Thermodynamic definition

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Definitions of enthalpy changes

Enthalpy of atomisation

The enthalpy of atomisation of an element is the enthalpy change when 1 mole of gaseous atoms is formed from the element in its standard state

$Na\ (s) \rightarrow Na(g)\ [\Delta H_{at} = +148\ kJ\ mol^{-1}]$

$\frac{1}{2}\ O_2\ (g) \rightarrow O\ (g)\ [\Delta H_{at} = +249\ kJ\ mol^{-1}]$

The enthalpy change for a solid metal turning to gaseous atoms can also be called the Enthalpy of sublimation and will numerically be the same as the enthalpy of atomisation

$Na\ (s) \rightarrow Na(g)\ [\Delta H_{sub} = +148\ kJ\ mol^{-1}]$

Bond dissociation enthalpy

The bond dissociation enthalpy is the standard molar enthalpy change when a covalent bond is broken into two gaseous atoms (or free radicals)

$Cl_{2\ (g)} \rightarrow 2Cl_{(g)}$ $\Delta H_{diss} = +242\ kJ\ mol^{-1}$

Or

$CH_{4\ (g)} \rightarrow CH_{3\ (g)} + H_{(g)}$ $\Delta H_{diss} = +435\ kJ\ mol^{-1}$

For diatomic molecules the ΔHdiss of the molcule is the same as 2x ΔHat of the element

$Cl_{2\ (g)} \rightarrow 2Cl_{(g)}$ $\Delta H_{diss} = +242\ kJ\ mol^{-1}$

$\frac{1}{2}\ Cl_{2\ (g)} \rightarrow Cl_{(g)}$ $\Delta H_{at} = +121\ kJ\ mol^{-1}$

Ionisation enthalpy

The first ionisation enthalpy is the enthalpy change required to remove 1 mole of electrons from 1 mole of gaseous atoms to form 1 mole of gaseous ions with a +1 charge

$Mg\ (g) \rightarrow Mg^{+}\ (g) + e^{-}$ [ΔHi]

<u>second IE</u>

$Mg^{+}\ (g) \rightarrow Mg^{2+}\ (g) + e^{-}$ [ΔHi]

Electron Affinity

The first electron affinity is the enthalpy change that occurs when 1 mole of gaseous atoms gain 1 mole of electrons to form 1 mole of gaseous ions with a –1 charge

$O\ (g) + e^- \rightarrow O^-\ (g)$ $[\Delta H_{ea}] = -141.1\ kJ\ mol^{-1}]$

The first electron affinity is exothermic for atoms that normally form negative ions because the ion is more stable than the atom and because there is an attraction between the nucleus and the electron

second electron affinity

$O^-\ (g) + e^- \rightarrow O^{2-}\ (g)$ $[\Delta H_{ea} = +798\ kJ\ mol^{-1}]$

The second electron affinity for oxygen is endothermic because it take energy to overcome the repulsive force between the negative ion and the electron

Enthalpy of lattice formation

The Enthalpy of lattice formation is the standard enthalpy change when 1 mole of an ionic crystal lattice (under standard conditions)is formed from its constituent ions in gaseous form

$Na^+\ (g) + Cl^-\ (g) \rightarrow NaCl\ (s)$ $[\Delta H_L = -787\ kJ\ mol^{-1}]$

Enthalpy of lattice dissociation

The Enthalpy of lattice dissociation is the standard enthalpy change when 1 mole of an ionic crystal lattice (under standard conditions) is separated into its constituent ions in gaseous form

$NaCl\ (s) \rightarrow Na^+\ (g) + Cl^-\ (g)$ $[\Delta H_L = +787\ kJ\ mol^{-1}]$

Note the conflicting definitions and the sign that always accompanies the definitions

Enthalpy change of formation

The enthalpy change when 1 mole of a compound is formed from its elements **all reactants and products being in their standard states at standard conditions**

$Na\,(s) + \frac{1}{2}Cl_2\,(g) \rightarrow NaCl\,(s)$ $[\Delta H_f = -411.2\ kJ\ mol^{-1}]$

Enthalpy of Hydration ΔH_{hyd}

Enthalpy change when one mole of gaseous ions become aqueous ions. This is always exothermic.

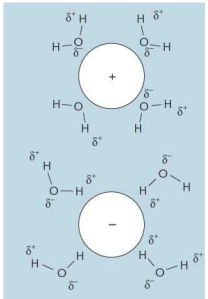
$X^+_{(g)} + aq \rightarrow X^+_{(aq)}$ For Li^+ $\Delta H_{hyd} = -519\ kJ\ mol^{-1}$

or

$X^-_{(g)} + aq \rightarrow X^-_{(aq)}$ For F^- $\Delta H_{hyd} = -506\ kJ\ mol^{-1}$

These are always exothermic because bonds are made between the ions and the water molecules

The negative ions are attracted to the δ^+ hydrogens on the polar water molecules and the positive ions are attracted to the δ^- oxygen on the polar water molecules



Enthalpy of Solution ΔH_{sol}

The enthalpy of solution is the standard enthalpy change for the process in which one mole of an ionic solid dissolves in an large enough amount of water to ensure that the dissolved ions are well separated and do not interact with one another

$NaCl_{(s)} + aq \rightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$