Mark Scheme

Q1.

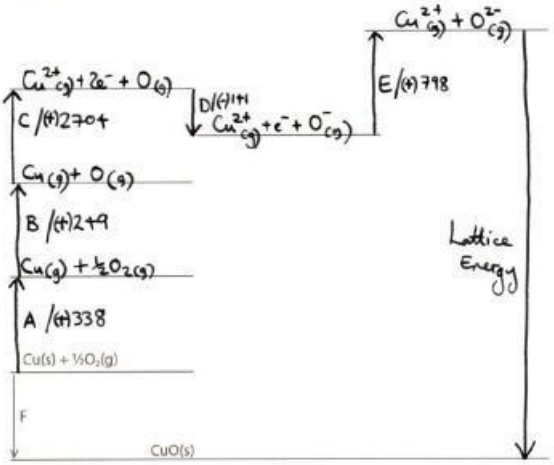
Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following points: • identification and correction of the first error **(1)** • identification and correction of the second error **(1)**	Allow corrections to be made on the diagram Error 1 – arrow for enthalpy change of formation should go down/be reversed Error 2 – the word 'half ' should be deleted from the enthalpy change of atomisation of hydrogen	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	• calculation of first electron affinity of hydrogen	Example of calculation 1st EA= –(218+496+107)–56 +804 = –73 (kJ mol^{-1}) Allow a TE 1st EA = +39(kJ mol^{-1}) if the first arrow reversed direction is not identified	**(1)**

Q2.

Question Number	Answer	Additional Guidance	Mark
	• application of Hess's law (1) • evaluation of lattice energy (1)	Example of calculation LE = (−1577 + (2 × −336) – (−73)) = = −2176 kJ mol^{-1} Final answer without working scores (2) (+) 2176 kJ mol^{-1} scores (1) for TE on incorrect application of Hess's law −1840 kJ mol^{-1} scores (1) for use of single −336 instead of double	(2)

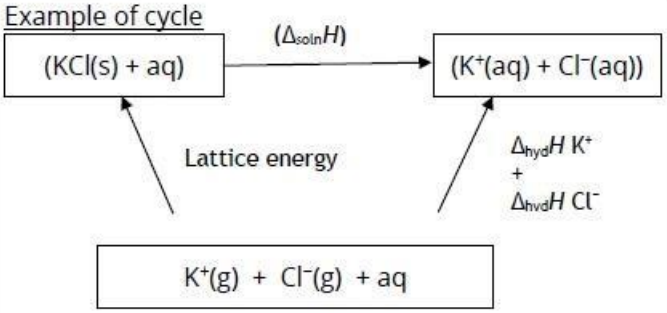
Q3.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that includes • species on lines (1) • state symbols (1) • energy changes / values (1) • arrows indicating direction (1)	Example of Born-Haber cycle and calculation Allow omission of electrons but if included then must be correct A and B can be drawn in either order or A then C followed by B Exemplar cycle:  Each different species error can be penalised so four different species errors scores (0)	(4)

Question Number	Answer	Additional Guidance	Mark
(ii)	• calculation of lattice energy	LE= −4105 (kJ mol^{-1})	(1)

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following points: • (ionic) radius **(1)** • (ionic) charge **(1)**	 Allow size (of ions) Do not award atomic radius/size of atoms Do not award atomic charge/charge of atoms Allow charge density for 1 mark if no other mark awarded	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)		Example of cycle  	(3)
	• correct species with state symbols in bottom box **(1)**	Ignore missing aq	
	• arrows in correct directions **and** labelled **(1)**	Allow any clear labels for arrows, including values for lattice energy and $\Delta_{hyd}H$ K^+, e,g, LE, HE Allow arrow on left reversed if labelled **–** lattice energy/+711 Allow two separate arrows on the RHS	
	• calculation of enthalpy change of hydration of Cl^- ions **(1)**	Standalone mark $\Delta_{hyd}H$ Cl^- = −711 +17.2 – (−322) = −371.8 (kJ mol^{-1}) No TE on incorrect arrows Ignore SF apart from 1SF	

Q5.

