Enthalpies of Formation

- Enthalpy change (delta) under standard conditions of formation.
- Usually exothermic.
- See table for $\Delta H_f^\circ$ value (Table A3).
- Enthalpy of formation of an element in its stable state = 0.
- These can be used to calculate $\Delta H^\circ$ for a reaction.

Standard Enthalpy Change

- Standard enthalpy change, $\Delta H^\circ$, for a given thermochemical equation is equal to the sum of the standard enthalpies of formation of the product minus the standard enthalpies of formation of the reactants.

$$\Delta H_{rxn} = \Sigma (\Delta H_f^\circ \text{ products}) - \Sigma (\Delta H_f^\circ \text{ reactants})$$

Example:

- Calculate $\Delta H$ for the combustion of one mole of propane: ($\Delta H_{C_3H_8} = -103.8 \text{ kJ}$)

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

$$\Delta H_{rxn} = \Sigma (\Delta H_f^\circ \text{ products}) - \Sigma (\Delta H_f^\circ \text{ reactants})$$

$$\Delta H_{rxn} = [3(-393.5 \text{ kJ})] + 4(-285.8 \text{ kJ}) - (-103.8 \text{ kJ})$$

$$\Delta H_{rxn} = -2219.9 \text{ kJ}$$
Standard Enthalpy Change

Example: The thermochemical equation for the combustion of benzene, \( \text{C}_6\text{H}_6 \), is:

\[
\text{C}_6\text{H}_6(\text{l}) + \frac{15}{2}\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})
\]

\[\Delta H^\circ = -3267.4 \text{ kJ}\]

Calculate the standard heat of formation of benzene.

\[-3267.4 \text{ kJ} = [6(-393.5 \text{ kJ}) + 3(-285.8 \text{ kJ})] - \Delta H^\circ/\text{C}_6\text{H}_6\]

\[-3267.4 \text{ kJ} = -3218.4 - \Delta H^\circ/\text{C}_6\text{H}_6\]

\[-49.0 \text{ kJ} = -\Delta H^\circ/\text{C}_6\text{H}_6\]

\[\Delta H^\circ/\text{C}_6\text{H}_6 = +49.0 \text{ kJ}\]

Example: When hydrochloric acid is added to a solution of sodium carbonate, carbon dioxide gas is formed. The equation for the reaction is:

\[2\text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})\]

Calculate \( \Delta H^\circ \) for this thermochemical equation.

\[\Delta H^\circ = [(-393.5 \text{ kJ}) + (-285.8 \text{ kJ})] - [2(0 \text{ kJ}) + (-677.1 \text{ kJ})]\]

\[\Delta H^\circ = (-679.3 \text{ kJ}) - (-677.1 \text{ kJ})\]

\[\Delta H^\circ = -2.2 \text{ kJ}\]

\[\Delta H^{\text{H}^+} = 0 \text{ kJ}\]

\[\Delta H^{\text{CO}_3^{2-}} = -677.1 \text{ kJ}\]