



Cambridge International AS & A Level

CHEMISTRY

9701/21

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.

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This document consists of **10** 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 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.

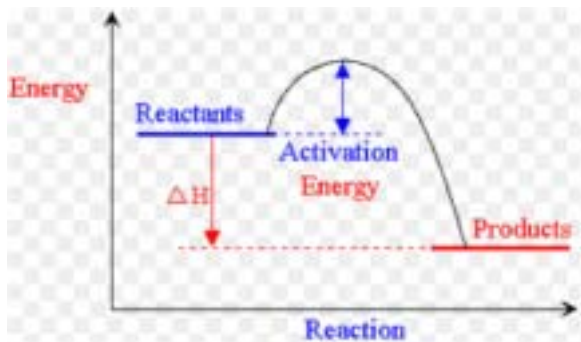
Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

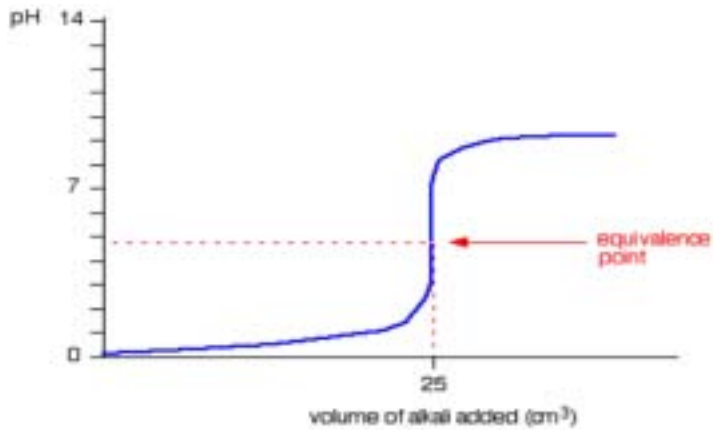
Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

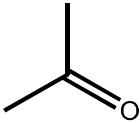
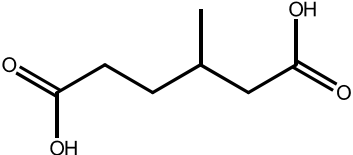
State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

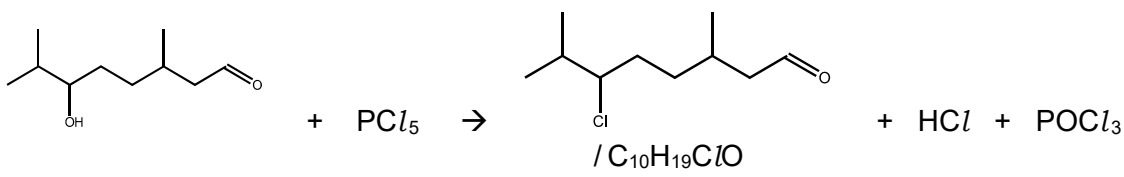
Question	Answer	Marks
1(a)	Identify and draw the shape of highest energy orbital of Ca 4s AND 	1
1(b)(i)	$\text{Ca}(\text{NO}_3)_2 \rightarrow \text{CaO} + 2\text{NO}_2 + \frac{1}{2}\text{O}_2$	1
1(b)(ii)	radium (nitrate) as thermal stability increases down group / has the greatest thermal stability	1
1(c)	white precipitate / solid (of radium sulfate)	1
1(d)(i)	number of protons: 12 number of neutrons: 13	1
1(d)(ii)	$1s^2 2s^2 2p^6 3s^2$	1
1(e)(i)	1 / 12 (one twelfth) the mass of a carbon-12 / ^{12}C atom	1
1(e)(ii)	M1 correct expression relating A_r to the mass / % abundance of the three isotopes $24.31 = x \times 0.7899 + 24.99 \times 0.1000 + 25.98 \times 0.1101$ M2 correct answer to 4 sig figs atomic mass of X = 23.99	2
1(e)(iii)	M1 (magnesium isotopes have) identical chemical properties AND same electron(ic) arrangement / configuration M2 different physical properties AND different number of neutrons	2
1(f)(i)	white flame / light OR white solid / smoke	1

