



Cambridge International AS & A Level

CHEMISTRY

9701/21

Paper 2 AS Level Structured Questions

May/June 2021

MARK SCHEME

Maximum Mark: 60

Published

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This document consists of **10** printed pages.

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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***.
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 - 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.

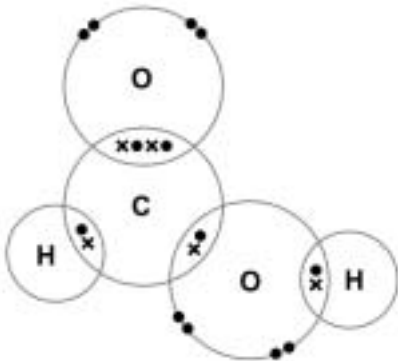
Question	Answer	Marks
1(a)(i)	option 1 M1 the mass of a molecule OR the (weighted) average / (weighted) mean mass of the molecule(s)	1
	option 1 and M2 relative / compared to 1 / 12 (the mass) of an atom of carbon–12	1
	OR on a scale in which a carbon–12 atom / isotope has a mass of (exactly) 12 (units) option 2 M1 mass of one mol of molecules	
	option 2 M2 relative / compared to 1 / 12 (the mass) of 1 mol of C-12 OR which one mol C-12 (atom / isotope) has a mass of (exactly) 12 g	
1(a)(ii)	CO ₂ H	1
1(a)(iii)	0.18/90 × 2 × 6.02 × 10 ²³ = 2.408 × 10 ²¹ (atoms) OR 2.4(1) × 10 ²¹ (atoms) M1 no mole ethanedioic acid 0.18 / 90 = 0.0020	1
	M2 no mole ethanedioic acid × 2 0.0020 × 2 = 0.0040	1
	M3 no mole ethanedioic acid × 6.02 × 10 ²³ 2.4 × 10 ²¹	1
1(b)(i)	CaC ₂ O ₄ (s) → CaO(s) + CO ₂ (g) + CO(g) M1 correct formulae	1
	M2 balancing equation AND state symbols.	1
1(b)(ii)	(thermal) decomposition OR disproportionation	1
1(b)(iii)	calcium carbonate / CaCO ₃	1

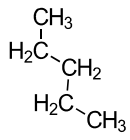
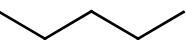
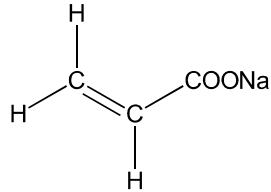
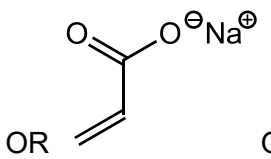
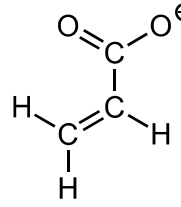
Question	Answer			Marks									
2(a)(i)	M1 both make triple (covalent) bond / 3 shared pairs of electrons			1									
	M2 one bond in CO is coordinate / dative covalent / formed by donating a pair of electrons from O (to C)			1									
2(a)(ii)	<table><tr><td></td><td>N₂</td><td>CO</td></tr><tr><td>number of electrons per molecule</td><td>14</td><td>14</td></tr><tr><td>type of van der Waals'</td><td>temporary / instantaneous dipole–induced dipole</td><td>permanent dipoles–(permanent) dipoles (and temporary / induced / instantaneous dipoles)</td></tr></table>				N ₂	CO	number of electrons per molecule	14	14	type of van der Waals'	temporary / instantaneous dipole–induced dipole	permanent dipoles–(permanent) dipoles (and temporary / induced / instantaneous dipoles)	2
	N ₂	CO											
number of electrons per molecule	14	14											
type of van der Waals'	temporary / instantaneous dipole–induced dipole	permanent dipoles–(permanent) dipoles (and temporary / induced / instantaneous dipoles)											
2(b)	CO / it is a polar molecule / it has a (permanent) dipole (but N ₂ is non-polar)			1									
2(c)(i)	high temperature AND low pressure			1									
2(c)(ii)	M1 CO is polar / has a permanent dipole OR N ₂ is non-polar			1									
	M2 IMF in CO are (more) significant / larger OR IMF in N ₂ are smaller / less significant			1									
	Alternative answer M1 (Size of) N ₂ smaller than CO OR volume of N ₂ molecules / particles smaller												
	Alternative answer M2 volume of N ₂ molecules / particles is more negligible ORA												

