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CAMBRIDGE
International Education

# Cambridge International AS & A Level

**CHEMISTRY** **9701/54**

Paper 5 Planning, Analysis and Evaluation **May/June 2026**

MARK SCHEME

Maximum Mark: 30

**Published**

This mark scheme contains the instructions and marking guidance that our examiners used to mark candidate responses for this component.

Before they start marking, examiners complete a standardisation process. They review a range of candidate responses and discuss the mark scheme in detail to agree which answers can and cannot be accepted. Examiners award marks where it is clear that candidate responses have met the requirements of the mark scheme. These requirements may vary between different components or different versions of the same component, depending on the exact requirements of the question and the candidate responses seen during the standardisation process.

Sometimes, our mark schemes may allow marks to be awarded to responses which contain elements that are factually incorrect or for content not covered by the syllabus. We do this in response to the demands of a specific question to support candidates and make sure that our assessments are fair. However, these allowances should not be used as a guide for teaching and learning.

We cannot discuss the mark scheme with schools, and we recommend that schools read the mark scheme together with the assessment material and the Principal Examiner Report for Teachers.

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**General marking principles**

All examiners must apply these marking principles when marking candidate responses.

| | |
|---|---|
| 1 | Examiners must award marks for each response in line with:<br><br>• the specific **content** defined in the mark scheme<br>• the specific **skills** defined in the mark scheme or in the level descriptions<br>• the **standard of response** required as exemplified by the standardisation scripts. |
| 2 | Examiners must award **whole marks** (not half marks, or other fractions). |
| 3 | Examiners must award marks **positively**. This means that:<br><br>• marks are not deducted for errors or omissions<br>• marks are awarded for correct/valid answers as defined in the mark scheme and also for **other valid answers** which go beyond the scope of the syllabus and mark scheme referring to your team leader as appropriate<br>• the quality of spelling, punctuation and grammar are judged **only** when the mark scheme indicates that these features are **specifically assessed** in the question. However, the meaning of all responses must be unambiguous. |
| 4 | Examiners must **consistently** apply the requirements of the mark scheme and any rules for what to do when candidates have not followed instructions correctly. |
| 5 | Examiners must use the **full range of marks** defined in the mark scheme, unless limited by the quality of the candidate responses seen. |
| 6 | Examiners must award marks according to the mark scheme and **must not** award marks with grade thresholds or grade descriptions in mind. |

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**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><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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## Annotations guidance for centres

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

## Annotations

| Annotation | Meaning |
|---|---|
|  | Correct point **or** mark awarded |
|  | Incorrect point **or** mark not awarded |
|  | Unclear |
|  | Information missing or insufficient for credit |
|  | Benefit of the doubt given |
|  | Contradiction in response otherwise markworthy, mark not given |
|  | Part of the correct answer has been seen. Full credit has not been awarded. |
|  | Error carried forward applied |
|  | Incorrect or insufficient point ignored while marking the rest of the response |
|  | Rounding error |

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| Annotation | Meaning |
|---|---|
| POT | Power of ten error |
| REP | Repeat error |
| SEEN | Blank page **or** part of script seen |
| SF | Error in number of significant figures |
| TE | Transcription error |

