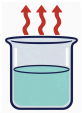
Enthalpy Changes Map

Cambridge International AS & A Level Chemistry · Topic 5 Chemical energetics · Enthalpy changes

1 Enthalpy change, ΔH

5.1.1

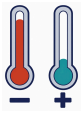
- **ΔH**: heat energy change
- Measured at **constant pressure**
- System: the chemicals
- Surroundings: everything else
- Units: kJ mol^{-1}



2 The sign of ΔH

5.1.1

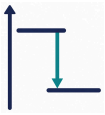
- **Exothermic**: heat out, ΔH **−**
- **Endothermic**: heat in, ΔH **+**
- Surroundings warm: exothermic
- Reverse reaction: sign reverses
- Double the equation: double ΔH

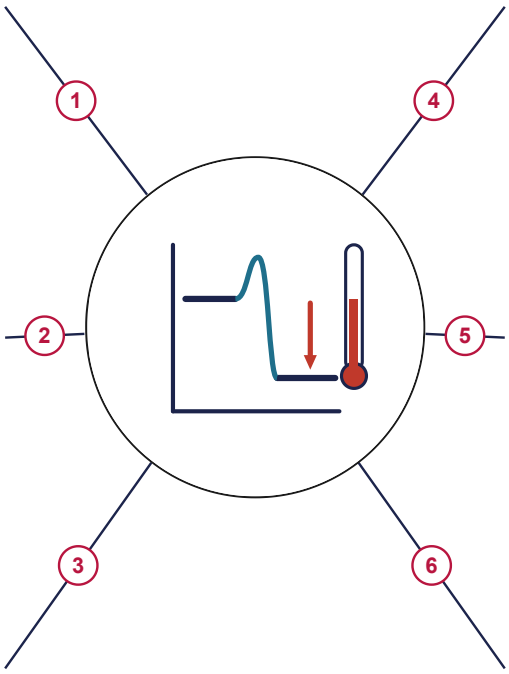


3 Diagrams and E_a

5.1.2

- One axis: **enthalpy, H**
- Exothermic: products **lower**
- Endothermic: products **higher**
- **E_a**: minimum energy to start
- Reverse E_a: from the products





4 Standard conditions

5.1.3

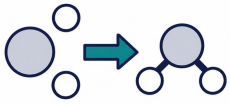
- **101 kPa**
- Usually **298 K**
- Substances in **standard states**
- Solutions 1 mol dm^{-3}
- ⊖ marks a standard value



5 Reaction and formation

5.1.3

- $\Delta H_r^\ominus$: amounts as written
- $\Delta H_f^\ominus$: **1 mol** of compound
- from its **elements** in standard states
- Fractions allowed: ½O_2
- Elements: $\Delta H_f^\ominus = 0$



6 Combustion and neutralisation

5.1.3

- $\Delta H_c^\ominus$: 1 mol burned completely
- Products: CO_2 and **$H_2O(l)$**
- $\Delta H_{neut}^\ominus$: **1 mol of water**
- Combustion: always exothermic
- One equation, two names



The four standard enthalpy changes

each is per mole of the species in bold; under standard conditions

Change	Per mole of	Example equation	Sign
$\Delta H_r^\ominus$	the equation as written	$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	either
$\Delta H_f^\ominus$	**compound** formed	$C(s) + 2H_2(g) \rightarrow CH_4(g)$	usually −
$\Delta H_c^\ominus$	**substance** burned	$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$	always −
$\Delta H_{neut}^\ominus$	**water** formed	$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$	always −

Reading ΔH

Reverse it

- $N_2 + 3H_2 \rightarrow 2NH_3$: −92
- $2NH_3 \rightarrow N_2 + 3H_2$
- **+92 kJ mol^{-1}**

Scale it

- $2NH_3$ formed: −92
- $\Delta H_f^\ominus$ is for 1 mol
- **−46 kJ mol^{-1}**

Two names

- $C(s) + O_2(g) \rightarrow CO_2(g)$
- $\Delta H_c^\ominus$ of carbon
- = **$\Delta H_f^\ominus$ of CO_2**

These definitions are measured by calorimetry and combined with Hess's law in the next two sections.

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