Honors Chemistry

Chapter 12 Study Questions

1. The following data were obtained for the reaction of methane with oxygen:

$$CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(l)$$

time(min)	$[CH_4]$ (mol/L)	$[CO_2]$ (mol/L)
0	0.050	0
10	0.030	0.020
20	0.020	?
30	0.015	?

a) How many moles of CO_2 are produced for each mole of CH_4 that is used up?
b) What concentration of CH_4 is used up after 10 minutes?
c) What is the concentration of carbon dioxide produced after 20 minutes?
d) Write an equation for reaction rate in terms of $\Delta[CO_2]$ over a time interval.
e) What is the reaction rate for the formation of carbon dioxide between 10 and 20 minutes?
f) What is the *average* reaction rate between 0 and 30 minutes?
g) Write an expression for reaction rate relating $\Delta[O_2]$ to $\Delta[CO_2]$.
h) At what rate is O_2 used up between 10 and 20 minutes?

2. Nitric oxide (NO) reacts with oxygen to form nitrogen dioxide:

$$2\,NO(g) + O_2(g) \rightarrow 2\,NO_2(g)$$

a) How could you tell how many steps are in this reaction?
b) The following two step mechanism has been proposed for this reaction:

$$NO + O_2 \rightarrow NO_3 \quad \text{(fast)}$$
$$NO_3 + NO \rightarrow 2\,NO_2 \quad \text{(slow)}$$

Which step is the rate determining step?
c) Write a rate equation for the rate determining step of this reaction, assuming it occurs as a single step that depends only on the collision between reactants.
d) What happens to the rate in (c) if the concentration of NO_3 is halved and the concentration of NO is tripled?
e) What is the order of the rate determining step with respect to NO? What is the overall order of this step?

3. Draw an energy diagram for a reaction where $\Delta H = -40$ kJ, the activation energy of the uncatalyzed reaction is +120 kJ, and the activation energy for a catalyzed reaction is + 80 kJ. Indicate the position of the activated complex for both catalyzed and uncatalyzed reactions.

4. List three factors that affect reaction rate and briefly explain the basis for their effects.

5. The breakdown of nitrous oxide gas (N_2O) to nitrogen gas and oxygen gas is believed to occur in two steps. In the first step, nitrous oxide breaks down to form nitrogen gas and a free oxygen atom.
a) Write a balanced equation for the overall reaction (do not use fractional coefficients).
b) Write balanced equations for each of the two steps.
c) Which substance could be considered a "reaction intermediate?"

6. The rate of the reaction, $HgCl_2(aq) + \frac{1}{2} C_2O_4^{2-}(aq) \rightarrow Cl^-(aq) + CO_2(g) + \frac{1}{2} Hg_2Cl_2(s)$, is followed by measuring the number of moles of Hg_2Cl_2 that precipitate per liter per second. The following data are obtained:

$[HgCl_2]$	$[C_2O_4^{2-}]$	Initial Rate (mol/L ·s)
0.10	0.10	1.3×10^{-7}
0.10	0.20	5.2×10^{-7}
0.20	0.20	1.0×10^{-6}
0.20	0.10	2.6×10^{-7}

a) What is the order of the reaction with respect to $HgCl_2$, with respect to $C_2O_4^{2-}$, and overall?

b) Write the rate equation for the reaction.

c) Calculate *k* for the reaction.

d) When the concentrations of both mercury(II) chloride and oxalate ion are 0.30 M, what is the rate of the reaction?

Summary of Chapter 12: Chemical Kinetics

reaction rate
- definition
- average rate for a time interval

rate laws
- order
- calculation of order and k from concentration and rate

factors affecting rate (and why)
- concentrations of reactants, temperature, surface area, catalysts

reaction mechanisms
- elementary steps
- rate laws for single step reactions
- multistep reactions
- rate determining step

activation energy
- relation to temperature
- relation to rate

energy diagrams

activated complex (transition state)

catalysis

inhibition