**Mark scheme abbreviations**

| | |
|---|---|
| **R** | reject the response |
| **A** | accept the response |
| **I** | ignore the response |
| ecf | error carried forward |
| **BOD** | benefit of doubt given |
| ora | or reverse argument |
| owtte | or words to that extent |
| underline | actual word given must be used by candidate (grammatical variants excepted) |
| ( ) | the word / phrase in brackets is not required but sets the context |
| max | indicates the maximum number of marks that can be given |
| **M** | marking point |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1(a) | (re)heat and (re)weigh to constant mass | **1** | **A** "heat to constant mass"<br>**A** description of the process of heating to constant mass<br>**A** "crucible and residue" or "sample" for "crucible and contents"<br><br>**R** "heat to constant weight" |
| 1(b)(i) | (mass of $Na_2CO_3$•***x***$H_2O$(s) added / g =) 4.89<br>(mass of residue / g =) 2.06<br>**AND**<br>(mass of water lost =) 2.83 | **1** | **R** any other values. |
| 1(b)(ii) | increase the mass of $Na_2CO_3$•***x***$H_2O$(s) used | **1** | **A** use more (than 4.89 g / mass calculated in 1(b)(i) of) $Na_2CO_3$•***x***$H_2O$(s)<br><br>**A** use of "amount" for "mass"<br>**A** use of "solid" or "crystals" or "contents" or "reactant" or "sample" or "hydrated sodium carbonate" or "sodium carbonate crystals" for "$Na_2CO_3$•***x***$H_2O$(s)"<br><br>**A** increase the "mass of crucible and contents"<br><br>**I** changes to heating<br>**I** repeat and take mean<br><br>**R** changing the crucible. e.g. increase the mass of crucible alone<br>**R** "anhydrous sodium carbonate" / "sodium carbonate" alone / "powder" / $Na_2CO_3$ for "$Na_2CO_3$•***x***$H_2O$ (s)"<br><br>**R** incorrect use of "weight" for "mass" but **A** ecf from 1(a).<br>**R** heat to constant mass |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1(c) | **M1** $n(H_2O) = 2.83 / 18 = (0.157(222))$<br><br>**AND**<br><br>$n(Na_2CO_3) = 2.06 / 106 = (0.0194(34))$<br><br>**M2** $x = \frac{n(H2O)}{n(Na2CO3)} = (0.157 / 0.0194 = 8.09 \rightarrow 8)$ | **2** | **M1**<br>**A** ecf from 1b(i)<br>**A** rounding of amounts e.g. $n(H_2O) = 0.16$ and $n(Na_2CO_3) = 0.02$<br>**A** valid alternative calculation routes<br><br>**M2**<br>**A** ecf from **M1** if values used in **M2** are calculated $n(H_2O)$ and $n(Na_2CO_3)$.<br><br>**R** non-integer value for ***x***. e.g. 8.0 |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1(d)(i) | **M1** add a (small) volume of (distilled) water (to the small beaker)<br>**AND**<br>dissolve the solid / $Na_2CO_3$•***x***$H_2O$(s)<br><br>**M2**<br>Transfer the solution and washings (using a funnel)<br>**AND**<br>into a 250 $cm^3$ volumetric flask. | **3** | **A** 'solution' produced in **M1** or **M2** for "dissolve the solid".<br>**A** "solid disappears" for dissolves.<br>**A** extra transfers as long as the exact number of moles of solid end up in the volumetric flask via rinsing. (Allow greater volume added when accommodated by vessel used.)<br>**A** prepare / make a solution for dissolve.<br><br>**I** use of measuring cylinder / stirring / glass rod<br>**I** description of measuring mass / incorrect mass used<br><br>**R** water volume > 50 $cm^3$ if specified **OR** fill (50 $cm^3$) beaker<br><br>**A** "rinse the beaker" or "wash the beaker" in place of "washings"<br>**BOD** assume rinsing and washing is of the beaker into the flask if not clearly indicated otherwise e.g. to wash the apparatus<br>**A** 250 volumetric flask / 250 $cm^3$ graduated flask / 250 $cm^3$ standard flask<br>**A M2** If solid added directly to 250 $cm^3$ volumetric flask **AND** beaker (+ funnel) are rinsed, **and** washings added to flask **AND** the solid dissolved in distilled / deionised water in flask before **M3**<br><br>**I** use of funnel / glass rod<br>**I** rinse the volumetric flask (with (distilled) water)(before adding solid / solution)<br><br>**R** transfer solution with burette or pipette<br>**R** weighing solid into flask |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1(d)(i) ctd. | **M3** Make up to the (calibration) mark / line (with distilled water).<br>**AND**<br>then invert (the stoppered flask) (several times) | | **A** '250 $cm^3$ calibration', 'line' or other similar for 'mark'.<br>**A** deionised water, DW, $dH_2O$, $diH_2O$ for 'distilled water'.<br>**A** make up to 250 $cm^3$ (with distilled water).<br>**A** 'shake', 'swirl' and 'invert' for 'invert flask'. Must describe action, not 'mix' alone.<br>**A M2** and **M3** if all correct except volume used to dissolve in **M1** > 50 $cm^3$ < 250 $cm^3$ if specified.<br>**A** use of pipette / burette to fill to mark.<br>**I** top up / fill alone.<br>**I** homogenise / mix<br>**R** stir<br>**R M3** if solid not dissolved before making up to the mark. If purpose of inverting / shaking is to dissolve solid.<br><br>**A** ecf **M3** for volume > 250 $cm^3$ (i.e. **I** volume from **M1** and **M2** when marking **M3**)<br><br>**M3**<br>Distilled **/** deionised water only needs to be mentioned once to infer its use throughout. If not mentioned, then **M3** not awarded. |
