CAMBRIDGE
International Education

Cambridge International AS & A Level

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2025**

MARK SCHEME

Maximum Mark: 30

Published

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(a)</td><td>M1 bromobenzene is a skin irritant

M2 toxic gas(es) (are produced)</td><td>2</td></tr>
<tr><td>1(b)(i)</td><td>warm in an oven</td><td>1</td></tr>
<tr><td>1(b)(ii)</td><td>fractional distillation</td><td>1</td></tr>
<tr><td>1(c)(i)</td><td>arrow pointing inwards at lower entry to condenser with label ‘water in’</td><td>1</td></tr>
<tr><td>1(c)(ii)</td><td>to prevent water getting into the apparatus</td><td>1</td></tr>
<tr><td>1(c)(iii)</td><td>to avoid pressure build up in the apparatus</td><td>1</td></tr>
<tr><td rowspan="2">1(d)</td><td>M1 order of weighing
1 weighing boat + Mg is weighed
2 weighing boat is weighed after Mg is transferred</td><td>1</td></tr>
<tr><td>M2 table + units
<table>
<tr><td></td><td>/ g</td></tr>
<tr><td>1 Mass of boat + Mg (before transfer)</td><td></td></tr>
<tr><td>2 Mass of boat (+ residue of Mg) (after transfer)</td><td></td></tr>
<tr><td>Mass of Mg powder (transferred)</td><td></td></tr>
</table></td><td>1</td></tr>
<tr><td>1(e)</td><td>5.23 cm^3</td><td>1</td></tr>
<tr><td>1(f)</td><td>to prevent the reaction becoming too violent</td><td>1</td></tr>
<tr><td>1(g)</td><td>hydrochloric acid is in excess</td><td>1</td></tr>
<tr><td>1(h)</td><td>beaker B
AND
ethoxyethane is less dense than water</td><td>1</td></tr>
</table>

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Question	Answer	Marks
1(i)(i)	**M1** (n(bromobenzene) = 0.0500) n(ethanal) = 3.00 cm^3 × 0.788 g cm^{-3} / 44.0 = **0.0537 mol** (Ratio is 1:1) (bromobenzene is the limiting reagent) **M2** 0.05 mol 1-phenylethanol has a mass of 0.05 mol × 122.0 g mol^{-1} = 6.10 g Percentage yield = 2.17 g / 6.10 g × 100% = **35.6 %**	**2**
1(i)(ii)	the product contains unreacted ethanal	**1**

Question	Answer	Marks
2(a)	**M1** the solution becomes more dilute **M2** the temperature is reduced	**2**
2(b)	appearance of a (permanent) pink colour	**1**

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<tr><td>2(c)(i)</td><td>
<table>
<tr><th>Time / mins</th><th>Titre, V_t / cm^3</th><th>$(V_f - V_t)$ / cm^3</th><th>log[$(V_f - V_t)$ / cm^3]</th></tr>
<tr><td>0</td><td>12.00</td><td>33.70</td><td>1.528</td></tr>
<tr><td>5</td><td>16.40</td><td>29.30</td><td>1.467</td></tr>
<tr><td>10</td><td>22.15</td><td>23.55</td><td>1.372</td></tr>
<tr><td>15</td><td>23.45</td><td>22.25</td><td>1.347</td></tr>
<tr><td>20</td><td>26.30</td><td>19.40</td><td>1.288</td></tr>
<tr><td>25</td><td>28.70</td><td>17.00</td><td>1.230</td></tr>
<tr><td>180</td><td>45.70</td><td></td><td></td></tr>
</table>

M1 column 3 correct

M2 column 4 correct to four significant figures as log(column 3)
</td><td>2</td></tr>
<tr><td>2(c)(ii)</td><td>**M1** six points correctly plotted

M2 straight line of best fit drawn</td><td>2</td></tr>
<tr><td>2(c)(iii)</td><td>anomalous point circled
AND
the actual time of the sample removed in step 4 was higher than the recorded time (10 mins)</td><td>1</td></tr>
<tr><td>2(c)(iv)</td><td>**M1** co-ordinates read and recorded correctly

M2 gradient to three significant figures</td><td>2</td></tr>
<tr><td>2(d)</td><td>**M1** gradient (in s^{-1}) = $-k$ / 2.303 **OR** k = –gradient × 2.303

