Exercise walk-through

Elementary Reactions ▪ 5.4

eXercise

You must be able to

- describe a **mechanism** 反应机理 as a sequence of **elementary steps** 基元反应
- identify **intermediates** 中间体 (made then used up)
- use **molecularity** to write an elementary step's rate law

Method — A mechanism is a sequence of steps

Most reactions happen in several **elementary steps**, not one giant collision. The steps must add up to the overall balanced equation.

Method — Intermediates

An **intermediate** is produced in one step and consumed in a later one, so it does **not** appear in the overall equation. (A catalyst is the reverse — used first, regenerated later.)

Method — Molecularity gives the step's rate law

For an **elementary** step (and only for elementary steps) the rate law uses the coefficients directly:

- $\mathrm{A} \rightarrow$ products: rate $= k[\mathrm{A}]$;
- $\mathrm{A} + \mathrm{B} \rightarrow$: rate $= k[\mathrm{A}][\mathrm{B}]$;
- $2\mathrm{A} \rightarrow$: rate $= k[\mathrm{A}]^2$.

Method — Checking a mechanism

Add the steps: intermediates should cancel, leaving the overall equation. Only then is the mechanism valid.

Practice 2.1 ▪ 1 mark

What is an intermediate?

Solution 2.1

Worked steps

A species made in one step and consumed in a later step (not in the overall equation) B1.

Practice 2.2 ▪ 1 mark

Write the rate law for the elementary step $A + B \rightarrow C$.

Solution 2.2

Method: Molecularity gives the step's rate law

Worked steps

rate $= k[\mathrm{A}][\mathrm{B}]$ **B1**.

Practice 2.3 ▪ 1 mark

In a two-step mechanism, a species is made in step 1 and used in step 2. Name it.

Solution 2.3

Method: Intermediates

Worked steps

An intermediate B1.

Exam-style 3.1 ▪ 1 mark

For an **elementary** step $2\mathrm{NO} \rightarrow \mathrm{N_2O_2}$, the rate law is

A $k[\mathrm{NO}]$

B $k[\mathrm{NO}]^2$

C $k[\mathrm{N_2O_2}]$

D k

Solution 3.1

Method: Molecularity gives the step's rate law

A $k[\mathrm{NO}]$

B $k[\mathrm{NO}]^2$ ✓

C $k[\mathrm{N_2O_2}]$

D k

Worked steps

B — an elementary step's rate law uses its coefficients: $k[\mathrm{NO}]^2$.

Exam-style 3.2 ▪ 1 mark

A mechanism is: Step 1 $A \rightarrow X$; Step 2 $X + B \rightarrow C$.
(a) Identify the intermediate.
(b) Write the overall equation.

Solution 3.2

Method: Intermediates

Worked steps

(a) X B1. (b) Adding the steps, X cancels: $A + B \rightarrow C$ M1 A1.

Exam-style 3.3 ▪ 2 marks

Explain why you cannot write the rate law of an **overall** reaction directly from its coefficients, but you can for an elementary step.

Solution 3.3

Method: Molecularity gives the step's rate law

Worked steps

The overall equation may hide several steps, so its coefficients need not match the true dependence; an elementary step **is** a single collision event, so its molecularity gives its rate law directly M1 A1.