Solutions to

Problem Set 5. due 04/14/01

1. Starting from

$$\frac{\mu_1-\mu_1^o}{RT}=\ln(1-\phi_2)+(1-\frac{1}{x_n})\phi_2+\chi_1\phi_2^2 \tag{1}$$

for a polydisperse polymer solution where the number average degree of polymerization is represented by x_n,

A) show that

$$\phi_{2,c}=\frac{1}{1+\sqrt{x_n}} \tag{2}$$

$$\chi_{1,c}=\frac{(1+\sqrt{x_n})^2}{2x_n} \tag{3}$$

$$\psi_1(\frac{\Theta}{T_c}-1)=\frac{1}{\sqrt{x_n}}+\frac{1}{2x_n} \tag{4}$$

where

$$(\mu_1-\mu_1^\circ)^E\equiv -RT\psi_1(1-\frac{\Theta}{T})\phi_2^2 \tag{5}$$

B) Plot $-\frac{\mu_1-\mu_1^o}{RT}$ vs. ϕ_2 at x_n=1000 for χ_1 = 0.50, 0.53, 0.532, 0.54, and 0.60, and find $\phi_{2,c}$ and $\chi_{1,c}$.

2. The following light scattering data are given for monodisperse fractions of poly(styrene) in benzene (n_0 =1.4977) at 20°C with a He-Ne laser as the light source. Find the molar mass M, RMS radius of gyration R_g and second virial coefficient A_2 by constructing a Zimm plot.

c/mg/mL	$(K\cdot c / R_\theta)\cdot 10^6$ /mol·g^{-1}					
	θ = 20°	40°	60°	80°	100°	120°
1.0	3.205	3.25	3.32	3.40	3.49	3.57
2.0	4.025	4.07	4.14	4.22	4.31	4.39
3.0	4.85	4.89	4.96	5.04	5.13	5.21
4.0	5.67	5.71	5.78	5.86	5.95	6.03

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3. For polydisperse systems, prove that the molar mass and mean square radius of gyration obtained from light scattering via

$$\frac{Kc}{R_\theta} = \frac{1}{M}\left\{1 + \frac{16}{3}\left(\frac{\pi}{\lambda'}\right)^2 \cdot R_g^2 \cdot \sin^2(\theta/2) + \cdots \right\} + 2A_2c + \cdots \qquad (6)$$

represent a weight average and z-average quantity, respectively.

4. Calculate the diffusion coefficient and sedimentation coefficient of hemoglobin, a globular protein assuming it to be spherical in shape, in the limit of infinite dilution in water at 20°C. Its $M=6.45\cdot10^4$ g/mol, the partial specific volume $\bar{v}_2$ in water is 0.75 cm^3/g, and the viscosity of water at 20°C is $1.005\cdot10^{-2}$ g/cm·s, i.e., 1.005 centipoise.

$$D = \frac{kT}{6\pi\eta Rs} \qquad (7)$$

$$S = \frac{MD(1-\bar{v}_2\rho)}{RT} \qquad (8)$$