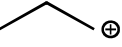
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Question	Answer	Marks
2(d)	M1 correct conversion to consistent units P = 101 000 V = 100 / 1 000 000 = (1×10^{-4}) T = 293	1
	M2 use of all values from M1 in correct relationship, $n = PV / RT$	1
	M3 calculation = $4.15 \times 10^{-3} \text{ mol}$	1

Question	Answer	Marks
3(a)(i)	$\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{NaHSO}_4 + \text{HCl}$ OR $2\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HCl}$	1
3(a)(ii)	displacement / acid-base (reaction)	1
3(b)(i)	hydrogen iodide / HI	1
3(b)(ii)	dark grey solid I_2 / iodine	1
	other product S / sulfur OR H_2S / hydrogen sulfide OR H_2O / water / steam	1
3(c)	M1 iodide ions are strong(er) reducing agents (than chloride ions) ORA	1
	M2 HI / iodide is oxidised OR HCl / chloride is not oxidised	1
3(d)	$2\text{Br}^- + 2\text{H}^+ + \text{H}_2\text{SO}_4 \rightarrow \text{Br}_2 + 2\text{H}_2\text{O} + \text{SO}_2$	1

Question	Answer	Marks
4(a)	Br / bromine as the oxidation number of Br decreases / goes from 0 $\rightarrow$ -1 OR bromine as it causes oxidation number of C (in methanoic acid) to increase / go from (+)2 $\rightarrow$ (+)4	1
4(b)	(solution) turns (from brown / orange / red to) colourless / decolorises OR brown / orange / red fades	1
4(c)(i)	rate = total change in concentration of Br ₂ divided by time taken <i>calculation dependent on graph</i> $(100 \times 10^{-5} - 12 \times 10^{-5}) / 600$ M1 average rate of reaction 1.47×10^{-6}	1
	M2 units mol dm ⁻³ s ⁻¹	1
4(c)(ii)	graph shown on same axes has steeper initial gradient AND reaches the same final [Br ₂]	1
4(c)(iii)	M1 (at increased temp the average kinetic) energy of particles / species / molecules increases.	1
	M2 (many) more/greater proportion of particles with energy $\geq E_a$	1
4(d)	 M1 correct bonding electrons M2 correct number of non-bonding electrons around each oxygen	1

Question	Answer	Marks
5(a)(i)	(compounds / molecules) containing only / entirely carbon and hydrogen (atoms)	1
5(a)(ii)	crude oil	1
5(b)(i)	(thermal) cracking	1
5(b)(ii)	<i>structure of W</i>  OR $\text{CH}_3(\text{CH}_2)_3\text{CH}_3$ OR 	1
5(c)(i)	CO_2H / carboxylic acid	1
5(c)(ii)	M1 (add) $\text{Br}_2(\text{aq})$ / bromine water	1
	M2 (solution) turns (from brown / orange / red to) colourless / decolorises OR brown / orange / red fades	1
5(d)	 OR $\text{CH}_2\text{CH}(\text{CO}_2^{(-)}\text{Na}^{(+)})$ OR $\text{CH}_2=\text{CH}(\text{COO}^{(-)}\text{Na}^{(+)})$  OR  , etc.	1
5(e)(i)	carbon dioxide / CO_2	1
5(e)(ii)	CO / hydrocarbons AND toxic / poisonous / harmful to health / (catalyses formation of) photochemical smog	1

Question	Answer	Marks									
6(a)	addition	1									
6(b)	M1 <i>catalyst</i> = sulfuric acid / phosphoric(V) acid	1									
	M2 <i>conditions of reaction</i> = steam / heat (and pressure)	1									
6(c)	<table border="1"> <tr> <td></td><td>σ</td><td>π</td></tr> <tr> <td>C₃H₆</td><td>8</td><td>1</td></tr> <tr> <td>C₃H₈O</td><td>11</td><td>0</td></tr> </table>		σ	π	C ₃ H ₆	8	1	C ₃ H ₈ O	11	0	2
	σ	π									
C ₃ H ₆	8	1									
C ₃ H ₈ O	11	0									
6(d)(i)	M1 more stable = CH ₃ C ⁺ (H)(CH ₃) 	1									
	M2 less stable = CH ₃ CH ₂ C ⁺ (H ₂) / 	1									
	M3 greater (positive) inductive effect of two alkyl groups OR greater electron donation of two alkyl groups owtte	1									
6(d)(ii)	propan-2-ol	1									
6(e)(i)	elimination	1									
6(e)(ii)	M1 NaOH / KOH	1									
	M2 ethanolic solution / ethanol / alcohol + heat	1									



