

Physical chemistry

Pearson Edexcel · International GCSE · Chemistry

Energy, speed and balance

Three questions decide whether a reaction is useful: does it heat or cool, how fast is it, and does it finish? Physical chemistry answers them – calorimetry and $Q = mc\Delta T$, collision theory with its four levers, and the dynamic equilibrium a reversible reaction reaches in a closed vessel.

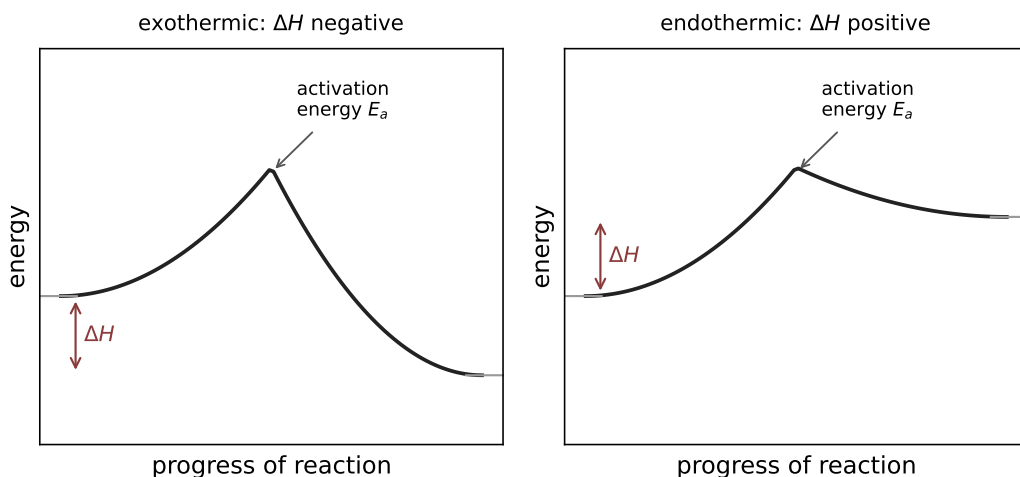
Edexcel International GCSE Chemistry 4CH1, Section 3 (statements 3.1–3.22C) is short but calculation-heavy. C-suffixed statements are Chemistry-only.

Energetics

Exothermic reactions give out heat (combustion, neutralisation, most displacements) – the mixture warms, ΔH is negative. **Endothermic** reactions take heat in (thermal decomposition, some dissolving) – the mixture cools. Simple **calorimetry** : measure the temperature change of a known mass (polystyrene cup for solutions; spirit burner under a water beaker for combustion).

$$Q = mc\Delta T$$

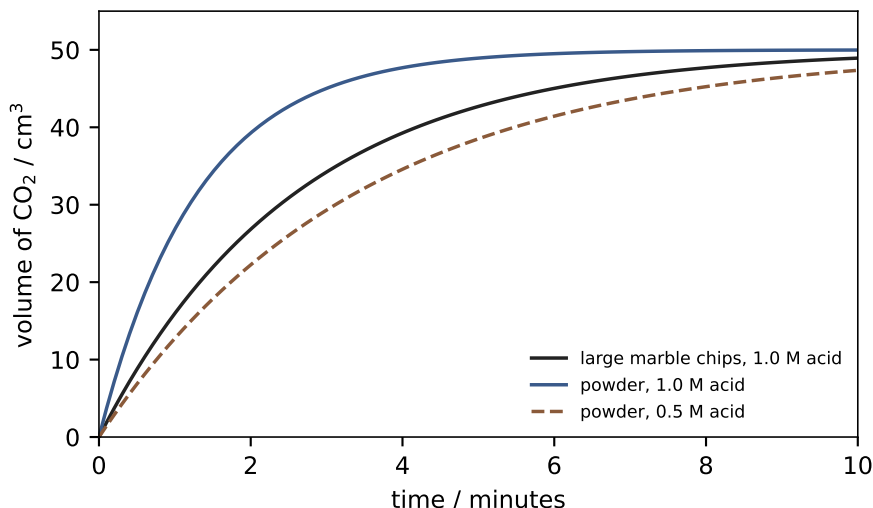
Worked check. 50 g of water rises 24 °C in a spirit-burner trial: $Q = 50 \times 4.2 \times 24 = 5040$ J. If 0.010 mol of fuel burned: $\Delta H = -5040/0.010 = -504\,000$ J mol⁻¹ = -504 kJ mol⁻¹.