M2 k = –**(c)(iv)** × 2.303 / 60</td><td>2</td></tr>
</table>

Question	Answer	Marks
2(e)	not reliable **AND** there is an anomalous point	**1**
2(f)	straight line sketched with more negative gradient with the same intercept	**1**

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Question	Answer	Marks
1(a)(i)	8.76 (g)	**1**
1(a)(ii)	**M1** dissolve the solid / ethanedioic acid (in the beaker) using (a small volume of) (distilled) water **M2** transfer / add to a (500 cm^3 volumetric) flask **AND** rinse (with distilled water) **M3** top the 500 cm^3 volumetric flask up to mark (with distilled water) **AND** (stopper and) invert the flask	**3**
1(b)	wear chemically resistant gloves	**1**
1(c)	to remove water from (the surface of) the activated carbon	**1**
1(d)	4.0 (cm^3)	**1**
1(e)	burette	**1**
1(f)	to ensure a uniformly mixed sample	**1**

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<tr><td>1(g)(i)</td><td>
<table>
<tr><th>time / mins</th><th>mass of non-adsorbed $(COOH)_2$ in 5.0 cm^3 sample / mg</th><th>mass of $(COOH)_2$ adsorbed by activated carbon in 5.0 cm^3 sample / mg</th></tr>
<tr><td>0</td><td>2.50</td><td>0.00</td></tr>
<tr><td>5</td><td>1.90</td><td>0.60</td></tr>
<tr><td>15</td><td>1.52</td><td>0.98</td></tr>
<tr><td>30</td><td>1.43</td><td>1.07</td></tr>
<tr><td>45</td><td>0.99</td><td>1.51</td></tr>
<tr><td>60</td><td>0.88</td><td>1.62</td></tr>
<tr><td>90</td><td>0.81</td><td>1.69</td></tr>
<tr><td>120</td><td>0.80</td><td>1.70</td></tr>
<tr><td>150</td><td>0.80</td><td>1.70</td></tr>
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</td><td>1</td></tr>
<tr><td>1(g)(ii)</td><td>**M1** all points plotted correctly

M2 smooth curved line of best fit passing close to all points except marked anomaly</td><td>2</td></tr>
<tr><td>1(g)(iii)</td><td>time (of sample removal)</td><td>1</td></tr>
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AND
the actual time (of removing sample) was less than recorded time (30 minutes)</td><td>1</td></tr>
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Question	Answer	Marks
1(h)(i)	**M1** co-ordinates correctly recorded from line given in Fig 1.2 **M2** gradient calculated to at least two significant figures **M3** units = g mg^{-1}	**3**
(h)(ii)	q_0 = 1 / gradient in **(h)(i)**	**1**
1(h)(i)	percentage error of experimental result compared to data book value $= \frac{(86.0 - 78.1)}{86.0} \times 100\% = 9.2\%$ **AND** 9.2% > 6.5% **AND** other factors contributed towards error	**1**

Question	Answer	Marks
2(a)	**M1** change in temperature of water / °C = 57.3 **M2** mass of butane burned / g = 2.10	**2**
2(b)	320 g × 4.18 J g^{-1} K^{-1} × 57.3 K = 76 600 (J)	**1**
2(c)	**M1** number of moles of butane burned = 0.0362 mol **M2** ΔH_c = –2120 (kJ mol^{-1})	**2**
2(d)	stir the water before taking reading	**1**
2(e)	2.5 / 320 × 100% = 0.78%	**1**
2(f)	use a lid	**1**
2(g)(i)	percentage error (of temperature change or mass change of butane) increases	**1**

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Question	Answer	Marks
2(g)(ii)	less heat loss	**1**

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✔	Correct point **or** mark awarded

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(a)</td><td>M1 bromobenzene is a skin irritant

