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A2 LEVEL CHEMISTRY

5.2.1 LATTICE ENTHALPY

5.2.2 ENTHALPY AND ENTROPY

TEST

Answer all questions

Max 52 marks

Name	……..
Mark	……../52 ……...% Grade ……

1. Sodium bromide is formed from its elements at 298 K according to the equation

$$Na(s) + \tfrac{1}{2} Br_2(l) \rightarrow NaBr(s)$$

Use this information and the data in the table below to answer the questions which follow.

Name of energy change	Enthalpy change /kJmol^{-1}
Atomisation energy of sodium (ΔH_{at}(Na))	+107
Atomisation energy of bromine (ΔH_{at}(Br))	+97
First ionisation of sodium (ΔH_{IE1}(Br))	+496
First electron affinity of bromine (ΔH_{EA1}(Br))	-325
Lattice enthalpy of sodium bromide (ΔH_{LE}(NaBr))	-742

(a) Construct a Born-Haber cycle for sodium bromide. Label the steps in the cycle with symbols like those used above rather than numerical va1ues.

(6)

(b) Use the data above and the Born-Haber cycle in part (a) to calculate the enthalpy of formation of sodium bromide.

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(3)

(Total 9 marks)

2. (a) The tables show values for the lattice enthalpy of the metal chlorides of the Group 1 and Group 2 metals.

Group 1 metal chloride	LiCl	NaCl	KCl	RbCl	CsCl
Lattice enthalpy/kJ mol^{-1}	–846	–771	–701	–675	–645

Group 2 metal chloride	$BeCl_2$	$MgCl_2$	$CaCl_2$	$SrCl_2$	$BaCl_2$
Lattice enthalpy/kJ mol^{-1}	–3006	–2493	–2237	–2112	–2018

(i) Define the term *lattice enthalpy.*

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(2)

(ii) Write the chemical equation for the reaction whose enthalpy change is equal to the lattice enthalpy of NaCl. Include state symbols in your equation.

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(1)

(iii) Explain, in terms of the effects of ionic radius and charge, why the lattice enthalpy of the Group 1 metal chlorides decreases from LiCl to CsCl.

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(3)

(iv) Explain, in terms of the effects of ionic radius and charge, why the lattice enthalpy of $MgCl_2$ is greater than that of NaCl.

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(3)

(Total 9 marks)

3. In this question, one mark is available for the quality of spelling, punctuation and grammar.

The lattice enthalpy of magnesium chloride, $MgCl_2$, can be determined using a Born-Haber cycle and the following enthalpy changes.

name of process	enthalpy change / kJ mol^{-1}
enthalpy change of formation of $MgCl_2(s)$	–641
enthalpy change of atomisation of magnesium	+148
first ionisation energy of magnesium	+738
second ionisation energy of magnesium	+1451
enthalpy change of atomisation of chlorine	+123
electron affinity of chlorine	–349

(a) Define, using an equation with $MgCl_2$ as an example, what is meant by the term *lattice enthalpy*.

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(b) Construct a Born-Haber cycle for $MgCl_2$, including state symbols, and calculate the lattice enthalpy of $MgCl_2$.

(c) Explain why the lattice enthalpy of NaBr is much less exothermic than that of $MgCl_2$.

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[11]
Quality of Written Communication [1]
[Total 12 marks]

4. At 298 K, the enthalpy of solution of calcium chloride is –123 kJ mol^{-1} and the enthalpy of lattice formation of this salt is –2255 kJ mol^{-1} The enthalpy of hydration of the calcium ion is -1650 kJ mol^{-1}.

(i) Write equations using calcium chloride or its ions to illustrate the terms *enthalpy of solution, enthalpy of lattice formation* and *enthalpy of hydration.*

Enthalpy of solution......

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Enthalpy of lattice formation......

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Enthalpy of hydration......

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(ii) Use the data above to determine the enthalpy of hydration of the chloride ion.

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(7)
(Total 7 marks)

5. Use the data in the table below to answer the following questions.

Give chemical equations and calculate numerical values of ΔS wherever possible.

Entropy data

Species	$S^\ominus$/JK^{-1}mol^{-1}	Species	$S^\ominus$/JK^{-1}mol^{-1}
C(graphite)	6	$H_2O(g)$	189
C(diamond)	3	$H_2O(l)$	70
$H_2(g)$	131	$CH_4(g)$	186
CO(g)	198	CaO(s)	40
$CO_2(g)$	214	$CaCO_3(s)$	90

(a) At all temperatures below 100 °C, steam at atmospheric pressure condenses spontaneously to form water. Explain this observation in terms of ΔG and calculate the enthalpy of condensation of steam at 100 °C.

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(4)

(b) Explain why the reaction of 1 mol of methane with steam to form carbon monoxide and hydrogen ($\Delta H^\ominus$ = +210 kJ mol^{-1}) is spontaneous only at high temperatures.

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(6)

(c) Explain why the change of 1 mol of diamond to graphite ($\Delta H^{\ominus} = -2$ kJ mo1^{-1}) is feasible at all temperatures yet does not occur at room temperature.

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(3)

(d) The reaction between 1 mol of calcium oxide and carbon dioxide to form calcium carbonate ($\Delta H^{\ominus} = -178$ kJ mol^{-1}) ceases to be feasible above a certain temperature, T_s. Determine the value of T_s.

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(Total 15 marks)