

# AQA Chemistry A-level

## 3.1.4: Energetics

### Detailed Notes

This work by [PMT Education](https://www.pmt.education) is licensed under [CC BY-NC-ND 4.0](https://creativecommons.org/licenses/by-nc-nd/4.0/)





### 3.1.4.1 - Enthalpy Change ( $\Delta H^\circ$ )

In a reaction, bonds are broken and then made. For bonds to be **broken**, energy is **taken in** from the surroundings and when bonds are **formed**, energy is **given out**. The overall energy change of the reaction depends on how much energy is transferred in these processes.

When energy is taken in from the surroundings, the **enthalpy change is positive**. When energy is released, the **enthalpy change is negative**.

Overall enthalpy change ( $\Delta H$ ) can be calculated:

$$\Delta H = \text{energy to break bonds (+ve)} + \text{energy to make bonds (-ve)}$$

#### Measuring Enthalpy Change

Enthalpy is measured under standard conditions of **100 kPa pressure** and a temperature of **298 K**.

#### Enthalpy of Formation ( $\Delta_f H^\circ$ )

This is defined as:

**The enthalpy change when one mole of a substance is produced from its elements under standard conditions.**

#### Enthalpy of Combustion ( $\Delta_c H^\circ$ )

This is defined as:

**The enthalpy change when one mole of a substance is burned completely in oxygen under standard conditions.**

#### Mean Bond Enthalpies

Different covalent bonds require different amounts of energy to be broken. Values can be found experimentally using **calorimetry** methods. The bond enthalpy values calculated in this way often differ from the **data book values** as they are **not exact** and **vary in each situation**. This means the data book values are **averaged values**.

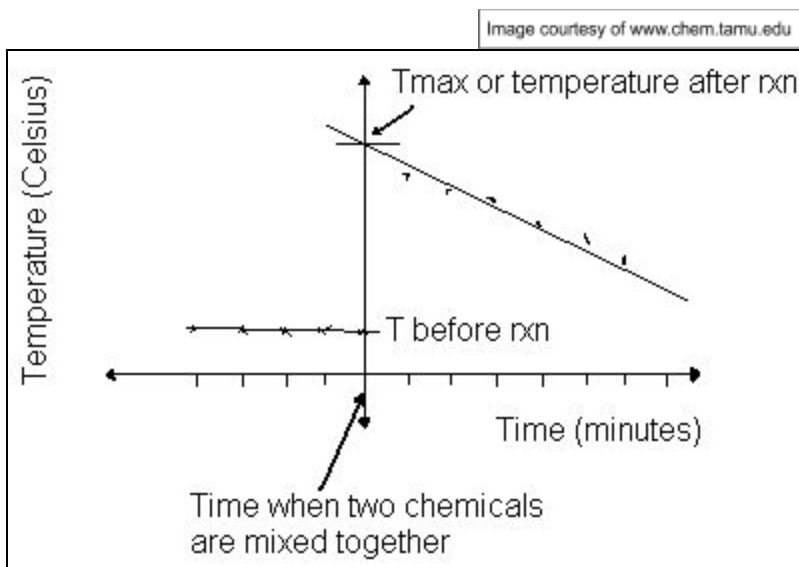




### 3.1.4.2 - Calorimetry

Calorimetry is an **experimental method** for finding enthalpy change by measuring **temperature change over time**. When observed and plotted on a graph, data can be **extrapolated** to give an accurate value for the change in temperature.

*Example:*



This measured change in temperature is **proportional** to the energy change:

$$q = mc\Delta T$$

(q = energy change) (m = mass) (c = specific heat capacity) ( $\Delta T$  = temperature change)

It allows the energy in or out of a substance of known mass to be calculated, which depends on its **specific heat capacity**, defined as:

**The energy required to raise 1g of substance by 1K without a change of state.**

Using this energy value (q), **enthalpy change per mole** of substance can be calculated:

$$\Delta H = \frac{q}{\text{moles}}$$

$\Delta H$  values found using calorimetry are **never completely accurate** as energy is easily lost from the system through **conduction** or **convection** and inaccuracies in measuring temperatures.



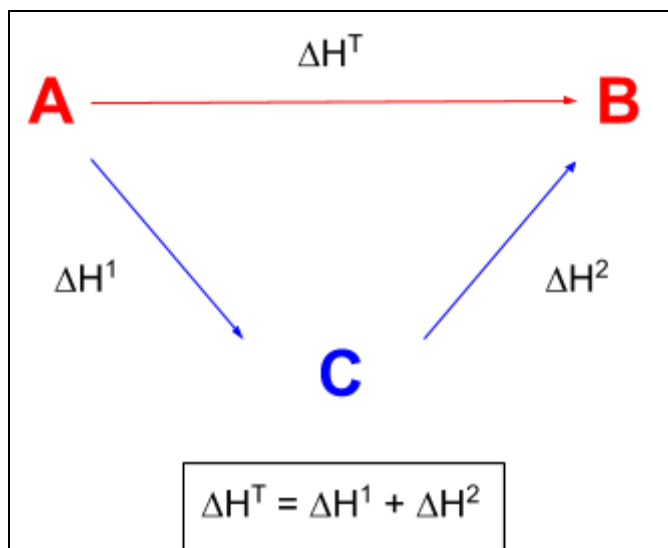


### 3.1.4.3 - Hess's Law

Energy in a reaction system must be **conserved**, as it cannot be created or destroyed. Therefore the **overall enthalpy change** for a reaction is **the same**, regardless of the **route taken**.