Question Number	Acceptable Answer	Additional Guidance	Mark
(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)

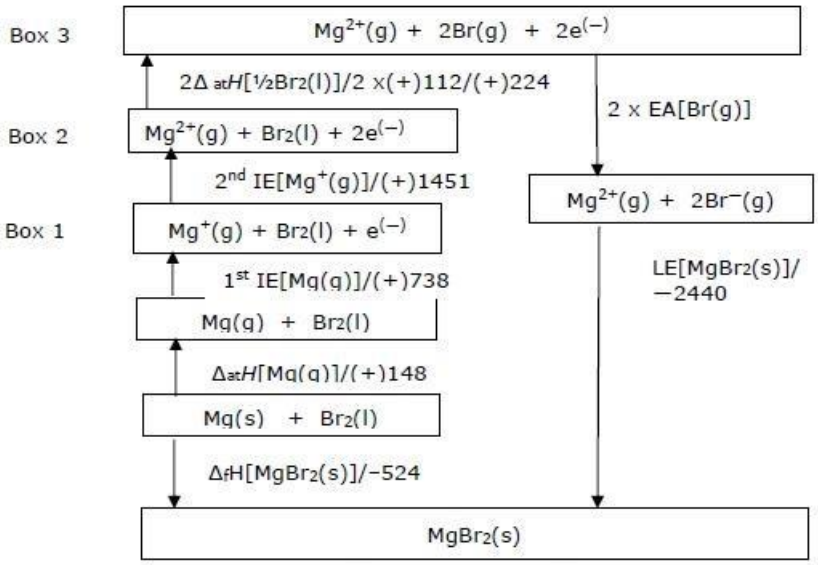
Question Number	Acceptable Answer	Additional Guidance	Mark
6(b)(ii)	• $mol^3\ dm^{-9}$	Allow $dm^{-9}\ mol^3$ mol^3/dm^9 Ignore any working before the answer	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(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
(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
(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)

Q6.

Question Number	Answer and Additional Guidance	Mark
(i)		(3)

- Correct arrows with 1st **and** 2nd IE of Mg labelled **and** correct Mg symbols with state symbols in boxes 1 and 2 or 2 and 3
  (1)
- 2 x $\Delta_{at}H^{\ominus}[\frac{1}{2}Br_2(l)]$ / 2 x(+)112 / (+)224 **and** 2Br(g) in box 3 or 1 **and** 2 x EA[Br(g)] labelled **and** $2Br^-(g)$ in box 4 **and** correct arrows
  (1)
- LE$[MgBr_2(s)]$ / −2440 labelled **and** arrow in correct direction
  (1)

Allow any unambiguous labels for the arrows with words and/or numbers – state symbols not required
Accept enthalpy change of atomisation of bromine before IEs of magnesium
Ignore missing electrons / $2e^{(-)}$ in boxes 1, 2 and 3
Allow 1 state symbol missing but penalise 2 missing, or an incorrect state symbol in boxes once only

Question Number	Answer	Additional Guidance	Mark
(ii)	• correct expression for 2 x EA(Br) in numbers or symbols **(1)** • calculation of EA(Br) **(1)**	Example of calculation 2 x EA(Br) = − (2 x +112) − (+1451) − (+738) − (+148) + (−524) − (−2440) EA(Br) = $\frac{-645}{2}$ = −322.5 /−323 (kJ mol^{-1}) Correct answer with no working scores (2) Allow for 1 mark: (+)322.5 / (+)323 (wrong sign) −266.5 /−267 (2 missing from $\Delta_{at}H$ (Br)) −645 (2 missing from EA) −533 (both 2s missing for Br) Ignore units No TE on incorrect arrows in (b)(i)	**(2)**

