

**Quantitative Analysis—Chem 201**  
**Final Exam**  
8 December 2009

Name \_\_\_\_\_

**Potentially Useful Information**

$$F = 96,485 \text{ C/mol}$$

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

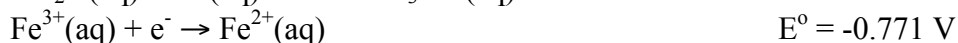
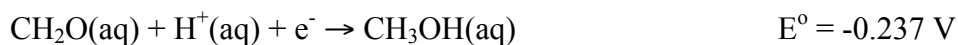
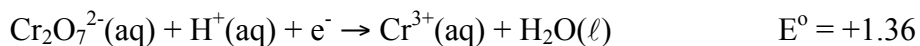
$$K = \frac{[X]_S}{[X]_M}$$

$$k' = K \frac{V_S}{V_M} = \frac{t'_R}{t_M}$$

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

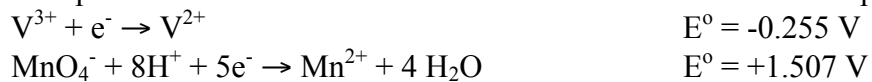
$$R = \frac{\Delta t_R}{w_{av}} = .589 \frac{\Delta t_R}{w_{1/2,av}}$$

1. (20 points) Dichromate ion,  $\text{Cr}_2\text{O}_7^{2-}$ , oxidizes methanol,  $\text{CH}_3\text{OH}$ , to formaldehyde,  $\text{CH}_2\text{O}$ , under acidic conditions.



60.00 mL of 0.2007 M  $\text{Cr}_2\text{O}_7^{2-}$  was added to 10.00 mL of a solution containing methanol in water. The excess  $\text{Cr}_2\text{O}_7^{2-}$  was then titrated with 39.84 mL of 0.2500 M  $\text{Fe}^{2+}$  solution. Determine the molar concentration of methanol in the  $\text{CH}_3\text{OH}/\text{H}_2\text{O}$  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.



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,  $\text{Ag}_2\text{SO}_4$ , was measured to be  $E = 0.7158 \text{ V}$  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,  $K_{\text{sp}}$ , for silver sulfate.



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

$$\alpha_{\text{SO}_4^{2-}} = 400 \text{ pm}$$

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