

Mark Scheme (Results)

Summer 2018

Pearson Edexcel GCE
In Chemistry (9CH0) Paper 01
Advanced Inorganic and Physical Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answer	Additional Guidance	Mark
1(a)	An answer that makes reference to the following points: • ammonium **(1)** • bromide **(1)**	Mark independently Allow names in either order Ignore symbols as well as names Do not award ammonia Do not award bromine Allow (1) for just NH_4Br	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
1(b)	A description that makes reference to the following points: • add (excess) dilute ammonia / dilute NH_3 (to the precipitate) **and** the precipitate is insoluble /does not dissolve **(1)** • add (excess) concentrated (aqueous) ammonia / concentrated NH_3 (to the precipitate) **and** it is soluble / dissolves / forms a colourless solution **(1)**	Allow ammonium hydroxide for ammonia Ignore pure ammonia / ammonia with no concentration / ammonia gas Allow no change for the observation Allow 'if it dissolves it is not bromide' Allow redissolves for soluble **Note** If no other mark is awarded allow (1) for adding dilute and concentrated ammonia with no / incorrect observation(s) **Alternative test**: add concentrated sulfuric acid **(1)** brown fumes **(1)**	**(2)**

(Total for Question 1 = 4 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
2(a)	• ^{6}Li – 3 protons **and** 3 neutrons **and** 3 electrons **(1)** • $^{7}Li^{+}$ – 3 protons **and** 4 neutrons **and** 2 electrons **(1)**	Example of table Particle | Protons | Neutrons | Electrons ^{6}Li | 3 | 3 | 3 $^{7}Li^{+}$ | 3 | 4 | 2 If no oher mark is scored, allow (1) for any 4 correct numbers Ignore + or - signs	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
2(b)	An answer that makes reference to the following points: • identification of oxygen / O **(1)** • identification of isotopes corresponding to any 3 *m/z* values **(1)** • Conditional on M2 awarded identification of isotopes corresponding to other 2 *m/z* values **(1)**	Isotopes in ions at each *m/z* value: (32 –) $^{16}O=^{16}O^{+}$ / $^{16}O_2^{+}$ (33 –) $^{16}O=^{17}O^{+}$ (34 –) $^{16}O=^{18}O^{+}$ **and** $^{17}O=^{17}O^{+}$ / $^{17}O_2^{+}$ (35 –) $^{17}O=^{18}O^{+}$ (36 –) $^{18}O=^{18}O^{+}$ / $^{18}O_2^{+}$ Allow single bonds Allow any other unambiguous ways of showing the masses of the isotopes for each *m/z* value e.g. 16+16, O_2^{16} Allow use of X / another symbol e.g. Cl instead of O for M2 and M3 Ignore missing charges as given in question Penalise negative charge once only	**(3)**

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th></th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>2(c)</td><td>• 1s orbital – 2 electrons
• 2p subshell – 6 electrons
• third quantum shell – 18 electrons</td><td>(1)
(1)
(1)</td><td><u>Example of table</u>
<table><tr><th>Region</th><th>Maximum number of electrons</th></tr><tr><td>the 1s orbital</td><td>2</td></tr><tr><td>the 2p subshell</td><td>6</td></tr><tr><td>the third quantam shell</td><td>18</td></tr></table>Allow $1s^2$ for 2
Allow $2p^6$ for 6
Ignore $3s^23p^63d^{10}$ for the third number
Do not award more than one number written in the box e.g. 8 or 18 in the third box</td><td>(3)</td></tr>
</table>

