Test Name: Born Haber Cycles

Marking Guides

Question: 1 (301657)

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**
			-- 	
			
			Correct species **and** state symbols required for all marks
			
			IF an electron has formed, it **MUST** be shown as e⁻ **OR** e
				4	***ANNOTATIONS MUST BE USED***
					
					-- 	
					ALLOW marks by **ECF** as follows:
					Follow order at top of Answer column
					
					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** ------------------------------ $(-616) = (+159) + (+79) + (+520) + (-328) + \Delta H_{LE}(\text{LiF})$ **OR** $\Delta H_{LE}(\text{LiF}) = (-616) - [(+159) + (+79) + (+520) + (-328)]$ ✓ $= -616 - 430$ $= -1046 \ (\text{kJ mol}^{-1})$ ✓	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 –186 +430 instead of –430 +186 +616 instead of –616 –1006.5 (+79) $\Delta H_{at}(F)$ halved to +39.5 –1702 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	

Question: 2 (309329)

Question		Expected Answers		Marks	Additional Guidance

a		F
		B
		    G
		E
		D
		FIVE correct ✓✓✓
		FOUR correct ✓✓
		THREE correct ✓
				3	**ALLOW**
					  1450
					  736
					        G
					  76
					  −642

b		Correct calculation −642 − (+76 + (2 × 150) + 736 + 1450 + (2 × −349)) ✓ −642 − 1864 = − 2506 ✓ (kJ mol⁻¹)		2	**ALLOW** for 1 mark: −2705 (2 × 150 and 2 × 349 not used for Cl) −2356 (2 × 150 not used for Cl) −2855 (2 × 349 not used for Cl) +2506 (wrong sign) **DO NOT ALLOW** any other answers
c		Magnesium ion **OR** Mg^{2+} has greater charge (than sodium ion **OR** Na$^+$) **OR** Mg^{2+} has greater charge density ✓ Magnesium ion **OR** Mg^{2+} is smaller ✓ Mg^{2+} has a stronger attraction (than Na$^+$) to Cl⁻ ion **OR** Greater attraction between oppositely charged ions ✓		3	***ANNOTATIONS MUST BE USED*** **ALLOW** magnesium/Mg is 2+ but sodium/Na is 1+ **DO NOT ALLOW** Mg **atom** is 2+ but Na **atom** is 1+ **ALLOW** 'charge density' here **only** **ALLOW** Mg **OR** magnesium is smaller **DO NOT ALLOW** Mg^{2+} has a smaller **atomic** radius **ALLOW** anion **OR** negative ion for Cl⁻ **DO NOT ALLOW** chlorine ions **DO NOT ALLOW** Mg has greater attraction **ALLOW** 'attracts with more force' for greater attraction but **DO NOT ALLOW** 'greater force (could be repulsion) **ALLOW** reverse argument throughout in terms of Na$^+$
			Total	8	

Question: 3 (308861)

Question			Expected answers	Marks	Additional 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**: 2Na$^+$(g) + O^{2-}(g) ⟶ Na$_2$O(s) *Question asks for a definition, not an equation*

b	i		C (or 2C) A B
			
			D G
			
			E (or 2E)
			
			F
			All seven correct ✓✓✓
			Five **OR** six correct ✓✓
			Three **OR** four correct ✓
				3	**ALLOW**
					  496 (**OR** 992) −141 790
					
					  249 **G OR**
					           Lattice enthalpy/LE
					                   [OR answer to (ii)]
					  108 (**OR** 216)
					
					  −414

	ii		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = −2520 (kJ mol⁻¹) award 2 marks** -- −414 = (2 × 108) + 249 + (2 × 496) + (−141) + 790) + ΔH_{LE} **OR** ΔH_{LE} = −414 − [(2 × 108) + 249 + (2 × 496) + (−141) + 790] ✓ = −414 − 2106 = **−2520** (kJ mol⁻¹) ✓	2	**IF** there is an alternative answer, check **the list below for marking of common errors** -- **ALLOW** for **1 mark**: −1692 wrong sign for 414 −1916 2 × 108 and 2 × 496 not used for Na$^+$ −2412 2 × 108 not used for Na$^+$ −2024 2 × 496 not used for Na$^+$ +2520 wrong sign for final answer −2802 sign changed for 1st electron affinity of oxygen −2395.5 atomisation of oxygen halved