Question	Answer	Marks
1(f)(ii)	M1 sketch shows exothermic reaction with a 'hump' AND labelled reactants ($\text{Mg} + \text{O}_2$) and products (MgO) M2 arrow from reactants / $\text{Mg} + \text{O}_2$ to products / MgO shown as ΔH M3 arrow showing activation energy / E_a / (+)148 	3
1(g)	M1 (heat / energy released from burning Mg) provides more particles with energy $\geq E_a$ M2 frequency of successful / effective collisions is greater	2

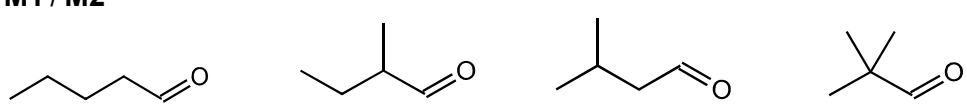
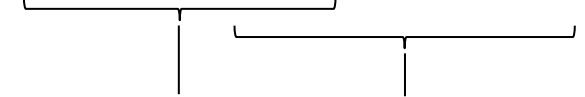
Question	Answer	Marks
2(a)	M1 one sigma / σ bond and two pi / π bonds M2 sp hybridisation (in each N atom) M3 sigma / σ forms from direct / head-on / end-on overlap of orbitals AND pi / π forms sideways / lateral overlap of (p) orbitals	3
2(b)(i)	M1 react with (unburnt) hydrocarbons M2 (form) PAN / peroxyac(et)yl nitrate	2
2(b)(ii)	$2\text{NO} + 2\text{CO} \rightarrow 2\text{CO}_2 + \text{N}_2$ OR $\text{NO}_2 + 2\text{CO} \rightarrow \frac{1}{2}\text{N}_2 + 2\text{CO}_2$	1

Question	Answer	Marks
2(c)	any Group 1 hydroxide or $\text{Ca}(\text{OH})_2$ / $\text{Sr}(\text{OH})_2$ / $\text{Ba}(\text{OH})_2$	1
2(d)(i)	M1 proton / H^+ donor M2 fully dissociates (in aqueous solution / water / solvent)	2
2(d)(ii)	$\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$	1
2(d)(iii)	M1 correct basic shape extending to $\sim 50 \text{ cm}^3$ with vertical portion of curve at 25 cm^3 M2 initial pH at 0–2 (based on idea that HCl is a strong acid) AND final pH at between 8–12 (based on idea that NH_3 is a weak alkali) 	2

Question	Answer	Marks
3(a)	M1 optical M2 one of the C atoms has 4 different groups / atoms attached	2
3(b)	 OR $(\text{CH}_3)_2\text{CO}$  OR $\text{HOOC}(\text{CH}_2)_2\text{CH}(\text{CH}_3)\text{CH}_2\text{COOH}$	2
3(c)(i)	NaBH_4 / sodium borohydride / LiAlH_4 / lithium tetrahydridoaluminate	1
3(c)(ii)	M1 $\text{H}_2\text{O}(\text{g})$ / steam M2 phosphoric acid (catalyst) / H_3PO_4 (catalyst)	2
3(c)(iii)	M1 Q AND intermediate / cation is (more) stable M2 (as the) C^+ has 3 / more alkyl groups attached M3 (so) greater (positive) inductive effect	3
3(d)(i)	M1 Q orange → green M2 R orange → green M3 $-\text{CHO}$ / aldehyde (in both) (and 2° / secondary alcohol in R) reacts / oxidised	3

Question	Answer	Marks
3(d)(ii)	 M1 correct formula of organic product M2 correct inorganic products	2
3(d)(iii)	M1 water reacts with / hydrolyses PCl_5 M2 $\text{H}_2\text{O} + \text{PCl}_5 \rightarrow \text{POCl}_3 + 2\text{HCl}$ OR $4\text{H}_2\text{O} + \text{PCl}_5 \rightarrow \text{H}_3\text{PO}_4 + 5\text{HCl}$	2