M2 toxic gas(es) (are produced)</td><td>2</td></tr>
<tr><td>1(b)(i)</td><td>warm in an oven</td><td>1</td></tr>
<tr><td>1(b)(ii)</td><td>fractional distillation</td><td>1</td></tr>
<tr><td>1(c)(i)</td><td>arrow pointing inwards at lower entry to condenser with label ‘water in’</td><td>1</td></tr>
<tr><td>1(c)(ii)</td><td>to prevent water getting into the apparatus</td><td>1</td></tr>
<tr><td>1(c)(iii)</td><td>to avoid pressure build up in the apparatus</td><td>1</td></tr>
<tr><td rowspan="2">1(d)</td><td>M1 order of weighing
1 weighing boat + Mg is weighed
2 weighing boat is weighed after Mg is transferred</td><td>1</td></tr>
<tr><td>M2 table + units
<table>
<tr><td></td><td>/ g</td></tr>
<tr><td>1 Mass of boat + Mg (before transfer)</td><td></td></tr>
<tr><td>2 Mass of boat (+ residue of Mg) (after transfer)</td><td></td></tr>
<tr><td>Mass of Mg powder (transferred)</td><td></td></tr>
</table></td><td>1</td></tr>
<tr><td>1(e)</td><td>5.23 cm^3</td><td>1</td></tr>
<tr><td>1(f)</td><td>to prevent the reaction becoming too violent</td><td>1</td></tr>
<tr><td>1(g)</td><td>hydrochloric acid is in excess</td><td>1</td></tr>
<tr><td>1(h)</td><td>beaker B
AND
ethoxyethane is less dense than water</td><td>1</td></tr>
</table>

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Question	Answer	Marks
1(i)(i)	**M1** (n(bromobenzene) = 0.0500) n(ethanal) = 3.00 cm^3 × 0.788 g cm^{-3} / 44.0 = **0.0537 mol** (Ratio is 1:1) (bromobenzene is the limiting reagent) **M2** 0.05 mol 1-phenylethanol has a mass of 0.05 mol × 122.0 g mol^{-1} = 6.10 g Percentage yield = 2.17 g / 6.10 g × 100% = **35.6 %**	**2**
1(i)(ii)	the product contains unreacted ethanal	**1**

Question	Answer	Marks
2(a)	**M1** the solution becomes more dilute **M2** the temperature is reduced	**2**
2(b)	appearance of a (permanent) pink colour	**1**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(c)(i)</td><td>
<table>
<tr><th>Time / mins</th><th>Titre, V_t / cm^3</th><th>$(V_f - V_t)$ / cm^3</th><th>log[$(V_f - V_t)$ / cm^3]</th></tr>
<tr><td>0</td><td>12.00</td><td>33.70</td><td>1.528</td></tr>
<tr><td>5</td><td>16.40</td><td>29.30</td><td>1.467</td></tr>
<tr><td>10</td><td>22.15</td><td>23.55</td><td>1.372</td></tr>
<tr><td>15</td><td>23.45</td><td>22.25</td><td>1.347</td></tr>
<tr><td>20</td><td>26.30</td><td>19.40</td><td>1.288</td></tr>
<tr><td>25</td><td>28.70</td><td>17.00</td><td>1.230</td></tr>
<tr><td>180</td><td>45.70</td><td></td><td></td></tr>
</table>

M1 column 3 correct

M2 column 4 correct to four significant figures as log(column 3)</td><td>2</td></tr>
<tr><td>2(c)(ii)</td><td>**M1** six points correctly plotted

M2 straight line of best fit drawn</td><td>2</td></tr>
<tr><td>2(c)(iii)</td><td>anomalous point circled
AND
the actual time of the sample removed in step 4 was higher than the recorded time (10 mins)</td><td>1</td></tr>
<tr><td>2(c)(iv)</td><td>**M1** co-ordinates read and recorded correctly

M2 gradient to three significant figures</td><td>2</td></tr>
<tr><td>2(d)</td><td>**M1** gradient (in s^{-1}) = $-k$ / 2.303 **OR** k = –gradient × 2.303

M2 k = –**(c)(iv)** × 2.303 / 60</td><td>2</td></tr>
</table>

Question	Answer	Marks
2(e)	not reliable **AND** there is an anomalous point	**1**
2(f)	straight line sketched with more negative gradient with the same intercept	**1**

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CAMBRIDGE
International Education

Cambridge International AS & A Level

CHEMISTRY **9701/54**

Paper 5 Planning, Analysis and Evaluation **May/June 2025**

MARK SCHEME

Maximum Mark: 30

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 2025 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.

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Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

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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 ***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.

