Exercise walk-through

Reversible reactions and equilibrium ▪ 6.3

eXercise

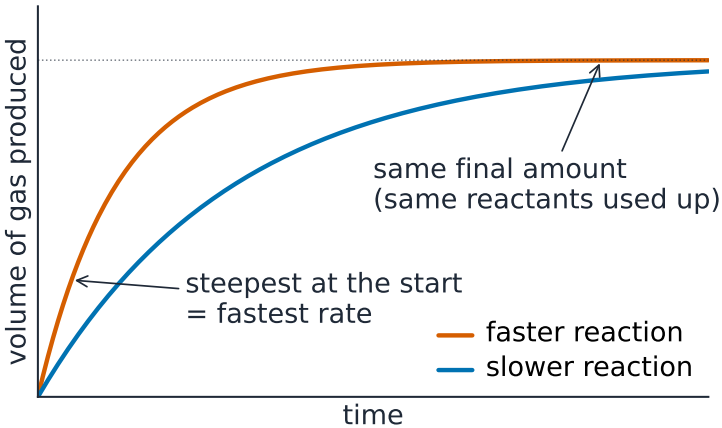
You must be able to

- describe a reversible reaction (e.g. hydrated/anhydrous salts)
- state the conditions for equilibrium in a closed system
- predict how temperature/pressure/concentration shift the equilibrium

Method — Equilibrium and the Haber process

- **Haber:** $N_2 + 3H_2 \rightleftharpoons 2NH_3$; ~450 °C, ~200 atm, iron catalyst.
- **shifts:** more pressure → side with fewer gas molecules; add a substance → moves to use it up.
- a **catalyst** does **not** shift the position — only speeds up reaching equilibrium.

Method — Equilibrium and the Haber process



A rate graph levelling off — at equilibrium forward rate = reverse rate

Practice 2.1 ▪ 2 marks

State the two conditions for a reaction at equilibrium.

Solution 2.1

Worked steps

the forward and reverse reactions occur at the same rate B1; the concentrations of reactants and products stay constant B1.

Practice 2.2 ▪ 1 mark

Give the catalyst used in the Haber process.

Solution 2.2

Method: Equilibrium and the Haber process

Worked steps

iron B1.

Exam-style 3.1 ▪ 1 mark

Adding a catalyst to a reaction at equilibrium:

A moves the equilibrium to the products

B moves it to the reactants

C does not move the position, but reaches equilibrium faster

D stops the reaction

Solution 3.1

Method: Equilibrium and the Haber process

A moves the equilibrium to the products

B moves it to the reactants

C does not move the position, but reaches equilibrium faster ✓

D stops the reaction

Worked steps

C. A catalyst does not change the position; it only speeds up reaching equilibrium.

Exam-style 3.2 ▪ 2 marks

In the Haber process $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$.
(a) State the effect of increasing the pressure on the amount of ammonia.
(b) Explain why a temperature of about $450\,^{\circ}C$ is used, even though a lower temperature would give more ammonia.

Solution 3.2

Method: Equilibrium and the Haber process

Worked steps

(a) the amount of ammonia increases **M1**; because the equilibrium moves to the side with fewer gas molecules (2 vs 4) **A1**.
(b) a lower temperature gives more ammonia but the reaction is too slow **M1**; $450\,^{\circ}\mathrm{C}$ is a compromise that keeps a good rate **A1**.

Exam-style 3.3 ▪ 2 marks

Anhydrous copper(II) sulfate is white; adding water turns it blue. State what this is used to test for, and why this is a reversible reaction.

Solution 3.3

Worked steps

it tests for water M1; the reaction can go both ways — losing water (heating) and gaining it again A1.