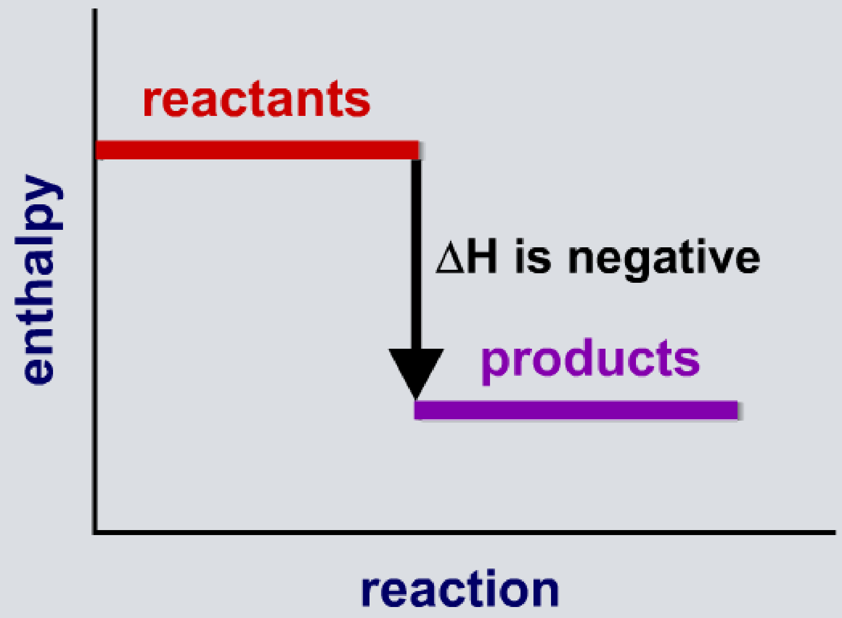
Enthalpy Change



What is enthalpy?

The **enthalpy**, ***H***, of a system is a measure of the energy stored in (or heat content of) a system. It cannot be measured directly.

During reactions, the enthalpy of the reactants and the products is not the same. This results in energy being either given out or taken in during the reaction. This energy is the **enthalpy change**, ΔH ('delta H').

The enthalpy change for a reaction is usually observed as a change in temperature, which can be measured or calculated.

Enthalpy changes

The **enthalpy change** of a reaction is the heat energy exchange with its surroundings at constant pressure.

Enthalpy is the energy content of the reactants and is given the symbol ***H***.

In science, change is represented by the upper case Greek letter delta, Δ.

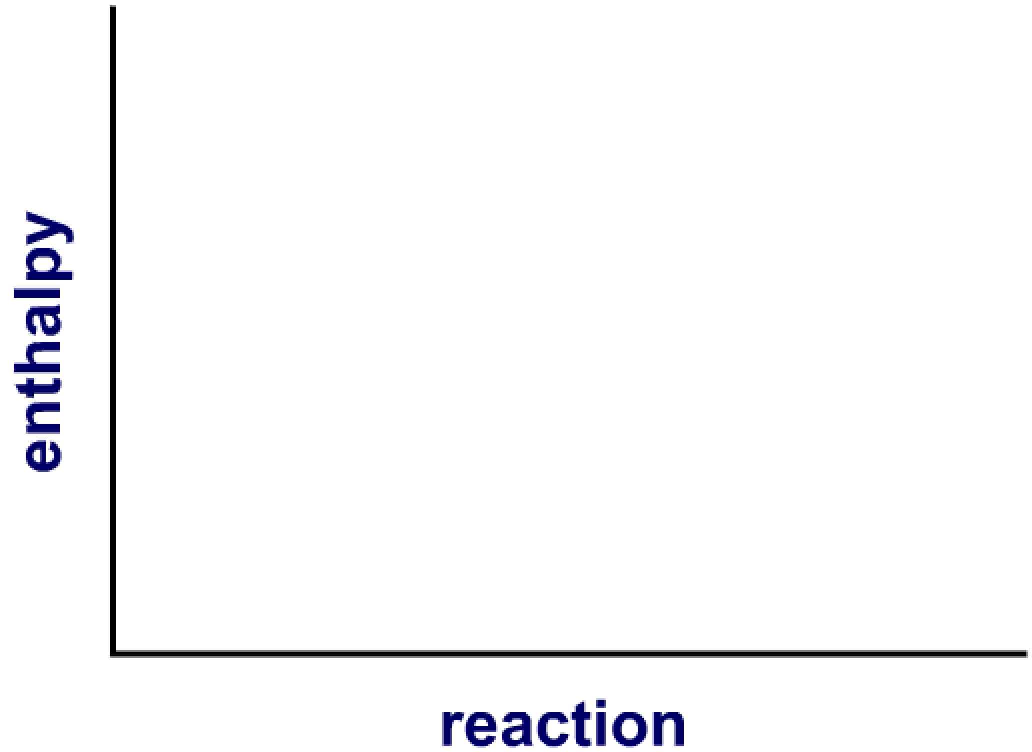
Therefore, enthalpy change is represented by ΔH. It has the units kilojoules per mole ($kJ\,mol^{-1}$).