Question	Answer	Marks									
4(a)	M1 % / A_r for C H O M2 each % / A_r for C H O divided by the smallest value for % / A_r to give simplest whole number ratio / empirical formula M3 compare M_r from M2 ratio with 280 to deduce the actual molecular formula <table border="0"> <tr> <td>C</td> <td>H</td> <td>O</td> </tr> <tr> <td>$77.2 / 12 = 6.433$</td> <td>$11.4 / 1 = 11.4$</td> <td>$11.4 / 16 = 0.7125$</td> </tr> <tr> <td>9(.03)</td> <td>16</td> <td>1</td> </tr> </table> $M_r(\text{C}_9\text{H}_{16}\text{O}) = 140$ so molecular formula of V = $\text{C}_{18}\text{H}_{32}\text{O}_2$	C	H	O	$77.2 / 12 = 6.433$	$11.4 / 1 = 11.4$	$11.4 / 16 = 0.7125$	9(.03)	16	1	3
C	H	O									
$77.2 / 12 = 6.433$	$11.4 / 1 = 11.4$	$11.4 / 16 = 0.7125$									
9(.03)	16	1									
4(b)(i)	M1 (add) group 1 carbonate / group 1 bicarbonate / Na_2CO_3 / NaHCO_3 etc. M2 effervescence / fizzing / bubbling	2									
4(b)(ii)	3.196 g $\text{Br}_2 = 3.196 / 159.8 (= 0.02 \text{ mol } \text{Br}_2)$ AND $2.8(00) / 280 (= 0.01 \text{ mol } \text{V})$ 2 alkene / 2 C=C (groups)	1									
4(c)(i)	carbonyl	1									

Question	Answer	Marks
4(c)(ii)	CHI_3	1
4(c)(iii)	M1 / M2  M3 chain (isomerism)	3
4(d)	29 C_2H_5^+ 57 $\text{COCH}_2\text{CH}_3^+ \text{ OR } \text{C}_3\text{H}_5\text{O}^+ \text{ OR } \text{CH}_2\text{COCH}_3^+$  identity of Z pentan-3-one / $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$ pentan-2-one / $\text{CH}_3\text{COCH}_2\text{CH}_2\text{CH}_3$	3



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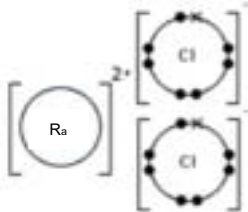
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Question	Answer	Marks						
1(a)	M1 comment explaining high melting point of Mg in terms of many strong metallic bonds OR many strong (electrostatic) attractions between cations and delocalised electrons OR strong bonds in giant metallic structure. 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 border="1"> <tr> <td>species</td><td>magnesium in Mg₃N₂</td><td>nitrogen in Mg₃N₂</td></tr> <tr> <td>oxidation number</td><td>2(+) / (+)II</td><td>3– / –III</td></tr> </table>	species	magnesium in Mg ₃ N ₂	nitrogen in Mg ₃ N ₂	oxidation number	2(+) / (+)II	3– / –III	1
species	magnesium in Mg ₃ N ₂	nitrogen in Mg ₃ N ₂						
oxidation number	2(+) / (+)II	3– / –III						
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 Mg₃N₂ formed in reaction 3.645 ÷ 24.3 mol Mg produces 0.15 ÷ 3 mol of Mg₃N₂ OR 0.05 mol of Mg₃N₂ M2 use M1 in correct expression to find energy released by 1 mol Mg₃N₂ 23.05 ÷ M1 OR 23.05 ÷ mol Mg₃N₂ OR 23 050 ÷ M1 OR 23 050 ÷ Mg₃N₂ M3 calculate value from M2 expression correctly $\Delta H = -(M2) = -461(.0) \text{ kJ mol}^{-1}$ OR $-461\,000 \text{ J mol}^{-1}$	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)	$\text{Ra} + 2\text{H}_2\text{O} \rightarrow \text{Ra}(\text{OH})_2 + \text{H}_2$	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

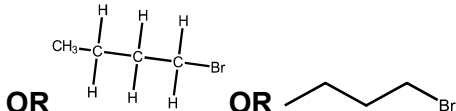
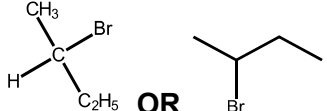
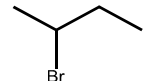
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2(c)(iii)	option 1 <i>suggest why these reactions occur at different rates (collision theory)</i> M1 difference in activation energy / ionisation energy M2 affects the frequency of effective collisions (between particles / molecules) OR affects the proportion of particles with energy greater than activation energy option 2 <i>suggest why the elements have different reactivity in terms of atomic structure (which results in a different rate)</i> 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

