Hess's Law & Calculating Enthalpy Changes

Hess's Law: If you can add 2 or more thermochemical equations to produce a final equation for a reaction, then the sum of the enthalpy changes for the individual reactions is the enthalpy change for the final reaction.

Examples

1. Calculate ΔH_{rxn} for this overall reaction:

$$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$$

given the steps below:

(1) $N_2(g) + O_2(g) \rightarrow \cancel{2NO(g)}$ $\Delta H_1 = 180\,kJ$

(2) + $\cancel{2NO(g)} + O_2(g) \rightarrow 2NO_2(g)$ + $\Delta H_2 = -112\,kJ$

$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$ $\Delta H_{rxn} = 68\,kJ$

2. Calculate ΔH_{rxn} for this reaction:

$$C_{graphite}(s) \rightarrow C_{diamond}(s)$$

given the steps below:

(1) $C_{graphite}(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H_1 = -394\,kJ$

(2) $C_{diamond}(s) + O_2(g) \rightarrow CO_2(g)$ reverse $\Delta H_2 = -396\,kJ$

$C_{graphite}(s) + \cancel{O_2(g)} \rightarrow \cancel{CO_2(g)}$ $\Delta H_1 = -394\,kJ$

+ $\cancel{CO_2(g)} \rightarrow C_{diamond}(s) + \cancel{O_2(g)}$ + $\Delta H_2 = +396\,kJ$

$C_{graphite}(s) \rightarrow C_{diamond}(s)$ $\Delta H_{rxn} = 2\,kJ$

If you need, you can reverse a reaction, but you have to change the sign of ΔH_{rxn}

3. Calculate ΔH_{rxn} for this reaction:

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

given:

(1) $S(s) + \frac{3}{2}O_2(g) \rightarrow SO_3(g)$ $\Delta H_1 = -395.2\,kJ$

(2) $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ reverse $\Delta H_2 = -198.2\,kJ$

$3-1=2$

$2S(s) + \cancel{2\tfrac{3}{2}}O_2(g) \rightarrow \cancel{2SO_3(g)}$ $2(\Delta H_1 = -395.2\,kJ)$

$+$ $\cancel{2SO_3(g)} \rightarrow 2SO_2(g) + \cancel{O_2(g)}$ $\Delta H_2 = +198.2\,kJ$

$2S(s) + 2O_2(g) \rightarrow 2SO_2(g)$ $\Delta H_{rxn} = -592.2\,kJ$

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$S(s) + O_2(g) \rightarrow SO_2(g)$ $\Delta H_{rxn} = -296.1\,kJ$

You can multiply any step by any number to solve the problem.

4. Calculate ΔH_{rxn} for this reaction:

$$C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)$$

given:

(1) $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H_1 = -393.5\,kJ$

(2) $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$ reverse $\Delta H_2 = -566.0\,kJ$

(3) $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ reverse $\Delta H_3 = -483.6\,kJ$

$2C(s) + \cancel{2O_2(g)} \rightarrow \cancel{2CO_2(g)}$ $2(\Delta H_1 = -393.5\,kJ)$

$+$ $\cancel{2CO_2(g)} \rightarrow 2CO(g) + \cancel{O_2(g)}$ $\Delta H_2 = +566.0\,kJ$

$2H_2O(g) \rightarrow 2H_2(g) + \cancel{O_2(g)}$ $\Delta H_3 = +483.6\,kJ$

$2C(s) + 2H_2O(g) \rightarrow 2CO(g) + 2H_2(g)$ $\Delta H_{rxn} = 262.6\,kJ$

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$C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)$ $\Delta H_{rxn} = 131.3\,kJ$