Chemistry 2000B Spring 2002 Assignment 2

Due: Thursday, Feb. 7, noon

1. The half-life of ^{102}Tc is 5.3 s. How long would it take for 95% of the ^{102}Tc in a freshly prepared sample to decay? [5 marks]

2. Benzylpenicillin is an antibiotic which is commonly administered to farm animals to increase productivity by preventing the animals from contracting diseases while living in crowded conditions. Unfortunately, many humans are hypersensitive to penicillins. There has therefore been some concern over the presence of residues of this antibiotic in meat products. Fortunately, benzylpenicillin is not very heat stable. When meat is cooked in oil at 140°C, the half-life of benzylpenicillin is 45 min. At 180°C (a more common frying temperature), the half-life is 20 min.[1] Assume that the chemical decay process obeys first-order kinetics.

   (a) What are the activation energy and preexponential factor for the decay of benzylpenicillin? [8 marks]
   Note that since there are only two points, there is no need to use a graphical method.

   (b) Beef obtained from animals treated with benzylpenicillin typically contains approximately 13 mg of the antibiotic per kilogram of meat. Tolerances of hypersentitive individuals toward penicillin derivatives are quite low. Suppose that a safe level for these individuals is about 1 mg/kg. How long would you have to fry a piece of meat at 180°C to reduce the level of benzylpenicillin to 1 mg/kg? Is this practical? [4 marks]

3. Suppose that for the reaction $\mathrm{A} \underset{k_-}{\overset{k_+}{\rightleftharpoons}} 2\mathrm{B}$, $k_+ = 13\,\mathrm{s}^{-1}$ and the phenomenological equilibrium constant is $1.3 \times 10^{13}\,\mathrm{mol/L}$. What is k_-? [5 marks]

4. The reaction $4\mathrm{HCl}_{(g)} + \mathrm{O}_{2(g)} \rightarrow 2\mathrm{Cl}_{2(g)} + 2\mathrm{H_2O}_{(g)}$ comes to equilibrium at 400°C in a 2 L flask. Analysis of the equilibrium mixture shows that it contains 60 g of Cl_2, 12 g of $\mathrm{H_2O}$, 20 g of HCl and 8 g of O_2. Calculate the equilibrium constant. [10 marks]

   Note: In this course, "equilibrium constant" will always mean the proper thermodynamic equilibrium constant unless otherwise qualified.

5. The equilibrium constant for the reaction $\mathrm{H}_{2(g)} + \mathrm{I}_{2(s)} \rightleftharpoons 2\mathrm{HI}_{(g)}$ is 0.352 at 25°C.

   (a) Suppose that an excess of solid iodine is placed in a rigid flask with 0.400 atm of hydrogen gas and 0.300 atm of hydrogen iodide. In what direction will the reaction proceed to reach equilibrium? [4 marks]

   (b) What will the pressures of the two gases be at equilibrium? [8 marks]

6. Dinitrogen tetroxide dissociates into nitrogen dioxide. A bulb with a volume of 1296 cm^3 is filled with 2.33 g of dinitrogen tetroxide at 22.9°C. The total pressure of both gases at equilibrium is 441 mm Hg. What is the value of the equilibrium constant? [10 marks]

   Hints: This is quite a difficult question, so take it slowly. Start by calculating the initial pressure of $\mathrm{N_2O_4}$. Get all your pressures into the same units. The total pressure is given by Dalton's law of partial pressures. Look this up in the textbook if you have forgotten what that means. Create a table of initial and final partial pressures. The final partial pressures will involve an unknown which you can solve for using Dalton's law and the known total pressure. You should be able to take it from there.

[1] M. D. Rose et al., Analyst **122**, 1095 (1997).