(Total for Question 2 = 8 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
3(a)	An answer that makes reference to the following point: • to make sure that (all) the (nitric) acid / HNO_3 / H^+ has reacted / been neutralised / is used up	Allow (nitric acid) / HNO_3 is the limiting reagent Allow so that 0.025 mol of water / H_2O forms Ignore to make sure that 1 mol of water / H_2O forms Ignore just 'to ensure that reaction is complete'	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
3(b)	• calculation of heat produced **(1)** • calculation of amount (mol) of HNO_3 **(1)** • calculation of enthalpy change **(1)** • negative sign **and** units **and** answer to 2 / 1 SF **(1)**	Example of calculation heat produced = 50.0 x 4.18 x 6.8 = 1421.2(J) / 1.4212 (kJ) amount HNO_3 used = 25.0 x 1.00/1000 = 0.025 / 2.5 x 10^{-2} (mol) Ignore moles NaOH and total moles calculated enthalpy change = $\frac{1421.2}{0.025}$ = 56848 (J mol^{-1}) **or** = $\frac{1.4212}{0.025}$ = 56.848 (kJ mol^{-1}) TE on heat produced and amount **HNO_3** final answer −57 / −60 kJ mol^{-1} **or** −57 000 / −60 000 J mol^{-1} TE on enthalpy change Do not award 3 SF Correct final answer with sign, units and 2 or 1 SF but no working scores (4) Ignore units and sign of enthalpy change in M1 and M3	**(4)**

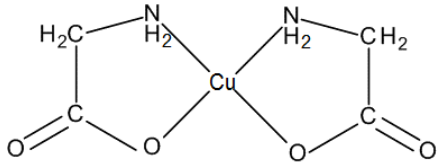
(Total for Question 3 = 5 marks)

Question Number	Answer	Mark
4(a)	**The only correct answer is C** ***A*** *is not correct because it is* $3d^3$ *not* $3d^5$ ***B*** *is not correct because it is* $3d^6$ *not* $3d^5$ ***D*** *is not correct because it is* $3d^4$ *not* $3d^5$	**(1)**

Question Number	Answer	Mark
4(b)	**The only correct answer is C** ***A*** *is not correct because it is +1 not +3* ***B*** *is not correct because it is +2 not +3* ***D*** *is not correct because it is +2 not +3*	**(1)**

Question Number	Answer	Mark
4(c)	**The only correct answer is B** ***A*** *is not correct because covalent is missing* ***C*** *is not correct because it has ionic is incorrect* ***D*** *is not correct because it has ionic is incorrect*	**(1)**

Question Number	Answer	Mark
4(d)	**The only correct answer is B** ***A*** *is not correct because it is not an explanation* ***C*** *is not correct because the d-orbitals can be split in energy* ***D*** *is not correct because there are ten electrons in the d-subshell*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(e)	• **2** glycinate ligands attached to Cu through nitrogen atoms **(1)** • **2** glycinate ligands attached to Cu through single bonded oxygen atoms **and** rest of structure correct **(1)**	Example of structure  Allow the two ligands attached to any 2 pairs of adjacent bonds Allow *cis* or *trans* isomer / delocalised carboxylate groups / skeletal formulae Ignore bond lengths and bond angles Ignore lone pairs of electrons, charge on the copper or oxygen ions and direction of dative covalent bonds Do not award M1 if bond between Cu and H of NH_2	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(f)	An explanation that makes reference to the following points: • (the initial rate of reaction is slow) because both reacting species are negatively charged / repel each other **or** the reaction has a high activation energy / few particles have energy greater than (or equal to) the activation energy **(1)** • (the rate of reaction increases) because **Mn^{2+} ions** (are formed) **and** they act as a catalyst / are autocatalytic / provide an alternative route with a lower activation energy **(1)** • (the rate decreases) because the concentrations /amounts of the reactants decrease / the reactants are used up **(1)**	Allow because there is no catalyst / no Mn^{2+} ions present at the start Allow a description of how the Mn^{2+} ions are acting as a catalyst e.g. the idea of Mn^{2+} ions reacting **and** being regenerated Do not award 'enzyme' Allow example of one of the reagents used up / becoming a limiting factor Do not award 'the Mn^{2+} ions are used up'	**(3)**