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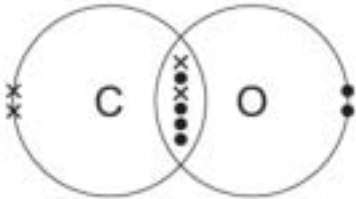
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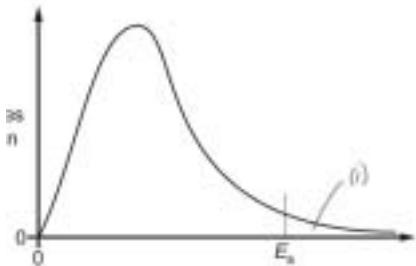
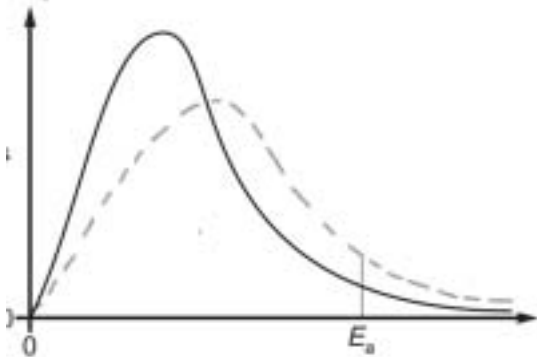
Question	Answer	Mark
1(a)	M1 cream	1
	M2 AgBr	1
1(b)	(1) $\text{MBr}_2 + 2\text{AgNO}_3 \rightarrow 2\text{AgBr} + \text{M}(\text{NO}_3)_2$	1
1(c)	M1 calculate M_r of MBr_2 using $8.415 \times 10^{-4} \text{ mol MBr}_2$ in 0.250 g $M_r = \dots\dots = 297(.1)\dots\dots$	1
	M2 calculate the atomic mass of M using M_r calculated in M1 $297.1 - (2 \times 79.9) = 137(.4)$	1
	M3 identify group 2 element from A_r in M2 Ba / barium	1
1(d)(i)	(solution / mixture / liquid) turns (colourless to) orange or brown	1
1(d)(ii)	displacement	1
1(e)	M1 reagent: concentrated sulfuric acid	1
	M2 observation: brown vapour / gas (forms)	1
1(f)(i)	explain how the action of heat is used to identify the 3 samples	1
	M1 nitrate AND carbonate lose mass / less than 1 g	
	M2 nitrate produces brown (NO_2) fumes	1
	M3 MgO no reaction / MgO no change	1
1(f)(ii)	electronic configuration of Mg^{2+} ($1s^2$) $2s^2 2p^6$	1

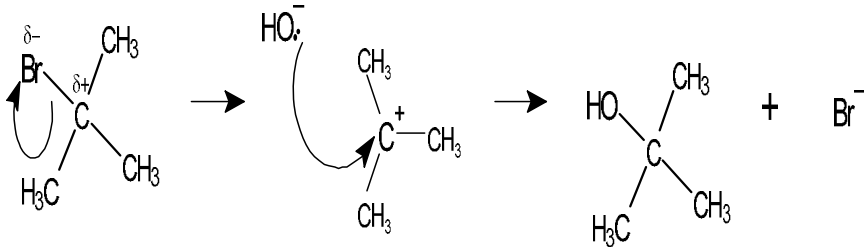
Question	Answer	Mark
1(g)	One similarity M1 solid(s) disappear(s)	1
	One difference M2 MgCO_3 fizzes (due to CO_2) OR no fizzing with Mg(OH)_2	1

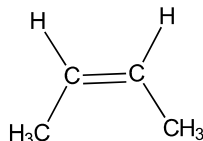
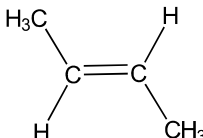
Question	Answer	Marks
2(a)(i)	Li^+ AND S^{2-}	1
2(a)(ii)	M1 giant	1
	M2 (many) strong force(s) of attraction between oppositely charged ions OR (many) strong ionic bond(s)	1
2(b)(i)	(covalent) bond with both electrons are provided from the same / one species OR shared pair (of electrons) are provided from the same species / one atom <i>owtte</i>	1
2(b)(ii)	3 bonding pairs between C and O, 4 $\bullet$'s AND 2 $\times$'s 1 lone pair on C, $\times\times$, AND 1 lone pair on O, $\bullet\bullet$. 	2