| 1(d)(ii) | (0.01(00) mol $dm^{-3}$) hydrochloric acid / HC*l*((aq)). | **1** | **A** (rinse with the) solution to be used (for the titration in the burette)<br>**A** dilute hydrochloric acid<br><br>**I** wash with distilled water / propanone before wash with (0.0100 mol $dm^{-3}$) HC*l*<br><br>**R** wash with distilled water / propanone after wash with (0.0100 mol $dm^{-3}$) HC*l* |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1(e)(i) | (it is calculated from) titrations 1 and 3<br><br>**AND**<br><br>which are concordant. | **1** | **A** titrations 1 and 3 (are used), which are within 0.1(0) ($cm^3$) of each other / are ±0.1(0) ($cm^3$)<br>**A** the difference between titres 1 and 3 is 0.1(0) ($cm^3$)<br>**A** the difference between titres 1 and 3 is equal or less than 0.1(0) ($cm^3$)<br>**A** the difference between titres 1 and 3 is within 0.1(0) ($cm^3$) (of each other)<br><br>**A** values for titrations 1 and 3. e.g. 25.25 and 25.15<br>**A** values clearly indicated and annotated in Table 1.1<br><br>**I** mention of not using titration 2<br><br>**R** if titration 2 is used |
| 1(e)(ii) | **M1** $n(HCl)$ in mean titre= $0.0252 \times 0.0100$<br>$= 2.52 \times 10^{-4}$ (mol)<br><br>**M2** $n(Na_2CO_3)$ in 25.0 $cm^3$ of solution<br>$= (2.52 \times 10^{-4} \div 2) = 1.26 \times 10^{-4}$ (mol)<br><br>**M3** $n(Na_2CO_3)$ in 250.0 $cm^3$ of solution<br>$= 1.26 \times 10^{-4} \times 10 = 1.26 \times 10^{-3}$ (mol)<br>$M_r$ ($Na_2CO_3$•***x***$H_2O$) = $0.365 / 1.26 \times 10^{-3} = 289.68$<br><br>**M4** ***x*** = (289.68 – 106) / 18 = 10.20 → 10<br><br>Missing factor of 10 in **M3** leads to ***x*** = 155.<br>**M4** still available.<br><br>Missing ÷ 2 in **M2** leads to ***x*** = 2. **M3** and **M4** still available. | **4** | **A** ecf throughout<br>**A** valid alternative calculation routes<br><br>**M3 A** m($Na_2CO_3$) in 0.365 g = $1.26 \times 10^{-4} \times 10 \times 106$<br>= 0.134 g<br>m($H_2O$) = 0.365 – 0.134 = 0.231 g<br><br>$n(H_2O)$ = 0.231 / 18 = 0.012858<br><br>**M4** x= $0.012858 / 1.26 \times 10^{-3}$ = 10.20 → 10<br><br>**A ECF** for **M4** if values used are calculated $n(H_2O)$ and $n(Na_2CO_3)$.<br><br>**M4 R** non-integer value for ***x***, but **A** ecf from e.g. 8.0 in 1(c) for e.g.10.0. |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1(e)(iii) | correct working must be shown<br><br>maximum percentage error = $\frac{2 \times 0.05}{25.15} \times 100 = 0.3976(14)$ | 1 | **A** $\frac{2 \times (½ \times 0.10)}{25.15} \times 100 = 0.3976$<br><br>**A** $\frac{0.05 + 0.05}{25.15} \times 100 = 0.3976$<br><br>**A** the following values for the answer following a correct expression – 0.4, 0.40, 0.39, 0.397 etc<br><br>**I** missing × 100 if correct answer given<br><br>**R** incorrectly calculated answer with correct working<br><br>**R** (0.005 × 2 / 25.15) × 100 = 0.0398 |
| 1(f) | (effect on value of =) increases<br><br>**AND**<br><br>$n(Na_2CO_3)$ is lower **OR** $n(H_2O)$ is greater (than true value).<br><br>**OR**<br><br>(effect on value of ***x*** =) no / negligible effect<br><br>**AND**<br><br>value of ***x*** is to the nearest integer so (small) change in volume does not affect value | 1 | **A** 'higher' or 'greater' or 'overestimated' for 'increases' etc<br>**A** "decreases" or "smaller" or "underestimated" for "lower" etc<br><br>**A** 'sodium carbonate' or '$Na_2CO_3$•***x***$H_2O$(s)' for '$Na_2CO_3$'<br>**A** 'number of moles' or 'mole number' or 'amount' for *n*<br><br>**I** powder / crystals<br>**I** measured volume of solution A / $Na_2CO_3$(aq) is less<br>**I** recorded volume of solution A / $Na_2CO_3$(aq) is larger<br><br>**A** 'slight increase' for 'negligible' |
| 2(a)(i) | $n(NH_4Cl) = 5.00 / 53.5 = 0.0935$<br><br>mass of $Ca(OH)_2 = 0.0935 / 2 \times 74.1 = 3.46$ g | 1 | **R** any answer other than 3.46 g |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 2(a)(ii) | hazardous gas (ammonia) produced | 1 | **A** toxic / corrosive / irritant for 'hazardous'<br><br>**I** flammable<br>**I** bad smell<br>**I** harmful / dangerous / 'harmful to health'<br>**I** alkaline |
| 2(a)(iii) | to remove water (vapour) (from (ammonia) gas) | 1 | **A** to absorb water (from gas)<br>**A** to avoid water passing into gas jar<br>**A** to dry (the gas)<br>**A** to ensure (ammonia) gas does not contain water<br><br>**I** to flush any air out of the tube.<br>**I** dehydrate / dehydration<br>**I** to purify<br>**I** to prevent ammonia dissolving in water.<br>**I** 'CaO reacts with water' alone (no reference to removing water)<br>(no mark – to make sure only ammonia reaches the gas jar)<br><br>**R** to remove chlorine<br>**R** to react with ammonia<br>**R** "to dry water" alone |
| 2(a)(iv) | ammonia is less dense than (most gases in) air | 1 | **A** '$NH_3$' for 'ammonia'<br>**A** "ammonia is less dense than oxygen and nitrogen"<br>**A** "ammonia has a smaller density than (most gases in) air"<br>**A** ammonia has a smaller $M_r$ than mean $M_r$ for air<br><br>**I** 'lighter'<br>**I** it will displace the air<br>**I** atmosphere<br>**I** 'less dense than oxygen alone or nitrogen alone'<br>**R** less dense than any other named gas. e.g. chlorine |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 2(b) | ammonia is soluble (in water) | **1** | **A** '$NH_3$' for 'ammonia'<br>**A** ammonia would react with water<br>**A** correct species in balanced equation for reaction of ammonia with water, ignore state symbols (allow =, → or ⇌)<br>e.g. $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$<br>**A** suck back could occur<br>**A** ammonia would / can / will dissolve (in the water)<br><br>**I** incorrect reaction equations, products etc |