(Total for Question 4 = 9 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
5(a)	• (high resistance) voltmeter **(1)** • platinum /Pt (electrode) **(1)** • manganese(II) **and** manganese(III) ions / Mn^{2+} **and** Mn^{3+} **(1)**	Allow potentiometer / Wheatstone bridge / just 'V' Ignore high voltage Do not award voltameter Ignore just 'inert metal' Do not award manganese / Mn Allow any named manganese(II) salt **and** manganese(III) salt Ignore concentration and units	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(b)(i)	• potassium nitrate / KNO_3	If name and formula are given, both must be correct If more than one substance given, all must be correct Allow potassium chloride / KCl sodium nitrate / $NaNO_3$ sodium chloride / NaCl ammonium nitrate / NH_4NO_3 ammonium chloride / NH_4Cl Ignore concentration	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(b)(ii)	• wire does not allow the flow of ions **or** wire (only) allows flow of electrons **or** salt bridge allows flow of ions **or** salt bridge does not allow the flow of electrons **or** a flow of ions is needed to complete the circuit **or** ions (need to) flow between the half-cells / between the solutions	Allow any indication of movement for flow in all points Allow the salt bridge donates / removes ions (to balance the charges in the solution and the wire does not do this) Ignore just 'the circuit is not complete' Ignore references to changes in potential difference / $E^{\ominus}$ / $E^{\ominus}_{cell}$	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(c)(i)	• correct equation	<u>Example of equation</u> $2Mn^{3+} + Cu \rightarrow 2Mn^{2+} + Cu^{2+}$ Allow multiples Allow ⇌ provided equation is written in the direction shown Ignore state symbols, even if incorrect Ignore cancelled electrons e.g. $2Mn^{3+} + Cu + 2e \rightarrow 2Mn^{2+} + Cu^{2+} + 2e$ Do not award equation with uncancelled electrons	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(c)(ii)	• $E^{\ominus}$ = 1.15 – (−0.34) = (+)1.49 (V)	Stand alone mark Correct answer with no working scores the mark	**(1)**

(Total for Question 5 = 7 marks)

Question Number	Answer	Mark
6(a)	**The only correct answer is D** ***A*** *is not correct because it is the 2nd most soluble* ***B*** *is not correct because it is the 3rd most soluble* ***C*** *is not correct because it is the least soluble*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
6(b)(i)	An answer that makes reference to the following point: • the concentration of a solid / $Mg(OH)_2$ is constant / unchanged / changes very little	Allow magnesium hydroxide is in a different phase / state (from the aqueous ions) Ignore solids do not appear in K_c expressions / just 'it is solid' Ignore solid does not affect the concentration of the solution Ignore it is a heterogeneous equilibrium Ignore it is difficult to measure the concentration of a solid Do not award the solid does not have a concentration	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
6(b)(ii)	• $mol^3\ dm^{-9}$	Allow $dm^{-9}\ mol^3$ mol^3/dm^9 Ignore any working before the answer	(1)

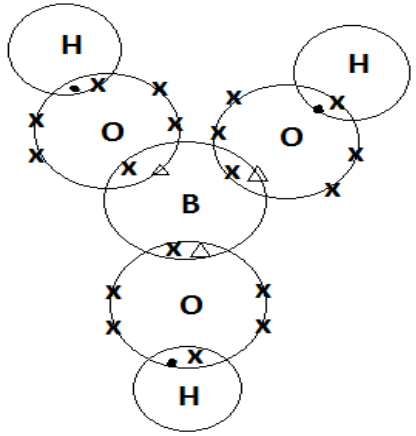
Question Number	Acceptable Answer	Additional Guidance	Mark
6(b)(iii)	• use of $\Delta_{sol}H = \Delta_{hyd}H[Mg^{2+}(aq)] + 2\Delta_{hyd}H[OH^-(aq)] - \Delta_{latt}H[Mg(OH)_2(s)]$ **(1)** • calculation of $\Delta_{sol}H$ **(1)**	Example of calculation $\Delta_{sol}H = -1920 + 2(-460) - (-2842)$ Allow this shown on a Hess cycle $\Delta_{sol}H = (+)2\ (kJ\ mol^{-1})$ Allow 2000 J mol^{-1} Correct answer with no working scores 2	(2)