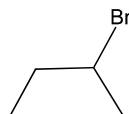
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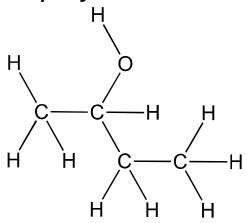
Question	Answer	Mark				
2(c)(i)	<i>Any two assumptions about the behaviour of particles in an ideal gas from</i> • (particles / molecules have mass but) negligible size / volume (compared to total volume of gas / container) • no / negligible forces / interactions (between particles / molecules) • collisions are elastic	2				
2(c)(ii)	M1 IMF become larger / more significant	1				
	M2 volume of <u>molecules</u> / <u>particles</u> becomes significant / no longer negligible	1				
2(c)(iii)	<table><tr><td>N₂(g)</td><td>CO(g)</td></tr><tr><td>instantaneous dipole–induced dipole ✓</td><td>instantaneous dipole–induced dipole (and) permanent dipole–permanent dipole ✓</td></tr></table>	N ₂ (g)	CO(g)	instantaneous dipole–induced dipole ✓	instantaneous dipole–induced dipole (and) permanent dipole–permanent dipole ✓	2
N ₂ (g)	CO(g)					
instantaneous dipole–induced dipole ✓	instantaneous dipole–induced dipole (and) permanent dipole–permanent dipole ✓					
2(c)(iv)	O is more electronegative than C	1				

Question	Answer	Mark
3(a)	change in amount of substance with time	1
3(b)(i)	label area under the original curve to the right of E_a . 	1
3(b)(ii)	M1 curve starts at the origin but peak lies to the right of original.	1
	M2 peak at higher temperature is lower than the original AND graph crosses the original once only – beyond the peak of original 	1
3(b)(iii)	no change / none	1

Question	Answer	Mark
3(c)(i)	 M1 correct dipole on haloalkane AND arrow from bond to Br or just beyond	1
	M2 correct intermediate	1
	M3 arrow from lone pair on <u>O</u> of OH ⁻ / ⁻ OH to central C of their intermediate shown in M2 OR arrow from lone pair on <u>O</u> of OH ⁻ / ⁻ OH to central C of 2-bromo 2-methylpropane if S _N 2 mechanism shown	1
3(c)(ii)	nucleophilic substitution	1
3(d)	M1 more time (because the rate is lower)	1
	M2 C-Cl (bond) is stronger (than C-Br)	1

Question	Answer			Mark
4(a)(i)		structural formula	name	4
	A	CH ₃ CH ₂ CH=CH ₂	but-1-ene OR 1-butene	
	B		cis / Z but-2-ene OR cis / Z 2-butene	
	C		trans / E but-2-ene OR trans / E 2-butene	
	D	CH ₂ =C(CH ₃) ₂	(2) methyl prop(-1-)ene	
	M1 correct identification of but-1-ene (for A) M2 correct identification of but-2-ene for B and C M3 identification of cis / trans (Z / E) for B and C (in correct order) M4 correct name of D			
4(a)(ii)	(molecules with the) same structural formula (and same molecular formula) with different arrangement of atoms / groups in space			1
4(b)(i)	A			1

Question	Answer	Mark								
4(b)(ii)	 M1 skeletal formula only	1								
	M2 <i>explanation in terms of increased / greater stability of intermediate / carbocation intermediate / (secondary) carbocation / CH₃C⁺(H)(CH₂CH₃) is (more) stable</i>	1								
	M3 <i>reason for increased stability of intermediate in terms of greater number of alkyl groups showing largest inductive (electron releasing) effect</i> greater (positive) inductive effect due to two alkyl groups OR greater electron donation of two alkyl groups	1								
4(c)	dehydrating agent / cause dehydration	1								
4(d)(i)	oxidation	1								
4(d)(ii)	<table><tr><td>functional group</td><td>present in Z</td></tr><tr><td>aldehyde</td><td>✓</td></tr><tr><td>ketone</td><td></td></tr><tr><td>carboxylic acid</td><td></td></tr></table>	functional group	present in Z	aldehyde	✓	ketone		carboxylic acid		1
functional group	present in Z									
aldehyde	✓									
ketone										
carboxylic acid										

