Lattice Enthalpy & Born-Haber Cycles AS & A Level

Question Paper 1

Level	A Level
Subject	Chemistry
Exam Board	OCR
Module	Physical Chemistry & Transition Elements
Topic	Lattice Enthalpy & Born-Haber Cycles
Paper	AS & A Level
Booklet	Question Paper 1

Time allowed: **46 minutes**

Score: **/34**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

Lattice enthalpy can be used as a measure of ionic bond strength. Lattice enthalpies can be determined indirectly using Born–Haber cycles.

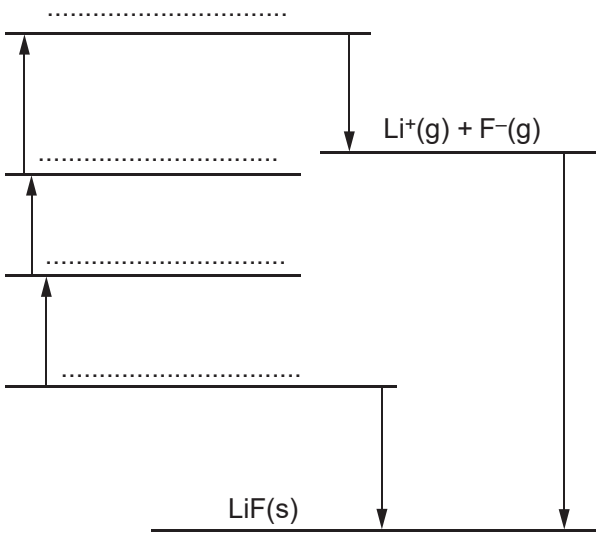
The table below shows the enthalpy changes that are needed to determine the lattice enthalpy of lithium fluoride, LiF.

enthalpy change	**energy / kJ mol^{-1}**
1st electron affinity of fluorine	–328
1st ionisation energy of lithium	+520
atomisation of fluorine	+79
atomisation of lithium	+159
formation of lithium fluoride	–616

(a) Define the term *lattice enthalpy*. [2]

(b) The diagram below shows an incomplete Born–Haber cycle that would allow the lattice enthalpy of lithium fluoride to be determined.

(i) On the four dotted lines, add the species present, including state symbols.



[4]

(ii) Calculate the lattice enthalpy of lithium fluoride. [2]

(c) The change that produces lattice enthalpy is spontaneous but has a negative entropy change.

Why is this change able to take place spontaneously? [1]

(d) The lattice enthalpies of sodium fluoride, sodium chloride and magnesium fluoride are shown below.

compound	**lattice enthalpy / kJ mol^{-1}**
sodium fluoride	–918
sodium chloride	–780
magnesium fluoride	–2957

Explain the differences between these lattice enthalpies.

In your answer, your explanation should show how different factors affect lattice enthalpy.

[3]

[Total 12 Marks]

Born–Haber cycles provide a model that chemists use to determine unknown enthalpy changes from known enthalpy changes. In this question, you will use a Born–Haber cycle to determine an enthalpy change of hydration.

(a) Magnesium chloride has a lattice enthalpy of –2493 kJ mol^{-1}.

Define in words the term *lattice enthalpy*. [2]

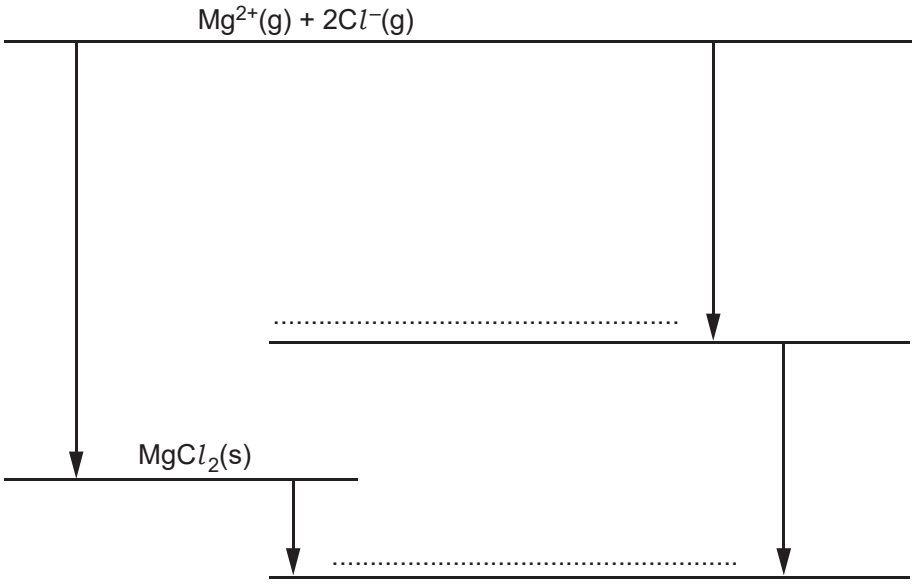
(b) The table below shows the enthalpy changes that are needed to determine the enthalpy change of hydration of magnesium ions.

enthalpy change	energy/kJ mol^{-1}
lattice enthalpy of magnesium chloride	–2493
enthalpy change of solution of magnesium chloride	–154
enthalpy change of hydration of chloride ions	–363

(i) Why is the enthalpy change of hydration of chloride ions exothermic? [1]

(ii) In this part, you will use the Born–Haber cycle to determine the enthalpy change of hydration of magnesium ions.

