# Chemical Energetics

IGCSE Chemistry ▪ Topic 5

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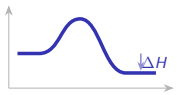





## What we will cover

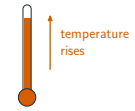
1. Exothermic vs endothermic
2. Enthalpy change $\Delta H$
3. Activation energy
4. Reaction pathway diagrams
5. Bonds & energy


*bonds and energy*

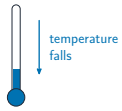
# 1 Direction of energy



## 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**.

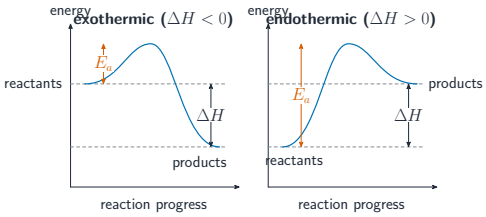


## Reaction pathway diagrams

- 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 $\Delta H$.



## Reaction pathway diagrams, in detail




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

# 2 Bonds



## Bonds and energy

**bond breaking 断键**
takes energy in – endothermic

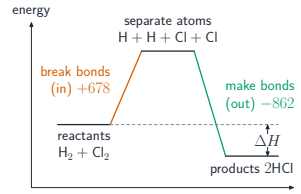
**bond making 成键**
gives energy out – exothermic

> $\Delta H$ = (energy to break bonds) − (energy released making bonds). More out than in ⇒ 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 $= 862$

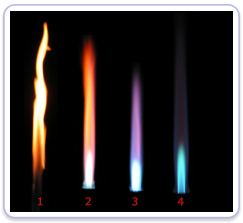
$\Delta H = 678 - 862 = \mathbf{-184}$

negative ⇒ exothermic

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



## Bonds and energy, continued




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



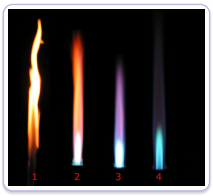
## Exothermic, endothermic, and activation energy

| | |
|---|---|
| **exothermic** | gives out heat, so the surroundings warm and $\Delta H$ 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 $\Delta H$ 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 $\Delta H$ |

> $\Delta H$ = 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 $\Delta H$ is *negative*; **endothermic** takes in heat, so the surroundings cool and $\Delta H$ 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



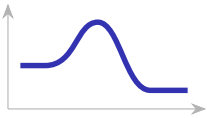
## Topic 5 – key takeaways

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. $\Delta H$
   break minus make energy



## Check yourself

1. What sign is $\Delta H$ 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 $\Delta H$?



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