Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/22**

Paper 2 AS Level Structured Questions **May/June 2023**

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 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

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	<u>‘List rule’ guidance</u> 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.

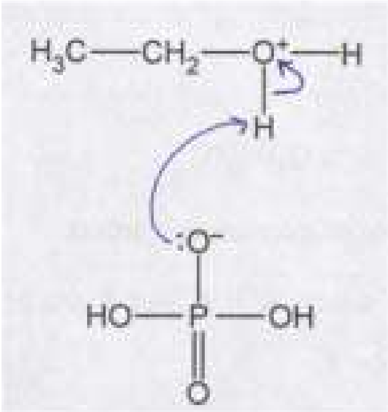
State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

Question	Answer	Marks
1(a)(i)	bonding in magnesium – metallic **AND** bonding in sodium chloride – ionic	**1**
1(a)(ii)	bonds in NaC*l* are stronger than bonds in Mg	**1**
1(a)(iii)	**M1** S_8 / molecules of sulfur have more electron**s** (than P_4 / molecules of phosphorus) **M2** S has stronger instantaneous dipole–induced dipole forces (than phosphorus / P)	**2**
1(b)(i)	power of an atom to attract electrons to itself	**1**
1(b)(ii)	(across a period) • increase in nuclear charge • similar shielding • (so) increase in nuclear attraction for bonding / outer / valence electrons **OR** bonding / outer / valence electron(s) are more strongly attracted to nucleus Two correct for one mark, three correct for two marks	**2**
1(b)(iii)	hydrogen bond	**1**
1(b)(iv)	**M1** link shown as a dashed line between the lone pair of electrons from N of one NH_3 to one H on other NH_3 **M2** minimum 3 correct partial charges (on adjacent atoms) over two NH_3 molecules **EITHER** $^{\delta-}$N—$^{\delta+}$H - - - $^{\delta-}$N **OR** $^{\delta+}$H - - -$^{\delta-}$N—$^{\delta+}$H	**2**
1(b)(v)	**M1** O is more electronegative than N **M2** two H-bonds per water molecule : 1 per ammonia molecule.	**2**

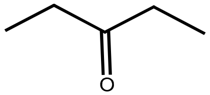
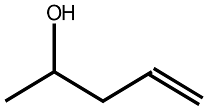
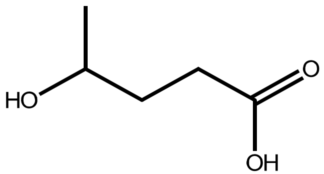
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)(i)</td><td><table><tr><td>element</td><td>Na</td><td>Mg</td><td>Al</td><td>Si</td><td>P</td></tr><tr><td>maximum oxidation number of elements in chlorides</td><td>(+)1</td><td>(+)2</td><td>(+)3</td><td>(+)4</td><td>(+)5</td></tr></table>All correct for one mark</td><td>1</td></tr>
<tr><td>2(a)(ii)</td><td>number of outer/valence electrons</td><td>1</td></tr>
<tr><td>2(b)(i)</td><td>$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$</td><td>1</td></tr>
<tr><td>2(b)(ii)</td><td>1–4</td><td>1</td></tr>
<tr><td>2(c)(i)</td><td>$PCl_5 + 4H_2O \rightarrow 5HCl + H_3PO_4$</td><td>1</td></tr>
<tr><td>2(c)(ii)</td><td>1–4</td><td>1</td></tr>
<tr><td>2(d)(i)</td><td>$Cl_2 + H_2O \rightleftharpoons HOCl + HCl$</td><td>1</td></tr>
<tr><td>2(d)(ii)</td><td>$3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$</td><td>1</td></tr>
<tr><td>2(e)(i)</td><td>ClO^-</td><td>1</td></tr>
<tr><td>2(e)(ii)</td><td>$NaClO + H_2O_2 \rightarrow O_2 + NaCl + H_2O$</td><td>1</td></tr>
<tr><td>2(e)(iii)</td><td>**M1** *(show how to calculate) mol O_2 gas*
42 cm^3 gas = 42 / 24000 mol oxygen gas (= 1.75×10^{-3} mol)
M2 *(process to find) amount NaClO in 10 cm^3 sample = 100 cm^3 (diluted) bleach*
M1 x 4 (= $4 \times 1.75 \times 10^{-3}$ mol in 10 cm^{-3} = 0.007)
M3 correct calculation using M2 to find concentration
= (M2 /10) $\times$ 1000 $\times$ 74.5 = 52.2 (g / dm^3)</td><td>3</td></tr>
</table>

