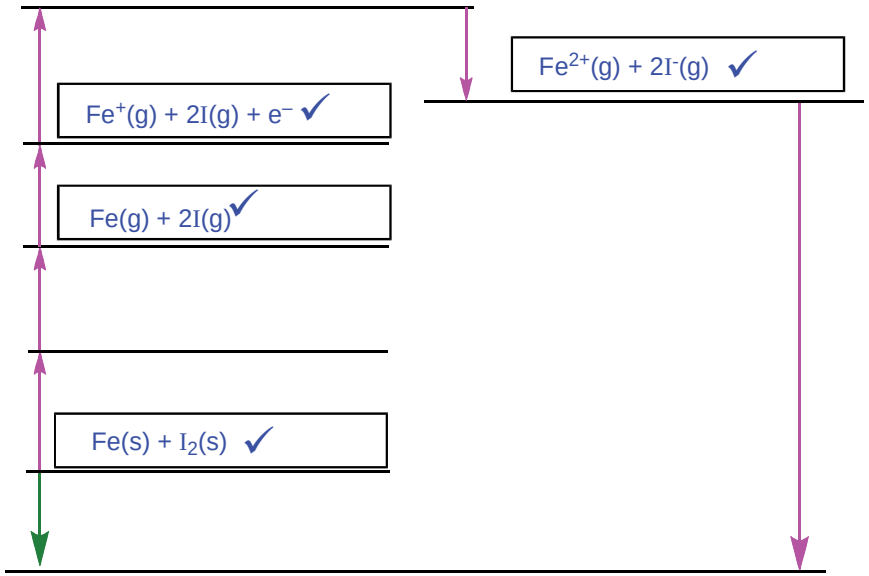
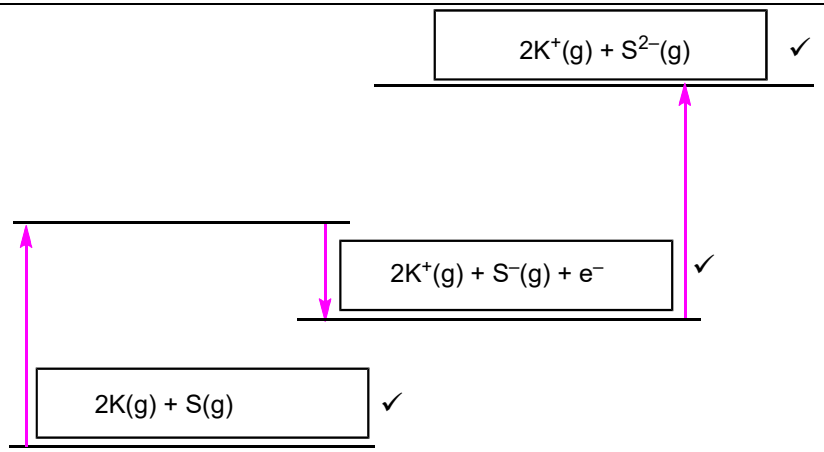
Question			Answer	Marks	Guidance
1	(a)	(i)	 **Mark each marking point independently**	4	Correct species **AND** state symbols required for each marks **ALLOW** e for e^{-} **TAKE CARE**: In top left box, e^{-} may be in centre of response and more difficult to see than at end. There is only **ONE** correct response for each line *From the gaps in the cycle, there is **NO** possibility of any **ECF***

Question			Answer	Marks	Guidance
	(a)	(ii)	(The enthalpy change that accompanies) the **formation** of **one mole** of a(n ionic) compound from its **gaseous ions** (under standard conditions) ✓✓ Award marks as follows. **1st mark: formation** of **compound** from **gaseous ions** **2nd mark: one mole** for compound **only** **DO NOT ALLOW** 2nd mark without 1st mark **DO NOT ALLOW** any marks for a definition for enthalpy change of **formation BUT** note the two concessions in guidance	**2**	**IGNORE** 'Energy needed' **OR** 'energy required' **ALLOW one mole** of compound is **formed/made** from its **gaseous ions** **ALLOW** as alternative for compound: lattice, crystal, substance, solid **IGNORE**: $Fe^{2+}(g) + 2I^{-}(g) \longrightarrow FeI_2(s)$ (Part of cycle) **ALLOW** 1 mark for absence of 'gaseous' only, i.e. the **formation** of **one mole** of a(n ionic) compound from its **ions** (under standard conditions) ✓ **ALLOW** 1 mark for ΔH_f definition with 'gaseous': the **formation** of **one mole** of a(n ionic) compound from its **gaseous** elements (under standard conditions) ✓

