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 3 species to interact 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

5. Given the following mechanism for the decomposition of ozone in the stratosphere, identify the intermediate and the catalyst.

   $O_3 + \cancel{Cl} \rightarrow O_2 + \cancel{ClO}$
   $\cancel{ClO} + O \rightarrow \cancel{Cl} + O_2$
   $O_3 + O \rightarrow 2O_2$

   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.

   $O_3 + \cancel{NO} \rightarrow O_2 + \cancel{NO_2}$
   $\cancel{NO_2} + O \rightarrow \cancel{NO} + O_2$
   $O_3 + O \rightarrow 2O_2$

   NO Catalyst

   NO_2 Intermediate

7. Looking at the reaction, $2\ NO_{(g)} + O_{2(g)} \rightarrow 2\ NO_{2(g)}$, and the mechanism shown below, how many elementary steps does it have? What is the molecularity of each step?

   Step 1 $2\ NO \rightarrow N_2O_2$ → NO + NO → N_2O_2 Bimolecular
   Step 2 $N_2O_2 + O_2 \rightarrow 2\ NO_2$ Bimolecular

Key 2/2

Rate – Determining Step

8. If the rate law for the reaction $2\ NO(g) + Cl_{2(g)} \rightarrow 2\ NOCl_{(g)}$, is rate = k[NO][$Cl_2$], is the mechanism that follows consistent with this? Why?

$NO_{(g)} + Cl_{2(g)} \rightarrow NOCl_{2(g)}$ slow

$NO_{(g)} + NOCl_{2(g)} \rightarrow 2\ NOCl_{(g)}$ fast

① $2\ NO + Cl_2 \rightarrow 2\ NOCl$ Addition of mechanisms Results in correct overall Rxn ∴ 1st requirement met

② Rate = K[NO][Cl_2]
The Rate for the slow (Rate determing Step) matches the overall Rate Reaction ∴ 2nd Requirement met

9. If the rate law for the reaction, $2\ NO_{(g)} + O_{2(g)} \rightarrow 2\ NO_{2(g)}$, is rate = k[NO][$O_2$]^3 , which is the rate-determining step? How do you know this?
   a. $2\ NO \rightarrow N_2O_2$
   b. $N_2O_2 + O_2 \rightarrow 2\ NO_2$

A) Rate = [NO]^2 The overall Rate Law has [NO] to the 1st order & Step A has it to the 2nd order ∴ it cannot Be the RDS

B) $Rate_B$ = $[N_2O_2][O_2]$ N_2O_2 is intermediate so must Rearrgement

$[N_2O_2]$ = $[NO]^2$

$Rate_B = [NO]^2[O_2]$ matches overall Rate ∴ is RDS

10. If the rate law for the reaction, $2\ H_2O_2 \rightarrow 2\ H_2O + O_2$, is rate = k[$H_2O_2$] [I] , which of the following is the rate-determining step? How do you know this?
   a. $H_2O_2 + I \rightarrow H_2O_2 + IO$
   b. $H_2O_2 + IO \rightarrow H_2O + O_2 + I$

A) $Rate_A = K[H_2O_2][I]$ Rate A is same as the overall Rate ∴ is Rate determing step (RDS)

B) $Rate_B = K[H_2O_2][IO]$ NO