Problems - Chapter 19 (without solutions)

1) Define the following terms: a) catalyst; b) half-life; c) reaction intermediate

2) (19.10) Write the reaction rate expressions for the following reactions in terms of the disappearance of the reactants and the appearance of products.

a) $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$

b) $4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$

3) Consider the reaction

$$2\ N_2O(g) \rightarrow 2\ N_2(g) + O_2(g)$$

a) Express the rate of reaction with respect to each of the reactants and products.

b) In the first 15.0 s of the reaction, 0.015 mol of O_2 is produced in a reaction vessel with a volume of 0.500 L. What is the average rate of the reaction over this time interval (including correct units)?

4) A reaction in which A, B, and C react to form products is zero order in A, second order in B, and first order in C.

a) Write a rate law for the reaction.

b) What is the overall order of the reaction?

c) By what factor does the reaction rate change if [A] is doubled, and the other reactants are held constant?

d) By what factor does the reaction rate change if [B] is doubled, and the other reactants are held constant?

e) By what factor does the reaction rate change if [C] is doubled, and the other reactants are held constant?

f) By what factor does the reaction rate change if the concentrations of all three reactants are doubled?

5) (19.19) The rate law for the reaction

$$NH_4^+(aq) + NO_2^-(aq) \rightarrow N_2(g) + 2\ H_2O(\ell)$$

is

$$\text{rate} = k\ [NH_4^+]\ [NO_2^-]$$

At T = 25. °C, k = 3.0 x 10^{-4} L/mol•s. Find the rate of reaction when $[NH_4^+]$ = 0.36 mol/L and $[NO_2^-]$ = 0.075 mol/L.

6) (19.30) The thermal decomposition of phosphine (PH_3) into phosphorus and molecular hydrogen is a first order reaction

$$4\ PH_3(g) \rightarrow P_4(g) + 2\ H_2(g)$$

The half-life of the reaction is $t_{1/2}$ = 35.0 s at T = 680. °C. Find the following:

a) The first order rate constant for the reaction.

b) The time required for 95.0 % of the initial phosphine to disappear.

7) Consider the reaction

$$A + B \rightarrow \text{"products"}$$

Initial rate data, obtained at T = 360. K, are given below.

Trial	$[A]_0$ (mol/L)	$[B]_0$ (mol/L)	Initial Rate (mol/L•min)
1	0.0100	0.0100	3.6×10^{-5}
2	0.0200	0.0100	14.6×10^{-5}
3	0.0100	0.0200	7.0×10^{-5}

Find the following:

a) The order of the reaction with respect to A and with respect to B.

b) The rate constant for the reaction (including correct units).

c) The initial rate of the reaction when $[A]_0$ = 0.01500 M, $[B]_0$ = 0.0300 M.

8) The data below show the concentration of N_2O_5 verses time for the reaction

$$N_2O_5(g) \rightarrow NO_3(g) + NO_2(g)$$

time (s)	$[N_2O_5]$ (M)	time (s)	$[N_2O_5]$ (M)
0.0	1.000	125.0	0.377
25.0	0.822	150.0	0.310
50.0	0.677	175.0	0.255
75.0	0.557	200.0	0.210
100.0	0.458		

a) Determine the order of the reaction, the value for the rate constant (including correct units), and the half-life for the reaction.

b) Predict the concentration of N_2O_5 at 250.0 s.

9) (19.32) The reaction

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

is second order in NO_2 and second order overall. The rate constant for the reaction at T = 300. °C is k = 0.54 L/mol•s. How long (in seconds) will it take for the concentration of NO_2 to decrease from 0.65 mol/L to 0.18 mol/L?

10) The following reaction was monitored as a function of time

$$AB \rightarrow A + B$$

A plot of 1/[AB] vs time yields a straight line with slope m = 0.055 L/mol·s.

