Lattice Energy and the Born-Haber Cycle

For ionic compounds, the sum of various enthalpies is equal to the enthalpy of formation by Hess' Law:

$$\Delta H_{sub} + \Delta H_{IE} + \Delta H_{BE} + \Delta H_{electron\ affinity} + \Delta H_{lattice\ energy} = \Delta H_f$$

The above enthalpies apply to the metal, non-metal or both. Enthalpies are in kJ/mol. The role of each enthalpy is summarized below.

<u>Enthalpy of Sublimation</u> (ΔH_{sub})

- Endothermic
- $X(s) \rightarrow X(g)$
- If ΔH_{sub} unavailable, then it can be calculated from $\Delta H_{sub} = \Delta H_{fus} + \Delta H_{vap}$
- Applies to a species that is a solid in its standard state.
- Species which are liquids need ΔH_{vap}.

<u>Ionization Energy</u> (ΔH_{IE})

- Endothermic
- $M(g) \rightarrow M^{+n}(g) + ne^-$
- Total ionization energy = sum of first, second, third, etc. (depends on charge)
- Applies to metal.

<u>Bond Energy</u> (ΔH_{BE})

- Endothermic
- $\frac{1}{2}X_2(g) \rightarrow X(g)$
- Is actually half of the bond energy listed in tables.
- Applies to diatomic elements.

<u>Electron Affinity</u> $\Delta H_{electron\ affinity}$

- Exothermic or endothermic
- $X(g) + ne^- \rightarrow X^{n-}(g)$
- Total electron affinities = sum of first, second, third, etc (depends on charge)
- Applies to non-metal

<u>Lattice Energy</u> $\Delta H_{lattice\ energy}$

- Very exothermic
- $M^{+m}(g) + X^{-n}(g) \rightarrow MX(s)$ [formula depends on charges]
- Closely tied with Coulomb's Law

<u>Enthalpy of Formation</u> ΔH_f

- Exothermic (almost always)
- (elements in their standard states) → (ionic solid)

Example Born-Haber Cycle with NaBr(*s*)