AP CHEMISTRY • EXERCISE SHEET

5.8 Finding the Rate Law From a Mechanism

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

Objective

Build the skills to answer exam questions on **finding the rate law from a mechanism** (slow first step).

You must be able to:

- write the rate law from the **rate-determining step** when it is first
- confirm the mechanism is consistent with an experimental rate law
- avoid putting intermediates in the final 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.

Slow first step → easy rate law

If the **first** step is the slow (rate-determining) step, its reactants are the original reactants, so the rate law comes straight from its molecularity.

A worked example

Mechanism: Step 1 (slow) $H_2 + ICl \rightarrow HI + HCl$; Step 2 (fast) $HI + ICl \rightarrow I_2 + HCl$. The slow step gives

$$\text{rate} = k[H_2][ICl].$$

Consistency check

A proposed mechanism is **valid** only if its predicted rate law matches the **experimental** one and its steps add to the overall equation.

No intermediates in the rate law

The final rate law may contain only **reactants** (or catalysts), never intermediates. If the slow step contains an intermediate, you must substitute for it (next subtopic).

2 Practice

Now apply the methods above.

2.1 If the slow step is $A + B \rightarrow X$, write the rate law. [1]

2.2 Can the final rate law contain an intermediate? [1]

2.3 A slow first step is $2NO \rightarrow N_2O_2$. Write its rate law. [1]

3 Exam-style questions

3.1 For a mechanism with a slow **first** step, the rate law is written from [1]

- **A** the overall equation
- **B** the slow first step's molecularity
- **C** the fast step
- **D** the products

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

(a) Write the predicted rate law. [2]

(b) The experimental rate law is rate $= k[NO_2]^2$. Is the mechanism consistent? [1]

3.3 Explain why the concentration of CO does **not** appear in the rate law for the mechanism in 3.2. [2]

4 Go further

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

- work through the **5.8 Finding the Rate Law From a Mechanism** lesson on the **Learn** page;
- read the **Finding the Rate Law From a Mechanism** section of the AP Chemistry handout on the **Know** page.

Solutions

2.1 rate = k[A][B].

2.2 No.

2.3 rate = $k[\mathrm{NO}]^2$.

3.1 B —the slow first step's molecularity.

3.2 (a) rate = $k[\mathrm{NO_2}]^2$. (b) Yes —it matches the experimental rate law.

3.3 CO reacts only in the fast **second** step, after the rate-determining step; the slow step (which sets the rate) does not involve CO, so it is absent from the rate law.