CAMBRIDGE
International Education

Cambridge International AS & A Level

CHEMISTRY **9701/44**

Paper 4 A Level Structured Questions **May/June 2025**

MARK SCHEME

Maximum Mark: 100

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.

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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.

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.

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.

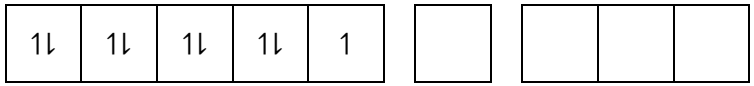
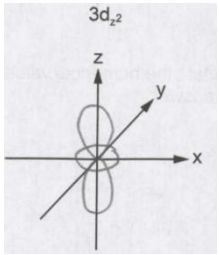
We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of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

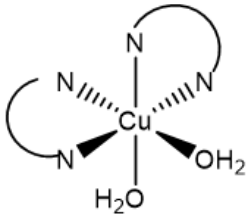
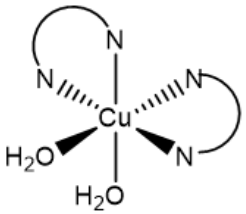
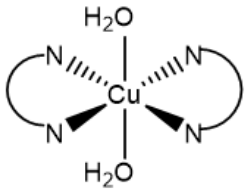
The annotations listed below were available to examiners marking this component in this series.

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
	Benefit of the doubt not applied in this instance

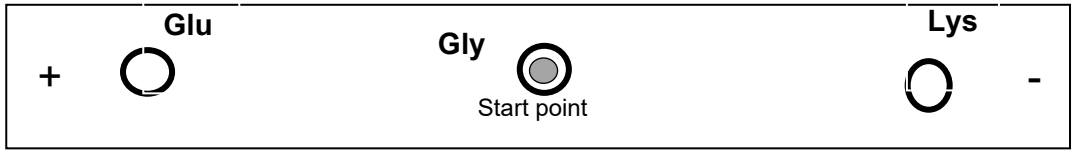
Annotation	Meaning
RE	Rounding error
REP	Repetition
SEEN	Blank page **or** part of script seen
SF	Error in number of significant figures
TE	Transcription error

Question	Answer	Marks
1(a)(i)	**M1:** (thermal stability) increases (down the group *or* from Mg to Ba) **OR** carbonates become more stable (down the group *or* from Mg to Ba) **M2:** ion / cation size / radius increases **OR** charge density on ion / cation decreases **M3:** less polarised $CO_3^{(2)-}$ / anion / carbonate ion **OR** weakens the C-O / C=O / covalent bonds less **OR** weakens bonds in the anion less **OR** lattice enthalpy of MO falls (less exothermic) faster than MCO_3 (due to differing sizes of anions)	**3**
1(a)(ii)	$CuCO_3 \longrightarrow CuO + CO_2$	**1**
1(b)(i)	[Ar] 	**1**
1(b)(ii)		**1**
1(b)(iii)	the (3)d and (4)s are close / similar in energy	**1**
1(c)(i)	**M1:** species with / has two lone pairs of electrons **M2:** that form dative (covalent) / co-ordinate bond(s) to a (central) transition-element / metal AND atom / ion **OR** donates electron pair(s) to a (central) transition-element / metal AND atom / ion	**2**

Question	Answer	Marks
1(c)(ii)	   cis-1 cis-2 trans each correct structure = [1]	**3**
1(c)(iii)	optical **AND** geometrical / cis-trans	**1**
1(c)(iv)	identification of either cis isomer **AND** dipoles / polar bonds / partial charges do not cancel **OR** identification of either cis isomer **AND** it is asymmetric and has polar bonds	**1**
1(d)(i)	complex ion in $Na_3Al F_6$: AlF_6^{3-} ligand in $Na_3Al F_6$: F^-	**1**
1(d)(ii)	**M1:** charge passed = $1.5 \times 30 \times 60$ **OR** 2700 (C) **M2:** $n(e^-) = 2700 / 96500$ **OR** 2.80×10^{-2} (mol) **M3:** $n(Al) = 2.80 \times 10^{-2} \div 3$ **OR** 9.33×10^{-3} (mol) **M4:** mass $(Al) = (27 \times 9.33 \times 10^{-3}) = 0.25$ (g)	**4**