Question			Answer	Marks	Guidance
	(a)	(iii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = –2473 (kJ mol^{-1}) award 2 marks** --- (–113) = 416 + (2 × +107) + 759 + 1561 + (2 × –295) + $\Delta H_{LE}(FeI_2)$ **OR** $\Delta H_{LE}(FeI_2)$ = –113 – (416 + (2 × +107) + 759 + 1561 + (2 × –295)) **OR** –113 – 2360 ✓ = – 2473 ✓ (kJ mol^{-1})	**2**	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below. **See list below for marking of answers from common errors** --- **ALLOW** for 1 mark: +2473 wrong sign –2661 107 and –295 used instead of **2 ×** 107 and **2 ×** –295 –236 +107 used instead of **2 ×** 107 –276 –295 used instead of **2 ×** –295 –365 wrong sign for 295 –224 wrong sign for 113 –164 wrong sign for 416 –204 wrong sign for 2 **×** 107 –95 wrong sign for 750 +64 wrong sign for 1561 –365 wrong sign for **2 ×** –295 Any other number: **CHECK** for **ECF** from 1st marking point for expressions with **ONE** error only e.g. one transcription error: e.g. +461 instead of +416
	(b)	**(i)**	Fe^{2+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ ✓ Br^-: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$ ✓	**2**	**ALLOW** 4s before 3d, ie $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$ **ALLOW** $1s^2$ written after answer prompt (*ie* $1s^2$ twice) **ALLOW** upper case D, etc and subscripts, e.g. …...$4S_2 3D_1$ **ALLOW** for Fe^{2+} **……..**$4s^0$ **DO NOT ALLOW** [Ar] as shorthand for $1s^2 2s^2 2p^6 3s^2 3p^6$ Look carefully at $1s^2 2s^2 2p^6 3s^2 3p^6$ – there may be a mistake

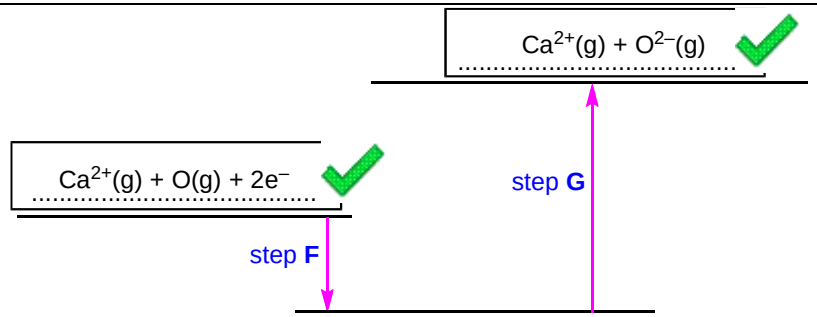
Question			Answer	Marks	Guidance
	(b)	(ii)	With Cl_2 **AND** Br_2 **AND** I_2 products are Fe^{2+} (AND halide ion) $FeCl_2$ **AND** $FeBr_2$ **AND** FeI_2 ✓ **OR** Evidence that **two** electrode potentials have been compared for at least **ONE** reaction, ✓ e.g. Fe –0.44 **AND** Cl_2 +1.36 e.g. Iron has more/most negative electrode potential With Cl_2 **AND** Br_2, products are Fe^{3+} (AND halide ion) $FeCl_3$ **AND** $FeBr_3$ ✓	**3**	**FULL ANNOTATIONS NEEDED** **ALLOW** products within equations (even if equations are not balanced) **IF stated, IGNORE reactants** **ALLOW** response in terms of positive 'cell reactions', e.g $Fe + Cl_2 \rightarrow Fe^{2+} + 2Cl^-$ E = (+)1.80 V **IGNORE** comments about reducing and oxidising agents and electrons
	(c)		**BOTH EQUATIONS REQUIRE IONS PROVIDED IN QUESTION** **OR** **Reaction 1: 2 marks** **1st mark** for **ALL CORRECT species** e.g.: $Fe^{2+} + NO_3^- + H^+ \rightarrow Fe^{3+} + NO + H_2O$ **2nd mark** for **CORRECT balanced equation** $3Fe^{2+} + NO_3^- + 4H^+ \rightarrow 3Fe^{3+} + NO + 2H_2O$ ✓✓ --- **Reaction 2: 1 mark** $_2O)_6]^{2+} + NO \rightarrow [Fe(H_2O)_5NO]^{2+} + H_2O$ ✓	**3**	**ALLOW** correct multiples throughout **ALLOW equilibrium signs in all equations** **For 1st mark, IGNORE** e^- present **Check** carefully for correct **charges**
			[Fe(H **Total**	**16**	

