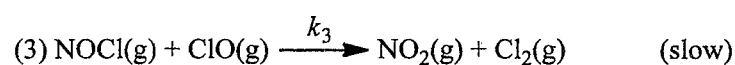
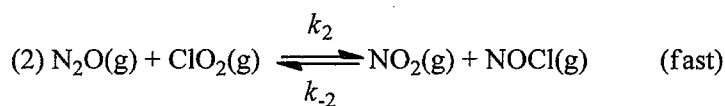
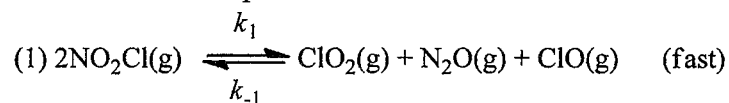
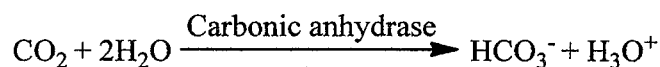


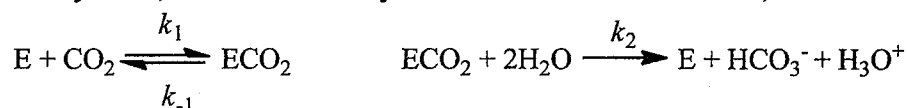
1. (10%) Nitryl chloride ( $\text{NO}_2\text{Cl}$ ) decomposes to nitrogen dioxide ( $\text{NO}_2$ ) and chlorine gas ( $\text{Cl}_2$ ) according to the following mechanism. Please determine the overall rate law expression.



2. Human blood contains an enzyme (carbonic anhydrase) that catalyzes the formation of  $\text{HCO}_3^-$  and the hydration of  $\text{CO}_2$  according to the following reaction:



When catalyzed by carbonic anhydrase, the reaction obeys Michaelis-Menten kinetics, and all elementary steps are shown here:



Its Michaelis-Menten constants are  $K_M = 8 \times 10^{-5} \text{ mol/L}$  and  $k_2 = 6 \times 10^5 \text{ s}^{-1}$ .

- (a) (5%) If the concentration of dissolved  $\text{CO}_2$  (non-hydrated) is 0.5 M. What is the reaction order of non-hydrated  $\text{CO}_2$ ?  
 (b) (5%) Calculate the maximum reaction rate of  $\text{CO}_2$  if the total enzyme concentration is  $5 \times 10^{-6} \text{ M}$ .  
 (c) (5%) Calculate the concentration of  $\text{CO}_2$  at which the reaction rate reaches 30% of its maximum value calculated in part (b) where the total enzyme concentration is  $5 \times 10^{-6} \text{ M}$ .

3. (10%) Determine the order of the reaction (a and b) in the rate equation,  $\text{rate} = kC_A^a C_B^b$ , given the following table:

Rate (mol/L·s)	0.04	0.12	0.36	1.08
$C_{A,0}$ (mol/L)	0.5	0.5	1	1
$C_{B,0}$ (mol/L)	0.5	1	0.5	1

4. (5%) The activation energy for the isomerization of cyclopropane to propene is 274 kJ/mol. By what factor does the rate of reaction increase as the temperature rises from 500 °C to 550 °C, assuming all else remains constant? ( $R = 8.314 \text{ J/mol}\cdot\text{K}$ ).
5. (5%) Determine the average velocity of a  $\text{H}_2$  molecule at 273 K if the average velocity of an  $\text{O}_2$  molecule at this temperature is  $500 \text{ ms}^{-1}$ .
6. (5%) A mixture of  $5.000 \times 10^{-3} \text{ mol}$  of  $\text{H}_2$  and  $1.000 \times 10^{-2} \text{ mol}$  of  $\text{I}_2$  is placed in a 5.000 L container at 448 °C, and allowed to come to equilibrium. Analysis of the equilibrium mixture shows that the concentration of  $\text{HI}$  is  $1.87 \times 10^{-3} \text{ M}$ . Calculate equilibrium constant ( $K_c$ ) at 448 °C for the reaction:
- $$\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$$
7. (9%) Consider an ideal refrigerator operating between 0 °C and 25 °C. The refrigerator is to cool the water initially at 25 °C and then produce 1.0 g of ice each second at 0 °C. How much work must be done? The molar heat of fusion of water is 6.0095 kJ/mol and the molar heat capacity is 75.3 J/K·mol.
8. (8%) Assume that graphite can be changed to diamond at 298 K by increasing the pressure to  $1.5 \times 10^4 \text{ bar}$ . Given  $\Delta H_m = 1895 \text{ J/mol}$  and the volume change  $\Delta V_m = -1.92 \times 10^{-3} \text{ L/mol}$  for this process, determine the temperature at which graphite can be changed to diamond at 1 bar.
9. (8%) What is the entropy change for the system for producing 1-mol sample of artificial air consisting of 79%  $\text{N}_2$  and 21%  $\text{O}_2$ ?
10. (8%) The standard reduction potential for  $\text{Ni}^{2+}(\text{aq})$  is -0.250 V. What is the half-cell potential at 25 °C if the activity of  $\text{Ni}^{2+}$  is 0.015?
11. (9%) Assume that  $\text{C}_6\text{H}_6$  and  $\text{C}_6\text{H}_5\text{CH}_3$  form ideal solutions, calculate  $\Delta G$ ,  $\Delta H$ , and  $\Delta S$  at 25 °C for the addition of 1.00 mol of  $\text{C}_6\text{H}_6$  to an infinitely large amount sample of solution with the mole fraction of  $\text{C}_6\text{H}_6$  equal to 0.35. The vapor pressure of  $\text{C}_6\text{H}_6$  at 25 °C is 0.153 bar.
12. (8%) A glass filter with a uniform pore diameter of 0.20  $\mu\text{m}$  is filled with water at 20 °C. Estimate the pressure that would be necessary to blow the capillary water out of the pores of the filter. The surface tension of water at 20 °C is 72.75 dyne/cm.