AP CHEMISTRY • EXERCISE SHEET

5.4 The Steps a Reaction Really Takes

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

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

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 $2NO \rightarrow N_2O_2$, the rate law is [1]

- **A** $k[NO]$
- **B** $k[NO]^2$
- **C** $k[N_2O_2]$
- **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]

4 Go further

You are now ready for the real exam questions on this subtopic:

- work through the **5.4 The Steps a Reaction Really Takes** lesson on the **Learn** page;
- read the **The Steps a Reaction Really Takes** section of the AP Chemistry handout on the **Know** page.

Solutions

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

2.2 rate = k[A][B].

2.3 An intermediate.

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

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

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.