Question			Answer	Marks	Guidance
2	(a)	(i)		3	Mark each marking point independently Correct species **AND** state symbols required for each mark For S^{2-}, **DO NOT ALLOW** S^{-2} For e^-, **ALLOW** e For e^- **only**, **IGNORE** any state symbols added **ALLOW** k and s *It can be very difficult distinguishing K from k; S from s*

	(a)	**(ii)**	(The enthalpy change that accompanies) the **formation** of **one mole** of a(n ionic) compound from its **gaseous ions** (under standard conditions) ✓✓ Award marks as follows. **1st mark: formation** of **compound** from **gaseous ions** **2nd mark: one mole** for compound **only** **DO NOT ALLOW** 2nd mark without 1st mark Note: A definition for enthalpy change of **formation** will receive **no** marks	**2**	**IGNORE** 'Energy needed' **OR** 'energy required' **ALLOW one mole** of compound is **formed/made** from its **gaseous ions** **ALLOW** as alternative for compound: lattice, crystal, substance, solid **IGNORE**: $2K^+(g) + S^{2-}(g) \longrightarrow K_2S(s)$ (question asks for words) **ALLOW** 1 mark (special case) for absence of 'gaseous' only, i.e. the **formation** of **one mole** of a(n ionic) compound from its **ions** (under standard conditions) ✓

	(a)	**(iii)**	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = –2116 (kJ mol^{-1}) award 2 marks** --- –381 – (2 × +89 + 279 + 2 × +419 –200 + 640) ✓ –381 – 1735 = – 2116 ✓ (kJ mol^{-1})	**2**	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below. **See list below for marking of answers from common errors** --- **ALLOW** for 1 mark **ONE** mistake with sign **OR** use of 2: –2027 (**2** × 89 not used for K) –1697 (**2** × 419 not used for K) –2516 (+200 rather than –200 for S 1st electron affinity) (+)2116 (wrong sign) –1354 (+381 instead of –381) (+)1354 (+1735 instead of –1735) –836 (–640 instead of +640) –1558 (–279 instead of +279) –1760 (–2 × 89 instead of +2 x 89) –439 (–2 × 419 instead of +2 x 419) –2120 (rounded to 3SF) **For other answers**, check for a **single** transcription error or calculator error which could merit 1 mark **DO NOT ALLOW** any other answers, e.g. –1608 (2 errors: **2** × 89 and **2 x** 419 not used for K) –846 (3 errors:)

