Born–Haber cycles

Born–Haber cycles are named after the two German scientists **Max Born** and **Fritz Haber**. The cycles were originally developed to calculate the lattice enthalpy of an ionic compound using **Hess's law**. For this you need to know the **standard enthalpy change of formation** as well as the various **enthalpy changes** needed to make the **gaseous ions** from the elements in their standard states.

You can also use these cycles to compare which processes contribute most significantly to the overall stability of the ionic compound.

How to draw a Born–Haber cycle for sodium chloride

It's helpful to draw the cycle as an **enthalpy level diagram** so that the **endothermic** and **exothermic** processes are easily distinguished.

1. Break the existing **metallic and covalent bonding** in the elements to form gaseous atoms of the metal and non-metal.
2. Remove the outer electron from the gaseous metal atoms. This is **endothermic** as you have to work against the attraction of the nucleus to remove an electron.
3. Transfer the electron removed from the metal to the gaseous non-metal atoms. This is **exothermic** as the attraction of the nucleus pulls the additional electron towards the atom.
4. Bring the gaseous ions together to form the solid ionic lattice. This is highly **exothermic** due to the strong attraction between the ions throughout the crystal.
5. Complete the cycle by directly connecting the starting elements to the solid ionic compound.

Larger cycles can also be drawn for the formation of compounds involving 2+ and 2- ions.

Drawing cycles involving 2+ or 2- ion charges

All Born–Haber cycles have the same overall structure but you need to modify them if more than one electron is transferred between each metal and non-metal atom.

If the metal atom loses two electrons (eg Mg^{2+}), then add the **second ionisation energy** to step 2 after the first ionisation energy.

If the non-metal atom gains two electrons (eg O^{2-}), then add the **second electron affinity** to step 3. Note that, unlike the first electron affinity, it will be **endothermic** due to repulsion between the second electron and the negative ion.

If the formula of the ionic compound has a 1:2 ratio between elements (eg $MgCl_2$ or Na_2O), then you must double the relevant enthalpy changes in steps 1, 2 or 3.