(C) **Bond breaking is endothermic; bond making is exothermic.** $\Delta H = \text{bonds broken} - \text{bonds formed}$. **Worked check.** $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$: broken 436 + 242 = 678; formed $2 \times 431 = 862$; $\Delta H = 678 - 862 = -184$ kJ/mol (exothermic).

Rates of reaction

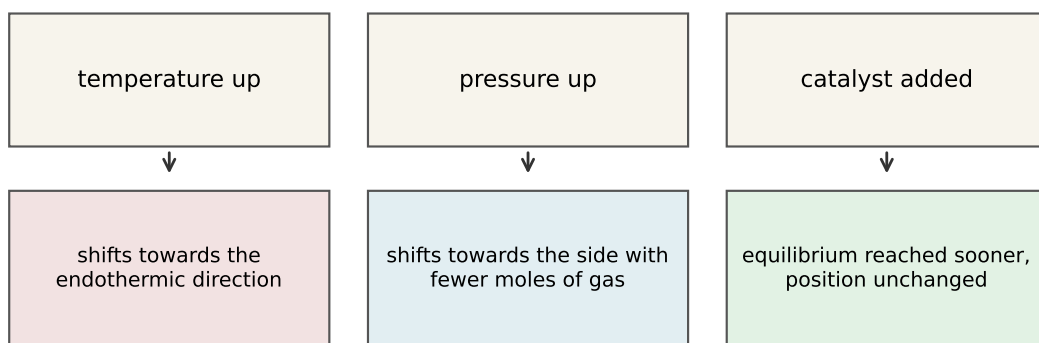
Experiments follow a reaction that is visible: gas volume (marble + acid), mass loss on a balance, or disappearing cross (sodium thiosulfate + acid). Four levers: **surface area** of a solid, **concentration** (or gas pressure), **temperature**, and a **catalyst**



Collision theory explains them all: reactions need collisions with at least the **activation energy**. Powder gives more exposed surface → more collisions per second; higher concentration or pressure packs particles closer → more frequent collisions; higher temperature makes particles faster → collisions both more frequent and more energetic – the only lever that raises the *fraction* of successful collisions. A catalyst provides an **alternative pathway with lower activation energy** – more collisions succeed – and is chemically unchanged at the end; it does not change the amount of product, only how fast it appears.

Reversible reactions and equilibria

A reversible reaction ($\rightleftharpoons$) runs both ways: hydrated copper(II) sulfate $\rightleftharpoons$ anhydrous salt + water (heat drives it forward, water reverses it); ammonium chloride $\rightleftharpoons$ ammonia + hydrogen chloride on heating. (C) In a **sealed container** it reaches **dynamic equilibrium**: forward and reverse rates are equal, and all concentrations stay constant – both reactions still run.



(C) **Temperature up** → equilibrium shifts in the **endothermic** direction; **pressure up** → shifts towards the side with **fewer moles of gas**; a **catalyst** speeds both directions equally and leaves the position unchanged.

Check yourself

1. Classify as exo- or endothermic: combustion, thermal decomposition, neutralisation.
2. 100 g of water cools by 8.0 °C in a dissolving experiment. Calculate Q .
3. (C) State the sign of ΔH for bond breaking and bond making.
4. Use bond energies to find ΔH for $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ (H–H 436, O=O 498, O–H 463 kJ/mol).
5. Why does powdered marble react faster with acid than one large chip?
6. Which rate lever increases the fraction of successful collisions, and why?
7. Define a catalyst.
8. (C) State the two characteristics of dynamic equilibrium.
9. (C) $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$: what does raising the pressure do, and why?
10. (C) Why does a catalyst not change the position of equilibrium?

Answers: 1 exothermic (combustion), endothermic (thermal decomposition), exothermic (neutralisation); 2 $Q = 100 \times 4.2 \times 8.0 = 3360 \text{ J}$ taken in – the water cools, so the dissolving is endothermic; 3 (C) breaking positive (endothermic), making negative (exothermic); 4 broken: $2(436) + 498 = 1370$; formed: $4(463) = 1852$; $\Delta H = 1370 - 1852 = -482 \text{ kJ/mol}$ (per 2 mol H_2O); 5 powder exposes far more surface, so more acid collisions per second; 6 temperature – faster particles collide more often AND more collisions exceed the activation energy; 7 a substance that increases the rate but is chemically unchanged at the end; 8 (C) forward and reverse rates equal; concentrations of all substances constant; 9 (C) shifts right – 4 moles of gas on the left, 2 on the right, so higher pressure favours the fewer-mole side.

Answers continued: 10 (C) it lowers the activation energy of forward and reverse equally, speeding both without changing their balance.