** Ra is the first to stop fizzing **ora**	**1**

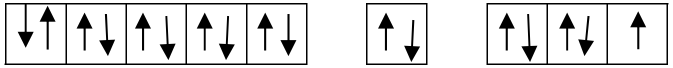
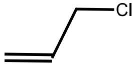
Question	Answer	Marks
2(c)(iii)	**option 1** *suggest why these* reactions *occur at different rates (collision theory)* **M1** difference in activation energy / ionisation energy **M2** affects the frequency of effective collisions (between particles / molecules) **OR** affects the proportion of particles with energy greater than activation energy **option 2** *suggest why the elements have different reactivity in terms of atomic structure (which results in a different rate)* **M1** ionisation energies are different **M2** a decrease in nuclear attraction due to **EITHER** increase in shielding **OR** increase in distance of outer electron from nucleus **OR** increase in number of shells of electrons **ora**	**2**
2(c)(iv)	**M1** • pH value (or values) for each solution must be greater > 7 **AND** • pH value (or range values) identified for solution made from Ra must be greater than pH values (or range of values) stated for Ca **M2** *any one from:* • solubility of group 2 hydroxides increases down the group • $Ra(OH)_2$ is more soluble • greater concentration of $OH^-(aq)$ in the solution involving Ra • more OH^- (aq) in the solution involving Ra	**2**

Question	Answer	Marks
2(d)	<table><tr><td>step</td><td>method</td><td>observation with $CaCl_2$</td><td>observation with $CaBr_2$</td><td>observation with CaI_2</td></tr><tr><td>step **1**</td><td>$AgNO_3(aq)$ $(+HNO_3(aq))$</td><td>white ppt</td><td>cream **OR** off-white ppt</td><td>(pale) yellow ppt</td></tr><tr><td>step **2**</td><td>NH_3 (aq)</td><td>(ppt) dissolves / (completely) soluble (in dilute or conc) OR (forms) colourless solution</td><td>(ppt) partly soluble / slightly soluble (in dilute or conc) **ALLOW** (ppt) dissolves in excess (in dilute or conc) **ALLOW** (ppt) soluble in **conc.**NH_3</td><td>(ppt) insoluble / solid remains (in dilute or concentrated)</td></tr></table> **M1** step **1** $AgNO_3(aq)$ / silver nitrate solution **AND** step **2** $NH_3(aq)$ / ammonia solution / dilute NH_3 / concentrated NH_3 **M2** ALL solid / precipitate **AND** correct colours described in row 1 **M3** correct observations on addition of ammonia	**3**

Question	Answer	Marks
3(a)(i)	**M1** rate(s) of forward and reverse / backward reactions are equal / are the same **M2** no change in measurable properties **OR** concentration of reactants and products remain constant	**2**
3(a)(ii)	(colourless gas) becomes purple (gas)	**1**
3(a)(iii)	$K_p = \dfrac{(pH^2)(pI^2)}{(pHI)^2}$	**1**
3(a)(iv)	**M1** *use correct expression for finding amount of HI used up in reaction* 86.4 = 100 × (0.025 – x) / 0.025 – x + x / 2 + x / 2) where x = *HI mol used up* OR 86.4 = 100 × (0.025 – 2x) / (0.025 – 2x + x + x) where 2x = *HI mol used up* **M2** *correct calculation to find amount of HI(mol) at equilibrium based on* *HI(mol) at eq'm = 0.025 – HI(mol) used* = 0.025 – 0.0034 = 0.0216 **OR** 0.022 (mol) **alternative method** **M1** *use the pp H_2 and pp I_2 at equilibrium (= 13.6) to calculate no mol H_2 & I_2 at equilibrium* (either 0.0034 in total **OR** 0.0017 each) **M2** *use value for no mol H_2 + I_2 in expression to find no mol HI* 0.025 – (no mol H_2 + I_2) = 0.0216	**2**
3(b)	evaluation, to give a value, based on calculation using: • all three correct bond energies [HI = 299, H_2 = 436, I_2 = 151] • correct use of stoichiometry to calculate ΔH for 1 mol HI $x = 1$ and $y = ½$ • *calculate a value for ΔH correctly* i.e. $x(299) – y(436 + 151)$ ΔH = (+)5.5 kJ mol^{-1}	**2**
3(c)	none / no change	**1**
3(d)(i)	acid-base	**1**

Question	Answer	Marks
3(d)(ii)	$8HI + H_2SO_4 \rightarrow 4I_2 + H_2S + 4H_2O$ **OR** $8H^+ + 8I^- + H_2SO_4 \rightarrow 4I_2 + H_2S + 4H_2O$	1
3(d)(iii)	*explanation in terms of comparison of reducing nature of HI to HCl* i.e. HI / I^- is stronger reducing agent compared to Cl^- / HCl **OR** *explanation in terms of additional behaviour of HI (compared to HCl)* i.e. HI / I^- reduces S (in sulfuric acid) / (concentrated) sulfuric acid	1