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6	<u>Calculation specific guidance</u> 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	<u>Guidance for chemical equations</u> 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
?	Unclear
^	Information missing or insufficient for credit
BOD	Benefit of the doubt given
CON	Contradiction in response otherwise markworthy, mark not given
✗	Incorrect point **or** mark not awarded
●	Part of the correct answer has been seen. Full credit has not been awarded.
ECF	Error carried forward applied
Highlighted text	Highlighting areas of text
I	Incorrect or insufficient point ignored while marking the rest of the response
NBOD	Benefit of the doubt not applied in this instance

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Question	Answer	Marks
1(a)(i)	0.9976 (g cm^{-3})	**1**
1(a)(ii)	**M1** mass of water = 161.175 – 31.022 g = 130.153 g **M2** volume = mass of water / density in **(a)(i)** = 130.153 / 0.9976 = 130.466 (cm^3)	**2**
1(b)(i)	to ensure the vapour (Y) (in the conical flask) has reached the temperature (of the boiling water / 100 °C)	**1**
1(b)(ii)	mass of vapour (occupying flask)(at step 7) is used in calculation	**1**
1(b)(iii)	(perform the experiment in a) fume hood	**1**
1(c)(i)	$\frac{(0.0005 \times 2) \times 100}{31.123}$ = 3.21×10^{-3} (%)	**1**
1(c)(ii)	**M1** correct value and units used for each quantity • 99000 Pa • 1.2956×10^{-4} m^3 (129.56×10^{-6}) • 373 K (273 +100) **M2** rearranges equation to give n=pV / RT **AND** correct evaluation $n = \frac{99000 \times 129.56 \times 10^{-6}}{8.31 \times 373}$ = 4.138055×10^{-3} (mol)	**2**
1(c)(iii)	M_r = 0.306 / **(c)(ii)** = 73.94778	**1**
1(d)	(calculated Mr would be) greater (than true value) **AND** mass of vapour measured is greater (all other measurements are the same)	**1**
1(e)	temperature (of water bath) not high enough (to boil methylbenzene)	**1**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>24.15 (g)</td><td>1</td></tr>
<tr><td>2(b)</td><td>M1 add a (small) volume of (distilled) water (to the small beaker)
AND
dissolve the solid / $Cu(NO_3)_2{\bullet}3H_2O(s)$

M2 transfer the solution to a 100 cm^3 volumetric flask with washings

M3 make up to the (calibration) mark / line (with distilled water)
AND
invert the (stoppered) flask (to mix)</td><td>3</td></tr>
<tr><td>2(c)</td><td>to allow ion(s) to move (between half-cells / two beakers)</td><td>1</td></tr>
<tr><td>2(d)</td><td><table><tr><th>log [$\mathbf{M}^{n+}$]</th><th>electrode potential of $\mathbf{M}^{n+}$(aq) / M(s) / V</th></tr><tr><td>–2.00</td><td>–2.958</td></tr><tr><td>–2.30</td><td>–2.967</td></tr><tr><td>–3.00</td><td>–2.988</td></tr><tr><td>–3.30</td><td>–3.006</td></tr><tr><td>–4.00</td><td>–3.017</td></tr><tr><td>–5.00</td><td>–3.047</td></tr></table></td><td>1</td></tr>
<tr><td>2(e)</td><td>concentration of $\mathbf{M}^{n+}$ ((aq))</td><td>1</td></tr>
<tr><td>2(f)(i)</td><td>M1 points plotted correctly

M2 straight line of best fit drawn</td><td>2</td></tr>
</table>

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Question	Answer	Marks
2(f)(ii)	point most anomalous to the plotted line of best fit circled **AND** the actual concentration of the solution was lower than recorded value (5.00×10^{-4})	**1**
2(f)(iii)	repeat the procedure for the solution giving an anomalous result	**1**
2(g)(i)	**M1** two acceptable coordinates from line of best fit expressed in the form (x,y) **M2** gradient correctly calculated from points listed for **M1** to three significant figures	**2**
2(g)(ii)	y = E m = $2.303RT / nF$ c = $E^{\ominus}$	**3**
2(g)(iii)	**M1** correct rearrangement **AND** values $n = \frac{2.303 \times 8.31 \times 298}{gradient \times 9.65 \times 10^4}$ **M2** correctly calculated value rounded to whole number	**2**

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