Chemistry 24b (Spring term 2004)
Problem Set #1
Due: 4/12/04, 11AM, in class

Part I

From Tinoco, Sauer, Wang and Puglisi: Chapter 6, Problems 13, 18, 23, 24

Part II

Problem A
A typical electric-field strength for an electrolysis experiment is 10 V/cm. The experimental electric mobility extrapolated to infinite dilution for Mg^{2+} ions in water at 25°C and 1 atm is 55 x 10^{-5} $cm^2V^{-1}s^{-1}$.

(i) Calculate the drift speed for Mg^{2+} ions in this field in dilute aqueous solution at 25°C and 1 atm.
(ii) Compare the result of (i) with the rms speed of random thermal motion of these ions.

Problem B
The partial specific volume of hemoglobin is $\bar{u}_2$ = 0.749 cm^3 g^{-1} and molecular weight is 6.45 x 10^4 g mol^{-1}. Calculate:

(i) The radius of the sphere, which has the same volume as hemoglobin.
(ii) The frictional coefficient expected for such a sphere when η = 1.00 centipoise.
(iii) The sedimentation coefficient of the sphere; solvent density equals 1.

Problem C
The measured sedimentation coefficient of hemoglobin is $s_{20,w}$ = 4.31 S. Use also the information from Problem B to:

(i) Calculate the amount of water (δ_1) that would have to be hydrated by hemoglobin (in grams water per grams protein) to produce a sphere of sedimentation coefficient 4.31 S. Assume that the volume of the sphere is

$$V = \frac{M}{N_A}\left(\bar{u}_2 + \delta_1 \bar{u}_1\right)$$

in which $\bar{u}_1$ = 1.00 cm^3 g^{-1} is the partial specific volume of water.
(ii) Calculate the axial ratio of hemoglobin that would be required to produce a prolate ellipsoid of the observed sedimentation coefficient if there is no water of hydration.
Hint: Insert trial values of a/b into the following equation until the observed f/f_0 is obtained.

$$\frac{f}{f_0} = \frac{(a/b)^{2/3}\left(1 - b^2/a^2\right)^{1/2}}{\ln\left\{\dfrac{1 + \left(1 - b^2/a^2\right)^{1/2}}{b/a}\right\}}$$