# Chemistry 2710 Spring 2003 Test 1

**Name:** ____________________________________

**Student number:** __________________

**Aids allowed:** Calculator. One $8\frac{1}{2} \times 11$-inch piece of paper containing any information you need. No other printed materials (e.g. periodic tables, calculator manuals) are allowed.

**Instructions:** Answer all questions in the spaces provided. If you run out of space for a particular question, you can use the backs of the pages but make sure to clearly label any continued work.

Graphs should be drawn on the graph paper attached and clearly labeled with the corresponding question number. You can use a graphing calculator instead of hand-drawn graphs, but you should in these cases provide a clearly labeled and reasonably accurate sketch of the graph. This sketch need not be presented on the graph paper.

Clarity may be considered in evaluating your answers. Make sure to explain in detail the procedures used to obtain the answers you present.

| Question | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Mark | | | | |

DO NOT OPEN THIS PAPER UNTIL INSTRUCTED TO DO SO.

1. (a) In a particular experiment, the rate of the reaction

$$2NO_{2(g)} + H_2O_{(g)} \rightarrow HNO_{2(g)} + HNO_{3(g)}$$

was found to be $0.26\,\mathrm{mol\,L^{-1}min^{-1}}$. What is the rate of change of the concentration of $NO_{2(g)}$? [2 marks]

(b) The empirical rate law for this reaction is $v = k[H_2O][NO_2]$. Suppose that we repeated the experiment for which data was given in part a but tripled the initial concentration of water and doubled the initial concentration of $NO_2$. What rate of reaction would you predict would be measured? [2 marks]

2. Consider the following table of initial rate data for a reaction A $\rightarrow$ 2B:

| Experiment | $a$ (mol/L) | $b$ (mol/L) | $v$ (kmol L$^{-1}$s$^{-1}$) |
|---|---|---|---|
| 1 | 1.5 | 1.3 | 17 |
| 2 | 3.5 | 1.3 | 23 |
| 3 | 9.2 | 1.3 | 31 |
| 4 | 1.5 | 0.55 | 18 |
| 5 | 1.5 | 0.13 | 17 |

Verify that this reaction has a simple rate law. Determine the rate law, the overall order, and the rate constant. [10 marks]

3. When ion channels are opened in a cell membrane (e.g. the membranes of neurons), the flow of ions creates a voltage difference between the two sides of the membrane. This voltage is not established instantaneously but obeys the rate law

$$\frac{d(\Delta V)}{dt} = -\frac{\Delta V}{RC},$$

where $\Delta V$ is the difference between the transmembrane voltage and its equilibrium value,

$$\Delta V = V - V_{\text{eq}},$$

$R$ is the membrane electrical resistance, and $C$ is its capacitance. Resistance is measured in ohms ($\Omega$), and capacitance is measured in farads (F). The units of resistance and capacitance combine as follows: $1\,\Omega \times 1\,\text{F} = 1\,\text{s}$.

(a) Derive an integrated rate law for the voltage. Write your final answer in the form $V =$ something. Show all your steps. [8 marks]

(b) A membrane has a capacitance of 15 pF and a resistance of 10 MΩ. If the initial transmembrane voltage is 0 mV and the equilibrium voltage is 100 mV, how long would it take for the membrane voltage to reach 99 mV? [4 marks]
Note: p is the SI prefix for $10^{-12}$.

4. Winkler and Hinshelwood have studied the thermal decomposition of acetaldehyde at 600°C:[1]

$$CH_3CHO_{(g)} \rightarrow CH_{4(g)} + CO_{(g)}.$$

The reaction was monitored by measuring the change in pressure, i.e. the difference between the pressure at time $t$ and the initial pressure. The reaction vessel was initially filled with 240 torr of acetaldehyde. The following data were obtained:

| $t$ (s) | $\Delta P$ (torr) |
|---|---|
| 26 | 24 |
| 71 | 86 |
| 129 | 128 |
| 239 | 169 |
| 380 | 191 |
| 600 | 206 |
| 1048 | 218 |
| 1503 | 222 |
| 1891 | 227 |

As we will see later, gas-phase decomposition reactions often display simple rate laws with an order of 1 or 2, although the order of the reaction generally depends strongly on the reaction conditions, especially the initial pressure. In some pressure ranges, a complex rate law is observed. Are these data consistent with a simple rate law of either first- or second-order? If so, calculate the rate constant. [15 marks]

[1] C. A. Winkler and C. N. Hinshelwood, Proc. R. Soc. London, Ser. A **149**, 355 (1935).