Question	Answer	Mark
5(a)	<i>displayed formula of butan-2-ol structure with O—H shown</i> 	1
5(b)(i)	2-bromobutane	1
5(b)(ii)	substitution	1
5(b)(iii)	<i>reagent</i> M1 NaCN or KCN	1
	<i>conditions</i> M2 ethanolic AND heat (under reflux)	1
5(b)(iv)	(1)C₄H₉CN + (1)H⁺ + 2H₂O → (1)C₄H₉CO₂H + (1)NH₄⁺ ✓✓ <i>correct organic product showing carboxylic acid functional group</i> M1 C₄H₉CO₂H / C₄H₉COOH	1
	M2 balanced equation with a C ₅ H ₁₀ O ₂ or equivalent structure as product	1
5(b)(v)	2200–2250 (cm ⁻¹ due to) C≡N / triple bond between C and N.	1



Cambridge International AS & A Level

CHEMISTRY

9701/23

Paper 2 AS Level Structured Questions

May/June 2021

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 2021 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **9** 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.

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Question	Answer	Marks
1(a)(i)	increases	1
1(a)(ii)	chlorine gas bromine liquid iodine solid	1
1(b)	M1 observation with $\text{Cl}_2(\text{aq})$ (colourless / pale green to) orange / brown	1
	M2 observation with $\text{I}_2(\text{aq})$ no visible change	1
	M3 explanation chlorine is a stronger oxidising agent (than bromine) AND iodine is a weaker oxidising agent	1
1(c)	$\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$	1
1(d)(i)	proton / H^+ acceptor	1
1(d)(ii)	$\text{ClO}^- + \text{H}_2\text{O} \rightarrow \text{HClO} + \text{OH}^-$	1
1(e)	M1 Use volume O_2 to express / find no mol O_2 produced $24 / 24\,000 \text{ mol O}_2 \text{ produced} = 1 \times 10^{-3} \text{ (mol)}$	1
	M2 Use 1:1 ratio to deduce no mol NaClO in 1000 cm^3 sample $\text{M1} \times 1000 / 5 = 0.2 \text{ (mol dm}^{-3}\text{)}$	1
	M3 Use amount of NaClO and its molecular mass (74.5) to find the mass of NaClO added $24 / 24\,000 \times 1000 / 5 \times 74.5 = 14.9 \text{ (g dm}^{-3}\text{)}$	1
1(f)	M1 products contain Cl^- AND Cl_2	1
	M2 correct balanced equation $\text{ClO}^- + 2\text{HCl} \rightarrow \text{Cl}^- + \text{H}_2\text{O} + \text{Cl}_2$	1

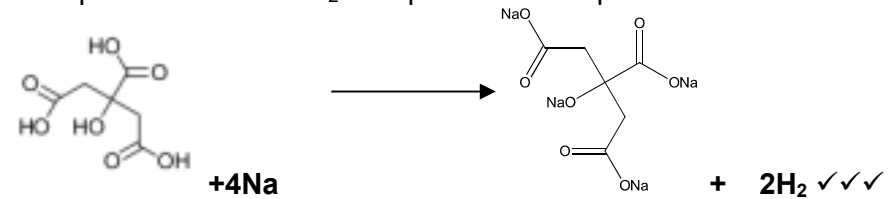
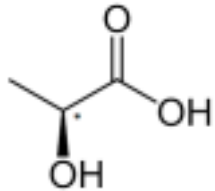
Question	Answer	Marks
2(a)	M1 H-bond between an O and an H in OH groups in water and methanol molecules	1
	M2 minimum three partial charges (in sequence) over one water and one methanol molecule, <i>i.e.</i> :	1
	M3 either $\delta^- \text{O} - \text{H}^{\delta+} - \dots - \delta^- \text{O}$ or $\text{H}^{\delta+} - \dots - \delta^- \text{O} - \text{H}^{\delta+}$ lone pair of electrons on O of H-bond, in line with H-bond	1
2(b)(i)	M1 (methanol) gas (particles / molecules) in equilibrium with liquid	1
	M2 (methanol) gas (particles) exert a pressure (on the walls of a container / on the surface of the liquid)	1
2(b)(ii)	(liquid) particles (at the surface) have enough energy (to overcome attractive forces / evaporate / to become a vapour)	1
2(b)(iii)	M1 (liquid) H_2O molecules are held by stronger hydrogen bonding OR it takes more energy to break the hydrogen bonds between water molecules (in the liquid state) OR each water molecule forms two hydrogen bonds (whereas methanol can (only) form one per molecule)	1
	M2 fewer H_2O liquid molecules (able to) escape / become gaseous ora	1
2(c)(i)	M1 rates of forward and reverse / backward reactions are equal	1
	M2 closed / sealed system / container OR no change in measurable properties / no change in macroscopic properties	1
2(c)(ii)	M1 mol fraction = $0.97 / (0.030 + 0.060 + 0.97) = 0.97 / 1.06 = (0.9151)$	1
	M2 $M1 \times 1.0 \times 10^7 = 9.2 \times 10^6 \text{ (Pa)}$ ✓✓	1
2(c)(iii)	<i>expression for K_p</i> M1 $K_p = p(\text{CH}_3\text{OH}) / p(\text{CO}) \times p(\text{H}_2)^2$	1
	M2 units = Pa^{-2}	1

