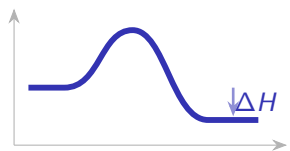
Chemical Energetics

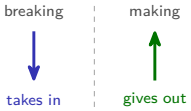
IGCSE Chemistry ▪ Topic 5

IGCSE Chemistry



What we will cover

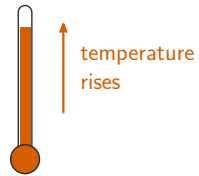
1. Exothermic vs endothermic
2. Enthalpy change ΔH
3. Activation energy
4. Reaction pathway diagrams
5. Bonds & energy



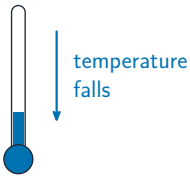
bonds and energy

1 Direction of energy

Exothermic vs endothermic



exothermic
heat given out, so the surroundings get hotter
($\Delta H < 0$)

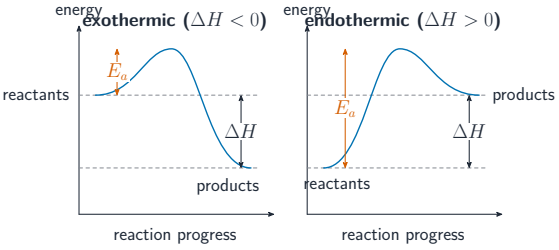


endothermic
heat taken in, so the surroundings get colder
($\Delta H > 0$)

- An **exothermic reaction** 放热反应 gives out **thermal energy** 热能 to the **surroundings** 环境. So the temperature of the surroundings goes **up**.
- An **endothermic reaction** 吸热反应 takes in thermal energy from the surroundings. So the temperature of the surroundings goes **down**.

Reaction pathway diagrams

- The line starts at the energy level of the **reactants** 反应物.
- It rises over a 'hill' – the height of this hill is the activation energy E_a.
- It then falls or rises to the energy level of the **products** 生成物.
- The gap between the reactant level and the product level is the enthalpy change ΔH.



2 Bonds

Bonds and energy

bond breaking 断键

takes energy in – endothermic

bond making 成键

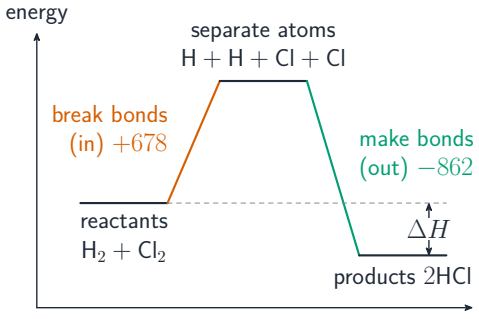
gives energy out – exothermic

$\Delta H =$ (energy to break bonds) $-$ (energy released making bonds). More out than in $\Rightarrow$ exothermic.



Exothermic reactions release energy as heat

Worked example: $H_2 + Cl_2 \rightarrow 2HCl$



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

Bond energies (kJ/mol)

broken: H–H + Cl–Cl = $436 + 242 = 678$

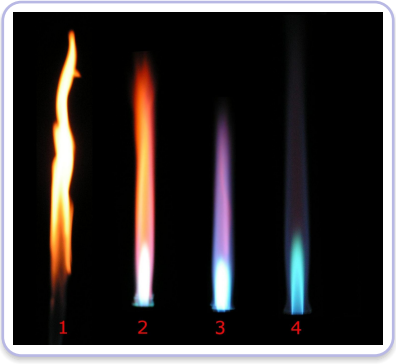
made: $2\times$H–Cl $= 862$

$\Delta H = 678 - 862 = \mathbf{-184}$

negative $\Rightarrow$ exothermic

Breaking bonds takes energy in $(+678)$; making bonds gives more out (-862); so $\Delta H = -184$ kJ/mol

Breaking and making bonds



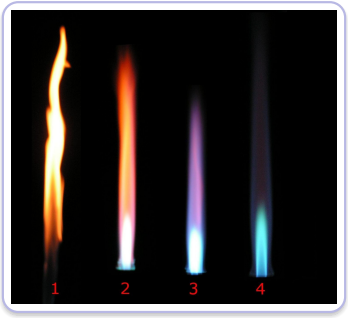
Breaking and making bonds transfers energy – the flame supplies it here.

Exothermic, endothermic, and activation energy

exothermic	gives out heat, so the surroundings warm and ΔH is negative
the examples	**combustion** 燃烧 – burning a fuel – and **neutralisation** 中和, an acid reacting with an alkali
endothermic	takes in heat, so the surroundings cool and ΔH is positive
the examples	thermal **decomposition** 分解, and photosynthesis
activation energy 活化能	E_a – the smallest energy **colliding** 碰撞 **particles** 粒子 must have to react at all
bond energy 键能	breaking bonds takes in energy, making them gives out energy – and the difference is ΔH

ΔH = energy in to break bonds − energy out from making them. Getting that subtraction the right way round decides the sign.

Enthalpy change, ΔH



A Bunsen flame supplies energy: enthalpy change ΔH is the heat transferred at constant pressure

Exam tips

- **Exothermic** gives out heat, so the surroundings warm up and ΔH is *negative*; **endothermic** takes in heat, so the surroundings cool and ΔH is *positive*.
- **Bond breaking** takes energy in (endothermic); **bond making** gives energy out (exothermic). Use
  $\Delta H =$ (energy to break bonds) $-$ (energy released making bonds).
- If more energy is released making bonds than is used breaking them, the reaction is exothermic. Always check the sign of your final answer.
- On a **reaction pathway diagram**, an exothermic reaction ends *lower* than it starts; an endothermic one ends *higher*. The height of the hill is the **activation energy**.

3 Recap

Topic 5 – key takeaways

1 Exo & endo

out warms ($\Delta H < 0$); in cools ($\Delta H > 0$)

2 Pathway

hill $= E_a$; reactant-product gap $= \Delta H$

3 Bonds

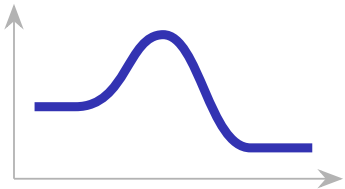
breaking takes in, making gives out

4 ΔH

break minus make energy

Check yourself

1. What sign is ΔH for an exothermic reaction?
2. What does the hill height represent?
3. Is bond breaking endothermic or exothermic?
4. If 678 kJ goes in and 862 kJ comes out, what is ΔH?



Answers **1.** negative **2.** the activation energy E_a **3.** endothermic **4.** -184 kJ/mol (exothermic)