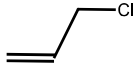
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2(d)	step	method	observation with CaCl_2	observation with CaBr_2	observation with CaI_2	3
	step 1	$\text{AgNO}_3(\text{aq})$ (+ $\text{HNO}_3(\text{aq})$)	white ppt	cream OR off-white ppt	(pale) yellow ppt	
	step 2	$\text{NH}_3(\text{aq})$	(ppt) dissolves / (completely) soluble (in dilute or conc) OR (forms) colourless solution	(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	(ppt) insoluble / solid remains (in dilute or concentrated)	
	M1 step 1 $\text{AgNO}_3(\text{aq})$ / silver nitrate solution AND step 2 $\text{NH}_3(\text{aq})$ / 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					

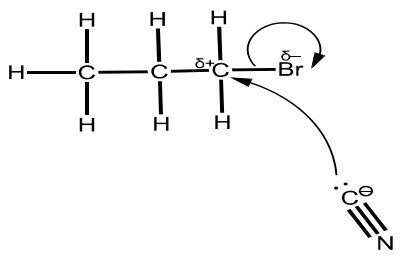
Question	Answer	Marks
3(a)(i)	M1 rate(s) of forward and reverse / backward reactions are equal / are the same M2 no change in measurable properties OR concentration of reactants and products remain constant	2
3(a)(ii)	(colourless gas) becomes purple (gas)	1
3(a)(iii)	$K_p = \frac{(pH^2)(pI^2)}{(pHI)^2}$	1
3(a)(iv)	M1 use correct expression for finding amount of HI used up in reaction $86.4 = 100 \times (0.025 - x) / 0.025 - x + x / 2 + x / 2$ where $x = HI \text{ mol used up}$ OR $86.4 = 100 \times (0.025 - 2x) / (0.025 - 2x + x + x)$ where $2x = HI \text{ mol used up}$ M2 correct calculation to find amount of HI(mol) at equilibrium based on HI(mol) at eq'm = $0.025 - HI(\text{mol}) \text{ used} = 0.025 - 0.0034 = 0.0216$ 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 $0.025 - (\text{no mol } H_2 + I_2) = 0.0216$	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 $y = \frac{1}{2}$ - calculate a value for ΔH correctly i.e. $x(299) - y(436 + 151)$ $\Delta H = (+)5.5 \text{ kJ mol}^{-1}$	2
3(c)	none / no change	1
3(d)(i)	acid-base	1

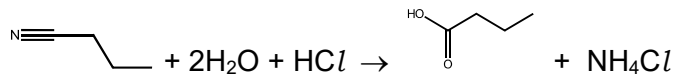
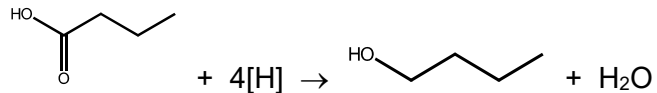
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3(d)(ii)	$8\text{HI} + \text{H}_2\text{SO}_4 \rightarrow 4\text{I}_2 + \text{H}_2\text{S} + 4\text{H}_2\text{O}$ OR $8\text{H}^+ + 8\text{I}^- + \text{H}_2\text{SO}_4 \rightarrow 4\text{I}_2 + \text{H}_2\text{S} + 4\text{H}_2\text{O}$	1
3(d)(iii)	<i>explanation in terms of comparison of reducing nature of HI to HCl</i> i.e. HI / I^- is stronger reducing agent compared to Cl^- / HCl OR <i>explanation in terms of additional behaviour of HI (compared to HCl)</i> i.e. HI / I^- reduces S (in sulfuric acid) / (concentrated) sulfuric acid	1

Question	Answer	Marks
4(a)(i)	$\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{Br}$  OR  name: 1-bromobutane $\text{CH}_3\text{CH}_2\text{CH}(\text{Br})\text{CH}_3$  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

