

5.2 Writing the Rate Law

Name: _____ Class: _____ Date: _____

Total: 12 marks

KEY WORDS order 级数 • rate law 速率定律 • rate constant 速率常数

Objective

Build the skills to answer exam questions on the **rate law** — how rate depends on concentration.

You must be able to:

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

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ 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.

■ Finding order by comparing experiments

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

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

■ A worked order

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

■ Finding k

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

2 Practice

Now apply the methods above.

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

2.2 Doubling [A] doubles the rate. What is the order in A? [1]

2.3 Are reaction orders taken from the balanced equation? [1]

3 Exam-style questions

3.1 If doubling a reactant's concentration quadruples the rate, the order is [1]

- A 0
 - B 1
 - C 2
 - D 3
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3.2 For $\text{A} + \text{B} \rightarrow \text{C}$, 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. [3]

(b) Write the rate law. [1]

3.3 Using experiment 1 above (rate = 2, $[A] = [B] = 0.1$) and your rate law, find k . [3]

Solutions

2.1 Second order in A; first order in B.

2.2 First order.

2.3 No — orders are found by experiment.

3.1 C — $2^m = 4 \Rightarrow m = 2$.

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

3.3 $2 = k(0.1)(0.1)^2 = k(0.001)$; $k = 2000 \text{ L}^2\text{mol}^{-2}\text{s}^{-1}$.