Exercise walk-through

Homogeneous and heterogeneous catalysts ▪ 26.2

eXercise

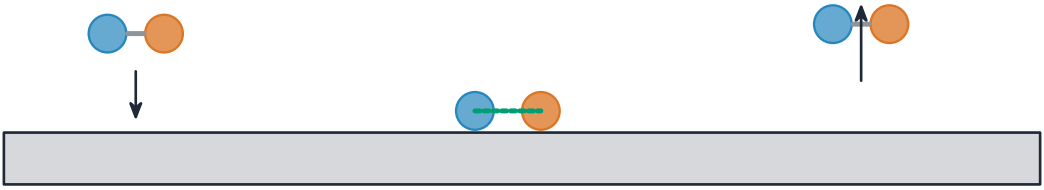
You must be able to

- describe heterogeneous catalysis (adsorption, bond weakening, desorption)
- describe homogeneous catalysis (used in one step, reformed in a later step)
- give the examples in the syllabus

Method — Heterogeneous catalysis

A heterogeneous catalyst works at its surface: ***adsorption*** *of reactants* $\rightarrow$ ***bond weakening*** $\rightarrow$ *reaction* $\rightarrow$ ***desorption*** *of products*
Examples: **iron** in the Haber process; **Pt/Pd/Rh** in catalytic converters (removing NO_x).

Method — Heterogeneous catalysis



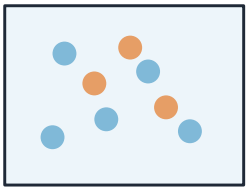
1. **adsorb** (stick on)

2. **react** (bonds weakened)

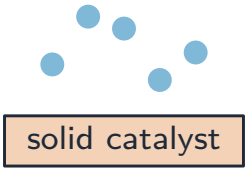
3. **desorb** (product leaves)

catalyst surface

Method — Heterogeneous catalysis



homogeneous
(same state,
mixed in)



heterogeneous
(different state,
a surface)

Homogeneous versus heterogeneous catalysis

Method — Homogeneous catalysis

A homogeneous catalyst (same state as the reactants) is **used in one step and reformed in a later step**. Examples: oxides of nitrogen catalysing $SO_2 \rightarrow SO_3$ in the atmosphere; Fe^{2+}/Fe^{3+} catalysing the $I^-/S_2O_8^{2-}$ reaction (the Fe ion is regenerated, so it is a catalyst not a reactant).

Practice 2.1 ▪ 3 marks

State the three stages of heterogeneous catalysis.

Solution 2.1

Method: Heterogeneous catalysis

Worked steps

adsorption of the reactants onto the surface; reaction (bonds weakened); desorption of the products **B1** *each*.

Practice 2.2 ▪ 1 mark

State what “homogeneous” means for a catalyst.

Solution 2.2

Worked steps

it is in the same physical state as the reactants B1.

Exam-style 3.1 ▪ 1 mark

In heterogeneous catalysis, the reactant molecules first:

A desorb from the surface

B adsorb onto the catalyst surface

C dissolve in the catalyst

D evaporate

Solution 3.1

A desorb from the surface

B adsorb onto the catalyst surface ✓

C dissolve in the catalyst

D evaporate

Worked steps

B. Reactants first adsorb onto the catalyst surface.

Exam-style 3.2 ▪ 1 mark

The iron catalyst in the Haber process is an example of a:

A homogeneous catalyst

B heterogeneous catalyst

C reactant

D product

Solution 3.2

Method: Heterogeneous catalysis

A homogeneous catalyst

B heterogeneous catalyst ✓

C reactant

D product

Worked steps

B. Solid iron with gaseous reactants is a heterogeneous catalyst.

Exam-style 3.3 ▪ 3 marks

Explain how a heterogeneous catalyst speeds up a reaction at its surface.

Solution 3.3

Method: Heterogeneous catalysis

Worked steps

reactant molecules adsorb onto the catalyst surface M1; this weakens their bonds and holds them close together, lowering the activation energy M1; the products then desorb, freeing the surface A1.

Exam-style 3.4 ▪ 2 marks

Fe^{2+} catalyses the reaction between iodide ions and peroxodisulfate ions. Explain why it is described as a homogeneous catalyst, not a reactant.

Solution 3.4

Method: Homogeneous catalysis

Worked steps

the Fe^{2+} is used in one step but is regenerated (reformed) in a later step M1, so it is not used up overall — it is a catalyst, in the same (aqueous) state as the reactants A1.