ICT: Thermodynamics: Use of a Spreadsheet

SCH4UE_08 - 09

1. Construct a spreadsheet which would allow you to determine the enthalpy of formation of an ionic solid, $MX_{(s)}$, via a Born – Haber cycle from given data, using $M_{(s)}$ and $X_{2(g)}$.

2. Write the expression for ΔH_f^0 in terms of various enthalpy changes involved.

3. Use your spreadsheet to calculate the enthalpy of formation for $KF_{(s)}$.

$\Delta H^0_{\text{(atomisation)}}\ K_{(s)} = 90.00$ kJ/mol

$\Delta H^0_{\text{Bond dissociation energy}}\ F_{2(g)} = 157.99$ kJ/mol

$\Delta H^0_{\text{(Ionisation Energy)}}\ K_{(g)} = 424.93$ kJ/mol

$\Delta H^0_{\text{Electron affinity}}\ F_{(g)} = -349.7$ kJ/mol.

Lattice energy ($KF_{(s)}$) $= -806.8$ kJ/mol

(**Answer**: -562.58 kJ mol^{-1})

Born-Haber cycle may also be used to **calculate ΔH_f^0 of a hypothetical compound** to see if it exists or why not, if both lattice energy and electron affinity are known.

4. Construct another spreadsheet which would allow you to determine the enthalpy of formation of an ionic solid, $MX_{2\,(s)}$, via a Born – Haber cycle from given data, using $M_{(s)}$ and $X_{2(g)}$.

5. Consider the formation of $MgCl_{(s)}$ and $MgCl_{2(s)}$ according to the following:

$$Mg^{+1}_{(s)} + \tfrac{1}{2}\, Cl_{2(g)} \longrightarrow MgCl_{(s)}$$

$$Mg^{+2}_{(s)} + 2\, Cl^{-1}_{(g)} \longrightarrow MgCl_{2(s)}$$

Given the following data:

$Mg_{(s)} \longrightarrow Mg_{(g)}$	$\Delta H^0 = 150.2$ kJ
$Mg_{(g)} \longrightarrow Mg^{+1}_{(g)} + e^{-1}$	$\Delta H^0 = 743.8$ kJ
$Mg_{(g)} \longrightarrow Mg^{+2}_{(g)} + 2e^{-1}$	$\Delta H^0 = 2200.3$ kJ
$Cl_{2(g)} \longrightarrow 2Cl_{(g)}$	$\Delta H^0 = 243.4$ kJ
$Cl_{(g)} + e^{-1} \longrightarrow Cl^{-1}_{(g)}$	$\Delta H^0 = -367.8$ kJ
$Mg^{+1}_{(g)} + Cl^{-1}_{(g)} \longrightarrow MgCl_{(s)}$	$\Delta H^0 = -676.1$ kJ
$Mg^{+2}_{(g)} + 2Cl^{-1}_{(g)} \longrightarrow MgCl_{2(s)}$	$\Delta H^0 = -2500.1$ kJ

a. Use your spreadsheet to calculate the enthalpy of formation for each compound $MgCl_{(s)}$ and $MgCl_{2(s)}$.
(**Answer**: $\Delta H_f\ (MgCl) = -28.20$ kJ mol^{-1}, $\Delta H_f\ (MgCl_2) = -641.8$ kJ mol^{-1})

b. Discuss the relative stability of MgCl and $MgCl_2$. Does this explain why Mg Cl is not known?