

# 6 Finding enthalpy changes – Part 2

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English               | 中文   | Write it 3 times (English) |
|-----------------------|------|----------------------------|
| enthalpy of reaction  | 反应焓  | _____                      |
| enthalpy of formation | 生成焓  | _____                      |
| Hess's law            | 盖斯定律 | _____                      |

## Recall

In Part A you measured reaction heat. Now **calculate** it from data:

- Breaking bonds takes in energy; making bonds gives energy out.
- You have used bond energies before to estimate a reaction's energy change.

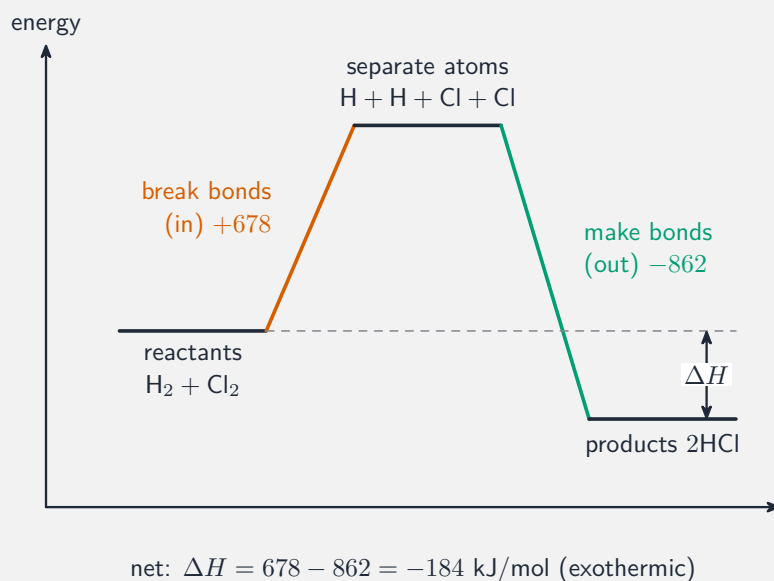
Each idea has a worked example before the Practice.

## New ideas

### ■ 1 Bond enthalpies

The **enthalpy of reaction** 反应焓  $\Delta H$  can be estimated from bond energies: add the energy to **break** all reactant bonds, then subtract the energy **released** forming the product bonds:

$$\Delta H \approx \sum(\text{bonds broken}) - \sum(\text{bonds formed}).$$



*Worked example.* For  $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$  (H-H = 436, Cl-Cl = 242, H-Cl = 431 kJ/mol): broken = 436 + 242 = 678; formed =  $2 \times 431 = 862$ ;  $\Delta H \approx 678 - 862 = -184 \text{ kJ}$  (exothermic).

## ■ 2 Enthalpy of formation

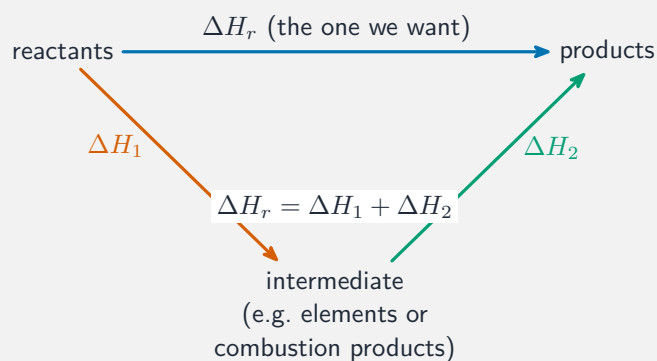
The **enthalpy of formation** 生成焓  $\Delta H_f$  is the energy to make one mole of a compound from its elements. A reaction's enthalpy is

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

*Worked example.* For  $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$  ( $\Delta H_f$ :  $\text{CH}_4 = -75$ ,  $\text{CO}_2 = -394$ ,  $\text{H}_2\text{O} = -286$ ,  $\text{O}_2 = 0$ ):  $\Delta H = [-394 + 2(-286)] - [-75] = -966 + 75 = -891 \text{ kJ}$ .

## ■ 3 Hess's law

**Hess's law** 盖斯定律 says that if a reaction is the sum of several steps, its  $\Delta H$  is the sum of the steps'  $\Delta H$  values –no matter what route is taken.



**Watch out:** breaking a bond **takes in** energy (positive) and forming a bond **releases** energy (negative). If the bonds formed are stronger than the bonds broken, the reaction is exothermic overall.

## Practice

Try these in order. The methods are all above.

**2.1** State whether breaking a bond takes in or gives out energy, and do the same for forming a bond. [2]

**2.2** A reaction breaks bonds worth 500 kJ and forms bonds worth 650 kJ. Find  $\Delta H$  and state whether it is exothermic. [3]

**2.3** For  $\text{H}_2 + \text{Br}_2 \rightarrow 2\text{HBr}$  ( $\text{H-H} = 436$ ,  $\text{Br-Br} = 193$ ,  $\text{H-Br} = 366$  kJ/mol), estimate

$\Delta H$ .

[3]

**2.4** State what Hess's law tells you about the enthalpy change of a reaction that goes in several steps. [1]

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