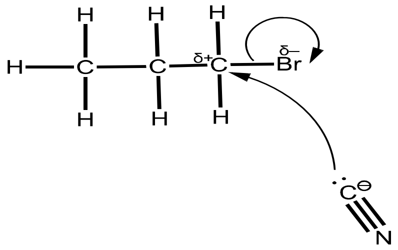
Question	Answer	Marks
4(a)(i)	$CH_3(CH_2)_2CH_2Br$ **OR**  **OR**  name: 1-bromobutane $CH_3CH_2CH(Br)CH_3$ **OR**  **OR**  name: 2-bromobutane **M1** structure of isomer 1 **AND** name **M2** structure of isomer 2 **AND** name (in any order)	2
4(a)(ii)	positional	1
4(b)(i)		1

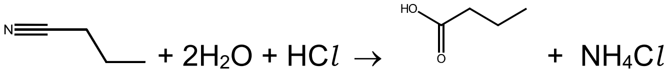
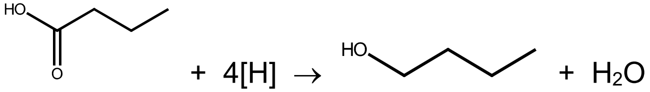
Question	Answer	Marks
4(b)(ii)	$CF_3CBrClH \rightarrow CF_3CHCl(\bullet) + Br(\bullet)$	**1**
4(b)(iii)	[Ar] 	**1**
4(c)(i)		**1**
4(c)(ii)	non-biodegradable **OR** poisonous / harmful HCl made when burnt	**1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>5(a)</td><td>
<table>
<tr><td>reaction</td><td>reagent and conditions</td><td>type of reaction</td></tr>
<tr><td>1</td><td>NaOH(aq) [M1]</td><td>substitution</td></tr>
<tr><td>2</td><td>NH_3 [M2]
in ethanol AND heat under pressure [M3]</td><td>substitution</td></tr>
<tr><td>3</td><td>NaOH in ethanol
AND heat [M4]</td><td>elimination</td></tr>
</table>

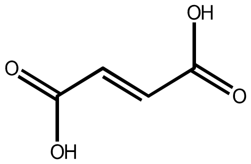
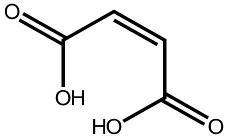
M5 and M6 types of reaction
[3 correct types = 2 marks and 2 correct types = 1 mark]

All reagents can be identified as (correct) formula or in words
</td><td>6</td></tr>
</table>

Question	Answer	Marks
5(b)	**M1** C–I (covalent bond) is weaker ora **M2** lower activation energy / lower E_a (with 2-iodopropane) **OR** **M2** *explain in terms of the SN_1 mechanism (that is dominant / preferred / occurring with 2-iodopropane is fast(er))* (identical) carbocation is made (more) quickly (with 2-iodopropane) **OR** low / less energy is required to make the (same)carbocation / intermediate (from 2-iodopropane) **OR** **M2** iodine / I (of C–I) has weaker attraction of nucleus to bonding / shared pair (of electrons) due to *any one of:* • more / high shielding (of electrons from inner shells) • more / 5 electron shells in iodine • C-I greater distance from nuclei (to bonding pair of electrons)	**2**
5(c)(i)	 **M1** dipole $C^{\delta+}$–$Br^{\delta-}$ **AND** curly arrow from C–Br bond to $Br^{\delta-}$ **M2** lone pair on C of ^{-}CN **AND** curly arrow from lone pair to C (on C-1 of bromopropane)	**2**

Question	**Answer**	**Marks**
5(c)(ii)	$CN(CH_2)_2CH_3 + 2H_2O + HCl \rightarrow HOOC(CH_2)_2CH_3 + NH_4Cl$ **OR** 	**1**
5(c)(iii)	$HOOC(CH_2)_2CH_3 + 4[H] \rightarrow HO(CH_2)_3CH_3 + H_2O$ **OR** 	**1**
5(c)(iv)	$LiAlH_4$ **OR** lithium tetrahydridoaluminate (in ether)	**1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>6(a)</td><td><table><tr><td>Br_2(aq)</td><td>orange to colourless OR orange disappears</td></tr><tr><td>Na_2CO_3(s)</td><td>fizzing OR bubbles OR effervescence</td></tr></table></td><td>2</td></tr>
<tr><td>6(b)</td><td>C : H : O
41.38 / 12 3.45 / 1 55.17 / 16
3.45 3.45 3.45 (so $C_{(1)}H_{(1)}O_{(1)}$)</td><td>1</td></tr>
<tr><td>6(c)(i)</td><td>Look for some reference to 116 as the mass of the molecular ion AND mass of $C_{(1)}H_{(1)}O_{(1)}$ = 29 to conclude molecular formula is $C_4H_4O_4$
116 / 29 = 4 so $C_4H_4O_4$</td><td>1</td></tr>
<tr><td>6(c)(ii)</td><td>M1 <i>m</i> / <i>e</i> 45: ^+COOH OR $^+CHO_2$
M2 <i>m</i> / <i>e</i> 71: $C_3H_3O_2^+$</td><td>2</td></tr>
</table>

Question	**Answer**	**Marks**
6(c)(iii)	 **OR** 	**1**