Exercise walk-through

Homogeneous and heterogeneous catalysts ▪ 8.3

eXercise

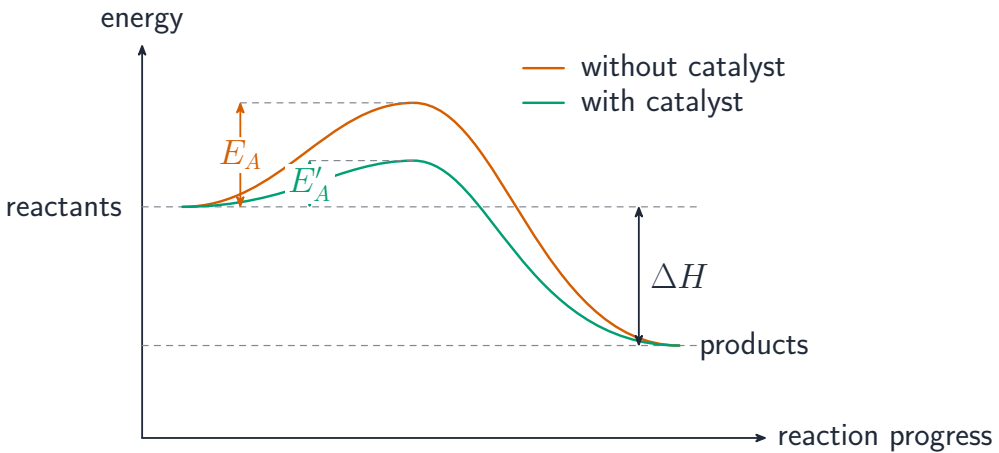
You must be able to

- explain that a catalyst gives a different mechanism of lower activation energy
- explain the catalytic effect using the Boltzmann distribution
- construct and interpret reaction pathway diagrams with and without a catalyst

Method — How a catalyst works

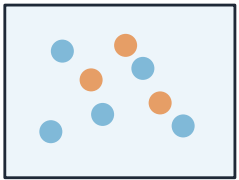
A **catalyst** speeds up a reaction without being used up. It provides a different **mechanism 反应机理** with a **lower activation energy**.
On the Boltzmann distribution, lowering E_A moves the line left, so more molecules can react $\rightarrow$ faster rate.

Method — How a catalyst works

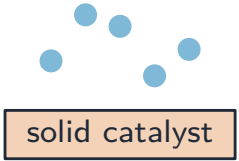


Method — Homogeneous vs heterogeneous

Homogeneous: same state as the reactants (e.g. acid in solution). Heterogeneous: a different state (e.g. solid iron with gases)



homogeneous
(same state,
mixed in)



heterogeneous
(different state,
a surface)

Practice 2.1 ▪ 2 marks

State what a catalyst does and what happens to it during the reaction.

Solution 2.1

Method: How a catalyst works

Worked steps

it speeds up the reaction B1; it is not used up / is regenerated B1.

Practice 2.2 ▪ 2 marks

State the difference between a homogeneous and a heterogeneous catalyst.

Solution 2.2

Method: Homogeneous vs heterogeneous

Worked steps

homogeneous — in the same physical state as the reactants; heterogeneous — in a different state B1 *each*.

Exam-style 3.1 ▪ 1 mark

A catalyst increases the rate of a reaction by:

A increasing the activation energy

B providing a route with a lower activation energy

C making the reaction more exothermic

D raising the temperature

Solution 3.1

Method: How a catalyst works

A increasing the activation energy

B providing a route with a lower activation energy ✓

C making the reaction more exothermic

D raising the temperature

Worked steps

B. A catalyst provides a route with lower activation energy.

Exam-style 3.2 ▪ 1 mark

Which property of a reaction is **not** changed by adding a catalyst?

A the rate

B the activation energy

C the enthalpy change, ΔH

D the mechanism

Solution 3.2

Method: How a catalyst works

A the rate

B the activation energy

C the enthalpy change, ΔH ✓

D the mechanism

Worked steps

C. The enthalpy change is unchanged by a catalyst.

Exam-style 3.3 ▪ 2 marks

(a) Explain, using the Boltzmann distribution, why a catalyst speeds up a reaction.
(b) Sketch a reaction pathway diagram showing the catalysed and uncatalysed routes for an exothermic reaction.

Solution 3.3

Method: How a catalyst works

Worked steps

(a) the catalyst lowers the activation energy **M1**; so a larger fraction of molecules now exceed E_A and can react — more effective collisions per second **A1**.
(b) reactants higher than products (exothermic) **B1**; two activation-energy humps, the catalysed one lower **B1**; same ΔH marked between reactants and products **B1**.

Exam-style 3.4 ▪ 2 marks

Iron is used in the Haber process. State whether it is a homogeneous or heterogeneous catalyst, and explain your answer.

Solution 3.4

Method: Homogeneous vs heterogeneous

Worked steps

heterogeneous B1; the iron is a solid while the reactants (N_2 and H_2) are gases — a different physical state B1.