Energy & Entropy

Lattice Enthalpy

The lattice enthalpy of an ionic solid is the enthalpy change when one mole of the solid in its standard state is formed from its ions in the gaseous state. For example:

$$Na^+_{(g)} + Cl^-_{(g)} \longrightarrow NaCl_{(s)} \qquad \Delta H^{\varnothing}_{LE} = -786 kJmol^{-1}$$

The problem is that you cannot react gaseous Na^+ with gaseous Cl^- and measure the enthalpy change as the solid NaCl is formed. The value of the enthalpy has to be determined indirectly. We make use of changes for which the data are available and link them together in an enthalpy cycle. This enthalpy cycle is based on the formation of the compound from its elements in their standard states. For NaCl this reaction is:

$$Na_{(s)} + \tfrac{1}{2}Cl_{(g)} \longrightarrow NaCl_{(s)}$$

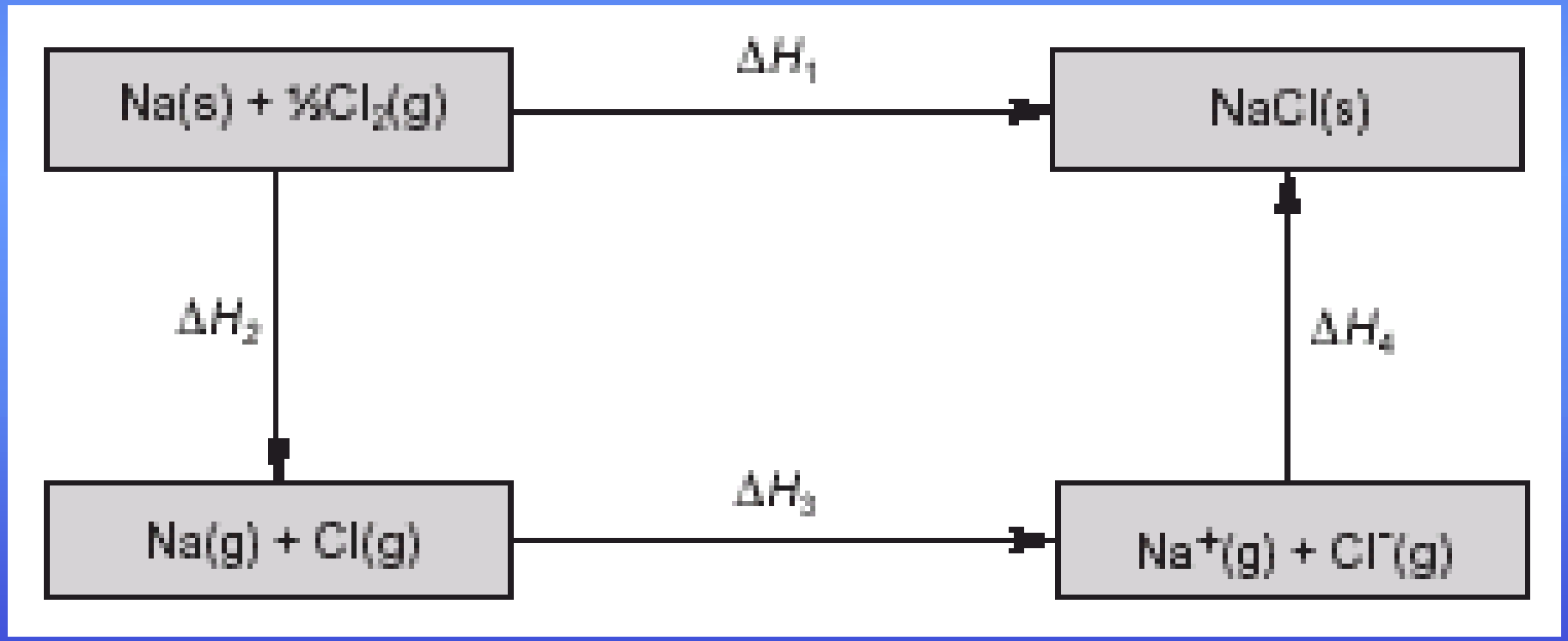
You can imagine this reaction occurring in a number of steps, one of which corresponds to the lattice enthalpy:

- The elements in their standard states are turned into gaseous atoms
- The gaseous atoms become gaseous ions
- The gaseous ions come together to form solid sodium chloride.

The resulting enthalpy cycle is known as a **Born-Haber cycle**.

The Born-Haber Cycle

This is the resulting enthalpy cycle for NaCl.



- ΔH_1 is the standard enthalpy change of formation for NaCl;

$\Delta H^{\varnothing}_f(NaCl) = -411$ kJ mol^{-1}

- ΔH_2 is made up of two components:

i) the standard enthalpy change of the atomisation of sodium:

$Na_{(s)} \quad Na_{(g)}$; $\Delta H^{\varnothing}_{at}(Na) = +107$ kJ mol^{-1}

ii) The standard enthalpy change of atomisation of chlorine:

$\frac{1}{2}Cl_{2\ (g)} \rightarrow Cl_{(g)}$; $\Delta H^{\varnothing}_{at}(Cl) = +121$ kJ mol^{-1}

- ΔH_3 is also made up of two components:

i) The 1st ionisation enthalpy of Na:

$Na_{(g)} \rightarrow Na^+_{(g)} + e^-$; $\Delta H^{\varnothing}_i(1) = +502$ kJ mol^{-1}

ii) The 1st electron affinity of Cl:

$Cl_{(g)} + e^- \rightarrow Cl^-_{(g)}$; $\Delta H^{\varnothing}_i(1) = -355$ kJ mol^{-1}

- ΔH_4 is the lattice enthalpy for sodium chloride; $\Delta H^{\varnothing}_{LE}(NaCl)$

Applying Hess's law to this Born-Haber cycle gives:

$\Delta H_1 = \Delta H_2 + \Delta H_3 + \Delta H_4$

$\Delta H^{\varnothing}_{LE}$ (NaCl) = $\Delta H_4 = \Delta H_1 - \Delta H_2 - \Delta H_3$

$= -411 - (+107 + 121) - (+502 - 355)$

$\Delta H^{\varnothing}_{LE}$ (NaCl) = -786 kJ mol^{-1}

Entropy: True or False?

Entropy is a measure of the number of ways of arranging molecules and distributing their quanta of energy.
A collection of molecules has a greater entropy if the molecules are spread out as much as possible.
There are more ways of arranging the energy of a collection of molecules if they spread out among the energy levels available to them.

The entropy is increased if the energy is shared among more molecules.
The entropy depends on the number of quanta of energy available. This in turn depends on the temperature and the spacing of energy levels.

Substances have higher entropies if their molecules contain heavier atoms or a larger number of atoms.
In general, gases have higher entropies than liquids, and have higher entropies than solids.


All True!!!