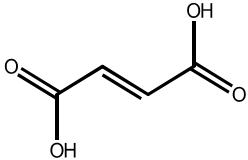
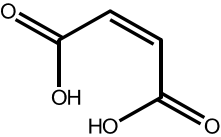
Question	Answer	Marks											
4(b)(ii)	$\text{CF}_3\text{CBrClH} \rightarrow \text{CF}_3\text{CHCl}(\bullet) + \text{Br}(\bullet)$	1											
4(b)(iii)	[Ar] <table border="1"><tr><td>↓↑</td><td>↑↓</td><td>↑↓</td><td>↑↓</td><td>↑↓</td><td>↑↓</td><td>↑↓</td></tr></table> <table border="1"><tr><td>↑↓</td></tr></table> <table border="1"><tr><td>↑↓</td><td>↑↓</td><td>↑</td></tr></table>	↓↑	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑	1
↓↑	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓							
↑↓													
↑↓	↑↓	↑											
4(c)(i)		1											
4(c)(ii)	non-biodegradable OR poisonous / harmful HCl made when burnt	1											

Question	Answer	Marks												
5(a)	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">reaction</th><th style="width: 45%;">reagent and conditions</th><th style="width: 40%;">type of reaction</th></tr> </thead> <tbody> <tr> <td style="text-align: center;">1</td><td>NaOH(aq) [M1]</td><td>substitution</td></tr> <tr> <td style="text-align: center;">2</td><td>NH₃ [M2] in ethanol AND heat under pressure [M3]</td><td>substitution</td></tr> <tr> <td style="text-align: center;">3</td><td>NaOH in ethanol AND heat [M4]</td><td>elimination</td></tr> </tbody> </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	reaction	reagent and conditions	type of reaction	1	NaOH(aq) [M1]	substitution	2	NH ₃ [M2] in ethanol AND heat under pressure [M3]	substitution	3	NaOH in ethanol AND heat [M4]	elimination	6
reaction	reagent and conditions	type of reaction												
1	NaOH(aq) [M1]	substitution												
2	NH ₃ [M2] in ethanol AND heat under pressure [M3]	substitution												
3	NaOH in ethanol AND heat [M4]	elimination												

Question	Answer	Marks
5(b)	M1 C–I (covalent bond) is weaker M2 lower activation energy / lower E_a (with 2-iodopropane) OR M2 <i>explain in terms of the S_N1 mechanism (that is dominant / preferred / occurring with 2-iodopropane is fast(er))</i> (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 <i>any one of</i>: • 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)	$\text{CN}(\text{CH}_2)_2\text{CH}_3 + 2\text{H}_2\text{O} + \text{HCl} \rightarrow \text{HOOC}(\text{CH}_2)_2\text{CH}_3 + \text{NH}_4\text{Cl}$ OR 	1
5(c)(iii)	$\text{HOOC}(\text{CH}_2)_2\text{CH}_3 + 4[\text{H}] \rightarrow \text{HO}(\text{CH}_2)_3\text{CH}_3 + \text{H}_2\text{O}$ OR 	1
5(c)(iv)	LiAlH_4 OR lithium tetrahydridoaluminate (in ether)	1

Question	Answer		Marks
6(a)	Br ₂ (aq)	orange to colourless OR orange disappears	2
	Na ₂ CO ₃ (s)	fizzing OR bubbles OR effervescence	
6(b)	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₎)		1
6(c)(i)	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 ₄ H ₄ O ₄ 116 / 29 = 4 so C ₄ H ₄ O ₄		1
6(c)(ii)	M1 <i>m / e</i> 45: +COOH OR +CHO ₂ M2 <i>m / e</i> 71: C ₃ H ₃ O ₂ ⁺		2

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



Cambridge International AS & A Level

CHEMISTRY

9701/23

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 **12** 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	<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.

