Hess's Law Map

Cambridge International AS & A Level Chemistry · Topic 5 Chemical energetics · Hess's law

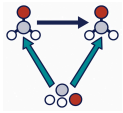
1 Hess's law 5.2.1

- ΔH is **independent of the route**
- Same start, same end
- Because energy is conserved
- Finds ΔH that cannot be measured
- Against an arrow: change sign



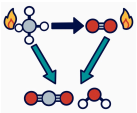
2 Formation cycles 5.2.2

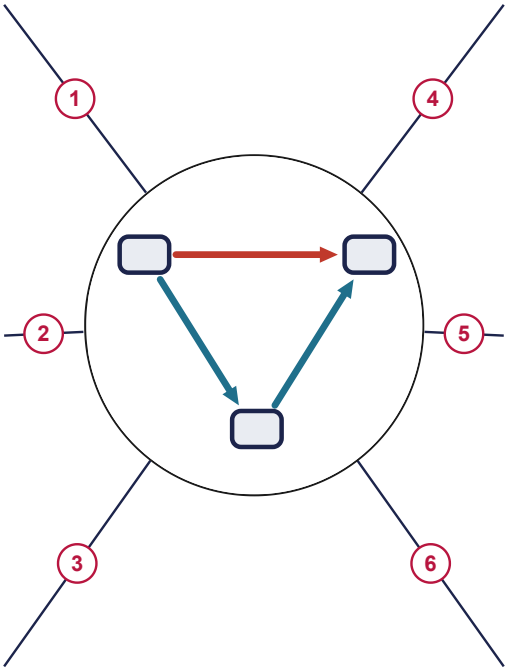
- **Elements** at the bottom
- ΔH_f arrows point **up**
- Multiply by coefficients
- Elements: $\Delta H_f = 0$
- **Products − reactants**



3 Combustion cycles 5.2.2

- **CO_2 + $H_2O(l)$** at the bottom
- ΔH_c arrows point **down**
- O_2 has no ΔH_c
- Gives ΔH_f of organic compounds
- **Reactants − products**





4 Combining equations 5.2.2

- Add equations to reach the target
- **Reverse**: change the sign
- **Multiply**: multiply ΔH
- Cancel species on both sides
- Check the target at the end



5 Hess's law practical 5.2.2

- Target: $2KHCO_3 \rightarrow K_2CO_3 + CO_2 + H_2O$
- Each solid + **excess HCl**
- ΔH_1 ($KHCO_3$): positive
- ΔH_2 (K_2CO_3): negative
- **$\Delta H_r = 2\Delta H_1 - \Delta H_2$**



6 Evaluating the result 5.1.7

- Corrected ΔT from graphs
- Heat exchange: main error
- Smaller ΔT: bigger % uncertainty
- % difference from data value
- Lid, probe, more solid



Which rule?

Δ in kJ mol⁻¹; always multiply each value by its coefficient

Data given	Third corner	Arrows	ΔH =	Example
ΔH_f	the elements	up	$\Sigma\Delta H_f$(prod) − $\Sigma\Delta H_f$(react)	$CaCO_3 \rightarrow CaO + CO_2$: +178
ΔH_c	combustion products	down	$\Sigma\Delta H_c$(react) − $\Sigma\Delta H_c$(prod)	$\Delta H_f(C_2H_6)$: −86
ΔH of solution	the aqueous solution	down	$\Delta H_1 - \Delta H_2$	$CuSO_4 + 5H_2O$: −78.2
ΔH with acid (practical)	$KCl(aq) + CO_2 + H_2O$	down	$2\Delta H_1 - \Delta H_2$	$2KHCO_3 \rightarrow \ldots$: +91

Worked cycles

Formation

- $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
- −966 − (−75)
- **−891 kJ mol⁻¹**

Combustion

- $2C + 3H_2 \rightarrow C_2H_6$
- −1646 − (−1560)
- **−86 kJ mol⁻¹**

Equations

- $2NO_2 \rightarrow N_2O_4$
- −66 + 9
- **−57 kJ mol⁻¹**

The next section estimates ΔH another way: from the bonds broken and made.

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