General Chemistry

Thermochemistry II

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Chapter Description

- <u>Expected Outcome:</u>
- At the end of the lecture, the students should be able to understand and solve the problems regarding on the Lattice Energy Born Haber Cycle & Hess Law.

- <u>References:</u>

1) Stephen B. Barone. Introduction to general chemistry. Blackwell Science.
2) James E. Bradry General Chemistry: Principles & Structure. John Wiley.

Content

- Lattice Energy
- Born Haber Cycle
- Hess Law

Lattice energy

- **Lattice energy formation** is the **energy released when one mole of a solid (ionic compound) is formed from its gaseous ions.**

$$Na^+_{(g)} + Cl^-_{(g)} \rightarrow NaCl_{(s)} \qquad \Delta H_{lattice} = -771\ kJ$$

(lattice formation)

Lattice energy

Lattice energy dissociation is the **energy required** to completely separate **one mole of a solid (ionic compound)** into its **gaseous ions**

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$$NaCl_{(s)} \rightarrow Na^{+}_{(g)} + Cl^{-}_{(g)} \qquad \Delta H_{lattice} = +771 \text{ kJ}$$

(lattice dissociation)

Lattice energy

The magnitude of lattice energy increases as:-

- The ionic charges increase ions attract each other more strongly.
- The ionic radii decrease they get closer together.

Electron Affinity

The amount of energy change to added 1 mole of electron into 1 mole of gaseous atoms or ions in their ground state.

$$\text{Atom}(g) \quad + \quad e^{-} \quad \rightarrow \quad \text{ion}^{-}(g) \qquad \Delta E = EA_{I} = \text{-ve}$$

These reactions usually <u>exothermic</u> (release energy) because when an electron is added to a neutral atom, it will experience an attraction of nucleus and release an amount of energy.

Electron Affinity

- **However, affinity does not always release energy. In some cases, affinity requires energy.**

  Example: Formation of oxide, O^{2-};

O^{2-}

$$O(g) + e^- \longrightarrow O^-(g) \qquad EA_1 = -ve$$

$$O^-(g) + e^- \longrightarrow O^{2-}(g) \qquad EA_2 = +ve$$

Electron Affinity

First Ionisation Energy

- Is the minimum energy required to remove one mole of electron from one mole of neutral gaseous atom in its ground state

$$X_{(g)} \longrightarrow X^{+}_{(g)} + e^{-}$$

Second Ionisation Energy

- Is the energy required to remove one mole of electron from one mole of gaseous positive ion in its ground state

$$X^{+}_{(g)} \longrightarrow X^{2+}_{(g)} + e-$$

Dissolution process of ionic solid

- Dissolution is the process by which a solid or liquid forms a solution in a solvent.
- Occur when an ionic solid dissolve in water
- Water molecules are polar

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

- Most ionic crystals are soluble in water
- Ions in the solid crystal can be separated from each other and converted to the gaseous ions ($\Delta H_{lattice}$)
- The attraction forces between gaseous ions and polar water molecules cause the ions to be surrounded by water molecules (ΔH_{hyd})