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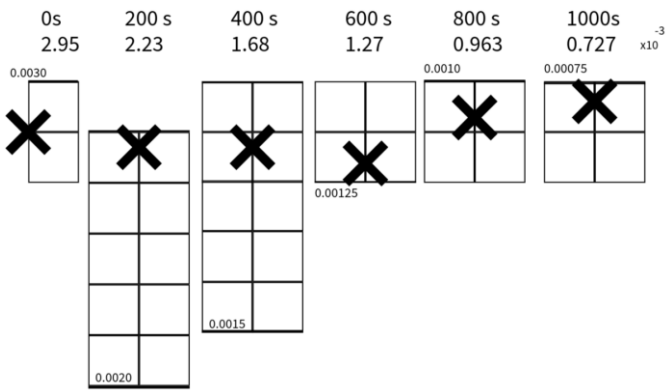
| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 2(c)(i) | **M1** <u>all six</u> points plotted correctly<br><br><br>**M2** line of best fit drawn | **2** | **M1**<br>If point should be on a line, it must be on the line.<br>If it should not be on the line, it must not be so.<br><br>Blobs/thick crosses should be less than ½ a small square across and be correctly centred.<br><br>**M1** not awarded if centre of at least one cross is clearly off a line it should be on, on a line it should not be or in the wrong small grid square.<br><br>Note: Other points are correctly plotted.<br>If not clearly plotted at a different *y* value, assume point at 0 s is present and obscured by the point at same time for tungsten. (In this case there is no need to check for this point).<br><br>**M2**<br>**A** ecf acceptable best fit line drawn for incorrectly plotted points<br>**I** remnants of lines that have been rubbed out<br><br>**R** double or “sketchy” lines.<br>**R** line that does not extend across full range of x-values for plotted points. (**A** ½ small square tolerance at each end) |
| 2(c)(ii) | $[NH_3]$ (in mol dm$^{-3}$) | **1** | **A** ‘concentration of ammonia’ or ‘concentration of $NH_3$’ for ‘$[NH_3]$’<br>**A** $[NH_3]$ / mol dm$^{-3}$<br><br>**I** type of catalyst |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 2d(i) | $2.95 \times 10^{-3}$ (mol $dm^{-3}$) | 1 | **A** 0.00295 (mol $dm^{-3}$).<br>**A** correct value written in an equation of the form $y = mx + c$, e.g. $y = -1.4 \times 10^{-6} \times x + 2.95 \times 10^{-3}$ (**I** value given for m) |
| 2(d)(ii) | there are no anomalous results | 1 | **A** there are no points off the line (of best fit)<br>**A** (all) the points are (very) close to / on the line (of best fit)<br>**A** (straight) line passes through / touching (all) points<br>**R** (straight) line passing all points<br>**A** "outliers" for "anomalous results"<br>**A** "anomalous" to mean "anomaly" or "anomalous result"<br>**A** "plots" for "points"<br><br>**I** the line fits the data<br>**I** "values" for "points"<br>**I** most points are on / close to the line of best fit |
| 2(d)(iii) | yes (it does support the student's conclusion)<br><br>**AND**<br><br>(the line has) constant gradient | 1 | **A** inferred agreement with student e.g. saying the reaction is zero order<br><br>**R** no, (it does not support the student's conclusion)<br><br>**A** the line is straight<br>**A** the graph / line is linear<br>**A** $t_{½}$ decreases (with time)<br>**A** rate (of decrease of $[NH_3]$) is constant (over the time period shown by the graph)(at a particular temperature)<br>**A** $[NH_3]$ has a linear relationship with time |

