Standard Enthalpy Values

Most tabulated $\Delta H$ values are labeled $\Delta H^\circ$
They are measured under standard conditions:
- $P = 1$ bar ($\sim 1$ atmosphere)
- Concentration = 1 mol/L
- $T = $ usually 25 $^\circ$C
- with all species in standard states
  e.g., $C =$ graphite and $O_2 =$ gas

NIST (National Institute for Standards and Technology) gives values of

$\Delta H^\circ_f =$ standard molar enthalpy of formation
This is the enthalpy change when 1 mol of compound is formed from elements under standard conditions.

See Table 6.2 and Appendix L
\[ \Delta H^\circ_f, \text{ standard molar enthalpy of formation} \]

\[ H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(g) \]

\[ \Delta H^\circ_f = -241.8 \text{ kJ/mol} \]

By definition, \( \Delta H^\circ_f = 0 \) for elements in their standard states.

Using Standard Enthalpy Values

Use \( \Delta H^\circ \)'s to calculate enthalpy change for

\[ H_2O(g) + C(\text{graphite}) \rightarrow H_2(g) + CO(g) \]

(the product CO is called “water gas”)

Get values for formation of \( H_2O(g) \) and \( CO(g) \), then “add” reactions.
Using Standard Enthalpy Values

\[ \text{H}_2\text{O}(g) + \text{C(graphite)} \rightarrow \text{H}_2(g) + \text{CO}(g) \]

From Appendix L we find

- \[ \text{H}_2(g) + \frac{1}{2} \text{O}_2(g) \rightarrow \text{H}_2\text{O}(g) \]
  \[ \Delta H^\circ \text{f of H}_2\text{O vapor} = -242 \text{ kJ/mol} \]

- \[ \text{C(graphite)} + \frac{1}{2} \text{O}_2(g) \rightarrow \text{CO}(g) \]
  \[ \Delta H^\circ \text{f of CO} = -111 \text{ kJ/mol} \]

To convert 1 mol of water to 1 mol each of \( \text{H}_2 \) and \( \text{CO} \) requires 131 kJ of energy.

The “water gas” reaction is endothermic.
Using Standard Enthalpy Values

In general, when ALL enthalpies of formation are known,

\[
\Delta H_{\text{rxn}}^o = \sum \Delta H_{f}^o (\text{products}) - \sum \Delta H_{f}^o (\text{reactants})
\]

Apr. 19, 2006

Using Standard Enthalpy Values

Calculate the heat of combustion of methanol, i.e., \( \Delta H_{\text{rxn}}^o \) for

\[ \text{CH}_3\text{OH}(g) + \frac{3}{2} \text{O}_2(g) \rightarrow \text{CO}_2(g) + 2 \text{H}_2\text{O}(g) \]

\[
\Delta H_{\text{rxn}}^o = \sum \Delta H_{f}^o (\text{prod}) - \sum \Delta H_{f}^o (\text{react})
\]

\( \text{(CO}_2\text{)} \) \( \Delta H_{f}^o = -393.5 \text{ kJ/mol} \)
\( \text{(H}_2\text{O)} \) \( \Delta H_{f}^o = -241.8 \text{ kJ/mol} \)
\( \text{(CH}_3\text{OH)} \) \( \Delta H_{f}^o = -201.5 \text{ kJ/mol} \)

Apr. 19, 2006
Using Standard Enthalpy Values

\[ \text{CH}_3\text{OH}(g) + \frac{3}{2} \text{O}_2(g) \rightarrow \text{CO}_2(g) + 2 \text{H}_2\text{O}(g) \]

\[ \Delta H^o_{\text{rxn}} = \Sigma \Delta H^o_f (\text{prod}) - \Sigma \Delta H^o_f (\text{react}) \]

\[ \Delta H^o_{\text{rxn}} = \Delta H^o_f (\text{CO}_2) + 2 \Delta H^o_f (\text{H}_2\text{O}) \]

\[ - \{ \frac{3}{2} \Delta H^o_f (\text{O}_2) + \Delta H^o_f (\text{CH}_3\text{OH}) \} \]

\[ = (-393.5 \text{ kJ}) + 2 (-241.8 \text{ kJ}) \]

\[ - \{ 0 + (-201.5 \text{ kJ}) \} \]

\[ \Delta H^o_{\text{rxn}} = -675.6 \text{ kJ per mol of methanol} \]