Standard enthalpy changes are measured at a standard pressure of **100 kPa** and temperature of **298 K**. Standard enthalpy changes are represented by $\Delta H^{\ominus}_{298}$ but this is usually shortened to $\Delta H^{\ominus}$.

Enthalpy level diagram for an exothermic reaction

During a chemical reaction, heat energy may be **released** to the surroundings. This is an **exothermic** reaction.

Click "**play**" to see the enthalpy level diagram.

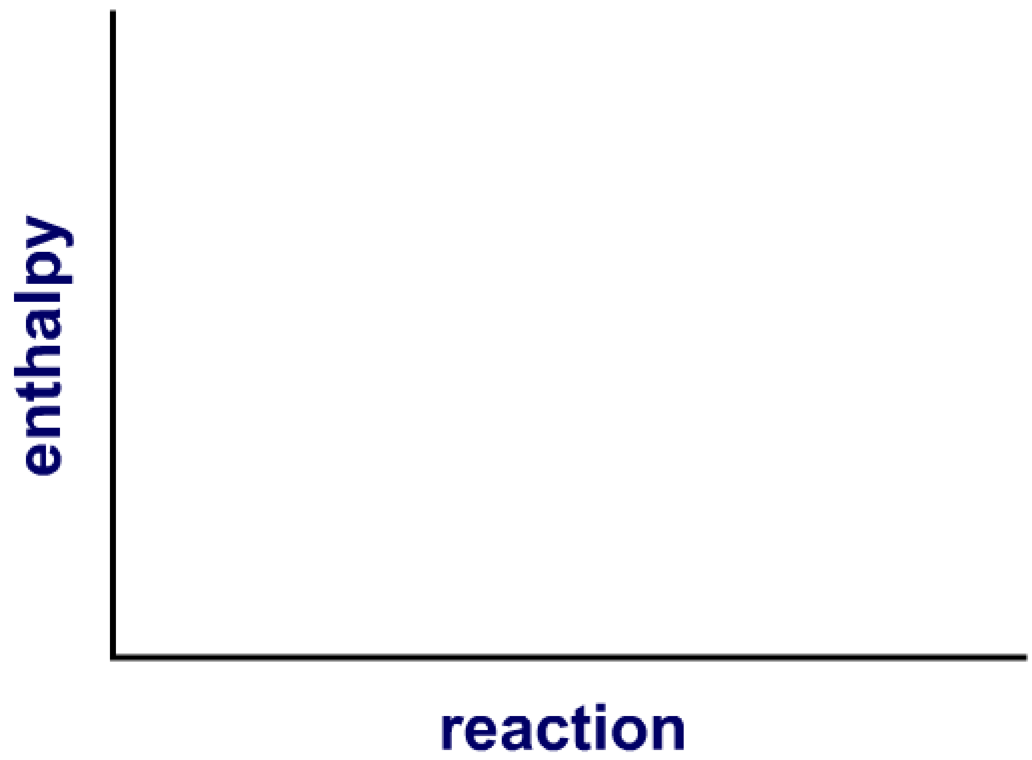


Endothermic reactions

Enthalpy level diagram for an endothermic reaction

During a chemical reaction, heat energy may be **taken in** from the surroundings. This is an **endothermic** reaction.

Click "**play**" to see the enthalpy level diagram.