	(b)		Lowest melting point **KI** **RbC*l*** Highest melting point **NaBr** Correct order ✓ **Mark 2nd and 3rd marking points independently** **Attraction and ionic size linked:** Greater attraction from smaller ions/closer ions/larger charge density ✓ *Comparison needed* **Energy AND attraction/breaking bonds linked:** More **energy**/**heat** to overcome attraction (between ions) **OR** More **energy**/**heat** to break (ionic) bonds ✓	**3**	***FULL ANNOTATIONS MUST BE USED*** **----------** **ORA** throughout Response must clearly refer to **ions** for explanation marks **2nd and 3rd marking point must be comparative** **DO NOT ALLOW incorrect named particles, e.g.** 'atoms', 'molecules', Na, Cl, Cl_2, 'atomic', etc **DO NOT ALLOW** responses using nuclear size or attraction **DO NOT ALLOW** responses linked with **loss** of electrons **IGNORE** larger **electron** density **ALLOW** smaller **sum** of radii gives a greater ionic attraction **IGNORE** NaBr has greater ionic attraction **IGNORE** NaBr has smallest ionic radius (*not focussing on size of **each** ion*) **ASSUME** bonds broken are ionic unless otherwise stated **DO NOT ALLOW incorrect named particles, e.g.** 'atoms', 'molecules', Na, Cl, Cl_2, 'atomic', etc **Note**: Comparison for energy **only** *(i.e. link between more energy and breaking bonds/overcoming attraction)*
			Total	**10**	

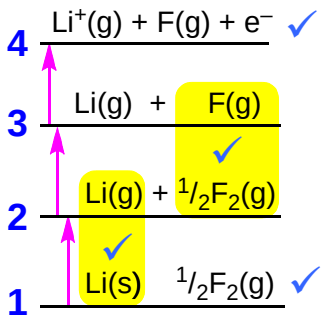
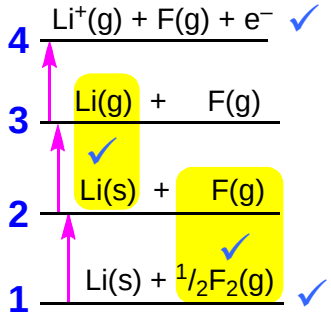
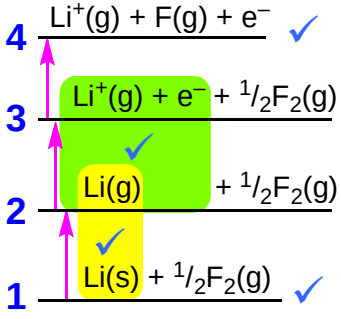
Question			Answer	Marks	Guidance
3	(a)		(The enthalpy change that accompanies) the formation of **one mole** of a(n ionic) compound ✓ from its **gaseous ions** (under standard conditions) ✓	2	**IGNORE** 'energy needed' **OR** 'energy required' **ALLOW** as alternative for compound: lattice, crystal, substance, solid **Note:** **1st mark** requires **1 mole** **2nd mark** requires **gaseous ions** **IF** candidate response has '1 mole of gaseous ions', award 2nd mark but **NOT** 1st mark
	(b)	(i)		2	Correct species **AND** state symbols required for both marks $2e^-$ required for left-hand response **ALLOW** e for e^- Mark each marking point independently
		(ii)	(enthalpy change of) formation (of calcium oxide) ✓ (enthalpy change of) atomisation of oxygen ✓ Second electron affinity (of oxygen) ✓	3	calcium oxide **not** required for this mark **DO NOT ALLOW** 'lattice formation' (*confusion with LE*) atomisation **AND** oxygen/O_2/½O_2/O both required (*atomisation of calcium is also in cycle)* **IGNORE** oxygen or oxygen species, e.g. O^- **DO NOT ALLOW** calcium

Question			Answer	Marks	Guidance
	(b)	(iii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = –3454 (kJ mol^{-1}) award 2 marks** ---------- –635 = 178 + 249 + 590 + 1145 + (–141) + 798 + ΔH_{LE}(CaO) **OR** ΔH_{LE}(CaO) = –635 – [178 + 249 + 590 + 1145 + (–141) + 798] **OR** –635 – 2819 ✓ = –3454 ✓ (kJ mol^{-1})	2	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below. **See list below for marking of answers from common errors** ---------- 1st mark for expression linking ΔH_{LE}(CaO) with ΔH values **ALLOW** LE for ΔH_{LE} **ALLOW** for 1 mark: –3736 use of +141 instead of –141 (+)3454 all signs reversed (+)2184 wrong sign before 2819 –218 wrong sign for 635 –185 wrong sign for +798 Any other number:**CHECK** for **ECF** from 1st marking point Award 1 mark for **one** transcription error only and everything else correct: e.g. +187 instead of +178 **IF** any value has been omitted, award zero