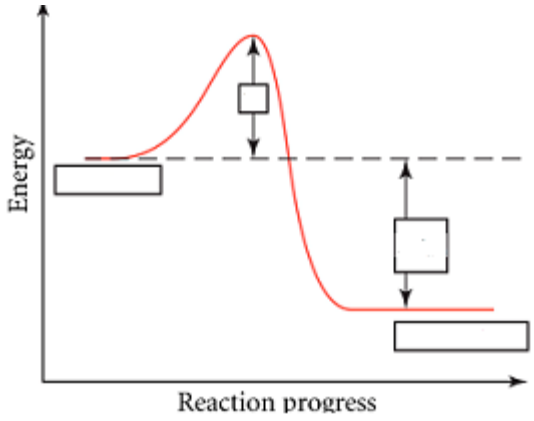
a) What is the value of the rate constant, k, (including correct units) for this reaction at this temperature?

b) Write the rate law for the reaction.

c) What is the half-life when the initial concentration is 0.55 mol/L?

d) If the initial concentration of AB is 0.250 mol/L, and the reaction initially contains no products, what are the concentrations of A and B after 75.0 s?

11) The diagram below shows the energy of the reaction as the reaction progresses. Label each of the following in the diagram (reactants, products, activation energy, enthalpy of reaction). Also, is the reaction exothermic or endothermic? How do you know?



12) (19.49) Rate constants are given for the first order reaction

$$2\ N_2O_5(g) \rightarrow 2\ N_2O_4(g) + O_2(g)$$

in the following table. Determine graphically the activation energy and pre-exponential factor for the reaction (including correct units).

T (K)	k (s^{-1})	T (K)	k (s^{-1})
298.	1.74×10^{-5}	328.	7.59×10^{-4}
308.	6.61×10^{-5}	338.	2.40×10^{-3}
318.	2.51×10^{-4}		

13) For a particular reaction $k = 2.6 \times 10^{-4}$ L/mol•s at T = 300. K, and $k = 5.3 \times 10^{-2}$ L/mol•s at T = 350. K. What are E_a and A, the activation energy and pre-exponential factor for the reaction?

14) (19.44) The rate constant for a particular first order reaction is $k = 4.60 \times 10^{-4}\ s^{-1}$ at T = 350. °C. If the activation energy for the reaction is E_a = 104.0 kJ/mol, find the temperature where the rate constant is $k = 8.80 \times 10^{-4}\ s^{-1}$.

15) The rate law for the reaction

$$2\ NO(g) + Cl_2(g) \rightarrow 2\ NOCl(g)$$

is given by the expression rate = k [NO][Cl_2].

a) What is the overall order of the reaction?

b) One proposed mechanism for the above reaction is the following:

step 1 $NO(g) + Cl_2(g) \rightarrow NOCl_2(g)$ (slow)

step 2 $NOCl_2(g) + NO(g) \rightarrow 2\ NOCl(g)$ (fast)

Is the above mechanism consistent with the proposed rate law? Explain

16) (19.63) The rate law for the reaction

$2\ H_2(g) + 2\ NO(g) \rightarrow N_2(g) + 2\ H_2O(g)$

is rate = $k\ [H_2][NO]^2$.

Which of the following is a possible mechanism for the reaction (Hint: Find the rate law corresponding to each mechanism, and see whether or not it agrees with the experimental rate law.)

Mechanism I

Step 1 $H_2(g) + NO(g) \rightarrow H_2O(g) + N(g)$	(slow)
Step 2 $N(g) + NO(g) \rightarrow N_2(g) + O(g)$	(fast)
Step 3 $O(g) + H_2(g) \rightarrow H_2O(g)$	(fast)

Mechanism II

Step 1 $H_2(g) + 2\ NO(g) \rightarrow N_2O(g) + H_2O(g)$	(slow)
Step 2 $N_2O(g) + H_2(g) \rightarrow N_2(g) + H_2O(g)$	(fast)

Mechanism III

Step 1 $2\ NO(g) \leftrightarrow N_2O_2(g)$	(fast, reversible)
Step 2 $N_2O_2 + H_2(g) \rightarrow N_2O(g) + H_2O(g)$	(slow)
Step 3 $N_2O(g) + H_2(g) \rightarrow N_2(g) + H_2O(g)$	(fast)