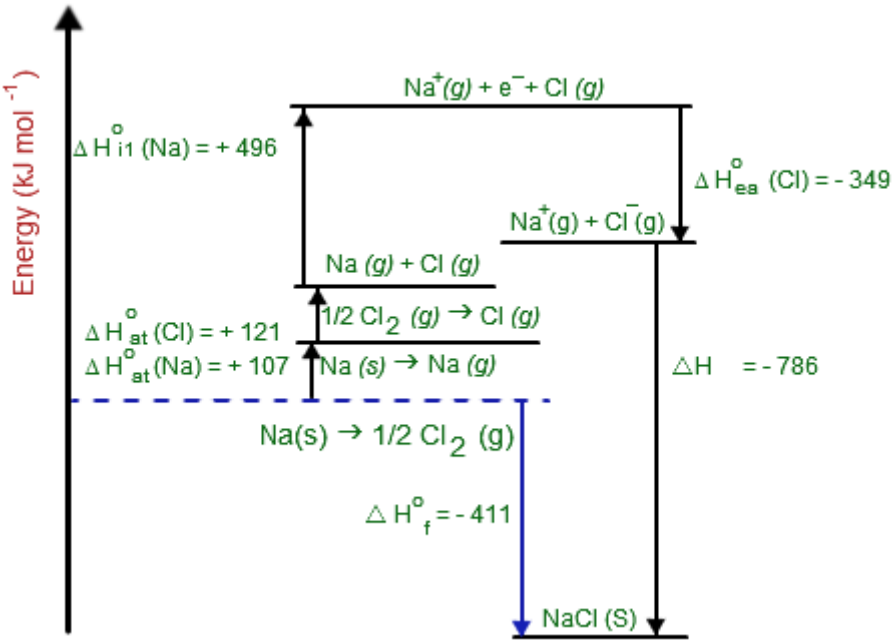
Answer on Question#59765 - Chemistry | General Chemistry



The energy change during the formation of sodium chloride crystal from metallic sodium and chlorine gas can be used to calculate lattice enthalpy of NaCl(s). The net enthalpy change for the formation of NaCl ($\Delta_f H°$) is 411.2 kj/mol.

$Na(s) + 1/2Cl_2(g) \rightarrow NaCl(s)$ $\Delta_f H° = -411.2$ kj/mol

The overall process can be explained in following steps.

- **Formation of sodium chloride:** The formation of one mole of sodium chloride from its elements under standard conditions releases 411 kj/mol of heat. This is known as standard enthalpy of formation and represented by $\Delta fH°$.

$Na(s) + ½\ Cl_2\ (g) \rightarrow NaCl(s)$ $\Delta H_f°(NaCl) = -411$ kJ/mol

- **Standard enthalpy of atomization of chlorine ($\Delta Ha°$):** The energy required to atomize one mole of gaseous chlorine molecules into one mole of gaseous chlorine atoms is known as standard enthalpy of atomization of chlorine. It's an endothermic step as the bonds between Cl-Cl atoms are being broken.

$½\ Cl_2\ (g) \rightarrow Cl\ (g)$ $\Delta Ha°\ (Cl_2) = +121$ kJ/mol

- **Standard enthalpy of electron affinity of chlorine ($\Delta H_{ea}°$):** The energy released when one mole of gaseous chlorine atoms gains one mole of electrons to form chloride ion. The electron affinity of chlorine atom is 349 kj/mol.

$Cl\ (g) + e^- \rightarrow Cl\text{-}(g)$ $\Delta H_{ea}°\ (Cl) = -349$ kJ/mol

- **Sublimation energy of sodium ($\Delta Hs°$):** This is the energy required to change one mole of solid sodium atoms into one mole of gaseous atoms. Sublimation of sodium is an endothermic process and requires energy to change the state from a solid to a gas.

$$\mathbf{Na\ (s) \rightarrow Na\ (g) \quad \Delta Hs°\ (Na) = +107\ kJ/mol}$$

- **Ionization energy of sodium ($\Delta H_{IE}°$ (Na):** Removal of one mole of electron from a gaseous metal atom involve some energy change, known as ionization energy. Endothermic, energy needs to be absorbed to remove the electron.

$$\mathbf{Na\ (g) \rightarrow Na^{+}(g) + e^{-} \quad (\Delta H_{IE}°\ (Na) = +496\ kJ/mol)}$$

- **Lattice enthalpy of sodium chloride (U):** The enthalpy change during the formation of one mole of sodium chloride from its constituent ions is called as lattice energy of lattice enthalpy. It is an exothermic step and release about 786 kj energy.

$$\mathbf{Na^{+}(g) + Cl^{-}(g) \rightarrow NaCl\ (s)\ \ U = -786\ kj/mol}$$

Applying Hess's law we get.

$$\mathbf{\Delta H_f° = \Delta\ Hs° + \Delta\ H_{IE}° + \Delta\ Ha° + \Delta\ Hea° + U}$$

Or Lattice enthalpy

$$\mathbf{\Delta\ HL° = 107 + 496 + 121 - 349 - 786 = -411\ kj/mol}$$