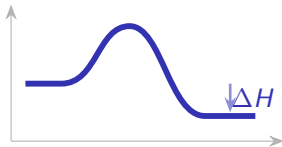


Chemical Energetics

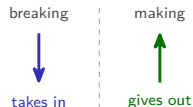
IGCSE Chemistry ■ Topic 5

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



Exothermic vs endothermic



temperature
rises

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



temperature
falls

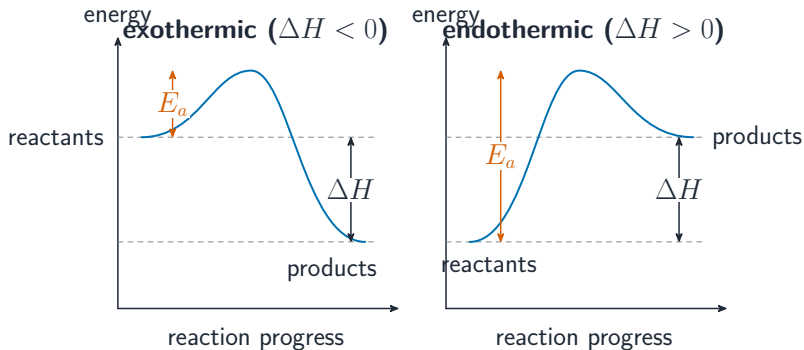
endothermic
heat taken in, so
the surroundings
get colder
($\Delta H > 0$)

- An **exothermic reaction** gives out **thermal energy** to the **surroundings**. So the temperature of the surroundings goes **up**.
- An **endothermic reaction** 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** .
- 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** .
- The gap between the reactant level and the product level is the enthalpy change ΔH .

Reaction pathway diagrams, in detail



It rises over a 'hill' – the height of this hill is the activation energy E_a .



Bonds and energy

bond breaking

takes energy **in** – endothermic

bond making

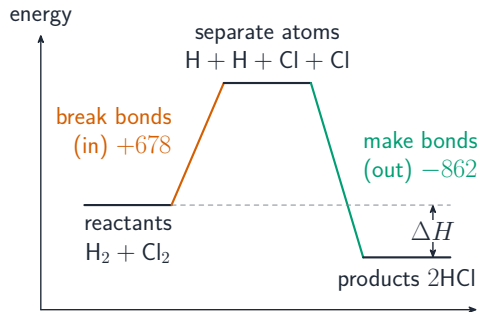
gives energy **out** – exothermic

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



Exothermic reactions release energy as heat

Worked example: $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$



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

Bond energies (kJ/mol)

broken: $\text{H}-\text{H} + \text{Cl}-\text{Cl} = 436 + 242 = 678$

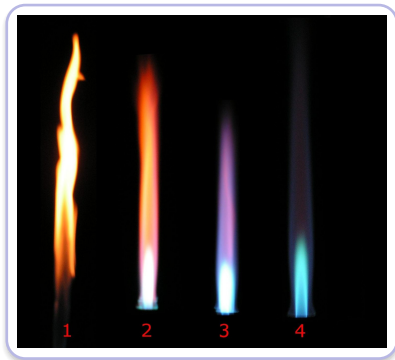
made: $2 \times \text{H}-\text{Cl} = 862$

$\Delta H = 678 - 862 = -184$

negative $\Rightarrow$ exothermic

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

Bonds and energy, continued



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 – burning a fuel – and **neutralisation**, an acid reacting with an alkali

endothermic

takes in heat, so the surroundings cool and ΔH is **positive**

the examples

thermal **decomposition**, and photosynthesis

activation energy

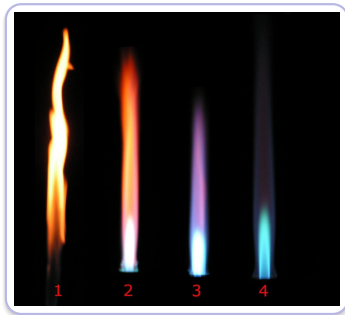
E_a – the **smallest** energy **colliding particles** must have to react at all

bond energy

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
$$\Delta H = (\text{energy to break bonds}) - (\text{energy released making bonds}).$$
- 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**.



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 = ΔH

3

Bonds

breaking takes in, making gives out

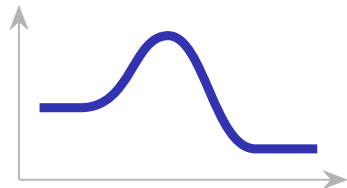
4

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)