Question: 1

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*.

_____

_____

_____

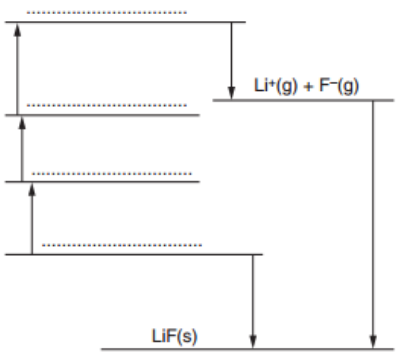
_____

_____

[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.

lattice enthalpy = ... $kJmol^{-1}$

_____

_____

_____

_____

_____

[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]

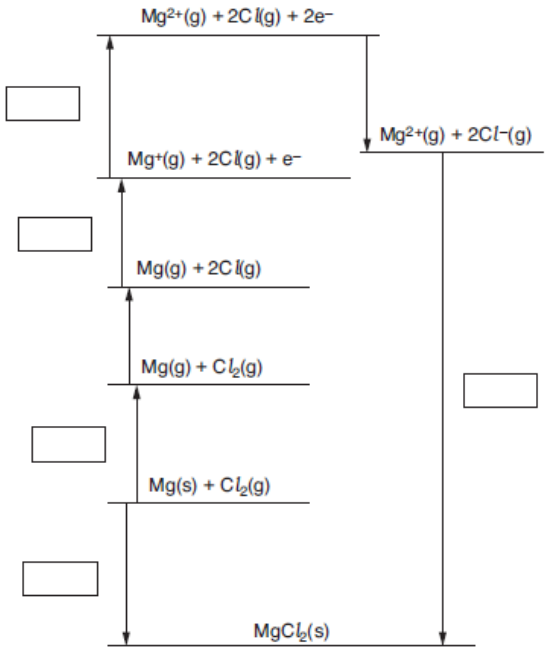
Question: 2

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

The table below shows the enthalpy changes that are needed to determine the lattice enthalpy of magnesium chloride, $MgCl_2$.

letter	enthalpy change	energy/ kJ mol^{-1}
A	1st electron affinity of chlorine	–349
B	1st ionisation energy of magnesium	+736
C	atomisation of chlorine	+150
D	formation of magnesium chloride	–642
E	atomisation of magnesium	+76
F	2nd ionisation energy of magnesium	+1450
G	lattice enthalpy of magnesium chloride	

(a) On the cycle below, write the correct letter in each empty box.



[3]

(b) Use the Born–Haber cycle to calculate the lattice enthalpy of magnesium chloride.

answer = ... kJ mol^{-1}

[2]

(c) Magnesium chloride has stronger ionic bonds than sodium chloride.

Explain why.

[3]

[Total: 8]

Question: 3

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

Table 2.1 shows enthalpy changes needed to calculate the lattice enthalpy of sodium oxide, Na_2O.

letter	enthalpy change	energy /kJ mol^{-1}
A	1st electron affinity of oxygen	–141
B	2nd electron affinity of oxygen	+790
C	1st ionisation energy of sodium	+496
D	atomisation of oxygen	+249
E	atomisation of sodium	+108
F	formation of sodium oxide	–414
G	lattice enthalpy of sodium oxide	

Table 2.1

(a) Define the term *lattice enthalpy*.

_____

_____

_____

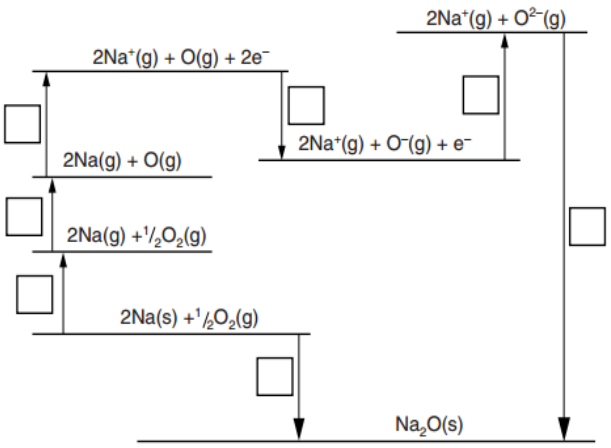
_____

_____

[2]

(b) The Born–Haber cycle below links the lattice enthalpy of sodium oxide with its enthalpy change of formation.

(i) On the Born–Haber cycle, write the correct letter from **Table 2.1** in each box.



[3]

(ii) Calculate the lattice enthalpy of sodium oxide, **G**.

Answer = ... kJ mol^{-1}

[2]

(c) Explain why it is difficult to predict whether the lattice enthalpy of magnesium sulfide would be more or less exothermic than the lattice enthalpy of sodium oxide.

_____

_____

_____

_____

_____

[3]

(d) A student wanted to determine the lattice enthalpy of sodium carbonate, Na_2CO_3. Unfortunately this is very difficult to do using a similar Born–Haber cycle to that used for sodium oxide in **(b)**.

(i) Suggest why this is very difficult.

_____

_____

_____

_____

_____

[1]

(ii) The student thought that he could determine the lattice enthalpy of Na_2CO_3 using a Born–Haber cycle that links lattice enthalpy with enthalpy change of solution. The enthalpy change of solution of Na_2CO_3 is exothermic.

- Sketch this Born–Haber cycle
- Explain how the lattice enthalpy of Na_2CO_3 could be calculated from the enthalpy changes in the cycle.

_____

_____

_____

_____

_____

[3]

[Total: 14]