

6 Finding enthalpy changes – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	Write it 3 times (English)
enthalpy of reaction	_____
enthalpy of formation	_____
Hess's law	_____

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.

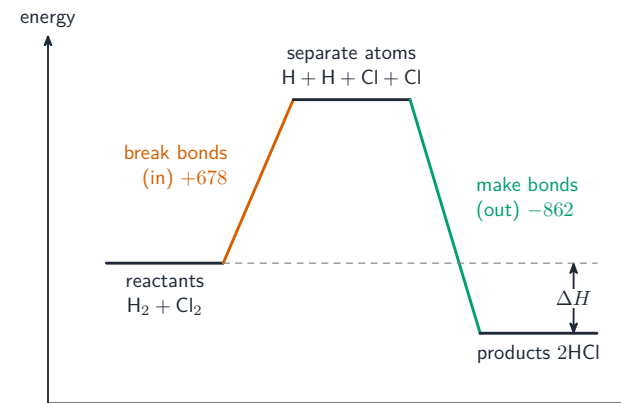
Each idea has a worked example before the Practice.

New ideas

■ 1 Bond enthalpies

The **enthalpy of reaction** ΔH can be estimated from bond energies: add the energy to **break** all reactant bonds, then subtract the energy **released** forming the product bonds:

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



$$\text{net: } \Delta H = 678 - 862 = -184 \text{ kJ/mol (exothermic)}$$

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

■ 2 Enthalpy of formation

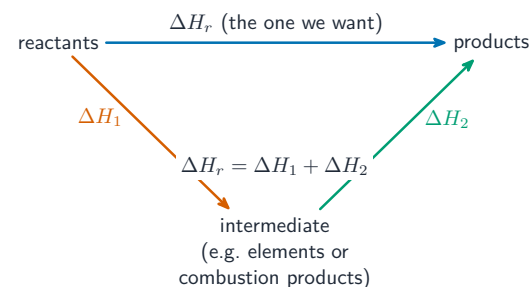
The **enthalpy of formation** ΔH_f is the energy to make one mole of a compound from its elements. A reaction's enthalpy is

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

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

■ 3 Hess's law

Hess's law says that if a reaction is the sum of several steps, its ΔH is the sum of the steps' ΔH 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 ΔH 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 ΔH . ^[3]

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