Question Number	Answer	Mark
6(b)(iv)	**The only correct answer is D** ***A*** *is not correct because it should not be linear and should level off* ***B*** *is not correct because it should not increase in that way and should level off* ***C*** *is not correct because it should not be horizontal*	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
6(b)(v)	An answer that makes reference to the following points: Addition of magnesium sulfate solution: • equilibrium position shifts to the left / in the backwards direction **(1)** • because increased concentration / amount of magnesium ions / $Mg^{2+}((aq))$ **(1)** Addition of dilute hydrochloric acid: • equilibrium shifts to the right / in the forwards direction **(1)** • because the hydrogen ions / $H^{+}((aq))$ react with / neutralise / removes the hydroxide ions / $OH^{-}((aq))$ **(1)**	Mark independently Allow more magnesium hydroxide precipitates / forms Allow more Mg^{2+} ions present Allow more magnesium hydroxide dissolves / dissociates Allow $H^{+}((aq)) + OH^{-}((aq)) \rightarrow H_2O((l))$ Allow magnesium hydroxide reacts with / is neutralised by acid / equation to show this Allow acid / HCl reacts with / neutralises / removes hydroxide ions Penalise reference to K_c changing once only	**(4)**

(Total for Question 6 = 10 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
7(a)	• correct equation	Examples of equation $Na_2B_4O_7.10H_2O + 2HCl \rightarrow 4H_3BO_3 + 2NaCl + 5H_2O$ **or** $Na_2B_4O_7.10H_2O + 2HCl \rightarrow 4B(OH)_3 + 2NaCl + 5H_2O$ Allow multiples Allow reversible arrow provided the equation is written in the direction shown. Ignore state symbols, even if incorrect	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(b)(i)	• all 6 bonding pairs correct **(1)** • 2 lone pairs on each O and no additional electrons on boron or hydrogen **(1)**	Example of diagram  Non-bonding electrons on O can be shown as pairs, all 4 together or as 3 and 1 Electrons in overlap regions can be on the lines or the gaps between the lines Allow (1) for electrons in correct places but incorrect symbols for electrons Ignore inner shell electrons shown on B and/or O **Note** If any double bonds are shown the answer scores (0)	**(2)**

Question Number	Answer	Mark
7(b)(ii)	**The only correct answer is C** ***A*** *is incorrect because 109.5^{o} is incorrect* ***B*** *is incorrect because 109.5^{o} and 180^{o} are incorrect* ***D*** *is incorrect because 180^{o} is incorrect*	**(1)**

Question Number	Answer	Mark
7(c)	**The only correct answer is B** ***A*** *is incorrect because covalent bonds are within molecules not between molecules* ***C*** *is incorrect because there are no ionic bonds* ***D*** *is incorrect because London forces are not the strongest force*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(d)(i)	• calculation of K_a **(1)** • calculation of $[H^+]$ **(1)** • calculation of pH **(1)**	<u>Example of calculation</u> $K_a = 10^{-pKa} = 10^{-9.24} = 5.7544 \times 10^{-10}$ (mol dm^{-3}) $[H^+] = \sqrt{K_a[H_3BO_3]} = \sqrt{5.7544 \times 10^{-10} \times 0.05}$ $= 5.364 \times 10^{-6}$ (mol dm^{-3}) TE on K_a pH = $-\log_{10}[H^+] = -\log_{10}5.364 \times 10^{-6}$ = 5.2705 / 5.271 / 5.27 / 5.3 TE on $[H^+]$ provided pH is >2 and <7 Accept alternative methods, for example $[H^+] = \sqrt{K_a[H_3BO_3]}$ pH = ½pK_a – ½log$[H_3BO_3]$ **(1)** = ½9.24 – ½log0.05 **(1)** = 5.2705 / 5.271 / 5.27 / 5.3 **(1)** Alternative method: $K_a = 10^{-pKa} = 10^{-9.24} = 5.7544 \times 10^{-10}$ (mol dm^{-3}) **(1)** $[H^+]^2 = K_a([H_3BO_3] - [H^+])$ $= 5.7544 \times 10^{-10} \times (0.05 - [H^+])$ $[H^+] = 5.135 \times 10^{-6}$ **(1)** pH = 5.29 **(1)** Ignore SF except 1SF Correct answer without working scores 3 marks	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(d)(ii)	An answer that makes reference to the following points: • $[H^+] = [H_2BO_3^-]$ **or** no H^+ from the (ionisation of) water / ionisation of water is negligible **or** H^+ is only from the acid **or** no H^+ from ionisation of $H_2BO_3^-$ **(1)** • ionisation / dissociation of the acid is negligible / very small / insignificant **or** $[H_3BO_3]_{initial} = [H_3BO_3]_{equilibrium}$ **or** $[H_3BO_3]_{equilibrium} = 0.05$ (mol dm^{-3}) **or** $[H^+]/[H_2BO_3_] << [H_3BO_3]$ **or** $[H_3BO_3]$ / acid concentration remains constant **or** $[H_3BO_3]_{equilibrium} = [H_3BO_3]_{initial} - [H^+]$ used in calculation in (i) **(1)**	Allow $[A^-]$ for $[H_2BO_3^-]$ / [HA] for $[H_3BO_3]$ Allow any of the expressions described in words Allow approximately equal to for = (in symbols or words) Ignore reference to standard conditions Do not award two marks from the same marking point Allow the effect of the third ionisation is negligible Ignore partial dissociation / not completely dissociated Do not award H_3BO_3 / [HA]is completely dissociated	**(2)**