This is **Hess's Law** and it is used to determine the enthalpy changes for reactions that cannot be found directly using an experimental method. To do this, a **triangular cycle method** is used with an inbetween product. The direction of the arrows indicates whether the values should be added or taken away. (They can be treated like vectors):

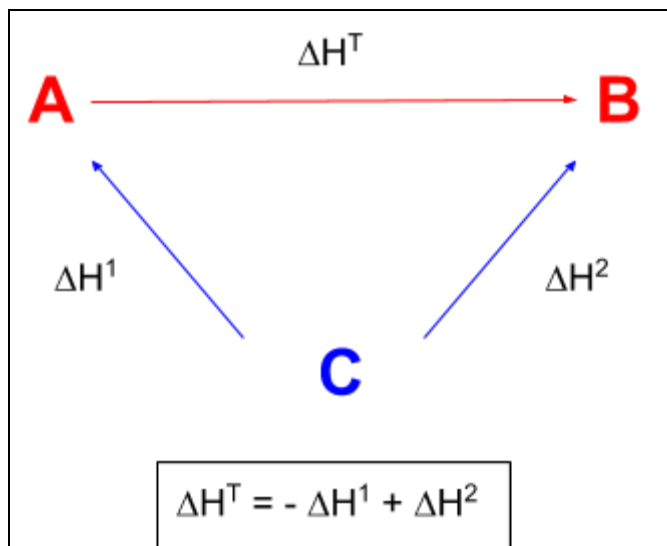
Example:



### Enthalpies of Formation

Hess's law can be used to calculate an enthalpy change using given enthalpies of formation. When setting up the triangular diagram, the **arrows point out from the central product C** as both A and B are formed from the elements at C.

Example:



*Note how  $\Delta H^1$  is subtracted as the reaction goes in the opposite direction to the arrow.*

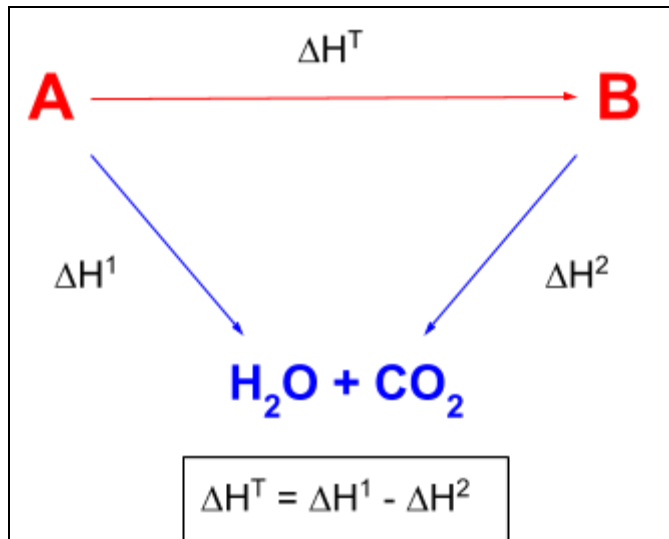




## Enthalpies of Combustion

Hess's law can also be used to calculate an enthalpy change using given enthalpies of combustion. When setting up the triangular diagram, the **arrows point towards the central product (which is always H<sub>2</sub>O and CO<sub>2</sub>)** as both A and B burn to form the products at C.

Example:



*Note how  $\Delta H^2$  is subtracted as the reaction goes in the opposite direction to the arrow.*

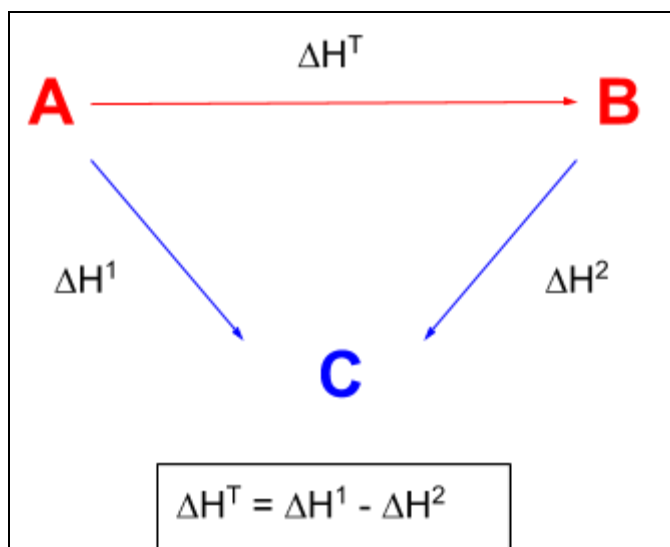
### 3.1.4.4 - Bond Enthalpies

Bond enthalpy data is an **averaged** value representing:

**The energy required to break one mole of the stated bond in a gaseous state, under standard conditions.**

They can be used alongside Hess's Law to find the **overall enthalpy change** for a reaction. The reaction **arrows always point towards the central product**.

Example:



*Note how  $\Delta H^2$  is subtracted as the reaction goes in the opposite direction to the arrow.*