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| 2(e) | **M1** two points from line of best fit correctly recorded.<br>(0, $2.95 \times 10^{-3}$) and ($x$, $1.475 \times 10^{-3}$)<br><br>**M2** half-life correctly calculated from correctly recorded points from LOBF when $2y_2 = y_1$<br><br>**OR**<br><br>Only use the mark scheme on the following page when the candidate has used a calculation method. | **2** | expected answer = 490 s approx.<br>tolerance $x$ value $\pm$ half a square (10 s) from stated $y$-value<br>**A** $1.48 \times 10^{-3}$ for $1.475 \times 10^{-3}$ (**A** $1.47 \times 10^{-3}$ **BOD**)<br>**A** coordinates 1 and 2 recorded in either order<br>**A** ecf from incorrect line of best fit for **M1** and **M2**<br><br>**M1 R** for points not on line of best fit<br><br>**M2 A** ecf for correctly evaluated $t_{½}$ from points on line of best fit, written ($x_1$,$y_1$) and ($x_2$,$y_2$) when $2y_2 = y_1$. i.e. correctly evaluated $t_{½}$ that does not begin at t=0<br><br>**M2 A** ecf for correctly evaluated $t_{½}$ from points on line of best fit written (0, $2.95 \times 10^{-3}$) and ($x$, $1.475 \times 10^{-3}$) if only error in **M1** is that $x$ has been incorrectly read from graph<br><br>**M2 A** ecf for correctly evaluated $t_{½}$ from points written ($2.95 \times 10^{-3}$, 0) and ($1.475 \times 10^{-3}$, $x$)<br><br>**M2 A** ecf for minor slip in recording correct coordinates e.g. missing $\times 10^{-3}$ (**M1** not awarded)<br><br>No ecf **M2** if $t_{½}$ measured does not begin at t=0 and any other mistake made in recorded coordinates<br><br>**R** negative value for **M2** |

