

5.4 The Steps a Reaction Really Takes

Name: _____ Class: _____ Date: _____

Total: 9 marks

KEY WORDS mechanism 反应机理 • elementary steps 基元反应 • intermediates 中间体
• rate law 速率方程 • catalyst 催化剂

Objective

Build the skills to answer exam questions on **reaction mechanisms** — the real steps a reaction takes.

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

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.

■ 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.

■ 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.)

■ Molecularity gives the step's rate law

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

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

■ Checking a mechanism

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

2 Practice

Now apply the methods above.

2.1 What is an intermediate? [1]

2.2 Write the rate law for the elementary step $A + B \rightarrow C$. [1]

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

3 Exam-style questions

3.1 For an **elementary** step $2\text{NO} \rightarrow \text{N}_2\text{O}_2$, the rate law is [1]

- A** $k[\text{NO}]$
- B** $k[\text{NO}]^2$
- C** $k[\text{N}_2\text{O}_2]$
- D** k

3.2 A mechanism is: Step 1 $A \rightarrow X$; Step 2 $X + B \rightarrow C$.

(a) Identify the intermediate. [1]

(b) Write the overall equation. [2]

3.3 Explain why you cannot write the rate law of an **overall** reaction directly from its coefficients, but you can for an elementary step. [2]

Solutions

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

2.2 $\text{rate} = k[\text{A}][\text{B}]$.

2.3 An intermediate.

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

3.2 (a) X. (b) Adding the steps, X cancels: $\text{A} + \text{B} \rightarrow \text{C}$.

3.3 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.