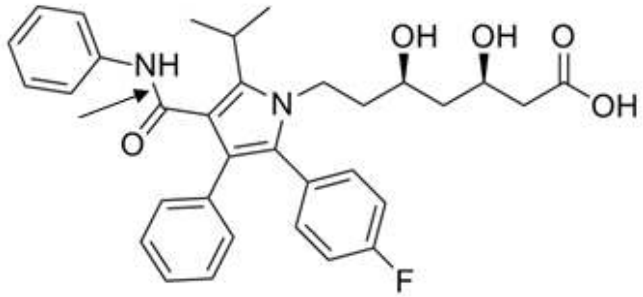
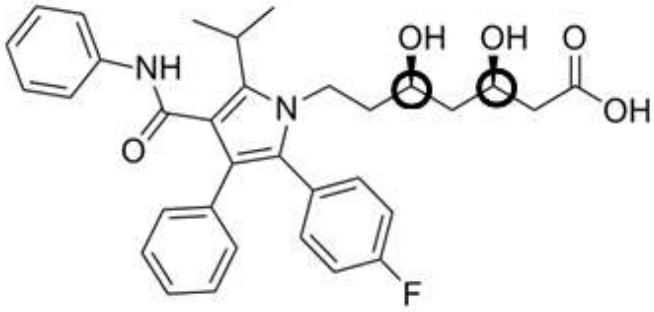
Question	Answer	Marks
2(a)(i)	white / steamy fumes	**1**
2(a)(ii)	number of (possible) arrangements of particles **AND** energy in a system	**1**
2(a)(iii)	due to the large number increase in gas molecules formed (in the reaction) **OR** there are much more gaseous molecules in the products **OR** six gas moles are produced	**1**
2(a)(iv)	**M1:** ΔH_r = (–859) + (2 x –297) + (4 x –92) – (–1460) – (2 x –246) **OR** +131 kJ mol^{-1} **M2:** use of $\Delta G = \Delta H - T\Delta S$ **AND** use of 298 (or 273+25) for T **M3:** ΔG = 131 – (298 x 0.768) = –97.9 (kJ mol^{-1})	**3**
2(b)(i)	$2Ba^{2+}(aq) + Cr_2O_7^{2-}(aq) + H_2O(l) \longrightarrow 2BaCrO_4(s) + 2H^+(aq)$	**1**
2(b)(ii)	**M1:** d orbital(s) of two different energies / d-d splitting occurs **OR** d orbital(s) / d (sub)-shell splits / d-d gap **OR** (inferred from movement of an electron) from lower d to higher d orbital **M2:** electron(s) promoted / excited **OR** electron(s) moves to higher (d–) orbital **OR** electron(s) jumps up (to d– orbital) / jumps to higher (d–orbital) **M3:** wavelength / frequency / light / photon / hν / hf absorbed **OR** radiation / energy from <u>visible</u> (region) absorbed **AND** colour (seen) is complementary **OR** wavelength / frequency / colour / light not absorbed is transmitted / reflected / seen	**3**
2(c)	**M1:** ΔH_{latt} and ΔH_{hyd} decrease / both become less exothermic / less negative **M2:** ΔH_{hyd} changes more / dominant factor / changes faster **OR** ΔH_{latt} changes less / becomes less exothermic by a smaller extent **M3:** ΔH_{sol} becomes less exothermic / less negative **OR** ΔH_{sol} becomes (more) endothermic / (more) positive	**3**

