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Hess's law

Except in a few cases, heats of formation cannot be measured directly. However, heats of formation can be calculated from heats of combustion (which are very accurate) using Hess's law.

Hess's law states that the heat change for a given reaction depends on the initial and final states of the system and is independent of the path followed.

Sample problem on Hess's law

2006 Q6(c) Higher level

The combustion of cyclohexane can be described by the following balanced equation.

$$C_6H_{12} + 9O_2 \longrightarrow 6CO_2 + 6H_2O$$

Given that the heats of formation of cyclohexane, carbon dioxide and water are −156, −394 and −286 kJ/mole respectively, calculate the heat of combustion of cyclohexane. (12 marks)

Solution

Step 1: First write the heat of formation reactions.

1. Cyclohexane: $6C + 6H_2 \longrightarrow C_6H_{12}$ $\Delta H = -156$ kJ/mole
2. Carbon dioxide: $C + O_2 \longrightarrow CO_2$ $\Delta H = -394$ kJ/mole
3. Water: $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$ $\Delta H = -286$ kJ/mole

Step 2: Write the reaction needed.

$$C_6H_{12} + 9O_2 \longrightarrow 6CO_2 + 6H_2O$$

Step 3: Combine the three reactions given to get the reaction needed.

Reverse reaction 1: $C_6H_{12} \longrightarrow 6C + 6H_2$ $\Delta H = 156$ kJ/mole (3 marks)

Reaction 2 × 6: $6C + 6O_2 \longrightarrow 6CO_2$ $\Delta H = -2364$ kJ/mole (3 marks)

Reaction 3 × 6: $6H_2 + 3O_2 \longrightarrow 6H_2O$ $\Delta H = -1716$ kJ/mole (3 marks)

$C_6H_{12} + 9O_2 \longrightarrow 6CO_2 + 6H_2O$ $\Delta H = -3924$ kJ/mole (3 marks)

Mandatory experiment: To determine the heat of reaction of hydrochloric acid and sodium hydroxide

Hydrochloric acid and sodium hydroxide neutralise each other and the reaction is exothermic. In the following experiment the heat released from this reaction will be measured. The equation for the reaction is shown.

$$HCl + NaOH \longrightarrow NaCl + H_2O$$