Question Number	Answer	Mark
7(e)	**The only correct answer is B** ***A*** *is not correct because it is the conjugate base not acid* ***C*** *is not correct because it is not the conjugate acid* ***D*** *is not correct because it is not the conjugate acid*	**(1)**

(Total for Question 7 = 11 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
8(a)(i)	• any 2 correct **(1)** • all 3 correct **(2)**	Example of table 1st IE: (590) 4s; 2nd IE: (1145) 4s; 3rd IE: (4912) 3p Accept $3p_x$ / $3p_y$ / $3p_z$ for 3rd IE Ignore any superscript numbers by 4s and 3p Allow (1) for just 's, s, p' or 's, s, p' with one or more incorrect numbers in front	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(a)(ii)	• correct equation	Examples of equations $Ca^{2+}(g) \rightarrow Ca^{3+}(g) + e^{(-)}$ **or** $Ca^{2+}(g) - e^{(-)} \rightarrow Ca^{3+}(g)$ Correct state symbols are required Ignore any state symbol for the electron	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(a)(iii)	An explanation that makes reference to the following points: • (there is a much larger difference between the 2nd and 3rd ionisation energies because the) 3rd electron is lost from a shell / energy level / sub-shell / (3p) orbital closer to the nucleus **or** the 3rd electron is lost from a shell / energy level / sub-shell / (3p) orbital of lower energy **(1)** • (there is a smaller difference between the 1st and 2nd ionisation energies because the) 1st and 2nd electrons removed from the same shell / energy level / sub-level / orbital **or** the first two electrons experience similar shielding (from the inner electrons) **or** there is only a small change in electron-electron repulsion as the first two electrons are removed **(1)**	Ignore electron is lost from a full (sub-)shell / a full (sub-)shell is more stable Ignore just '3rd electron lost is more strongly attracted to the nucleus' Allow the same amount of shielding Allow the 3rd electron (to be lost) experiences less shielding (from inner electrons)	**(2)**

Question Number	Answer	Mark
8(b)	**The only correct answer is B** ***A*** *is incorrect because (−1031) + (79 + 520 + 159) is incorrect* ***C*** *is incorrect because (−1031) + (79 + 520) is incorrect* ***D*** *is incorrect because (−1031) + 79 +520 +159 – 616 is incorrect*	**(1)**

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>8(c)*</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>

The following table shows how the marks should be awarded for structure and lines of reasoning.</td><td>Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning.</td><td>(6)</td></tr>
</table>

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.	2
Answer is partially structured with some linkages and lines of reasoning.	1
Answer has no linkages between points and is unstructured.	0

Comment:
Look for the indicative marking points first, then consider the mark for structure of answer and sustained line of reasoning

General points to note
If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).
e.g.
penalise any reference to 'molecule' once only
or
penalise 'ion' not mentioned in word or formula at least once in answer, once only

Allow reverse arguments for IP3 to IP6 Ignore mention of stoichiometry Ignore references to electronegativity

