Chemistry 2000 Spring 2001 Section B Test 1

Name: _____

Student number: _____

Aids allowed: Calculator. In particular, periodic tables and other written or printed materials are excluded.

Instructions: Answer all questions in the spaces provided. Use the backs of the printed pages only for rough work. If you run out of room for a particular question, you may write in the empty space on this page or in the empty space beneath the formulas on page 6.

Data and formulas are collected on the last page of this test.

DO NOT OPEN THIS PAPER UNTIL INSTRUCTED TO DO SO.

1. The following initial rate data were obtained for the reaction $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$ at 25°C:

Experiment	[NO] (mol/L)	$[O_2]$ (mol/L)	rate ($mol\,L^{-1}s^{-1}$)
1	0.0020	0.0010	2.8×10^{-5}
2	0.0040	0.0010	1.1×10^{-4}
3	0.0020	0.0020	5.6×10^{-5}

   (a) Determine the rate law. [4 marks]

   (b) Calculate the rate constant. [2 marks]

2. A solution of ethanol (CH_3CH_2OH) in water has a molarity of 9.919 mol/L and a density of 0.9139 kg/L. What is the mole fraction of ethanol in this solution? [9 marks]

3. The decomposition of dimethyl ether

$$(CH_3)_2O_{(g)} \rightarrow CH_{4(g)} + H_{2(g)} + CO_{(g)}$$

is a first order reaction with a half life of 1733 s at 500°C. If the initial pressure of dimethyl ether ($(CH_3)_2O_{(g)}$) is 0.9 atm, how long would it take to accumulate 0.7 atm of methane? Report your answer in hours and minutes, rounded to the nearest minute. [8 marks]

4. Suppose that you do a kinetics experiment for a reaction A → B in which you measure the concentration of A as a function of time. Explain how you could use this data to determine whether the reaction is of the first or second order. [6 marks]

5. The first-order rate constant for the reaction $CH_3CHO_{(g)} \rightarrow CH_{4(g)} + CO_{(g)}$ is $0.085\,s^{-1}$ at 477°C and $140\,s^{-1}$ at 727°C. What are the activation energy and preexponential factor for this reaction? [10 marks]

6. Consider the elementary reaction

$$\mathrm{H_{(g)} + Br_{2(g)} \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} HBr_{(g)} + Br_{(g)}}.$$

(a) Write down a mass-action rate equation for the concentration of HBr. [3 marks]

(b) Derive an equation relating the equilibrium constant for this reaction to the rate constants. [6 marks]

(c) If $k_1 = 2.09 \times 10^8\,\mathrm{L\,mol^{-1}s^{-1}}$ and the equilibrium constant is 1.5×10^{28}, what is k_{-1}? [2 marks]

Useful formulas and data

$k = k_\infty e^{-E_a/(RT)}$ $R = 8.314510\,\mathrm{J\,K^{-1}mol^{-1}}$

To convert degrees Celsius to Kelvin, add 273.15.

MOLAR MASSES

Element	M (g/mol)
C	12.011
H	1.0079
O	15.999

Order	Integrated rate law	Half life
1	$[\mathrm{A}] = [\mathrm{A}]_0 e^{-kt} = [\mathrm{A}]_0 \left(\frac{1}{2}\right)^{t/t_{1/2}}$	$\ln 2/k$
2	$\frac{1}{[\mathrm{A}]} = \frac{1}{[\mathrm{A}]_0} + kt$	$\frac{1}{k[\mathrm{A}]_0}$