On the two dotted lines, add the species present, including state symbols.



[2]

(iii) Calculate the enthalpy change of hydration of magnesium ions. [2]

(c) The enthalpy change of hydration of magnesium ions is more exothermic than the enthalpy change of hydration of calcium ions.

Explain why. [2]

[Total 9 Marks]

Lattice enthalpies can be calculated indirectly using Born–Haber cycles.

Table 1.1 shows enthalpy changes that can be used to calculate the lattice enthalpy of magnesium bromide, $MgBr_2$.

Letter	Enthalpy change	Energy /kJmol^{-1}
A	atomisation of magnesium	+146
B	1st ionisation energy of magnesium	+738
C	2nd ionisation energy of magnesium	+1451
D	atomisation of bromine	+112
E	1st electron affinity of bromine	–325
F	formation of magnesium bromide	–524
G	lattice enthalpy of magnesium bromide	

Table 1.1

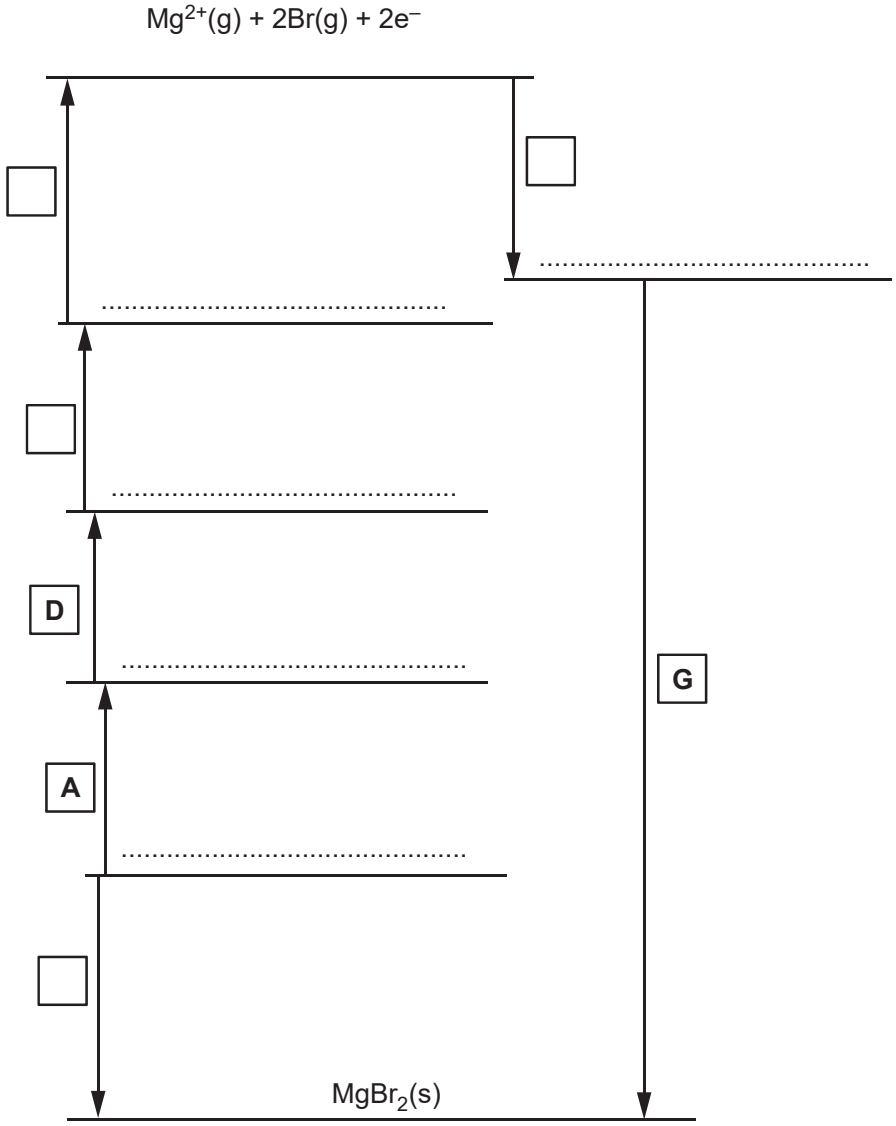
(a) Define the term *lattice enthalpy*. [2]

(b) Lattice enthalpies are exothermic.

Explain why it is difficult to predict whether the lattice enthalpy of magnesium bromide would be more or less exothermic than the lattice enthalpy of sodium chloride. [3]

(c) The Born–Haber cycle below links the lattice enthalpy of magnesium bromide with the enthalpy changes in **Table 1.1**.

(i) Add the correct letters from **Table 1.1** in the four empty boxes and write the correct species on the five dotted lines.



[6]

(ii) Calculate the lattice enthalpy of magnesium bromide.

[2]

[Total: 13 Marks]