Question	Answer				Marks
3(a)(i)		state at room temp	observations on add'n of sample to water	identity of sample	4
	R	solid	alkaline, colourless solution is made but some white solid remains	M1 Ba(OH) ₂ OR barium hydroxide	
	S	solid	white solid disappears, solution is neutral	M2 NaCl OR sodium chloride	
	T	liquid	misty fumes, white solid is made in vigorous reaction	M3 SiCl ₄ OR silicon(IV) chloride	
	U	solid	acidic, colourless solution is made in vigorous reaction	M4 P ₄ O ₁₀ OR phosphorus(V) oxide	
3(a)(ii)	SiO ₂				1
3(a)(iii)	phosphoric acid / phosphoric(V) acid				1
3(b)(i)	<i>any one physical property typical of ceramic materials from:</i> - strong / retain strength (over certain temperatures / conditions) - non-conductors of electricity / electrical insulators - high melting points				1
3(b)(ii)	SiO ₂				1

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Question	Answer	Marks
3(c)	% of O M1 $100 - 79.29 (= 20.71)$	1
	M2 express W and O as mol by / 183.8 and / 16 respectively	1
	M3 divide each by smallest number to give empirical formula WO ₃	1

Question	Answer	Marks															
4(a)(i)	1,3-dichloropropan(-2-)one	1															
4(a)(ii)	carbonyl / ketone	1															
4(a)(iii)	NaBH ₄ OR LiAlH ₄	1															
4(b)	<table border="1"> <thead> <tr> <th>reagent</th><th>observation with Q</th><th>observation with R</th></tr> </thead> <tbody> <tr> <td>2,4-DNPH</td><td>M1 red / orange / yellow AND precipitate / solid / crystals</td><td>M2 red / orange / yellow AND precipitate / solid / crystals</td></tr> <tr> <td>Na₂CO₃(aq)</td><td>M3 no visible change</td><td>M4 fizz / effervescence</td></tr> </tbody> </table>	reagent	observation with Q	observation with R	2,4-DNPH	M1 red / orange / yellow AND precipitate / solid / crystals	M2 red / orange / yellow AND precipitate / solid / crystals	Na ₂ CO ₃ (aq)	M3 no visible change	M4 fizz / effervescence	4						
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step	reagent and conditions	type of rxn															
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2	dilute sulfuric acid	Hydrolysis															
3	M2 KCN/NaCN in ethanol / alcohol	M4 Substitution															
4	dilute sulfuric acid	Hydrolysis															

Question	Answer	Marks
5(a)	M1 all 3 COOH form COONa / CO ₂ Na / COO ⁻ Na ⁺	1
	M2 the OH group forms CONa / CO ⁻ Na ⁺	1
	M3 equation describes H ₂ as a product and equation balanced correctly  OR $\text{C}(\text{CH}_2\text{COOH})_2(\text{COOH})(\text{OH}) + 4\text{Na} \rightarrow \text{C}(\text{CH}_2\text{COONa})_2(\text{COONa})(\text{ONa}) + 2\text{H}_2 \checkmark\checkmark\checkmark$	1
5(b)(i)	M1 skeletal formula of 2-hydroxypropanoic acid / similar chiral isomer that meet the criteria in table 	1
	M2 chiral carbon marked with *	1
5(b)(ii)	M1 citric acid has a tertiary alcohol group so is not oxidised	1
	M2 X has a secondary alcohol group which is oxidised (to a ketone)	1
5(c)	M1 chiral centre / non superimposable mirror image / has a C attached to 4 different groups	1
	M2 C=C where each C is attached to (two) different groups	1
5(d)	(molecules / isomers with) the same molecular formula / same number of atoms of each element AND different structural formulae / different structures	1