Question			Answer	Marks	Guidance
	(c)		**For first 2 marks,** • **IGNORE** nuclear attraction **OR** proton attraction • Property **AND** effect required • **IGNORE** 'atomic' and 'atoms' and 'molecules' and assume that 'size' and 'charge' refers to ions • **IGNORE** LE increases **OR** LE decreases • **IGNORE** bond strength; strength of ionic bonds		
			First 2 marks Decrease in (ionic) size **AND** **more negative** LE **OR** more **exo**thermic **OR** more attraction ✓ Increase in (ionic) charge **OR** charge density **AND** **more negative** LE **OR** more **exo**thermic **OR** more attraction ✓ --- *Link between LE and attraction* Lattice enthalpy correctly linked to attraction between **IONS** at least once ✓ *e.g. Greater attraction between **ions** gives **more negative** LE*	3	**ANNOTATE WITH TICKS AND CROSSES, etc** **ORA** throughout **ALLOW** pull for attraction **IGNORE** just 'greater force' (*could be repulsion*) **IGNORE** responses in terms of packing **IGNORE** electron density **IGNORE** lower/higher LE --- **For 3rd marking point ONLY, IONS is essential;** **DO NOT ALLOW** attraction between atoms or molecules **DO NOT ALLOW** nuclear attraction
			Total	**12**	

Question			Answer	Marks	Guidance
4	(a)		(The enthalpy change that accompanies) the formation of **one mole** of a(n ionic) compound ✓ from its **gaseous ions** ✓ (under standard conditions)	2	**IGNORE** 'Energy needed' **OR** 'energy required' **ALLOW** as alternative for compound: lattice, crystal, substance, solid, product **Note**: 1st mark requires **1 mole** **2nd mark** requires **gaseous ions** **IF** candidate response has '1 mole of gaseous ions', award 2nd mark but **NOT** 1st mark **IGNORE** reference to 'constituent elements' **IGNORE**: $Li^+(g) + F^-(g) \longrightarrow LiF(s)$ *Question asks for a definition, not an equation*

Question			Answer	Marks	Guidance
	(a)		(The enthalpy change that accompanies) the formation of **one mole** of a(n ionic) compound ✓ from its **gaseous ions** ✓ (under standard conditions)	2	**IGNORE** 'Energy needed' **OR** 'energy required' **ALLOW** as alternative for compound: lattice, crystal, substance, solid, product **Note**: 1st mark requires **1 mole** **2nd mark** requires **gaseous ions** **IF** candidate response has '1 mole of gaseous ions', award 2nd mark but **NOT** 1st mark **IGNORE** reference to 'constituent elements' **IGNORE**: $Li^+(g) + F^-(g) \longrightarrow LiF(s)$ *Question asks for a definition, not an equation*

Question			Answer	Marks	Guidance
	(b)	(i)	**1**. Mark **Line 1** first as below (right or wrong) **2**. Mark **Line 4** as below (right or wrong) **3**. Mark difference in species on **Line 1** and **Line 2** **MUST** match one of the enthalpy changes in the table: atomisation of Li(s) atomisation of ½F_2(g) first ionisation energy of Li(g) **4**. Repeat for differences on **Line 2** and **Line 3**		***ANNOTATIONS MUST BE USED*** --- **ALLOW** marks by **ECF** as follows: Follow order at top of Answer column
			 Correct species **and** state symbols required for all marks **IF** an electron has formed, it **MUST** be shown as e^- **OR** e	4	**ALLOW** atomisation of ½F_2(g) before atomisation of Li(s):  **ALLOW** ionisation of Li(g) before atomisation of ½F_2(g):  e^- required for marks involving **Line 3 AND Line 4** **Common errors** **Line 4**: Missing e^- and rest correct 3 marks **Line 1**: **IF** ½F_2(g) is **NOT** shown 2 max [**Line 4** and Li(s) → Li(g)] e.g., for F(g), F(s), F(l), F(aq), F_2(g) **DO NOT ALLOW** F*l* when first seen but credit subsequently