	Indicative content • **IP1 - Ionic** lithium chloride / LiCl (has very similar theoretical and experimental lattice energy values so) is (almost 100%) ionic • **IP2 - Covalency** magnesium iodide / MgI_2 (has different theoretical and experimental lattice energy values so) has (some) covalent character • **IP3 - Charge on cations** magnesium is Mg^{2+} and lithium is Li^+ • **IP4 - Polarising** – what does the polarising magnesium ion/Mg^{2+} is (more) polarising / has a large(r) polarising power (than lithium ion) • **IP5 - Size of anion** iodide ion / I^- is larger (than chloride ion / Cl^-) • **IP6 – Polarisable** – what is polarised iodide ion / I^- is (more easily) polarised / distorted	Allow **very** small amount of / no covalent character in LiCl Allow assumption that ions act as point charges / are spherical is true for LiCl Allow MgI_2 more covalent character than LiCl Allow magnesium has 2+ charge and lithium has 1+ charge / magnesium ion has a larger charge than a lithium ion Allow charge density for charge Allow iodine ion / I^- is a large atom / has a large atomic radius Ignore size of cation Do not award iodide has a larger charge density Allow this shown in a diagram Ignore just 'greater attraction to cation'	

(Total for Question 8 = 12 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>9(a)</td><td>• all 3 correct (2)
• any 2 correct (1)</td><td>Example of table
<table><tr><th>Reaction</th><th>Sign of ΔSsystem</th></tr><tr><td>$CO_2(s) \rightarrow CO_2(g)$</td><td>positive / + / +ve / plus</td></tr><tr><td>NaCl(s) + aq → NaCl(aq)</td><td>positive / + / +ve / plus</td></tr><tr><td>$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$</td><td>negative / – / –ve / minus</td></tr></table></td><td>(2)</td></tr>
</table>

Question Number	Acceptable Answer		Additional Guidance	Mark
9(b)	• use of $\Delta S_{surroundings} = -\Delta H/T$	**(1)**	Example of calculation -(178000÷298) / -(178÷298)	**(3)**
	• calculation of $\Delta S_{surroundings}$	**(1)**	-597(.315) (J K^{-1} mol^{-1}) **or** -0.597(315) (kJ K^{-1} mol^{-1}) TE on equation with minus sign missing	
	• calculation of ΔS_{total} **and** sign **and** units	**(1)**	$\frac{160}{1000}$ + (-0.597315) = -0.437(315) kJ K^{-1} mol^{-1} **or** 160 + (-0.597315 x 1000) = -437.(315) J K^{-1} mol^{-1} TE on $\Delta S_{surroundings}$ Allow correct units shown once in answer for ΔS_{total} or $\Delta S_{surroundings}$ Ignore SF except 1SF Correct answer with sign and units without working scores 3 marks	

Question Number	Acceptable Answer	Additional Guidance	Mark
9(c)(i)	• correct working **(1)** • correct answer **and** sign **(1)**	<u>Example of calculation</u> (2 x 95.6) – ((2 x 248.1) + 205.0) / (2 x 95.6) – (2 x 248.1) – 205.0 -510(.0) (J K^{-1} mol^{-1}) **or** -0.510 (kJ K^{-1} mol^{-1}) TE on working Ignore SF except 1SF Correct answer with sign and without working scores both marks	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
9(c)(ii)	• use of $\Delta G = \Delta H - T\Delta S_{system}$ **(1)** • calculation of ΔG **and** sign **and** units **(1)** • ΔG is negative / less than 0 / <0 **and** so the reaction is feasible **(1)**	<u>Example of calculation</u> The equation may be stated or numbers substituted directly e.g.−288.4 – (298 x −0.510) / −288400 – (298 x −510) −136(.42) kJ mol^{-1} / −136420 J mol^{-1} TE on ΔS_{system} in (i) Ignore SF except 1SF Correct answer with sign and units without working scores both marks Conditional on a stated number TE on sign of ΔG: ΔG is positive / greater than 0 / >0 so the reaction is not feasible	**(3)**