Question	Answer	Marks
3(a)(i)	**M1:** $K_{sp} = [Ni^{2+}][IO_3^-]^2$ **M2:** units: $mol^3\ dm^{-9}$	**2**
3(a)(ii)	$[Ni^{2+}] = 2.3 \times 10^{-2}$; $[IO_3^-] = 4.6 \times 10^{-2}$ $K_{sp} = (2.3 \times 10^{-2}) \times (4.6 \times 10^{-2})^2 = 4.87 \times 10^{-5}$	**1**
3(b)(i)	$E^{\ominus}_{cell} = 1.19 – (0.34) = (+)0.85$ (V) **AND** (positive electrode is) right hand side / nickel electrode / platinum / iodate	**1**
3(b)(ii)	(E_{cell} would be) less positive / more negative **AND** as $[IO_3^-]$ is less than 1.0 mol dm^{-3} / has a lower / smaller concentration	**1**
3(b)(iii)	**M1:** E_{cell} is less positive ticked **M2:** $[IO_3^-(aq)]$ is lowered due to the common ion effect **OR** $Ni(IO_3)_2$ precipitating or shown by equation **OR** solubility of $Ni(IO_3)_2$ decreasing	**2**
3(c)(i)	$[H^+] = 10^{-pH} = 10^{-0.47} = 0.34 / 0.339$ (mol dm^{-3}) min 2sf	**1**
3(c)(ii)	$[HIO_3]_{eqm} = 1.0 – 0.34 = 0.66$ (mol dm^{-3}) min 2sf **AND** $[H^+]_{eqm} = [IO_3^-]_{eqm} = 0.34$ (mol dm^{-3}) min 2sf	**1**
3(c)(iii)	$K_a = (0.34)^2 / 0.66 = 0.17– 0.18$ (mol dm^{-3}) min 2sf	**1**
3(d)(i)	**M1:** opposes / resists change in pH / controls pH / pH kept within a small range **M2:** when small amount of acid / H^+ or alkali / base / OH^- is added	**2**
3(d)(ii)	**M1:** $k = \{2.1 \times 10^{-2}\}/\{0.5 \times (1 \times 10^{-3})^2 \times 0.01^2\} = 4.20 \times 10^8$ min 2sf **M2:** $mol^{-4}\ dm^{12}\ s^{-1}$	**2**
3(d)(iii)	rate will be $(0.03 / 0.01)^2$ = 9 times as fast, so rate = $9 \times 2.1 \times 10^{-2}$ = 0.19 (0.189) (mol $dm^{-3}\ s^{-1}$) min 2sf	**1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(a)</td><td>
<table>
<tr><th>polymer</th><th>type of polymerisation</th><th>structure of monomer</th></tr>
<tr><td>X</td><td>condensation</td><td>$H_2(CH_2)_5CO_2H$
OR $NH_2(CH_2)_5COCl$</td></tr>
<tr><td>Y</td><td>addition</td><td>$CH_2{=}CHCO_2CH_3$</td></tr>
<tr><td>Z</td><td>condensation</td><td>$CH_3CH(OH)CO_2H$
OR $CH_3CH(OH)COCl$</td></tr>
</table>
Type of polymerisation (all three) = [1]
Structure of monomers = [1] for each structure</td><td>4</td></tr>
<tr><td>4(b)</td><td>pH (where) the species is a zwitterion (is the dominant form)
OR pH (where) the species is (electrically) neutral
OR pH (where) the species has a (net overall) charge of zero</td><td>1</td></tr>
<tr><td>4(c)(i)</td><td> 

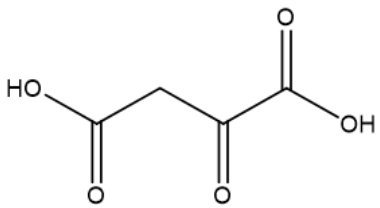
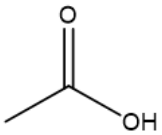
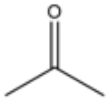
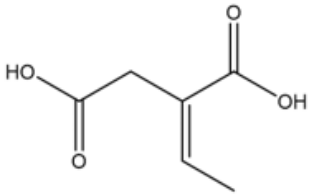
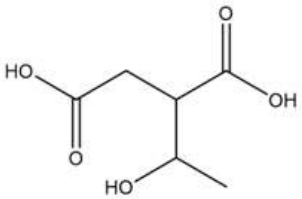
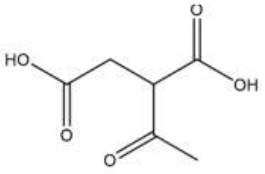
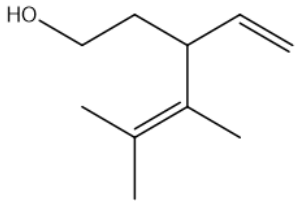
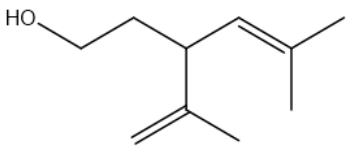
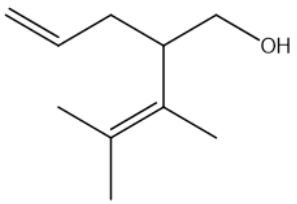
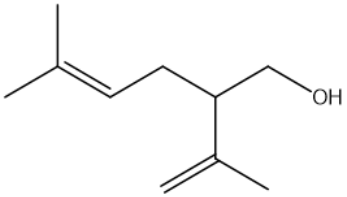
M1: Gly correct

