

Key 1/2

Advanced Chemistry II Reaction Mechanisms Practice Problems

Basic Definitions

1. Define the term elementary step.
one step in a series of steps that change reactants into products
2. Why do most reactions occur in small steps, rather than all at once?
 - activation energy
 - orientation of molecules at collision
 - Probability
3. How do you determine whether a reaction is unimolecular, bimolecular, or termolecular? Which type is least common? Why is that?
Look at the # of Reacting Species (atoms, molecules, or ions) on Reactant Side
if 1 Reactant - unimolecular
2 Reactant - Bimolecular
3 Reactant - Termolecular is least common
Because the probability of getting w/ correct orientation & energy is unlikely

Reaction Mechanisms

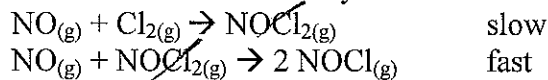
4. Which of the following species can be isolated from a chemical reaction?
a. Product b. Activated complex c. Intermediate
3 species to interact w/ correct orientation & energy is unlikely
5. Given the following mechanism for the decomposition of ozone in the stratosphere, identify the intermediate and the catalyst.
$$\begin{array}{l} \text{O}_3 + \cancel{\text{Cl}} \rightarrow \text{O}_2 + \cancel{\text{ClO}} \\ \cancel{\text{ClO}} + \text{O} \rightarrow \cancel{\text{Cl}} + \text{O}_2 \\ \hline \text{O}_3 + \text{O} \rightarrow 2\text{O}_2 \end{array}$$

Cl is a Reactant early & Product later
∴ Catalyst
ClO is an Intermediate
6. Identify the catalyst, any intermediates, and write the overall equation for the following mechanism.
$$\begin{array}{l} \text{O}_3 + \cancel{\text{NO}} \rightarrow \text{O}_2 + \cancel{\text{NO}_2} \\ \cancel{\text{NO}_2} + \text{O} \rightarrow \cancel{\text{NO}} + \text{O}_2 \\ \hline \text{O}_3 + \text{O} \rightarrow 2\text{O}_2 \end{array}$$

NO Catalyst
NO₂ Intermediate
7. Looking at the reaction, $2 \text{NO}_{(g)} + \text{O}_{2(g)} \rightarrow 2 \text{NO}_{2(g)}$, and the mechanism shown below, how many elementary steps does it have? What is the molecularity of each step?
Step 1 $2 \text{NO} \rightarrow \text{N}_2\text{O}_2$ **⇒ NO + NO → N₂O₂ Bimolecular**
Step 2 $\text{N}_2\text{O}_2 + \text{O}_2 \rightarrow 2 \text{NO}_2$ **Bimolecular**

Rate - Determining Step

8. If the rate law for the reaction $2 \text{NO}(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2 \text{NOCl}(\text{g})$, is $\text{rate} = k[\text{NO}][\text{Cl}_2]$, is the mechanism that follows consistent with this? Why?



① $2 \text{NO} + \text{Cl}_2 \rightarrow 2 \text{NOCl}$ Addition of mechanisms Results in correct overall Rxn \therefore 1st requirement met

② $\text{Rate} = k[\text{NO}][\text{Cl}_2]$
The Rate for the Slow (Rate determining Step) matches the overall Rate Reaction \therefore 2nd Requirement met

9. If the rate law for the reaction, $2 \text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{NO}_2(\text{g})$, is $\text{rate} = k[\text{NO}][\text{O}_2]^3$, which is the rate-determining step? How do you know this?

- a. $2 \text{NO} \rightarrow \text{N}_2\text{O}_2$
b. $\text{N}_2\text{O}_2 + \text{O}_2 \rightarrow 2 \text{NO}_2$

A) $\text{Rate} = [\text{NO}]^2$ The overall Rate Law has $[\text{NO}]$ to the 1st order & Step A has it to the 2nd order \therefore it cannot be the RDS

B) $\text{Rate}_B = [\text{N}_2\text{O}_2][\text{O}_2]$ N_2O_2 is intermediate so must Rearrangement
 $[\text{N}_2\text{O}_2] = [\text{NO}]^2$

$\text{Rate}_B = [\text{NO}]^2[\text{O}_2]$ matches overall Rate \therefore is RDS

10. If the rate law for the reaction, $2 \text{H}_2\text{O}_2 \rightarrow 2 \text{H}_2\text{O} + \text{O}_2$, is $\text{rate} = k[\text{H}_2\text{O}_2][\text{I}]$, which of the following is the rate-determining step? How do you know this?

- a. $\text{H}_2\text{O}_2 + \text{I} \rightarrow \text{H}_2\text{O}_2 + \text{IO}$
b. $\text{H}_2\text{O}_2 + \text{IO} \rightarrow \text{H}_2\text{O} + \text{O}_2 + \text{I}$

① $\text{Rate}_A = k[\text{H}_2\text{O}_2][\text{I}]$ Rate A is same as the ^{overall} Rate \therefore is Rate Determining step (RDS)

② $\text{Rate}_B = k[\text{H}_2\text{O}_2][\text{IO}]$ NO