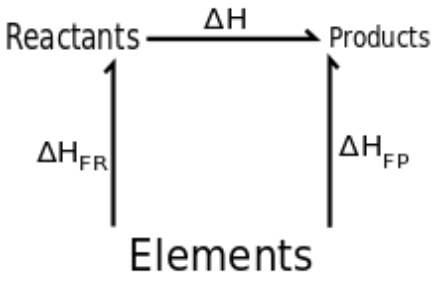
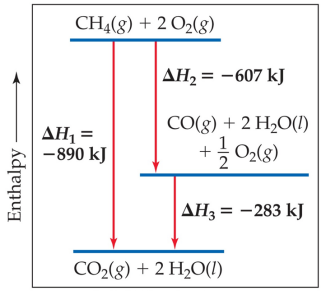
6.3 - Hess' Law



Hess's Law

Hess's law states that "If a reaction is carried out in a series of steps, ΔH for the overall reaction will be equal to the sum of the enthalpy changes for the individual steps."



Because ΔH is a state function, the total enthalpy change depends only on the initial state of the reactants and the final state of the products.

Characteristics of Enthalpy Changes

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

The magnitude of ΔH is directly proportional to the quantities of reactants and products in a reaction. If the coefficients in a balanced reaction are multiplied by an integer, the value of ΔH is multiplied by the same integer.

1. Hess' Law Example

Consider the following data:

$$2NH_{3(g)} \rightarrow N_{2(g)} + 3H_{2(g)} \qquad \Delta H = +92\,kJ$$

$$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)} \qquad \Delta H = -484\,kJ$$

Calculate ΔH for the reaction.

$$2N_{2(g)} + 6H_2O_{(g)} \rightarrow 3O_{2(g)} + 4NH_{3(g)}$$

1. Hess' Law Example

Reverse the two reactions so that the resulting reactants and products are on the correct sides with respect to the desired reaciton:

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)} \qquad \Delta H = -92\,kJ$$

$$2H_2O_{(g)} \rightarrow 2H_{2(g)} + O_{2(g)} \qquad \Delta H = +484\,kJ$$

Desired reaction:

$$2N_{2(g)} + 6H_2O_{(g)} \rightarrow 3O_{2(g)} + 4NH_{3(g)}$$

1. Hess' Law Example

Multiply reactions to give the correct numbers of reactants, products, and proportional energy change:

$$2\left(N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)} \qquad \Delta H = -92\,kJ\right)$$

$$3\left(2H_2O_{(g)} \rightarrow 2H_{2(g)} + O_{2(g)} \qquad \Delta H = +484\,kJ\right)$$

Desired reaction:

$$2N_{2(g)} + 6H_2O_{(g)} \rightarrow 3O_{2(g)} + 4NH_{3(g)}$$

1. Hess' Law Example

Final reactions: cancel duplicate reactants:

$$2N_{2(g)} + \cancel{6H_{2(g)}} \rightarrow 4NH_{3(g)} \qquad \Delta H = -184\,kJ$$

$$6H_2O_{(g)} \rightarrow \cancel{6H_{2(g)}} + 3O_{2(g)} \qquad \Delta H = +1452\,kJ$$

Desired reaction:

$$2N_{2(g)} + 6H_2O_{(g)} \rightarrow 3O_{2(g)} + 4NH_{3(g)}$$

ΔH = -184 J + 1452 J = +1268 kJ

Homework

Read 6.4 in your textbook.

6.3 Problems in your Booklet
Due: Next Class.