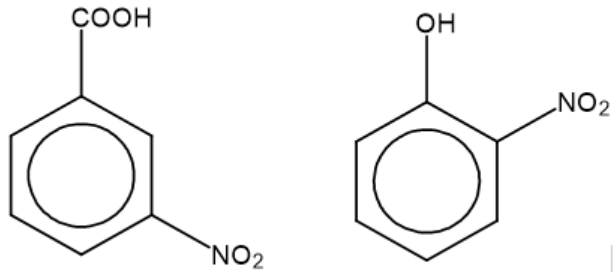
M2: Glu and Lys correct</td><td>2</td></tr>
<tr><td>4(c)(ii)</td><td>it would move towards the positive terminal / anode / side / end or to the left</td><td>1</td></tr>
</table>

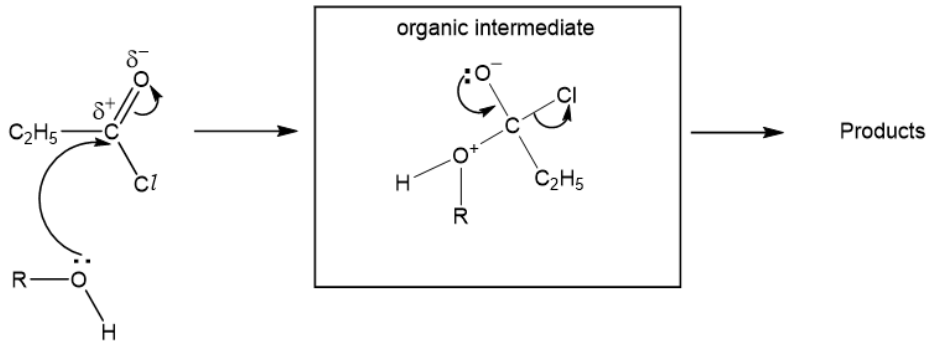
Question	Answer	Marks
5(a)(i)		**1**
5(a)(ii)	the OH / NH groups / O atoms **AND** can hydrogen bond with water	**1**
5(a)(iii)	$C_{33}H_{35}N_2O_5F$	**1**
5(a)(iv)		**1**
5(a)(v)	different / better biological activity	**1**
5(b)(i)	16 / sixteen	**1**
5(b)(ii)	**M1:** 4 / four **M2:** proton exchange between NH / OH with D	**2**

Question	Answer	Marks
5(c)	groups reacting • carboxylic acid • amide groups forming • (primary) alcohol • amine Any two [1] all four [2]	**2**

