AP CHEMISTRY • EXERCISE SHEET

5.7 The Sequence of Steps

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

Objective

Build the skills to answer exam questions on the **sequence of steps** —the rate-determining step.

You must be able to:

- identify the **rate-determining step** 决速步 (the slowest step)
- explain that the overall rate cannot exceed the slowest step
- check that steps add to the overall reaction

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 slowest step controls

A multi-step reaction goes no faster than its **slowest** step —the **rate-determining step (RDS)**. Like a slow lane on a highway, it sets the overall pace.

■ The bottleneck idea

If step 1 is slow and step 2 is fast, the overall rate is fixed by step 1. Speeding up the fast step does nothing; you must speed up the slow one.

■ The rate law comes from the RDS

The overall rate law is (usually) the rate law of the **rate-determining step**, written from its molecularity —provided that step's species are reactants (not intermediates).

■ Steps must sum correctly

Whatever the speeds, the elementary steps must add up (intermediates cancelling) to the overall balanced equation.

2 Practice

Now apply the methods above.

2.1 What is the rate-determining step? [1]

2.2 Step 1 is slow, step 2 is fast. Which sets the overall rate? [1]

2.3 If you speed up only the fast step, does the overall rate change much? [1]

3 Exam-style questions

3.1 The overall rate of a multi-step reaction is controlled by the [1]

- **A** fastest step
- **B** slowest step
- **C** first step always
- **D** last step always

3.2 A mechanism is: Step 1 (slow) $NO_2 + NO_2 \rightarrow NO_3 + NO$; Step 2 (fast) $NO_3 + CO \rightarrow NO_2 + CO_2$.

(a) Which step is rate-determining? [1]

(b) Write the rate law from that step. [2]

3.3 Explain, with the highway analogy or otherwise, why speeding up a fast step does not speed up the overall reaction if another step is slow. [2]

4 Go further

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

- work through the **5.7 The Sequence of Steps** lesson on the **Learn** page;
- read the **The Sequence of Steps** section of the AP Chemistry handout on the **Know** page.

Solutions

2.1 The slowest step in the mechanism, which sets the overall rate.

2.2 Step 1 (the slow step).

2.3 No —it is limited by the slow step.

3.1 B —the slowest step.

3.2 (a) Step 1. (b) rate = $k[NO_2]^2$ (from the slow elementary step).

3.3 The overall reaction can only proceed as fast as its slowest bottleneck; a faster fast-step just waits on the slow step, so the total time barely changes.