

5.2 Hess's law

Name: _____ Class: _____ Date: _____

Total: 20 marks

KEY WORDS hess's law 盖斯定律 • energy cycle 能量循环 • enthalpy change 焓变
• enthalpy change of formation 生成焓变 • exothermic 放热

Objective

Build the skills to answer exam questions on **Hess's law** 盖斯定律 — constructing **energy cycles** 能量循环 and calculating enthalpy changes from formation and combustion data.

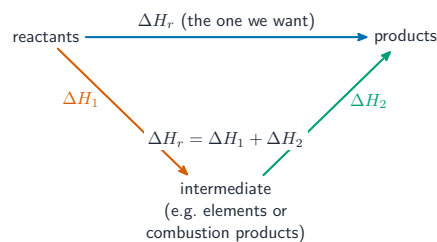
You must be able to:

- state Hess's law and construct simple energy cycles
- calculate an enthalpy change that cannot be measured directly
- use formation or combustion data (and bond energies) in a cycle

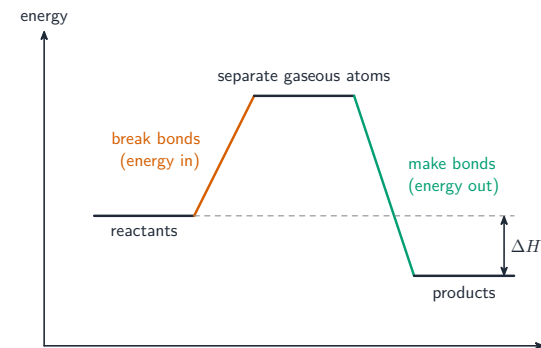
1 Worked examples

■ Hess's law

Hess's law: the total enthalpy change is the same whatever the route from reactants to products (energy is conserved).



The direct route equals the indirect route: $\Delta H_r = \Delta H_1 + \Delta H_2$



Bond energies feed an enthalpy (Hess) cycle

■ Using formation data

$$\Delta H_r = \sum \Delta H_f(\text{products}) - \sum \Delta H_f(\text{reactants})$$

Example. $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ (ΔH_f / kJ mol^{-1} : CaCO_3 -1207 , CaO -635 , CO_2 -394): $\Delta H_r = (-635 - 394) - (-1207) = +178 \text{ kJ mol}^{-1}$.

■ Using combustion data

$$\Delta H_r = \sum \Delta H_c(\text{reactants}) - \sum \Delta H_c(\text{products})$$

2 Practice

2.1 State Hess's law.

[1]

2.2 Give **one** reason Hess's law is useful (something it lets you find).

[1]

3 Exam-style questions

3.1 Hess's law is a consequence of:

[1]

- | | |
|---|---|
| A | B |
| C | D |
- A the conservation of mass
B the conservation of energy
C the ideal gas equation
D Avogadro's law

3.2 ΔH_r from formation data is calculated as:

[1]

- | | |
|---|---|
| A | B |
| C | D |
- A $\sum \Delta H_f(\text{reactants}) - \sum \Delta H_f(\text{products})$
B $\sum \Delta H_f(\text{products}) - \sum \Delta H_f(\text{reactants})$
C $\sum \Delta H_c(\text{products}) - \sum \Delta H_c(\text{reactants})$
D $mc\Delta T$

3.3 For $\text{C}_2\text{H}_4 + \text{H}_2 \rightarrow \text{C}_2\text{H}_6$, use ΔH_f (kJ mol^{-1} : C_2H_4 +52, C_2H_6 -85, H_2 0) to calculate ΔH_r .

[3]

3.4 Explain why Hess's law allows the enthalpy change of formation of a compound to be found even when the reaction cannot be carried out directly.

[2]

3.5 Use the standard enthalpy changes of formation below.

Compound	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$
$\text{CH}_3\text{OH}(\text{l})$	-239
$\text{CO}_2(\text{g})$	-394
$\text{H}_2\text{O}(\text{l})$	-286

(a) Write the equation for the complete combustion of methanol, then construct an energy cycle through the elements and use it to calculate $\Delta H_c^\ominus$ for methanol.

[5]

(b) Explain why $\Delta H_f^\ominus$ of $\text{O}_2(\text{g})$ is zero.

[2]

(c) A school laboratory obtains -690 kJ mol^{-1} . State whether that is more or less exothermic than your answer, and give one reason for the difference.

[2]

(d) State the principle that allows this calculation even though methanol is never actually burned along the route you drew.

[2]