Do these statements refer to exo- or endothermic reactions?

exothermic	endothermic

reactants have less enthalpy than products

Different types of standard enthalpies

The **standard enthalpy of reaction** is represented by $\Delta H_R^{\ominus}$ or $\Delta H_r^{\ominus}$. The 'r' for reaction is replaced by a specific letter for particular standard enthalpies.

Click a button to find out more about the types of standard enthalpy listed.

$\Delta H_f^{\ominus}$

$\Delta H_c^{\ominus}$

$\Delta H_a^{\ominus}$

$\Delta H_n^{\ominus}$

Standard enthalpies: examples

The **standard enthalpy of formation** of methane can be represented by:

$$C_{(s,\ graphite)} + 2H_{2(g)} \rightarrow CH_{4(g)} \qquad \Delta H_f^{\ominus} = -74.9\ kJ\ mol^{-1}$$

By definition, the standard enthalpy of formation of an element, in its standard state, must be zero.

The **standard enthalpy of combustion** of methane can be represented by:

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)} \qquad \Delta H_c^{\ominus} = -890\ kJ\ mol^{-1}$$

Enthalpy change summary

What are the missing words about enthalpy?

1. The enthalpy change of a reaction is the [A] energy exchange with its surroundings at constant [B].

2. The standard enthalpy of formation, $\Delta H_f^\ominus$, for a compound is the enthalpy change when 1 mole is formed from its [C] under standard conditions, with all substances being in their standard states.

Hess's law and thermodynamics

In 1840, the Russian chemist Germain Hess formulated a law which went on to be known as **Hess's Law**.

Hess's law states that the overall enthalpy change for a reaction is independent of the route the reaction takes.

This went on to form the basis of one of the laws of **thermodynamics**:

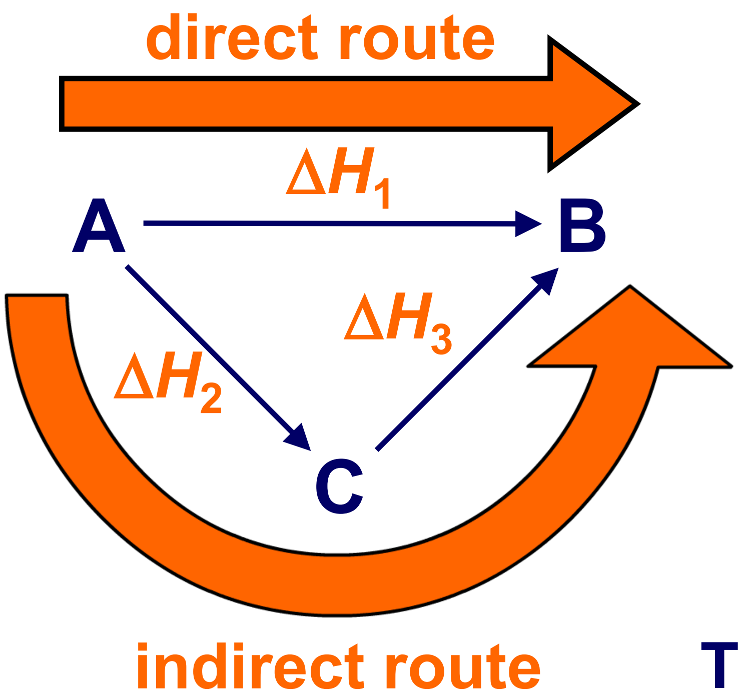
The **first law of thermodynamics** relates to the conservation of energy. It is sometimes expressed in the following form: *Energy cannot be created or destroyed, it can only change form.*

This means that in a closed system, the total amount of energy present is always constant.

Hess's Law and chemical reactions

Hess's law can be used to calculate the standard enthalpy change of a reaction from known standard enthalpy changes.

For example, the enthalpy change for A forming B directly, ΔH_1, is the same as the enthalpy change for the indirect route, $\Delta H_2 + \Delta H_3$.



$A \rightarrow B$ ΔH_1

$A \rightarrow C \rightarrow B$ $\Delta H_2 + \Delta H_3$

Therefore: $\Delta H_1 = \Delta H_2 + \Delta H_3$

Using enthalpy of formation

The standard enthalpy change of a reaction (ΔH_R) can be calculated from the enthalpies of formation of the reactants and products.

Click "**play**" to find out how this is done.

ΔH_R ?

$$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$$