Quantitative Analysis—Chem 201
Final Exam
8 December 2009

Name _____

Potentially Useful Information

F = 96,485 C/mol

$$\log(\gamma) = \frac{(-.51)Z^2\sqrt{\mu}}{1+\frac{\alpha\sqrt{\mu}}{305}}$$

$$K = \frac{[X]_S}{[X]_M}$$

$$k' = K\frac{V_S}{V_M} = \frac{t_R'}{t_M}$$

$$N = 16\left(\frac{t_R}{w}\right)^2 = 5.55\left(\frac{t_R}{w_{1/2}}\right)^2$$

$$R = \frac{\Delta t_R}{w_{av}} = .589\frac{\Delta t_R}{w_{1/2,av}}$$

1. (20 points) Dichromate ion, $Cr_2O_7^{2-}$, oxidizes methanol, CH_3OH, to formaldehyde, CH_2O, under acidic conditions.

$Cr_2O_7^{2-}(aq) + H^+(aq) + e^- \rightarrow Cr^{3+}(aq) + H_2O(\ell)$	$E^o = +1.36$
$CH_2O(aq) + H^+(aq) + e^- \rightarrow CH_3OH(aq)$	$E^o = -0.237$ V
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	$E^o = -0.771$ V

60.00 mL of 0.2007 M $Cr_2O_7^{2-}$ was added to 10.00 mL of a solution containing methanol in water. The excess $Cr_2O_7^{2-}$ was then titrated with 39.84 mL of 0.2500 M Fe^{2+} solution. Determine the molar concentration of methanol in the CH_3OH/H_2O solution.

2. (20 points) Vanadium is an environmental pollutant originating from some types of steel, but also from the combustion of fossil fuels. The amount of V^{2+} in an unknown sample is determined by potentiometric titration by 7.62 mM permanganate ion, MnO_4^-. 25.00 mL of unknown was titrated with 12.38 mL of 7.62 mM MnO_4^- using a SCE reference electrode (E_{ref} = 0.241 V). pH of the solution was maintained at pH = 4.00. Determine the potential at the equivalence point and the concentration of vanadium in the unknown sample.

$V^{3+} + e^- \rightarrow V^{2+}$ $\quad E^o = -0.255$ V

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4\ H_2O$ $\quad E^o = +1.507$ V

3. (20 points) A two-component mixture is analyzed by gas chromatography with flame ionization detection. Compound X has a retention time of t_R = 5.83 min with N = 7080 theoretical plates, and compound Y has a retention time of t_R = 6.07 min with N = 7160 theoretical plates. Calculate the chromatographic resolution for these compounds.

4. (20 points) An accurate way to determine solubility products is to measure the electrical potential of a cell containing a solution saturated with the salt of interest. The potential of a saturated silver sulfate solution, Ag_2SO_4, was measured to be E = 0.7158 V relative to a standard hydrogen electrode. The solution had an ionic strength of $\mu = 0.07596$. Only the silver ion undergoes a redox reaction—the sulfate ion remained in solution. Determine the solubility product, K_{sp}, for silver sulfate.

$Ag^+(aq) + e^- \rightarrow Ag(s)$ $\qquad E^o = +0.7993$ V

$\alpha_{Ag^+} = 250$ pm

$\alpha_{SO_4^{2-}} = 400$ pm

5. (20 points) Name four of the five critical components of a gas chromatograph and describe their function in effecting analytical separations.