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| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 2(e) ctd. | For straight line of best fit:<br>**M1** any two different points from line of best fit correctly recorded $(x_1,y_1)$ and $(x_2,y_2)$.<br>Can be awarded it is clear an attempt has been made to calculate a gradient.<br><br>**M2**<br>Calculates gradient of line correctly. $(y_2-y_1)/(x_2-x_1)$<br>**AND**<br>Calculates $t_{½}$ correctly using gradient and $y = mx + c$ to work out value of $x$ ($t_{½}$) at half value of $y_0$ ($y$ at t=0).<br><br>$t_{½} = ((y_0/2) - c)/m$<br><br>For a curved line of best fit:<br>**M1** any two different points from line of best fit correctly recorded $(x_1,y_1)$ and $(x_2,y_2)$.<br><br>Can be awarded if a clear attempt has been made to use calculation below.<br><br>**M2** states "assuming first order" owtte<br>**AND**<br>half-life correctly calculated as follows:<br>calculate $k$ using coordinates from line of best fit<br><br>$k = \frac{\ln(y1/y2)}{x2 - x1}$<br><br>expected value $k \approx 1.41 \times 10^{-3}$ s$^{-1}$<br>for a first-order reaction:<br>$t_{1/2} = \frac{0.693}{k}$<br>expected value $t_{½}$ = 491 s approx. | | Tolerance $x$ value $\pm$ half a square (10 s) from stated $y$-value.<br>**A** coordinates 1 and 2 recorded in either order<br><br>**M2 A** ecf for correctly evaluated $t_{½}$ from points on line of best fit if only error in **M1** is that one of the $x$ values has been incorrectly read from graph.<br>**M2 A** ecf correctly evaluated $t_{½}$ from otherwise correct LOBF points both written ($y$, $x$)<br>**M2 A** ecf for minor slip in recording correct coordinates. e.g. missing $\times 10^{-3}$ (**M1** not awarded)<br>No ecf **M2** if any two mistakes made in recorded coordinates<br><br>**R** negative value for **M2** |

GradeMax



| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 2(f) | (four half-lives: 4 × 550 =) 2200 s | **1** | |

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