Q7.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that includes • barium iodide has (almost) 100% ionic (bonds)	Allow small amount of/zero covalency Ignore just it is 'ionic'	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that includes • the magnesium ion is small and highly charged (1) • the iodide ion has a large ionic radius (1) • the iodide ion is **polarised** by the magnesium ion (1) • (so) the bonding in magnesium iodide has (partial) covalent character (which is why the lattice energy values are different) (1)	Allow magnesium ion has a high charge density Allow iodide ion has a much larger radius Ignore reference to atomic radius ALLOW description of polarisation such as distortion of the iodide electron cloud by the magnesium ion Do not award magnesium iodide is covalent Do not award 'MgI' Penalise once only reference to magnesium/iodine/iodide without 'ion' in marking points 1 to 3	(4)

Q8.

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*</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></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).</td><td>(6)</td></tr>
<tr><td></td><td><table><tr><th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr><tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning.</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured.</td><td>0</td></tr></table></td><td>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</td><td></td></tr>
</table>

	Indicative content • **IP1 - Ionic** lithium chloride / LiCl (has very similar theoretical and experimental lattice energy values so) is (almost 100%) ionic	Allow **very** small amount of / no covalent character in LiCl Allow assumption that ions act as point charges / are spherical is true for LiCl	
	• **IP2 - Covalency** magnesium iodide / MgI_2 (has different theoretical and experimental lattice energy values so) has (some) covalent character	Allow MgI_2 more covalent character than LiCl	
	• **IP3 - Charge on cations** magnesium is Mg^{2+} and lithium is Li^+	Allow magnesium has 2+ charge and lithium has 1+ charge / magnesium ion has a larger charge than a lithium ion	
	• **IP4 - Polarising** – what does the polarising magnesium ion/Mg^{2+} is (more) polarising / has a large(r) polarising power (than lithium ion)	Allow charge density for charge	
	• **IP5 - Size of anion** iodide ion / I^- is larger (than chloride ion / Cl^-)	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	
	• **IP6 – Polarisable** – what is polarised iodide ion / I^- is (more easily) polarised / distorted	Allow this shown in a diagram Ignore just 'greater attraction to cation'	

Q9.

Question Number	Answer	Additional Guidance	Mark
	• equation (1) • state symbols (1)	Example of equation $Cl(g) + e^- \rightarrow Cl^-(g)$ Allow just e for electron Stand alone mark for species on both sides of equation Ignore state symbol for electron	(2)

Q10.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to the following points • C=C bond is weaker than 2 x C-C bond **(1)** • as it consists of a pi and a sigma bond (rather than 2 sigma bonds) **(1)**	Ignore pi bond formed by sideways / less effective orbital overlap	**(2)**

Question number	Answer	Additional guidance	Mark
(ii)	• calculation of energy required to break reactant bonds **(1)** • calculation of energy release when product bonds form **(1)** • calculation of enthalpy change **(1)**	Example of calculation: 5(C-H) + (C=C)+(C- C)+(C-O)+(O-H)+4(O=O) 5(413) + (612) + (347) + (358) + (464) + (4x498) = 5838 (kJ mol^{-1}) 6(C=O) + 6(O-H) (6x805) + (6x464) = 7614 (kJ mol^{-1}) 5838 – 7614 = –1776 (kJ mol^{-1}) Ignore SF except 1 SF Allow TE from M1 and M2 Correct answer no working scores 3	**(3)**

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to one of the following points EITHER • ΔS_{total} is always positive (1) **(1)** • As both $\Delta S_{surroundings}$ and ΔS_{system} are positive **(1)** • OR • ΔG is always negative **(1)** • as ΔH is negative and $\Delta S_{(system)}$ is positive **(1)**	If no marking points awarded allow 1 mark for idea that ΔS_{system} / $\Delta S_{surroundings}$ / entropy increases with correct explanation	**(2)**