Exercise walk-through

Introduction to Rate Law ▪ 5.2

eXercise

You must be able to

- write a **rate law 速率定律** rate $= k[\mathrm{A}]^m[\mathrm{B}]^n$
- find the **order 级数** with respect to each reactant from data
- calculate the **rate constant** k

Method — The rate law

$$\text{rate} = k[\text{A}]^m[\text{B}]^n,$$

where m and n are the **orders** (found by experiment, not from coefficients) and k is the rate constant.

Method — Finding order by comparing experiments

Change one reactant's concentration and see how the rate responds:

- rate unchanged when $[\mathrm{A}]$ doubles $\rightarrow$ order 0 in A;
- rate doubles $\rightarrow$ order 1;
- rate quadruples $(\times 4) \rightarrow$ order 2.

Method — A worked order

If doubling [A] (with [B] fixed) makes the rate $4\times$ larger, then $2^m = 4$, so $m = 2$ (second order in A).

Method — Finding k

Substitute one experiment's rate and concentrations into the rate law and solve for k. Its units depend on the overall order.

Practice 2.1 ▪ 2 marks

In rate $= k[\mathrm{A}]^2[\mathrm{B}]$, state the order in A and in B.

Solution 2.1

Worked steps

Second order in A; first order in B B1 B1.

Practice 2.2 ▪ 1 mark

Doubling [A] doubles the rate. What is the order in A?

Solution 2.2

Worked steps

First order B1.

Practice 2.3 ▪ 1 mark

Are reaction orders taken from the balanced equation?

Solution 2.3

Worked steps

No — orders are found by experiment B1.

Exam-style 3.1 ▪ 1 mark

If doubling a reactant's concentration quadruples the rate, the order is

A 0

B 1

C 2

D 3

Solution 3.1

Method: Finding order by comparing experiments

A 0

B 1

C 2 ✓

D 3

Worked steps

C — $2^m = 4 \Rightarrow m = 2$.

Exam-style 3.2 ▪ 3 marks

For $\mathrm{A} + \mathrm{B} \rightarrow \mathrm{C}$, experiments give:

exp	[**A**]	[**B**]	**rate**
1	0.1	0.1	2
2	0.2	0.1	4
3	0.1	0.2	8

(a) Find the order in A and in B.
(b) Write the rate law.

Solution 3.2

Method: Finding order by comparing experiments

Worked steps

(a) A: exp 1→2 doubles [A], rate doubles → order 1; B: exp 1→3 doubles [B], rate $\times 4 \rightarrow$ order 2 M1 M1 A1. (b) rate $= k[\mathrm{A}][\mathrm{B}]^2$ B1.

Exam-style 3.3 ▪ 3 marks

Using experiment 1 above (rate $= 2$, $[\mathrm{A}] = [\mathrm{B}] = 0.1$) and your rate law, find k.

Solution 3.3

Method: The rate law

Worked steps

$2 = k(0.1)(0.1)^2 = k(0.001)$ M1 M1; $k = 2000\ \mathrm{L^2 mol^{-2} s^{-1}}$ A1.