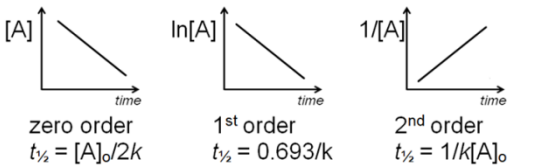
AP chem
Text: chapter 12

Review - 9
(Kinetics)

Name: _____

- rate laws, integrated rate laws, graphs and half-lives
- energy diagrams
- mechanisms



PROBLEMS

1. A reaction follows the rate law: rate = $k[A]^2$. Which of the following plots will give a straight line?
a. 1/[A] vs 1/time
b. $[A]^2$ vs time
c. 1/[A] vs time
d. ln[A] vs time
e. [A] vs time

2. For the following reaction: $NO_2(g) + CO(g) \rightarrow NO(g) + CO(g)$, the rate law is: rate = $k[NO_2]^2$. If a small amount of gaseous carbon monoxide (CO) is added to a reaction mixture that was 0.10 *M* in NO_2 and 0.20 *M* in CO, which of the following statements is true?
a. Both k and the reaction rate remain the same
b. Both k and the reaction rate increase
c. Both k and the reaction rate decrease
d. Only k increases; the reaction rate remains the same
e. Only the reaction rate increases; k remains the same

3. The specific rate constant, k, for radioactive beryllium-11 is 0.049 s^{-1}. What mass of a 0.500 mg sample of beryllium-11 remains after 28 seconds?
a. 0.250 mg
b. 0.125 mg
c. 0.0625 mg
d. 0.375 mg
e. 0.500 mg

4. The slow rate of a particular chemical reaction might be attributed to which of the following?
a. a low activation energy
b. a high activation energy
c. the presence of a catalyst
d. the temperature is high
e. the concentration of the reactants are high

5. The steps below represent a proposed mechanism for the catalyzed oxidation of CO by O_3.
Step 1: $NO_2 + CO \rightarrow NO + CO_2$
Step 2: $NO + O_3 \rightarrow NO_2 + O_2$
What are the overall products of the catalyzed reaction?
a. CO_2 and O_2
b. NO and CO_2
c. NO_2 and O_2
d. NO and O_2
e. NO_2 and CO_2

6. The decomposition of ammonia to the elements is a first-order reaction with a half-life of 200 s at a certain temperature. How long will it take the partial pressure of ammonia to decrease from 0.100 atm to 0.00625 atm?
a. 200 s
b. 400 s
c. 800 s
d. 1000 s
e. 1200 s

7. The energy difference between the reactants and the transition state is
a. the free energy
b. the heat of reaction
c. the activation energy
d. the kinetic energy
e. the reaction energy

8. The purpose of striking a match against the side of a box to light the match is
a. to supply the free energy for the reaction
b. to supply the activation energy for the reaction
c. to supply the heat of reaction
d. to supply the kinetic energy for the reaction
e. to catalyze the reaction

9. The table below gives the initial concentrations and rate for three experiments:

Exp	$[CO]_o$	$[Cl_2]$	$Rate_o$
1	0.200	0.100	3.9×10^{-25}
2	0.100	0.200	3.9×10^{-25}
3	0.200	0.200	7.8×10^{-25}

The reaction is $CO + Cl_2 \rightarrow COCl_2$. What is the rate law?
a. Rate = $k[CO]$
b. Rate = $k[CO]^2[Cl_2]$
c. Rate = $k[Cl_2]$
d. Rate = $k[CO][Cl_2]^2$
e. Rate = $k[CO][Cl_2]$

10. The reaction $(CH_3)_3CBr(aq) + H_2O(l) \rightarrow (CH_3)_3COH(aq) + HBr(aq)$ follows the rate law: rate = $k[(CH_3)_3CBr]$. What will be the effect of decreasing the concentration of $(CH_3)_3CBr$?
a. The rate of the reaction will increase.
b. More HBr will form.
c. The rate of the reaction will decrease.
d. The reaction will shift to the left.
e. The equilibrium constant will increase.

11. When the concentration of $H^+(aq)$ is doubled for the reaction $H_2O_2(aq) + 2Fe^{2+}(aq) + 2H^+(aq) \rightarrow 2Fe^{3+}(aq) + 2H_2O(g)$, there is no change in the reaction rate. This indicates that
a. the H^+ is a spectator ion.
b. the rate-determining step does not involve H^+.
c. the reaction mechanism does not involve H^+.
d. the H^+ is a catalyst.
e. the rate law is first order with respect to H^+.

12. The mechanism below has been proposed for the reaction of $CHCl_3$ with Cl_2.
1: $Cl_2 \rightleftharpoons 2Cl$ fast
2: $Cl + CHCl_3 \rightarrow CCl_3 + HCl$ slow
3: $CCl_3 + Cl \rightarrow CCl_4$ fast
Which of the following rate laws is consistent with this mechanism?
a. rate = $k[Cl_2]$
b. rate = $k[CHCl_3][Cl_2]$
c. rate = $k[CHCl_3]$
d. rate = $k[CHCl_3]/[Cl_2]$
e. rate = $k[CHCl_3][Cl_2]^{½}$

FREE-RESPONSE

13. A set of experiments were conducted to study the reaction: $2ClO_2(aq) + 2OH^-(aq) \rightarrow ClO_3^-(aq) + ClO_2^-(aq) + H_2O(l)$. The initial concentrations and rates are reported in the table below.

Exp	$[OH^-]$ (*M*)	$[ClO_2]$ (*M*)	Rate of formation of ClO_3^- (*M*/min)
1	0.030	0.020	0.166
2	0.060	0.020	0.331
3	0.030	0.040	0.661

a. Write the rate law of the reaction.

b. Determine the value of the rate constant, including units.

c. Calculate the initial rate of disappearance of ClO_2 in experiment 1.

d. The following mechanism has been proposed for this reaction:

Step 1: $ClO_2 + ClO_2 \rightleftharpoons Cl_2O_4$
Step 2: $Cl_2O_4 + OH^- \rightarrow ClO_3^- + HClO_2$
Step 3: $HClO_2 + OH^- \rightarrow ClO_2^- + H_2O$

Which step is the rate-determining step? Show that the mechanism is consistent with both the rate law for the reaction and with the overall stoichiometry.

1. C
2. A
3. B
4. B
5. A
6. C
7. C
8. B
9. E
10. C
11. B
12. E

13.
a. rate = $k[ClO_2]^2[OH^-]$
b. 1.4 x 10^4 / M^2min
c. -0.332 mol/L·min
d. Step 1: rate = $k_f[ClO_2]^2 = k_r[Cl_2O_4]$
Step 2: rate = $k[Cl_2O_4][OH^-] = k'[ClO_2]^2[OH^-]$ (by substituting $[Cl_2O_4] \propto [ClO_2]^2$ from the fast equilibrium in step 1)
Step 3: rate = $k'[HClO_2][OH^-]$

For Step 1, the ratio of $[Cl_2O_4]$ to $[ClO_2]$ is 1:2, based on the coefficients of the reaction in step 1. So the reaction in step 2 can be re-written as: $2ClO_2 + OH^- \rightarrow ClO_3^- + HClO_2$ and the rate becomes rate = $k[ClO_2]^2[OH^-]$, which matches the rate law in part a. This must mean that Step 2 is the rate-determining step.

Problems taken from "5 Steps to a 5", McGraw Hill