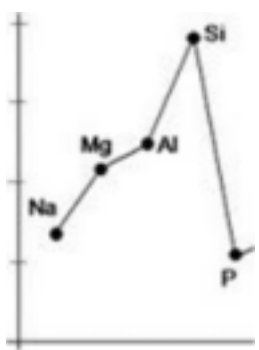
7 Guidance for chemical equations

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

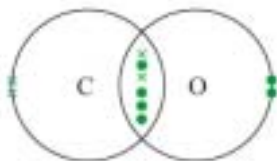
State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

Question	Answer	Marks										
1(a)	- energy required - when one electron is removed - from each atom in one mole of - gaseous atoms two or three points for one mark, four points for two marks	2										
1(b)	Group VI / 16 AND large increase (in IE) after 6th	1										
1(c)	M1 reference to spin pair repulsion in (3)p orbital (in S) OR due to repulsion of two electrons in a (3)p orbital (in S) M2 outweighs increased nuclear charge (in S)	2										
1(d)	M1 <i>similarity in electronic structure / shielding of Al^{2+} and Na</i> both remove electron from (3)s ¹ / single electron in (3)s (sub-level / orbital) OR Al^{2+} and Na have same electronic configuration OR shielding (of outer electron) is the same M2 <i>greater nuclear charge / number of protons</i> $Al^{(2+)}$ has greater nuclear charge OR 13p compared to 11p	2										
1(e)	<table><tr><td></td><td>atomic no.</td><td>nucleon no.</td><td>no.of neutrons</td><td>electronic arrangement</td></tr><tr><td>copper –65</td><td>29</td><td>65</td><td>65 – 29 = 36</td><td>1s² 2s² 2p⁶ 3s² 3p⁶ 3d¹⁰4s¹</td></tr></table> M1 29 AND 65 M2 nucleon no – atomic no ALLOW ecf from M1 M3 electronic arrangement		atomic no.	nucleon no.	no.of neutrons	electronic arrangement	copper –65	29	65	65 – 29 = 36	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ¹⁰ 4s ¹	3
	atomic no.	nucleon no.	no.of neutrons	electronic arrangement								
copper –65	29	65	65 – 29 = 36	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ¹⁰ 4s ¹								

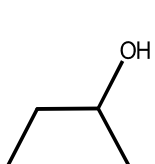
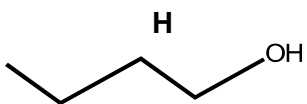
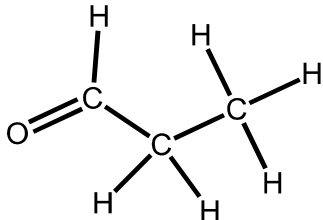
Question	Answer	Marks
1(f)(i)	$M_r = 63.5$ $(1.05 / 63.5) \times 6.022 \times 10^{23} = 9.958 \times 10^{21}$ OR 9.96×10^{21}	1
1(f)(ii)	M1 comment explaining high melting point of Cu many strong metallic bonds OR many strong (electrostatic) attractions between cations and delocalised electrons OR strong bonds in giant metallic structure. M2 comment explaining electrical conductivity of Cu delocalised electrons are free are to move through the structure (owtte)	2

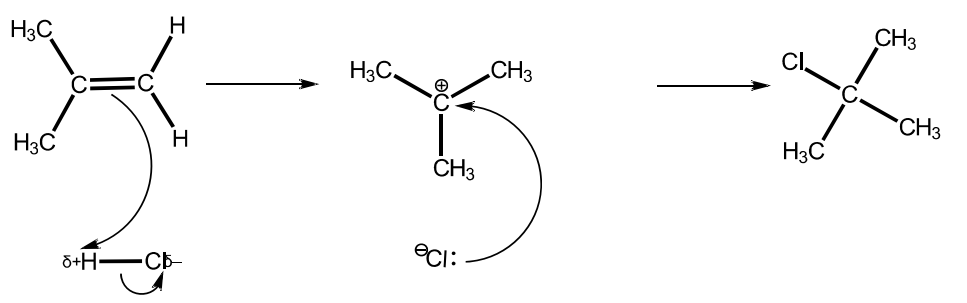
Question	Answer	Marks
2(a)(i)		3

Question	Answer				Marks
2(a)(ii)			sodium chloride	phosphorus (V) chloride	3
	state at room temperature		solid	solid	
	name of change which occurs on addition of water		dissolves	hydrolysis	
	pH of final solution		7	1–2	
2(b)(i)	M1 $2\text{NaTs} + \text{Br}_2 \rightarrow 2\text{NaBr} + \text{Ts}_2$ OR $2\text{Ts}^- + \text{Br}_2 \rightarrow 2\text{Br}^- + \text{Ts}_2$ M2 Ts^- reduces Br / Br_2 OR reducing strength of halide (ion) increases down the group				2
2(b)(ii)	element	chlorine	bromine	tennessine	2
	melting point / °C	–101	–7.2	> 250	
	lattice structure of crystalline solid	simple molecular	simple molecular	giant metallic	