Question	Expected answers	Marks	Additional guidance
			Any other number: **CHECK** for **ECF** from 1st marking point for expressions with **ONE** error only
c	**ALLOW** reverse argument throughout (**ORA**)		**ANNOTATIONS MUST BE USED**
			NOTE: For **ALL** marking points, assume that the following refer to 'ions', Mg^{2+}, etc.
			For 'ions', **ALLOW** 'atoms'
			For Mg^{2+}, Na^+, O^{2-} and S^{2-},
			ALLOW symbols: Mg, Na, O and S
			ALLOW names: magnesium, sodium, oxygen, oxide, sulfur, sulfide
			BUT DO NOT ALLOW molecules
			i.e. **ALLOW** Mg has a smaller (atomic) radius
			IGNORE idea of close packing of ions
			--
	Comparison of size AND charge of cations		**ORA:**
	Mg^{2+} is smaller **AND** Mg^{2+} has a greater charge		Na^+ is larger **AND** Na^+ has a smaller charge
	OR		**OR**
	Mg^{2+} has **a** greater charge density ✓		Na^+ has a smaller charge density ✓
			IGNORE just Mg^{2+} is small *comparison required*
	Comparison of size of anions		**ORA**
	S^{2-} is larger		O^{2-} is smaller
	OR		**OR**
	S^{2-} has a smaller charge density ✓		O^{2-} has a larger charge density ✓
			IGNORE just S^{2-} is large *comparison required*
	Comparison of attraction of a cation and an anion		**ALLOW** pull for attraction
	Mg^{2+} has stronger attraction **OR** Na^+ has weaker attraction		**ALLOW** 'attracts with more force' for greater attraction
	AND		**BUT … IGNORE** just 'greater force' (*could be repulsion*)
	S^{2-} has weaker attraction **OR** O^{2-} has stronger attraction ✓	3	**OR** comparison of bond strength/energy to break bonds
			IGNORE comparisons of numbers of ions

Question		Expected answers	Marks	Additional guidance
d	i	Cycle needs **formation** of CO_3^{2-} ions (from C and O) ✓	1	**ALLOW** carbonate ion contains C and O
		i.e. **NOT** breaking up of CO_3^{2-} ion		**ALLOW** carbonate ion contains 2 elements
				IGNORE sodium carbonate contains 3 elements
				IGNORE carbonate ion has covalent bonds
d	ii	See also **Appendix 1** at end of mark scheme		**ANNOTATIONS MUST BE USED**
				MARK AS FOLLOWS
		Mark allocation		1. Mark the cycle
		1 – $2Na^+(g) + CO_3^{2-}(g)$ on a top line		2. **IF** there is **no cycle**, mark the equation below
		AND $Na_2CO_3(s)$ on a lower line		--
		AND 'Lattice enthalpy' label (as below) links the lines ✓		**State symbols** are required for **ALL** species
				IGNORE direction of any arrows until **MARK 3**
		2 – $2Na^+(g) + CO_3^{2-}(g)$ on a top line		
		AND $2Na^+(aq) + CO_3^{2-}(g)$ on a middle line		**ALLOW** $Na_2CO_3(aq)$ on a lower line
		AND $2Na^+(aq) + CO_3^{2-}(aq)$ on a lower line		as an alternative for $2Na^+(aq) + CO_3^{2-}(aq)$
		AND 'ΔH hydration' labels (as below) link the lines ✓		
				ALLOW CO_3^{2-} hydrated first:
		NOTE: For hydration labels, see diagram below		*i.e.* $2Na^+(g) + CO_3^{2-}(aq)$ on middle line
		2 x hydration of Na^+		
		OR hydration of **2 x** Na^+ is **required**		**ALLOW** two hydration stages combined
				i.e. $2Na^+(g) + CO_3^{2-}(g)$ on a top line
				AND $2Na^+(aq) + CO_3^{2-}(aq)$ on a lower line
				AND BOTH 'Hydration' labels link the lines ✓
		3 – ΔH solution' label **BELOW** $Na_2CO_3(s)$		**IF** cycle shown using $NaCO_3$, Na^+ and CO_3^-
		AND ALL arrows in correct directions ✓	3	**ALLOW** ECF for third marking point only
				NOTE: DO NOT ALLOW ECF from any other species
				For simple energy cycles a maximum of 2 marks only can be awarded – See **APPENDIX 1**
				--
				For an equation, only **1 mark** can be awarded
				Lattice enthalpy $= -\Delta H$(solution) Na_2CO_3
				$+ [2 \times \Delta H$(hydration) $Na^+] + \Delta H$(hydration) CO_3^{2-}

Question			Expected answers	Marks	Additional guidance
					OR
					Lattice enthalpy $+ \Delta H$(solution) Na_2CO_3
					$= 2 \times \Delta H$(hydration) $Na^+ + \Delta H$(hydration) CO_3^{2-} ✓
					IGNORE state symbols for equation approach
			Total	**14**	

Diagram labels:
$2Na^+(g) + CO_3^{2-}(g)$
2 x Hydration of Na^+
Lattice enthalpy
$2Na^+(aq) + CO_3^{2-}(g)$
$Na_2CO_3(s)$
Hydration of CO_3^{2-}
Enthalpy change of solution
$2Na^+(aq) + CO_3^{2-}(aq)$