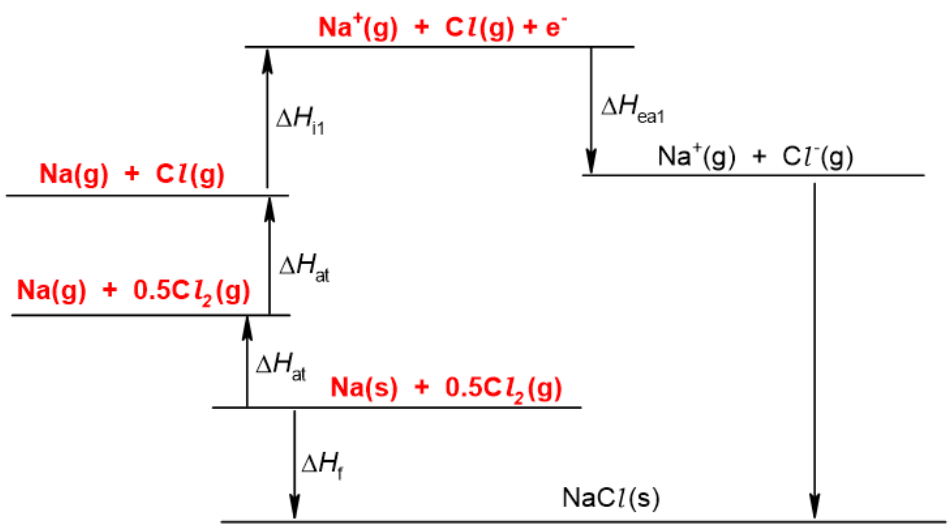
Question	Answer	Marks
6(a)	<table><tr><td colspan="6">test</td></tr><tr><td>sodium metal</td><td>Na_2CO_3(aq)</td><td>2,4-DNPH</td><td>I_2(aq) + OH^-(aq)</td><td>warm with Fehling's solution</td><td>Br_2(aq)</td></tr><tr><td>alcohol / carboxylic acid</td><td>carboxylic acid</td><td>carbonyl / ketone / aldehyde</td><td>(methyl) ketone / (methyl) alcohol</td><td>aldehyde</td><td>alkene</td></tr></table> Any two [1] any three [2] any five [3] all six [4]	**4**
6(b)(i)	(primary) alcohol	**1**
6(b)(ii)	**M1: A** → **B** oxidation/dehydrogenation **M2: C** → **E** reduction/(nucleophilic) addition **M3: E** → **F** elimination/dehydration	**3**

Question	Answer	Marks
6(b)(iii)	**G**  **H**  each correct structure [1]	**2**
6(b)(iv)	**D**  **F**  **E**  **C**  **A** any one of the following     each correct structure [1]	**5**

Question	Answer	Marks
7(a)	**M1:** benzoic acid > phenol > ethanol **M2 / M3:** any two [1] any three [2] • correct link of acidity once **AND** weakens O—H / OH bond / hydroxyl bond / -O-H **OR** H^+ more easily lost / (carboxylate) anion stabilised u / c • (benzoic acid) due to negative inductive effect / electron withdrawing effect **AND** of C=O / COOH / carboxyl • (phenol) as lone pair / p-orbital (electrons) on oxygen (on phenol) / **AND** overlap / delocalised into the ring / π-system • (ethanol) alkyl / ethyl / R group **AND** is electron donating / positive inductive effect	**3**
7(b)	 Each correct structure = [1]	**2**
7(c)(i)	ethyl propanoate	**1**

Question	Answer	Marks
7(c)(ii)	 **M1 / M2:** any two [1] all four [2] • lone pair on O • correct arrow from (lone pair) O to C (of C=O) • dipole on C=O • correct arrow on C=O **M3:** correct intermediate **M4:** arrow from lone pair or charge on O^- to C-O bond **AND** arrow from C-C*l* to C*l*	**4**
7(c)(iii)	(nucleophilic) addition – elimination	**1**

Question	Answer	Marks
8(a)(i)	**M1:** energy change / released when 1 mole of a (ionic) solid / lattice / crystal / compound is formed **M2:** from gas (phase) ions / gaseous ions (under standard conditions)	**2**
8(a)(ii)	(enthalpy change when) 1 mole of a substance / solid / solute / molecule **AND** dissolves in water (to give a solution of infinite dilution)	**1**
8(b)	$\Delta H_{sol}(NaCl) = \Delta H_{hyd}(Na^+) + \Delta H_{hyd}(Cl^-) - \Delta H_{latt}(NaCl)$	**1**

Question	Answer	Marks
8(c)	 **M1 / M2:** any two [1] all four [2] **M3:** all state symbols for the formula are present and correct	**3**
8(d)	**M1:** (more exothermic because) Cl^- **OR** NO_3^- because its (ionic) radius / size is smaller **M2:** (more exothermic because) (ion-dipole) attraction / bond between it and water is stronger **OR** **M1:** NO_3^- because it has lone pairs on O / more lone pairs **M2:** which can form hydrogen bonds with water	**2**