KWANTLEN UNIVERSITY COLLEGE
CHEMISTRY 1210 S-10
EXAM No. 1A
October 16, 1997

NAME: ____

Instructions: This exam contains **Seven** questions. Read the exam carefully and judge your time accordingly. A periodic chart is given on the last page of this exam. Return this exam paper with your exam booklet. **ALL CALCULATIONS MUST BE SHOWN TO RECIEVE ANY CREDIT !** Maximum Score: **61** points

USEFUL INFORMATION:

1 Faraday = 96,485 Coulombs/mole e^-

R = 8.314 J/mol·K = 0.08206 L-atm/mol-K

$\ln(X) = 2.303 \log_{10}(X)$

Nernst equation at 25 ºC: $\mathscr{E} = \mathscr{E}^{o} - (0.05916 / n) \log Q$

Arrhenius equation: $k = Ae^{-Ea/RT}$

Temperature dependence of k:

$$\ln(k_2 / k_1) = \frac{-E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) = \frac{E_a (T_2 - T_1)}{R\, T_1 T_2}$$

Integrated Rate Laws:

Zero Order:

$[A_o] - [A_t] = kt$

First Order:

$\ln[A_o] - \ln[A_t] = kt$

Second Order:

$[1/A_t] - [1/A_o] = kt$

Question One: (8 MARKS)

For the following oxidation-reduction reaction which takes place in **basic** solution.

$$CrO_4^{2-}(aq) + HSnO_2^-(aq) \text{ ---> } HSnO_3^-(aq) + CrO_2^-(aq)$$

a) Balance the above chemical equation. **(5)**

b) Which Species is the reducing agent? **(1)**

c) What is the equivalent weight of K_2CrO_4 (molar mass = 194.20) used in the above reaction for CrO_4^{2-} ? **(2)**

Question Two: (6 MARKS)

A mixture of NaCl and $NaNO_2$ was to be used in processing meat to make sausage. Before being used it was analyzed as follows: A 1.124 g portion of the mixture was dissolved in water and acidified converting NO_2^- to HNO_2. The HNO_2 that was formed was titrated with 0.2000 N $K_2Cr_2O_7$, which oxidized HNO_2 to NO_3^-. The titration required 21.47 mL of the $K_2Cr_2O_7$ solution.

a) How many equivalents of HNO_2 reacted in the titration? **(2)**

b) How many moles of $NaNO_2$ were in the 1.124 g sample? **(2)**

c) What was the percentage of $NaNO_2$ in the sample? **(2)**

(Note: Na^+ and Cl^- do not react in this titration. You do not need to write the complete balanced chemical equation.)

Question Three: (14 MARKS)

An electrochemical cell is constructed in which a platinum wire dips into a solution containing 2.00 *M* Fe^{3+} and 1.00 *M* Fe^{2+}, the other half-cell consists of copper metal immersed in a 1.00 *M* Cu^{2+} solution. The two half-cells are connected by a salt bridge and the temperature is maintained at 25.0 °C. Given the following reduction potentials:

$$Cu^{2+}(aq) + 2e^- \rightleftarrows Cu(s) \qquad \mathscr{E}^o = +0.34V$$

$$Fe^{3+}(aq) + e^- \rightleftarrows Fe^{2+}(aq) \qquad \mathscr{E}^o = +0.77V$$

a) Write the overall cell reaction and calculate $\mathscr{E}_{cell}$. **(4)**

b) Write the conventional cell notation for this electrochemical cell operating under the above conditions. **(2)**

c) Write the half reaction which takes place at the anode. **(1)**

d) What is the sign at the cathode? **(1)**

Question Three: (Continued)

e) Determine the equilibrium constant for the cell reaction. **(3)**

f) The copper electrode is placed in a solution of an unknown [Cu^{2+}]. The measured potential at 298K is +0.54V. What is the [Cu^{2+}] ? **(3)**

Question Four: (8 MARKS)

The total charge of electricity required to plate out 15.54g of a metal, M(s), from a solution of M^{2+} ions is 14475 coulombs.

a) Determine the identity of the unknown metal. **(3)**

b) Write the half reaction for the plating out of this metal. **(1)**

c) At which electrode does the plating out of this metal take place and what is the sign of this electrode? **(2)**

d) If the current used in this electrolysis was 2.00 amperes, how long did it take to plate out the 15.54g of this metal? **(2)**

Question Five: (9 MARKS)

a) The thermal decomposition of phosphine (PH_3) into phosphrous and hydrogen gas is a first-order reaction. The observed half-life of this reaction is 35.0s at 680 ºC.

i) Determine the rate constant for this reaction. **(3)**

ii) How long would it take for for 95.0 percent of the phosphine to decompose at this temperature? **(3)**

b) A catalyst speeds up a reaction by proceeding by a different pathway having a lower activation energy. If a reaction with a catalyst proceeds 10^4 times faster than without a catalyst, by how many kJ/mol is the activation energy lowered, if both reactions occur at 26.9 ºC? (Note: assume that "A" does not change.) **(3)**

Question Six: (10 MARKS)

The reaction between mercury(II) chloride and oxalate ions in aqueous solution is given by the equation,

$$2HgCl_2(aq) + C_2O_4^{2-}(aq) \text{ ---> } 2Cl^-(aq) + 2CO_2(g) + Hg_2Cl_2(s)$$

The table below gives the results of four experiments carried out at a constant temperature.

Experiment #	$[HgCl_2]$ (M)	$[C_2O_4^{2-}]$ (M)	$-d[C_2O_4^{2-}]/dt$ (mol/L·S)
1	0.105	0.15	1.8×10^{-5}
2	0.105	0.30	7.1×10^{-5}
3	0.052	0.30	3.5×10^{-5}
4	0.052	0.15	8.9×10^{-6}

a) Determine the rate law for this reaction. **(4)**

b) Determine the numerical value of the rate constant and **its units**. **(2)**

c) Calculate the rate of appearence of $Cl^-(aq)$ in experiment #3. **(2)**

d) What is the reaction rate when the concentration of $HgCl_2$ is 0.080 M and that of $C_2O_4^{2-}$ is 0.10 M at the same temperature as the above experiments. **(2)**

Question Seven: (6 MARKS)

The gas phase reaction for the decomposition of ozone is given by the equation:

$$2O_3(g) \rightleftharpoons 3O_2(g)$$

A proposed mechanism for this reaction is given as,

$$O_3 \underset{k_2}{\overset{k_1}{\rightleftharpoons}} O_2 + O \quad \text{(both fast with equal rates)}$$

$$O_3 + O \xrightarrow{k_3} 2O_2 \quad \text{(slow).}$$

Determine the rate law based on this proposed mechanism.