Question Number	Acceptable Answer		Additional Guidance	Mark
9(c)(iii)	• use of $\Delta G = -RT\ln K$	**(1)**	Example of calculation $-60000 = -\ 8.31 \times 700 \ln K$	**(3)**
	• rearrangement of equation **and** substitution of correct values	**(1)**	$(\ln K = -\Delta G/RT)$ $\ln K = \frac{-(-60000)}{(8.31 \times 700)}$ Allow $\ln K = \frac{60000}{8.31 \times 700}$ Allow $\ln K$ = 10.3146 / 10.315 / 10.32 / 10.3 / 10 TE on equation, provided equation involves all of ΔG, K, R and T and no others e.g. S	
	• calculation of K	**(1)**	$K = e^{10.315} = 3.016975 \times 10^4$ / 30169.75 TE on $\ln K$ expression / value Allow answers based on earlier correct rounding Ignore SF **including** 1SF Ignore units Correct answer without working scores 3 marks	

Question Number	Acceptable Answer	Additional Guidance	Mark
9(c)(iv)	An explanation that makes reference to any **two** of the following points: • **Yield** - even though the (percentage) yield / amount of SO_3 is higher at 298 K / lower temperature **(1)** • **Rate** - the rate of reaction is slower at 298 K / lower temperature **(1)** • **Compromise** - so 700 K is a compromise between a (high) yield and (high) rate **(1)**	Allow reverse argument for M1 and M2 Ignore reference to changing the pressure Allow the unused reactants can be recycled to increase the yield / products are removed to increase the yield Allow the reaction does not reach equilibrium in industry so there is no effect on the yield Ignore just a reference to 'equilibrium shifting' Ignore references to activation energy Allow at 700K the amount of product per unit time is larger Ignore just '700 K is more economically viable' **Note** If three points are made related to yield, rate and compromise and one of these is incorrect, maximum mark is (1) for 1 correct point	**(2)**

(Total for Question 9 = 15 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
10(a)	• correct equation	<u>Examples of equations</u> $Cu + 4HNO_3 \rightarrow Cu^{2+} + 2NO_3^- + 2NO_2 + 2H_2O$ **or** $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$ Allow multiples Allow $\rightleftharpoons$ provided equation is written in the direction shown Ignore state symbols, even if incorrect Ignore cancelled electrons Ignore Ag or Au on both sides	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
10(b)	• Indicator: starch **(1)** • Colour change: Starting colour: blue/black or blue or black Final colour: colourless **(1)**	M2 is conditional on starch or no indicator Ignore mention of precipitate Ignore other words to describe colour e.g. deep / dark Ignore clear	**(2)**

Question Number	Answer	Additional Guidance	Mark
10(c)	• calculation of moles of silver chloride **(1)** • calculation of mass of silver **(1)** • calculation of moles of Cu^{2+} **(1)** • calculation of mass of copper **(1)** • calculation of percentage of gold **(1)**	<u>Example of calculation</u> moles AgCl = 0.706/(107.9 + 35.5) = 0.00492329 / 4.92329 x 10^{-3} mass Ag = 0.00492329 x 107.9 = 0.531223 (g) moles S_2O^{2-} **or** moles Cu^{2+} = 39.40 x 0.100 / 1000 = 0.00394 / 3.94 x 10^{-3} mass Cu = 0.00394 x 63.5 = 0.25019 (g) mass Au = 1.250 – (0.531223 + 0.25019) = 0.468587 (g) percentage of gold = 0.468587/1.250 x 100 = 37.5 (%) **or** percentage of silver = 0.531223/1.250 x 100 = 42.4978 / 42.5 (%) percentage of copper = 0.25019/1.250 x 100 = 20.0151 / 20 (%) percentage of gold = 100 – (42.5 + 20) = 37.5 (%) Allow TE for each step Allow final answer based on correct rounding at each stage (36.3 to 37.9%) Ignore SF except 1 SF in final answer Correct answer without working scores (5) **Continued on next page**	**(6)**

	• deduction that alloy is 9 carat gold **(1)**	Conditional on some correct working to show the percentage of gold If calculated % is not 37.5, allow: calculated value of carat (24 x their percentage/100) or 'less than 9 carat gold' if calculated % is less than 37.5% or nearest carat value from table or a (rough) interpolated carat value or between the two relevant carat values	

(Total for Question 10 = 9 marks)

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