Question			Answer	Marks	Guidance
	(b)	(ii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = –1046 (kJ mol^{-1}) award 2 marks** --- (–616) = (+159) + (+79) + (+520) + (–328) + ΔH_{LE}(LiF) **OR** ΔH_{LE}(LiF) = (–616) –[(+159) + (+79) + (+520) + (–328)] ✓ = –616 – 430 = –1046 (kJ mol^{-1}) ✓	2	**IF** there is an alternative answer, check **the list below for marking of answers from common errors** --- **ALLOW** for **1 mark**: +1046 wrong sign –18 +430 instead of –430 +18 +616 instead of –616 –1006.5 (+79) ΔH_{at}(F) halved to +39.5 –170 wrong sign for 328 Any other number: **CHECK** for **ECF** from 1st marking point for expressions with **ONE** error only e.g. one transcription error: e.g. +195 instead of +159
	(c)		$\Delta H < T\Delta S$ ***OR*** $\Delta H - T\Delta S < 0$ **OR** ΔH is more negative than $T\Delta S$ **OR** Negative value of ΔH is more significant than negative value of $T\Delta S$ ✓ ——————— **NOTE** **IGNORE** comments about ΔG	1	***ANNOTATIONS MUST BE USED*** **ALLOW** 'exothermic' for negative **ALLOW** a negative lattice energy value **ALLOW** ΔH is negative **AND** magnitude of ΔH > magnitude of $T\Delta S$ **IGNORE ONLY** magnitude of ΔH > magnitude of $T\Delta S$

Question			Answer	Marks	Guidance
	(d)		For **FIRST TWO** marking points, assume that the following refer to 'ions', Mg^{2+}, etc. For 'ions', **ALLOW** 'atoms' For Mg^{2+}, Na^+, Cl^- and F^-, **ALLOW** symbols: Mg, Na, Cl and F **ALLOW** names: magnesium, sodium, chlorine, chloride, fluorine, fluoride *i.e.* **ALLOW** Mg has a smaller (atomic) radius For **THIRD** marking point, **IONS** must be used		**DO NOT ALLOW** molecules **ALLOW** F*l* for F
			Comparison of size of anions Chloride ion **OR** Cl^- is larger (than F^-) **OR** Cl^- has smaller charge density (than F^-) ✓ ***Comparison of size AND charge of cations*** Mg^{2+} is smaller (than Na^+) **AND** Mg^{2+} has a greater charge (than Na^+) ✓ ***Comparison of attraction between ions*** F^- has greater attraction for Na^+ / + ions **AND** Mg^{2+} has greater attraction for F^- / – ions ✓ **Quality of Written Communication**: --- Third mark needs to link ionic size and ionic charge with the attraction that results in lattice enthalpy	3	***ANNOTATIONS MUST BE USED*** --- **ORA** F^- is smaller **OR** F^- has a larger charge density ✓ **IGNORE** just Cl^- is large *comparison required* **ORA**: Na^+ is larger **AND** Na^+ has a smaller charge ✓ **IGNORE** just Mg^{2+} is small *comparison required* **ALLOW** 'greater charge density' for 'greater charge' but **NOT** for smaller size + ***AND*** – ***IONS must be used for this mark*** **IGNORE** greater attraction between **ions** in NaF **AND** MgF_2 + ***AND*** – *ions* ***OR*** *oppositely charged ions are required* **ASSUME** attraction to be electrostatic unless stated otherwise: e.g. **DO NOT ALLOW** nuclear attraction **ALLOW** pull for attraction **ALLOW** 'attracts with more force' for greater attraction **IGNORE** just 'greater force' (*could be repulsion*) **IGNORE** comparison of bond strength/energy to break bonds **IGNORE** comparisons of numbers of ions **IGNORE** responses in terms of packing
			Total	**12**	