Question	Answer	Marks
3(a)(i)		1

Question	Answer	Marks
3(a)(ii)	M1 expression OR value derived from using all bond energy values and ΔH correctly, ignoring stoichiometry $-7 = (n350 + m360 + p410) - (q410 + r350 + sC\equiv O)$. M2 correct calculation based on correct expression AND stoichiometry $[-7 = 2(350) + 2(360) + 10(410) - 10(410) - 350 - x] = (+)1077 \text{ kJ mol}^{-1}$	2
3(a)(iii)	M1 $K_c = \frac{[C_2H_6][CO][CH_4]}{[C_4H_{10}O]}$ M2 $\text{mol}^2 \text{ dm}^{-6}$	2
3(a)(iv)	M1 no change / none M2 I_2 is a catalyst AND does not affect position of equilibrium OR I_2 is a catalyst AND reduces time taken to reach (same) equilibrium	2
3(a)(v)	- start at origin and not crossing original until beyond the peak - peak to the right-hand side of original peak AND lower than original - line does not cross the original after the peak reached	2
3(b)(i)	functional group	1
3(b)(ii)	positional	1

Question	Answer	Marks
3(b)(iii)	 J name: butan-2-ol  H name: butan-1-ol M1 correct structures M2 correct structures in correct boxes H and J M3 correct corresponding name of both H and J	3
3(c)	displayed formula of propanal  M1 identification of propanal M2 correct use of displayed formula and correct formula used	2

Question	Answer	Marks
4(a)(i)	 M1 curly arrow from = to H AND correct dipole on H–Cl M2 correct intermediate M3 curly arrow from H–Cl bond to Cl AND curly arrow from lp on: Cl⁻ to C⁺	3
4(a)(ii)	- intermediate OR C⁺ OR carbocation (formed) is more stable - due to greater (positive) inductive effect. - caused by 3 methyl groups / 3 alkyl groups / more alkyl groups attached to C⁺ / central C	2
4(b)(i)	M1 hydroxy(l) M2 substitution	2
4(b)(ii)	$\text{I}^- + \text{Ag}^+ \rightarrow \text{AgI}$	1
4(b)(iii)	M AND C–I (bond) is weak(er)	1
4(b)(iv)	$\text{C}_2\text{H}_5\text{COO}^-$ OR $\text{CH}_3\text{CH}_2\text{CO}_2^-$ or propanoate (an)ion	1
4(b)(v)	$\text{CH}_3\text{CH}_2\text{CHICH}_3$ M1 correct identification of I on 4C molecule M2 unambiguous structure of M – unbranched with 4C and I on 2C	2

Question	Answer	Marks
5(a)(i)	cold + dilute	1
5(a)(ii)	M1 unbranched 4C structure AND any number of –OH in any position M2 0.001 mol H₂ made from 0.001 mol Y AND R–OH + Na → RNa + ½H₂ OR use of 1 OH (group) → ½H₂ M3 CH₃CH(OH)CH(OH)CH₃	3
5(b)(i)	$100 \times 2.2 / 1.1 \times 100 = \underline{2}$	1
5(b)(ii)	chlorine / Cl AND peak at M+2 represents the molecular ion with 37–Cl (rather than 35–Cl as relative abundance of (peaks) M: M+2 is 100:33 / 3:1) OR relative abundance of (peaks) M: M+2 is 100:33.3 / 3:1 (so peak at M+2 contains 37–Cl)	1
5(b)(iii)	m / e = 29: C₂H₅⁺ m / e = 49: CH₂C⁺l name of Z: chloroethane	3