Chemistry 2710 Spring 2006 Test 1

Time: 50 minutes

Marks: 48

Aids allowed: Calculator, formula sheet

Instructions: Answer all questions in the booklets provided. You are expected to use your graphing calculator to draw graphs. A reasonable facsimile of your graph with properly labeled axes should be drawn in your exam booklet.

Useful data:

$$\begin{aligned} 1\,\text{amu} &= 1\,\text{g/mol} \\ N_A &= 6.022\,142\,0 \times 10^{23}\,\text{mol}^{-1} \end{aligned}$$

$$\int \frac{dx}{(a+bx)(c+ex)} = \frac{1}{ae-bc} \ln\left(\frac{c+ex}{a+bx}\right)$$

1. Suppose that we are studying a reaction of order $\frac{1}{2}$ and that we have obtained measurements of the concentration of reactant, x, vs t. Describe a graphical method for calculating the rate constant from these data. [5 marks].

2. At 1800 K in the gas phase, ethane decomposes to ethene and hydrogen,

   $$C_2H_{6(g)} \rightarrow C_2H_{4(g)} + H_{2(g)},$$

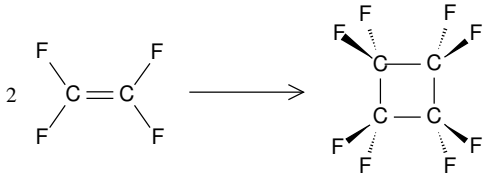
   with second-order kinetics. The rate constant at this temperature is $9.55 \times 10^{-2}\,\text{Pa}^{-1}\text{s}^{-1}$. If the initial pressure of ethane is 3.0×10^5 Pa, how long would it take for the pressure to reach 5.0×10^5 Pa? [10 marks]

3. The half-life of tritium (^{3}H) is 4500 days. The atomic mass of this isotope is 3.016 049 267 5 amu. Tritium decays by β particle (electron) emission.

   (a) If a sample contain 0.034 g of tritium, what is the rate of emission of β particles? [6 marks]

   (b) How long would it take for the rate of emission to decrease to less than 1000 particles per minute? [4 marks]

4. The following data were obtained for the gas-phase dimerization of C_2F_4 at 300°C:



t/min	$[C_2F_4]$/mol L^{-1}
0	0.0500
250	0.0250
750	0.0125
1750	0.00625
3750	0.00312

   (a) Show that the data are consistent with this being an elementary reaction and calculate the rate constant. [10 marks]

   (b) The rate constant for the reverse reaction is $9.6 \times 10^{-13}\,\mathrm{s}^{-1}$. What is the equilibrium constant? [3 marks]

5. It commonly happens that a chemical can generate two different products under given experimental conditions. Suppose that A produces the products B and C by the elementary reactions

$$\mathrm{A} \xrightarrow{k_1} \mathrm{B},$$

$$2\mathrm{A} \xrightarrow{k_2} \mathrm{C}.$$

   Derive an integrated rate law for $a = [\mathrm{A}]$. Leave your answer in the form $t =$ something. [10 marks]