CAMBRIDGE
International Education

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.

© Cambridge University Press & Assessment 2024

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.

© Cambridge University Press & Assessment 2024

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.

© Cambridge University Press & Assessment 2024

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.

© Cambridge University Press & Assessment 2024

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.

© Cambridge University Press & Assessment 2024

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(a)(i)</td><td>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</td><td>2</td></tr>
<tr><td>1(a)(ii)</td><td>
<table>
<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>
</td><td>4</td></tr>
<tr><td>1(b)(i)</td><td>(+)III</td><td>1</td></tr>
<tr><td>1(b)(ii)</td><td>number of outer / valence electrons</td><td>1</td></tr>
<tr><td>1(c)(i)</td><td>both states shown as solid</td><td>1</td></tr>
<tr><td>1(c)(ii)</td><td>M1 correctly balanced equation for aluminium oxide
$Al_2O_3 + 2NaOH + 3H_2O \rightarrow 2NaAl(OH)_4$

M2 correctly balanced equation for P_4O_{10} and an excess of NaOH
$P_4O_{10} + 12NaOH \rightarrow 4Na_3PO_4 + 6H_2O$</td><td>2</td></tr>
<tr><td>1(d)(i)</td><td>(+)IV</td><td>1</td></tr>
<tr><td>1(d)(ii)</td><td>thermal decomposition</td><td>1</td></tr>
</table>

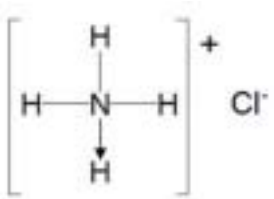
© Cambridge University Press & Assessment 2024

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** $K_p = (pNH_3)^2 / (pN_2)(pH_2)^3$ **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 × 3 / 2) = 1.26 **M2** express amount of ammonia as a mol fraction in terms of total amount of N_2+H_2+NH_3 at equilibrium = 1.16 / (N_2 + H_2 + 1.16) = 0.408 **OR** 0.41	**2**
2(c)(iii)	0.625 × 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* • $SO_2 + NO_2 \rightarrow NO + SO_3$ • $2NO + O_2 \rightarrow 2NO_2$ **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 $SO_3 + H_2O \rightarrow H_2SO_4$	**3**
2(d)(ii)	**M1** unburned hydrocarbons combine with NO and / NO_2 **M2** to form PAN / peroxyac(et)yl nitrate	**2**

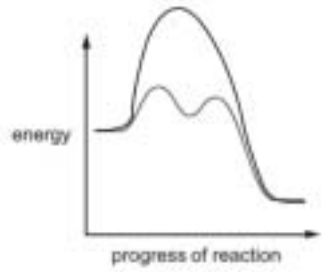
© Cambridge University Press & Assessment 2024

Question	Answer	Marks
3(a)	$H_2(g) + ½O_2(g) \rightarrow H_2O(l)$ **M1** correct equation only **M2** correct state symbols based on this equation	**2**
3(b)	$\Delta H = -(-1264) - (2 \times -46) + (2 \times -134) + (3 \times -286) = (+)230\ kJ\ mol^{-1}$ **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 mol B) **AND** 21.74 / 12 (=1.81(2) mol C) **M2** Find B : C ratio **AND** use this to state empirical formula 7.246 to 7.25 / 1.817 to 1.82 = 3.99 to 3.98 mol B : 1 mol C (so) B_4C OR CB_4	**2**

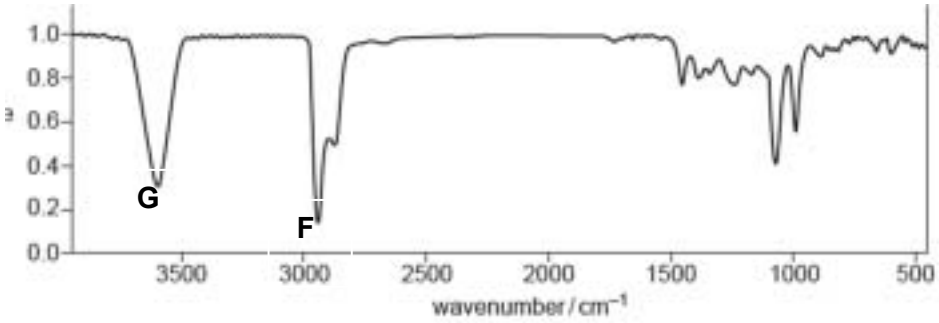
© Cambridge University Press & Assessment 2024

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)	$NH_4^+ + OH^- \rightarrow NH_3 + H_2O$	**1**
4(c)(i)	nucleophile	**1**
4(c)(ii)	OH^- (more reactive because) negatively charged species more attracted to halogenoalkane and / or $C^{\delta+}$ 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**

© Cambridge University Press & Assessment 2024

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 NH_3 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_4Br / 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**

© Cambridge University Press & Assessment 2024

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)	$C_8H_{12}O_4 + 8[H] \rightarrow C_8H_{16}O_2 + 2H_2O$	**1**
5(d)(iv)	$LiAlH_4$	**1**

© Cambridge University Press & Assessment 2024