Cambridge Assessment International Education

# Cambridge International AS & A Level

**CHEMISTRY** **9701/21**

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.



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**[Turn over**

**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.

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|---|
| GENERIC MARKING PRINCIPLE 5:<br><br>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:<br><br>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<br><br>For questions that require ***n*** responses (e.g. State **two** reasons …):<br><br>• The response should be read as continuous prose, even when numbered answer spaces are provided.<br>• Any response marked *ignore* in the mark scheme should not count towards ***n***.<br>• Incorrect responses should not be awarded credit but will still count towards ***n***.<br>• 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.<br>• Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science. |

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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) | **option 1**<br>**M1** the mass of a molecule OR the (weighted) average / (weighted) mean mass of the molecule(s) | **1** |
| | **option 1**<br>and<br>**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)<br>**option 2**<br>**M1** mass of one mol of molecules | |
| | **option 2**<br>**M2** relative / compared to 1 / 12 (the mass) of 1 mol of C-12 OR<br>which one mol C-12 (atom / isotope) has a mass of (exactly) 12 g | |
| 1(a)(ii) | $CO_2H$ | **1** |
| 1(a)(iii) | $0.18/90 \times 2 \times 6.02 \times 10^{23} = 2.408 \times 10^{21}$ (atoms) OR **$2.4(1) \times 10^{21}$** (atoms)<br>**M1** no mole ethanedioic acid $0.18 / 90 = 0.0020$ | **1** |
| | **M2** no mole ethanedioic acid $\times$ 2 $0.0020 \times 2 = 0.0040$ | **1** |
| | **M3** no mole ethanedioic acid $\times 6.02 \times 10^{23}$ $2.4 \times 10^{21}$ | **1** |
| 1(b)(i) | $CaC_2O_4(s) \rightarrow CaO(s) + CO_2(g) + CO(g)$<br>**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** |

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td rowspan="2">2(a)(i)</td><td>M1 both make triple (covalent) bond / 3 shared pairs of electrons</td><td>1</td></tr>
<tr><td>M2 one bond in CO is coordinate / dative covalent / formed by donating a pair of electrons from O (to C)</td><td>1</td></tr>
<tr><td>2(a)(ii)</td><td>
<table>
<tr><td></td><td>$N_2$</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<br><br>(and temporary / induced / instantaneous dipoles)</td></tr>
</table>
</td><td>2</td></tr>
<tr><td>2(b)</td><td>CO / it is a polar molecule / it has a (permanent) dipole (but $N_2$ is non-polar)</td><td>1</td></tr>
<tr><td>2(c)(i)</td><td>high temperature AND low pressure</td><td>1</td></tr>
<tr><td rowspan="4">2(c)(ii)</td><td>M1 CO is polar / has a permanent dipole OR $N_2$ is non-polar</td><td>1</td></tr>
<tr><td>M2 IMF in CO are (more) significant / larger OR IMF in $N_2$ are smaller / less significant</td><td>1</td></tr>
<tr><td>Alternative answer<br>M1 (Size of) $N_2$ smaller than CO<br>OR volume of $N_2$ molecules / particles smaller</td><td></td></tr>
<tr><td>Alternative answer<br>M2 volume of $N_2$ molecules / particles is more negligible<br>ORA</td><td></td></tr>
</table>

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

| Question | Answer | Marks |
|---|---|---|
| 3(a)(i) | $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$<br>OR<br>$2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl$ | **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<br>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) | $2Br^- + 2H^+ + H_2SO_4 \rightarrow Br_2 + 2H_2O + SO_2$ | **1** |

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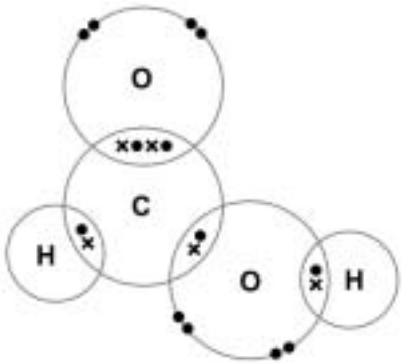
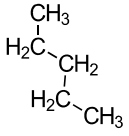
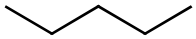
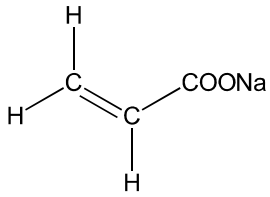
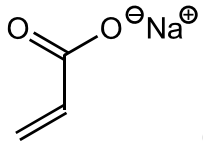
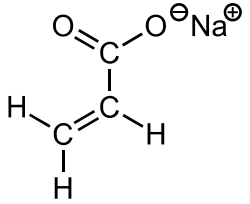
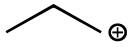
| Question | Answer | Marks |
|---|---|---|
| 4(a) | Br / bromine as the oxidation number of Br decreases / goes from 0 → –1<br>OR<br>bromine as it causes oxidation number of C (in methanoic acid) to increase / go from (+)2 → (+)4 | **1** |
| 4(b) | (solution) turns (from brown / orange / red to) colourless / decolorises<br>OR brown / orange / red fades | **1** |
| 4(c)(i) | rate = total change in concentration of $Br_2$ divided by time taken<br>*calculation dependent on graph*<br>*$(100 \times 10^{-5} – 12 \times 10^{-5}) / 600$*<br>**M1** average rate of reaction $1.47 \times 10^{-6}$ | **1** |
| | **M2** units mol $dm^{-3}$ $s^{-1}$ | **1** |
| 4(c)(ii) | graph shown on same axes has steeper initial gradient<br>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 ⩾ $E_a$ | **1** |
| 4(d) | <br>**M1** correct bonding electrons | **1** |
| | **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) | *structure of **W***  OR $CH_3(CH_2)_3CH_3$ OR  | **1** |
| 5(c)(i) | $CO_2H$ / carboxylic acid | **1** |
| 5(c)(ii) | **M1** (add) $Br_2(aq)$ / bromine water | **1** |
| | **M2** (solution) turns (from brown / orange / red to) colourless / decolorises<br>OR brown / orange / red fades | **1** |
| 5(d) |  OR $CH_2CH(CO_2^{(-)}Na^{(+)})$<br>OR $CH_2{=}CH(COO^{(-)}Na^{(+)})$<br> 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** *catalyst* = sulfuric acid / phosphoric(V) acid | **1** |
| | **M2** *conditions of reaction* = steam / heat (and pressure) | **1** |
| 6(c) | <table><tr><td></td><td>σ</td><td>π</td></tr><tr><td>$C_3H_6$</td><td>8</td><td>1</td></tr><tr><td>$C_3H_8O$</td><td>11</td><td>0</td></tr></table> | **2** |
| 6(d)(i) | **M1** more stable = $CH_3C^+(H)(CH_3)$  | **1** |
| | **M2** less stable = $CH_3CH_2C^+(H_2)$ /  | **1** |
| | **M3** greater (positive) inductive effect of two alkyl groups<br>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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