Question	Answer	Marks
3(a)(i)	KCN in ethanol + heat	**1**
3(a)(ii)	propanenitrile	**1**
3(a)(iii)	(acid) hydrolysis	**1**
3(a)(iv)	2 $CH_3CH_2COOH + Ca \rightarrow (CH_3CH_2COO)_2Ca + H_2$ **M1** H_2 as product **M2** balanced equation based on correct formula of Y	**2**
3(b)	acid (conditions) / $H^+(aq)$ **AND** heat under reflux	**1**
3(c)	<table><tr><td>type of bond in **X**</td><td>number of bonds in **X**</td></tr><tr><td>sigma σ</td><td>8</td></tr><tr><td>pi π</td><td>2</td></tr></table>	**2**

Question	Answer	Marks
4(a)	Method 1 • identification of number and type of bonds when all are broken 2O-H + 4C-H + C=C **OR** (2 × 460) + (4 × 410) + 610 • Identification of number and type of bonds when all are made O-H + 5C-H + C-C + C-O **OR** (460 + (5 × 410) + 350 + 360) • calculation of energy to break bonds – energy to make bonds 3170 – 3220 = – 50 (kJ mol^{-1}) Two correct for one mark, three correct for two marks. **OR** Method 2 • identification of number and type of relevant bonds broken (including the new C-H only) 2O-H + C=C **OR** (2 × 460) + 610 • identification of number and type of relevant bonds made (including the new C-H only) O-H + C-H + C-C + C-O **OR** (460 + 410 + 350 + 360) • calculation using energy to break bonds – energy to make bonds 1530 – 1580 = –50 (kJ mol^{-1}) Two correct for one mark, three correct for two marks.	**2**
4(b)	**M1** amount ethanol increases **M2** equilibrium moves to right **AND** to produce fewer moles gas OR smaller amount of gas (to reduce the pressure)	**2**
4(c)(i)	acid **AND** it donates a proton / H^+	**1**
4(c)(ii)	$(CH_3CH_2)^+$ OR $CH_3C^+H_2$ **AND** accepts a pair of electrons	**1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(c)(iii)</td><td>

M1 arrow from bond of one of the O-H to O of the cation
M2 arrow from lone pair on O of the anion to between H of H-O</td><td>2</td></tr>
<tr><td>4(c)(iv)</td><td>M1 a catalyst increases rate of reaction
M2 by producing an alternative reaction pathway with lower activation energy</td><td>2</td></tr>
<tr><td>4(c)(v)</td><td>it is regenerated OR it is reformed</td><td>1</td></tr>
<tr><td>4(c)(vi)</td><td>M1 (propan-2-ol is produced via a) more stable carbocation OR more stable intermediate OR $(CH_3)_2C^+H$ is more stable
M2 (positive) inductive effect of more alkyl/methyl groups
OR more electron donating alkyl / methyl groups
OR greater electron donating effect of two alkyl / two methyl groups</td><td>2</td></tr>
<tr><td>4(d)</td><td><table><tr><td></td><td>sigma</td><td>pi</td></tr><tr><td>type of orbitals involved in bond</td><td>$sp^2(-sp^2)$</td><td>(2)p(-(2)p)</td></tr><tr><td>how the orbitals overlap</td><td>direct</td><td>sideways</td></tr></table>Two correct for one mark, four correct for two marks.</td><td>2</td></tr>
</table>

Question	Answer	Marks
5(a)	molecules / isomers with the same molecular formula / same number of atoms of each element **AND** different structural formulae / different structures	**1**
5(b)(i)	carbonyl (group)	**1**
5(b)(ii)	 **A**  **B**	**2**
5(c)(i)	 **C** **M1** $CH_3CH(OH)$ present **M2** five carbons in a straight chain **AND** molecular formula $C_5H_{10}O$ **AND** 1 C=C structure which shows only one type of stereoisomerism	**2**
5(c)(ii)	optical	**1**
5(d)(i)	ester	**1**
5(d)(ii)	condensation	**1**
5(d)(iii)		**1**

Question	Answer	Marks
5(d)(iv)	Any two of the following differences in spectra **D** compared to **E**:	**2**

	bond	**functional group**	**value or range of values of absorbance inclusive (cm^{-1})**
E	*C=O / C double bond to O*	*(ester)*	*1710–1750*
D	*C=O*	*(carboxy(l))*	*1670–1740*
D	*O-H OR OH bond*	*(carboxy(l))*	*2500–3000*
D	*O-H OR OH bond*	*(hydroxy(l) OR alcohol)*	*3200–3600*