Predicting Enthalpy Changes-Hess's Law

Not every reaction of interest can be studied by means of calorimetry.
Why? - reactions are slow.

Example: The rusting of iron

- products may vary.

Example: The formation of carbon monoxide

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$
$\searrow CO_{(g)}$

In the event we want to determine an enthalpy change for a reaction, we can use predetermined reaction values.

This principle is known as Hess's Law of summation

$$\Delta H_{NET} = \Delta H_1 + \Delta H_2 + \Delta H_3 + \ldots$$

$$\Delta H_{NET} = \sum \Delta H_{RXN}$$

Characteristics of Enthalpy Changes

1. If a reaction is reversed, the sign of ΔH is also reversed.

- If $H_2(g) + 1/2\ O_2(g) \rightarrow H_2O(g)$
  $\Delta H = -285.5$ kJ
  then the reverse is:
  $H_2O(g) \rightarrow H_2(g) + 1/2\ O_2(g)$
  $\Delta H = +285.5$ kJ

2. The magnitude of ΔH is directly proportional to the quantities of reactants and products in a reaction.

×2

- If you multiply the equation by a number, you multiply the heat by that number:

$2\ H_2O(g) \rightarrow 2\ H_2(g) + O_2(g)$
$\Delta H = +571.0$ kJ

EX

a) Find the enthalpy change for the formation of butane. $\Delta H = ?$

Given:

$C_4H_{10(g)} + 13/2\ O_2 \rightarrow 4CO_{2(g)} + 5H_2O_{(g)}$ $\Delta H_{rxn} = -2657.4$KJ

$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H_{rxn} = -393.5$KJ

$H_{2(g)} + 1/2\ O_{2(g)} \rightarrow H_2O_{(g)}$ $\Delta H_{rxn} = -241.8$ KJ

Step 1: Write the net reaction if it is not given:

$4C_{(s)} + 5H_{2(g)} \rightarrow C_4H_{10(l)}$ $\Delta H = ?$

Step 2: Manipulate the given equations so they will add to yield the net equation.

- $C_4H_{10(g)} + 13/2\ O_2 \rightarrow 4CO_{2(g)} + 5H_2O_{(g)}$ $\Delta H_{rxn} = -2657.4KJ$ flip
- $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H_{rxn} = -393.5KJ$ $\times 4$

$H_{2(g)} + 1/2\ O_{2(g)} \rightarrow H_2O_{(g)}$ $\Delta H_{rxn} = -241.8\ KJ$ $\times 5$

$4CO_2 + 5H_2O \rightarrow C_4H_{10} + \frac{13}{2}O_2$ $\Delta H = 2657.4KJ$

$4C + 4O_2 \rightarrow 4CO_2$ $\Delta H = -1574KJ$

$5H_2 + \frac{5}{2}O_2 \rightarrow 5H_2O$ $\Delta H = -1209KJ$

$\Delta H = -125.6KJ$

Step 3: Cancel and add the remaining reactants and products

Step 4: Add the component enthalpy changes to obtain the net enthalpy change

Step 5: Determine molar enthalpy, if required

$C_{(s)}$ diamond ----> $C_{(s)}$ graphite

$\Delta H = ?$

reactions to use....

$C_{(s)}$ diamond + $O_{2\,(g)}$ -------> $CO_{2(g)}$ $\Delta H = -395.4$ KJ (alone)

$C_{\,(s)}$ graphite + $O_{2\,(g)}$ ------> $CO_{2(g)}$ $\Delta H = -393.5$ KJ (flip)

$C_{(s)}d + O_2 \rightarrow CO_2$ $\Delta H = -395.4$ KJ

$CO_2 \rightarrow C_{(s)}g + O_2$ $\Delta H = 393.5$ KJ

$\Delta H = -1.9$ KJ