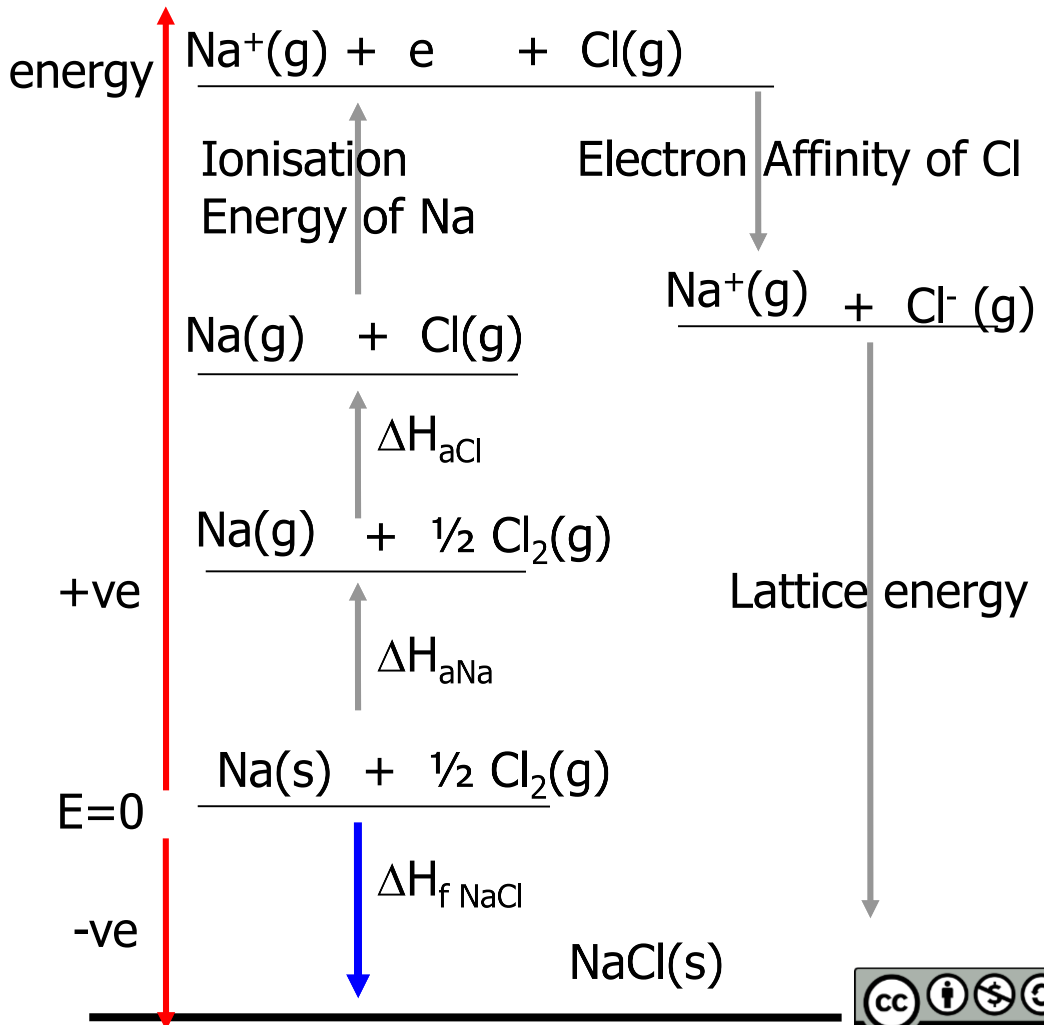
$$\Delta H_{soln} = \Delta H_{lattice\ dissociation} + \Delta H_{hyd}$$

Born Haber cycle

- Energy cycle for ionic compounds

- Connects enthalpy of formation with lattice energy

Born haber cycle diagram



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(lattice dissociation)

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  - ☞ ions attract each other more strongly
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  - ☞ they get closer together

Lattice energy

E.g.

ΔH for MgO is more negative than ΔH for Na_2O because Mg^{2+} is smaller in size and has bigger charge than Na^+

