

2.4.1 Rates: gradients, energy distributions and catalysts

Name: _____ Class: _____ Date: _____

Total: 15 marks

KEY WORDS activation energy

Objective

Choose the correct rate measure and explain collision and catalyst evidence. All questions and marking guidance are original.

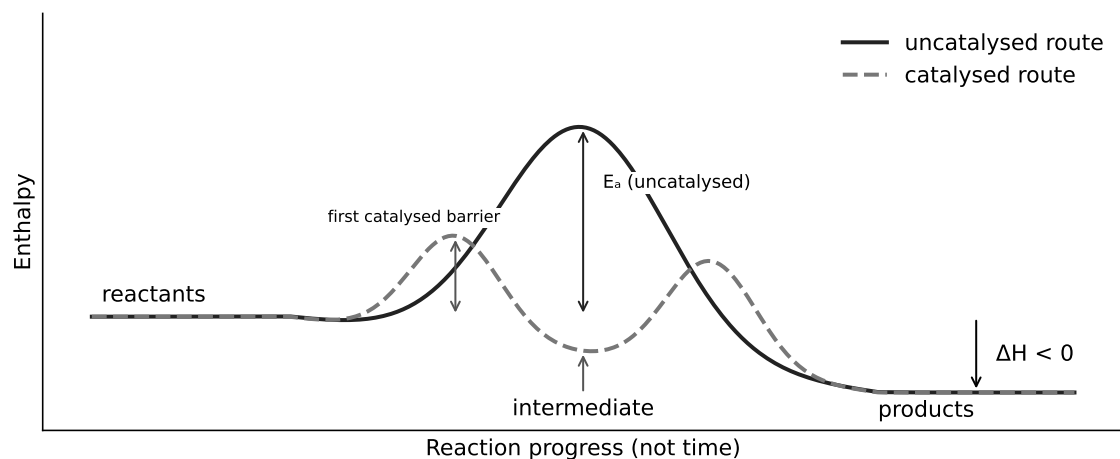
1 Key knowledge and worked examples

Successful collisions need enough energy and suitable orientation. Concentration, gas pressure and exposed surface affect collision frequency. Higher temperature increases the fraction above activation energy.

■ Worked method

A tangent to a gas-volume curve passes through (10 s, 12 cm³) and (50 s, 36 cm³).
 $\text{rate} = \Delta V / \Delta t = (36 - 12) / (50 - 10) = 0.60 \text{ cm}^3 \text{ s}^{-1}$. The points must lie on the tangent, not just the curve.

For a fixed endpoint, $1/t$ is a comparative rate in s⁻¹. A catalyst lowers the pathway barrier; it does not change the energy distribution at fixed temperature, the net enthalpy or the equilibrium composition. A catalysed pathway can pass through an intermediate.



2 Practice

2.1 Two trials reach the same visible endpoint in 40 s and 25 s. Calculate their comparative rates and their rate ratio, second/first. [3]

2.2 Explain why powdered calcium carbonate reacts faster than equal mass of large chips with the same excess acid. [2]

2.3 State two changes in a Maxwell–Boltzmann curve on raising temperature for the same number of molecules, and identify the area relevant to successful collisions. [3]

3 Exam-style questions

3.1 A gas-volume tangent passes through (20 s, 18 cm³) and (80 s, 42 cm³). Calculate instantaneous rate. Explain why (final volume)/(total time) answers a different question. [3]

3.2 A catalyst gives a two-step exothermic route. Draw the uncatalysed and two-step catalysed profiles on the same labelled axes, including the intermediate, and explain two different possible industrial benefits without saying a catalyst always raises atom economy. [4]

Solutions

Original marking guidance: M1 method, A1 accuracy, B1 explanation.

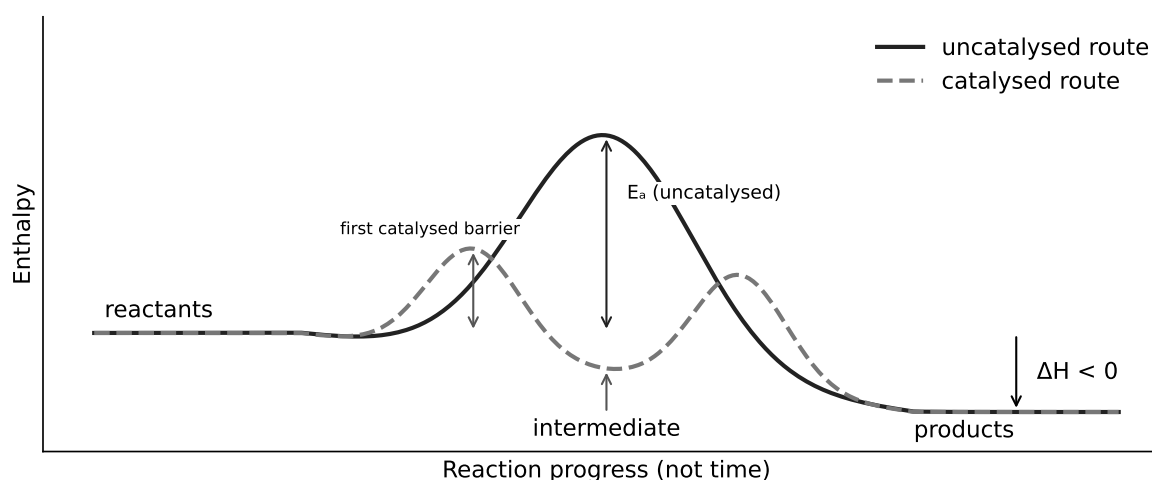
2.1 $1/40 = 0.0250 \text{ s}^{-1}$; $1/25 = 0.0400 \text{ s}^{-1}$; ratio $0.0400/0.0250 = 1.60$.

2.2 Powder has greater exposed surface area, so acid particles collide with accessible carbonate more frequently. It does not automatically increase the final CO_2 amount.

2.3 Peak becomes lower and shifts to higher energy. Area beyond the activation threshold increases; total area remains constant.

3.1 $\text{rate} = \Delta V/\Delta t = (42 - 18)/(80 - 20) = 0.40 \text{ cm}^3 \text{ s}^{-1}$. Final volume/time is an average over the whole interval, not the local tangent rate.

3.2



Two catalysed maxima with an intermediate minimum; lower activation barriers and unchanged initial/final levels/ ΔH . Adequate rate at lower temperature saves energy. A selective catalyst may reduce unwanted products and improve atom economy; this depends on the reaction pathways.