THE IONIC BONDING MODEL

LATTICE ENERGY, $\Delta H^o_{lattice}$

IMPORTANCE OF LATTICE ENERGY

$\Delta H^o_{lattice}$ of MgO = 3932 kJ mol^{-1}

Why ionic solid MgO with its 2+ ions, even exist? After all, much more energy is needed to form Mg^{2+} ions than Mg^+ ions.

- $Mg(g) \longrightarrow Mg^+(g) + e^-$; $IE_1 = 738$ kJ
- $Mg^+(g) \longrightarrow Mg^{2+}(g) + e^-$; $IE_2 = 1450$ kJ

$\therefore Mg(g) \longrightarrow Mg^{2+}(g) + 2e^-$; $\Delta H^o = 2188$ kJ

- $O(g) + e^- \longrightarrow O^-(g)$; $EA_1 = -141$ kJ
- $O^-(g) + e^- \longrightarrow O^{2-}(g)$; $EA_2 = 878$ kJ ← endothermic ('cos e^- is added to O^- ion)

$\therefore O(g) + 2e^- \longrightarrow O^{2-}(g)$; $\Delta H^o = (-141 + 878) = +737$ kJ

- $Mg(s) \longrightarrow Mg(g)$; $\Delta H^o_{atom} = \Delta H^o_{vap} = 148$ kJ
- $\frac{1}{2}O_2(g) \longrightarrow O(g)$; $\Delta H^o_{atom} = 249$ kJ

* Nevertheless, as a result of the ions Mg^{2+} & O^{2-} (ie. +2 and −2 charges), solid MgO readily forms whenever Mg burns in air.

$$Mg(s) + \tfrac{1}{2}O_2(g) \longrightarrow MgO(s) ; \Delta H^o_f = -601 \text{ kJ mol}^{-1}$$

** Clearly, the enormous lattice energy ($\Delta H^o_{lattice}$ of MgO = 3932 kJ mol^{-1}) more than compensates for these endothermic steps.

ie: $Mg^{2+}(g) + O^{2-}(g) \longrightarrow MgO(s)$; $\Delta H^o = -3932$ kJ mol^{-1}.
(− : very exothermic)

Remember !!

$$MgO(s) \longrightarrow Mg^{2+}(g) + O^{2-}(g) ; \Delta H^o_{lattice} = +3932 \text{ kJ mol}^{-1}.$$

Why $Na^{2+}Cl^{2-}$ doesnot exist? The attraction between these ions are greater - can form more stable compound, but why it cannot be formed?

$$E \propto \frac{q_1 q_2}{r} : \quad E_{attraction}(\text{of } Na^{2+}\cdot Cl^{2-}) = 4 \times E_{attraction}(\text{of } Na^{+}\cdot Cl^{-})$$

$$Na^{2+}(g) + Cl^{2-}(g) \longrightarrow \underbrace{NaCl(s)}_{Na^{2+}\cdot Cl^{2-}} ; \Delta H_{lattice} = -2200\ kJmol^{-1}$$

Compare to:

$$Na(g) \longrightarrow Na^{+}(g) + e^{-} \quad ; \quad IE_1 = 495.5\ kJmol^{-1}$$

[Ne]3s¹   [Ne]

Very high energy !!

$$Na^{+}(g) \longrightarrow Na^{2+}(g) + e^{-} \quad ; \quad IE_2 = 4562\ kJmol^{-1}$$

[Ne] $1s^2 2s^2 2p^5$ (removing e^- from a very stable ion Na^+)

Very stable ion (noble gas configuration)

$$\therefore Na(g) \longrightarrow Na^{2+} + 2e^{-} ; \Delta H = 5058\ kJmol^{-1}$$

* We donot know the EA_2 (2nd electron affinity) of Cl, but from Example 1, suggests that the value will be large and positive (endothermic : e^- added to negatively charged ion, Cl^-)

∴ So We can see why $Na^{2+}\cdot Cl^{2-}$ cannot be formed.

Forming Na^{2+} requires 4562 $kJmol^{-1}$ energy, which is much more than the 2200 $kJmol^{-1}$ energy released in the formation of the $Na^{2+}\cdot Cl^{2-}$ lattice.

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