Thermochemistry Continued

Enthalpy (H) - measurement of the amount of energy produced or absorbed by a chemical reaction
exothermic endothermic

Heat (q) - change in enthalpy @ constant pressure

Hess's Law -

Regardless of the multiple steps of a reaction, the total change in enthalpy (ΔH) for a reaction is the sum of all the changes.

Ex) Calculate ΔH for this overall reaction:

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

given these steps:

steps

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

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

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

Ex) Calculate ΔH for: $C_{graphite}(s) \rightarrow C_{diamond}(s)$ from:

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

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

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

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

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

If you need to, you can reverse a reaction, but you have to change the sign of ΔH

(Ex) Calculate ΔH for: $S(s) + O_2(g) \rightarrow SO_2(g)$ from

(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 $\Delta H_2 = -198.2\ kJ$

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

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

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

2

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

The magnitude of ΔH is directly proportional to the quantities of reactants & products in the reaction. You can multiply any step by any number to solve the problem.

(Ex) Calculate ΔH for: $C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)$ from:

(1) $C(s) + O_2(g) \rightarrow CO_2(g)$ multiply by 2 $\Delta H_1 = -393.5\ kJ$

(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 $\Delta H_3 = -483.6\ kJ$

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

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

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

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

2

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