WKS
Mechanisms & Rate Laws

Name: Answer Key
Date: _____

1. What is meant by the rate-determining step for a chemical reaction?
   The RDS is the slowest step in a mechanism, with the largest activation energy.

2. Write the general equation for the rate law, and label the various factors.
   Rate = k $[A]^x$ $[B]^y$

   Reactant Orders

   Rate Constant

   Reactant Concentrations

3. Determine the overall balanced equation for a reaction having the following proposed mechanism and write the corresponding rate law:

   Step 1: $B_2 + \cancel{B_2} \rightarrow \cancel{E_3} + D$ slow

   Step 2: $\cancel{E_3} + A \rightarrow \cancel{B_2} + C_2$ fast

   $B_2 + A \rightarrow D + C_2$

   Rate = k $[B_2]^2$

4. A reaction involving reactants A and B is found to occur in the one-step mechanism: $2A + B \rightarrow A_2B$. Write the rate law for this reaction and predict the effect of doubling the concentration of either reactant on the overall reaction rate.

   Rate = k $[A]^2[B]$

   Doubling A will increase the rate $\times 4$ (2^2)
   Doubling B will increase the rate $\times 2$ (2^1)

5. Determine the rate law for the following two reactions, given that each reaction occurs in one step.

   a) Overall Rxn: $NO\ (g) + O_3\ (g) \rightarrow NO_2\ (g) + O_2\ (g)$

   Rate = k $[NO][O_3]$

   b) Overall Rxn: $2\ H_2O_2\ (aq) \rightarrow 2\ H_2O\ (l) + O_2\ (g)$

   Rate = k $[H_2O_2]^2$

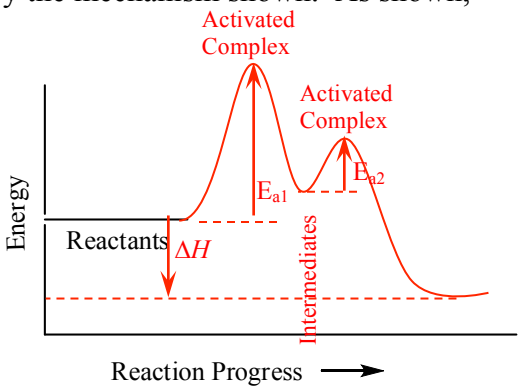
6. The reaction below does not occur in one step. Instead it occurs by the mechanism shown. As shown, the first step is slow and the second step is fast.

Overall Rxn: $NO_2\,(g) + CO\,(g) \rightarrow NO\,(g) + CO_2\,(g)$

Mechanism:

Step 1: $NO_2\,(g) + NO_2\,(g) \rightarrow NO_3\,(g) + NO\,(g)$ slow

Step 2: $NO_3\,(g) + CO\,(g) \rightarrow NO_2\,(g) + CO_2\,(g)$ fast



a) What is the rate law for the reaction?

Rate = $k\,[NO_2]^2$

b) In the energy diagram above, sketch an approximate energy diagram for the rxn. Indicate locations of the activated complexes and intermediates, and label E_a for each step and overall ΔH. *Your diagram should reflect the relative speeds of each step & that the overall rxn is exothermic.*

7. The following reaction is done in lab, $2\,NO_2(g) + F_2(g) \rightarrow 2\,NO_2F(g)$

Data from three experiments using varying concentrations of reactants are collected as shown below:

Run #	initial [NO_2] (M)	initial [F_2] (M)	Rate (1/s)
1	0.10	0.20	9.96×10^{-5}
2	0.30	0.20	29.9×10^{-5}
3	0.10	0.40	19.9×10^{-5}

a) Based on the experimental data given above, determine the rate law for the reaction. Justify.

Rate = $k\,[NO_2]\,[F_2]$

The rate triples from Run 1 to 2 when [NO_2] triples, so it is 1st order in NO_2.

The rate doubles from Run 1 to 3 when [F_2] doubles, so it is 1st order in F_2.

b) Which reaction mechanism is a possible mechanism for the reaction because it is consistent with the rate law?

Mechanism A: Only one step: $2\,NO_2(g) + F_2(g) \rightarrow 2\,NO_2F(g)$

Mechanism B: Step 1: $NO_2(g) + F_2(g) \rightarrow NO_2F(g) + F(g)$ fast

Step 2: $NO_2(g) + F(g) \rightarrow NO_2F(g)$ slow

Mechanism C: Step 1: $NO_2(g) + F_2(g) \rightarrow NO_2F(g) + F(g)$ slow

Step 2: $NO_2(g) + F(g) \rightarrow NO_2F(g)$ fast

Only mechanism C has a RDS that matches the rate law. In A, the rate law would be 2nd order in NO_2, and in B the intermediate [F] (NOT F_2) would be in the rate law. Only C is 1st order in NO_2 and 1st order in F_2.