$\therefore$ **$\Delta H^o_{lattice}$ (MgO) > $\Delta H^o_{lattice}$ (Na_2O)**

Lattice energy

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Born haber Cycle

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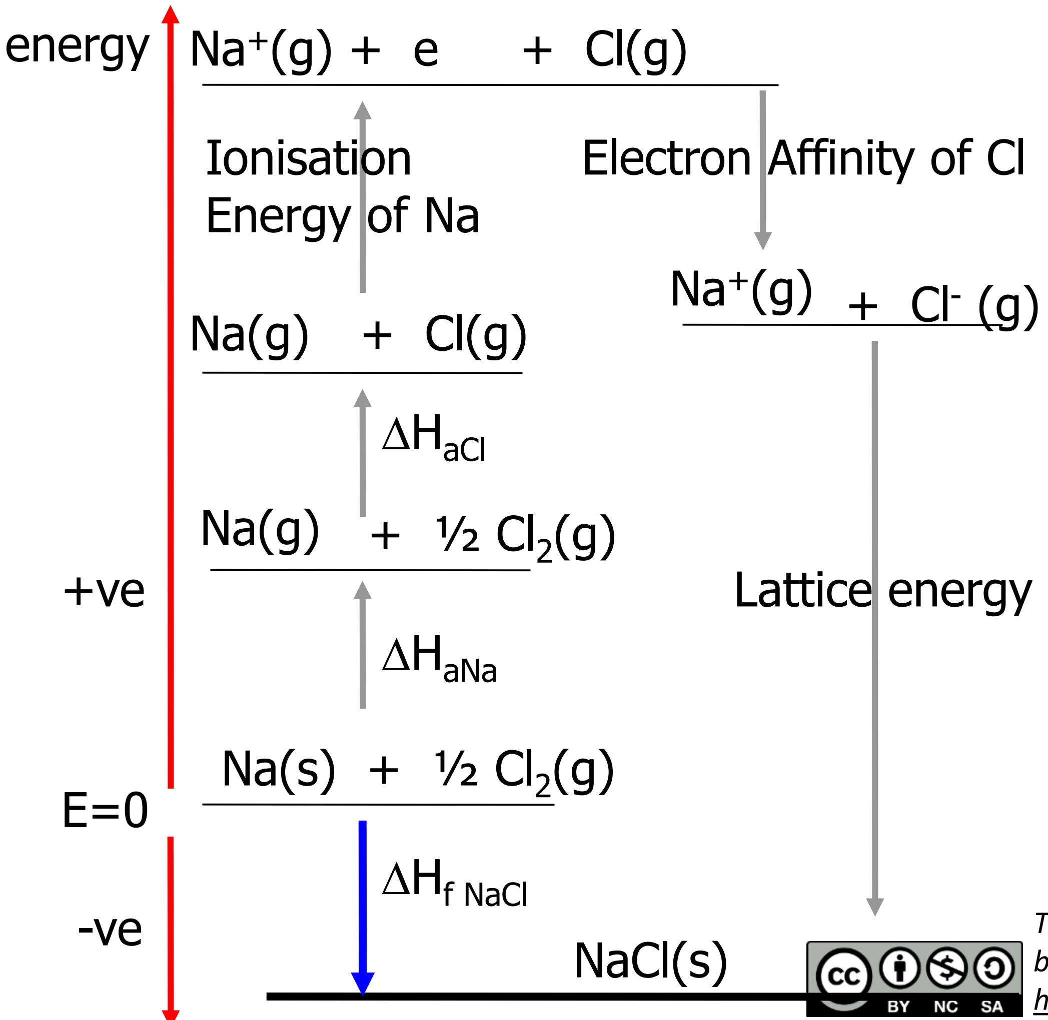
- Connects enthalpy of formation with lattice energy.

Born Haber energy cycle diagram



Lattice energy

From Hess's Law:

$\Delta H_{f\ NaCl} = \Delta H_{aNa} + \Delta H_{aCl} + IE_{Na} +$

EA_{Cl} + Lattice Energy

$\Delta H_f^o = \Delta H_s + IE$ [illegible] $EA + \Delta H_{lattice}$

$\Delta H_{lattice} = \Delta H_f^o - [\Delta H_s + IE$ [illegible] $E]$ [illegible]

$\Delta H_{lattice} = -411 - [$[illegible]

$\Delta H_{lattice} = -7$[illegible] kJ

Author Information

Aini Hidayah Mohamed is a lecturer from Faculty of Industrial Sciences & Technology Industry, Universiti Malaysia Pahang, Malaysia. She is also a chemist who is expert in general chemistry, industrial chemistry and natural product.