

23. Chemical energetics

23.2 Enthalpies of solution and hydration

Paper 4

Marking Scheme

Q1.

(c)	enthalpy change when one mole of a solute dissolves in water	1
(d)(i)	<p>M1 two arrows in blue M2 correct species in red with all state symbols</p>	2
(d)(ii)	$\Delta H_{\text{latt}} = -811.6 \text{ (kJ mol}^{-1}\text{)}$	1

Q2.

(a)	ΔH_{hyd} increases from left to right due to increase in charge ionic radius decreases from left to right causing increased attractive force to water molecules	[1] [1] [1]	3
(b)(i)	$\text{Mg}^{2+}(\text{aq}) + 2\text{Cl}^{-}(\text{aq})$	[1]	1
(b)(ii)	Enthalpy change of hydration of magnesium ions and chloride ions $\Delta H_{\text{hyd}}\text{Mg}^{2+} + 2\Delta H_{\text{hyd}}\text{Cl}^{-}$	[1] [1]	2
(b)(iii)	Selects 155, 1920 and 364 only 2×364 answer -2493	[1] [1] [1]	3
(c)	The number of arrangements of the particles and of the energy in the system	[1]	1

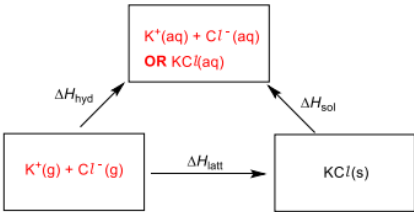
Q3.

(a)	energy change	always positive	always negative	either negative or positive	1
	lattice energy		✓		
	enthalpy of hydration		✓		
	enthalpy of solution			✓	
All correct for one mark					
(b)	The energy / enthalpy change when 1 mole of gaseous ions is dissolved in water				1
(c)(i)	M1 use of correct six numbers only 682.8 178.2 590 1145 111.9 324.6 M2 2× used correctly with Br (2 × 111.9 and 2 × 324.6) M3 correct signs and evaluation to give $-2170.6 \text{ kJ mol}^{-1}$				3
(c)(ii)	M1 use of correct three numbers only 2170.6 103.1 and 1579 M2 correct signs & evaluation -347 kJ mol^{-1}				2
(c)(iii)	M1 Br ⁻ has a smaller ionic radius M2 Br ⁻ has stronger attractive forces with water molecules				2

Q4.

(g)(i)	enthalpy change when one mole of gaseous ions forms an aqueous solution / dissolves in water [1]	1
(g)(ii)	Substances with state symbols: <ul style="list-style-type: none"> • $\text{AlF}_3(\text{s})$ • $\text{AlF}_3(\text{aq})$ OR $\text{Al}^{3+}(\text{aq}) + (3)\text{F}^{-}(\text{aq})$ • $\text{Al}^{3+}(\text{g}) (3)\text{F}^{-}(\text{g})$ [1] changes identified and three correct arrow directions (one given) [1] <div style="text-align: center; margin-top: 10px;"> </div>	2
(g)(iii)	$\Delta H_{\text{latt}} = -4690 + (3 \times -506) - (-209) = -5999 \text{ (kJ mol}^{-1}\text{)}$	1

Q5.

(a)	 <p>M1 $K^+(g)$ and $Cl^-(g)$ AND $KCl(aq)$ OR $K^+(aq) + Cl^-(aq)$</p> <p>M2 three correct directional arrows COND M1</p>	2
(b)	<p>use of data $-155, -2493$ AND 2×-364 [1]</p> <p>$\Delta H_{hyd} Mg^{2+} = -1920$ ($kJ\ mol^{-1}$) [1] min 3sf</p>	2

Q6.

(d)(i)	<p>energy change when one mole dissolves in water [1] energy change when one mole of gaseous ions dissolves in water [1]</p>	2
(d)(ii)	<p>$(-2237 - 83 + 1650) / 2$ [1] $= -335$ [1]</p>	2

Q7.

(a)(ii)	<p>$\Delta H_{sol} = (-2099) + (2 \times -378) - (-2824)$ $\Delta H_{sol} = -31\ kJ\ mol^{-1}$</p> <p>M1: use of $\times 2$ as only multiplier M2: correct signs and evaluation</p>	2
(a)(iii)	<p>M1: Cu^{2+} is smaller OR Cu^{2+} has a higher charge density M2: Cu^{2+} attracts water molecules more / stronger OR (Cu^{2+}) forms stronger ion-dipole forces to water molecules</p>	2

Q8.

(e)(i)	<p>(energy change) when 1 mole of gaseous ions is dissolved in (an excess of) water</p>	1
(e)(ii)	<p>M1: Br has a smaller ionic radii M2: stronger (ion-dipole) attractions with water molecules</p>	2

Q9.

(b)	(energy change) when 1 mole of solute is dissolved in an infinite amount of water to form a dilute solution	1
(c)	calculation of $\Delta H_{\text{sol}}^{\ominus}$ with -251 , -1284 and -2035 only and two correct signs [1] calculation of $\Delta H_{\text{sol}}^{\ominus}$ with -251 , -1284 and -2035 only and correct signs OR calculation of $\Delta H_{\text{sol}}^{\ominus}$ with (-251×3) , -1284 and -2035 only and two correct signs [2] $\Delta H_{\text{sol}}^{\ominus} = (3 \times -251) + (-1284) - (-2035) = -2 \text{ (kJ mol}^{-1}\text{)}$ [3]	3