Name:
Recitation Instructor:

20.110/2772J and 20.114J
Fall 2005
Exam III
December 1, 2005

You have 50 minutes for this exam.

WRITE YOUR NAME ON EVERY PAGE

CLOSED BOOK
3 pages of notes allowed

1 (40 points)		
2 (35 points)		
3 (25 points)		
total (100 points)		

$k = 1.38 \times 10^{-23}$ J/K

R= 8.314 J K^{-1} mol^{-1}, R=0.08314 L bar K^{-1} mol^{-1}, R = 0.08206 L-atm/mol-K
T(K)=t(°C)+273.15

760 Torr = 1atm = 1.013 bar

Please show all work. When possible do not erase or cross out "false starts" on problems.

Name:

1. 40 points As part of a lab experiment, you express and purify a 17-amino acid peptide that has a theoretical molecular weight of 2000 gm/mol. You lab instructor says you should check the molecular weight by osmometry, and thus you add 1 mg of the peptide to 1 mL of 0.1 M NaCl solution (in water) and measure the osmotic pressure against pure 0.1 M NaCl using a membrane that allows free passage of NaCl. The temperature is 300K.

(a) You measure an osmotic pressure of 7.38×10^{-3} atm (recall that 0.1 M NaCl is present in both the peptide solution AND the fluid on the other side of the osmometer membrane). Is this measurement consistent with the theoretical molecular weight of the peptide?

(b) Another student in your class used 10 mg peptide in 1 mL of 0.1 M NaCl and measured an osmotic pressure of 65.7×10^{-3} atm, using the same experimental apparatus. If the osmometry measurements can each be considered to reflect (dilute solutions", explain why the two measurements reported in part a are consistent with formation of peptide dimers, and estimate the equilibrium constant for the dimerization reaction: $P + P \leftrightarrow P{:}P$

Name:

(c) Your curiosity is piqued, and you measure the osmotic pressure at 285 K and find to your amazement that for a given concentration of peptide, the osmotic pressure is greater than what you observe at 300K. Explain why such a result is possible.

(d) Is the dimerization reaction endothermic or exothermic?

(e) This peptide contains several ionizable side chains. You decide to measure the osmotic pressure in pure water, and find that it is consistently higher in water than in the salt solution. Explain this observation in terms of the physical effects of salt on the equilibrium of the dimerization reaction.

Name:

(2) **35 points** Equal moles of liquid "A" and liquid "B" are mixed in glass vial at 298K. It is known that at 298 K, the interaction parameter has the value $\chi_{AB} = 3.0$ and the solution is "regular".

(a) Does the vial contain a single phase or do the liquids separate into two phases for this temperature (298K)? Support your answer with a quantitative calculation.

(b) You do an experiment where you cool the liquid to 270 K, where it is phase separated, and then slowly heat it under conditions that prevent evaporation of either liquid. At what temperature will the mixture just become a single phase? You may presume that the individual interaction energies w_{AA}, w_{BB} and w_{AB} are independent of temperature.

Name:

(c) You bring this mixture back to 279 K, where it is 2 phases, and add a solute so that the mole fraction is not more than 0.005 in either phase (very dilute). At this temperature, the solute has the following interaction parameters with each solvent:

$\chi_{SA} = 7$
$\chi_{SB} = 1.1$

In which phase (A or B) is this solute concentrated? What is the ratio x_{SA}/x_{SB} ?

Name:

(3). 25 points A series of polymers with different molecular weights are made from a monomer which yields a repeat unit length b = 0.30 nm. These polymers are subjected to various measurements and experiments so that they can be featured in this 20.110 exam. All measurements and activities are carried out at 300K in theta solvents unless otherwise noted.

(a) One of the polymers, designated "P-1", was synthesized under strict conditions to yield a polymer with N = 1010. The R_g (radius of gyration) of this polymer is determined by light scattering in a theta solvent to be 11.7 nm. Recall that

$$R_g = \frac{\left\langle r_0^2 \right\rangle^{1/2}}{\sqrt{6}}$$

Another polymer in the series, "P-23" has an unknown degree of polymerization, but is determined to have R_g = 23.4 nm. Approximately what is the value for N for this P-23 polymer?

(b) Calculate the work required to stretch the ends of the polymer "P1" a distance of 3 nm from the unperturbed state, and then the additional work required to stretch the ends another 3 nm.

(c) If the process in part b is carried out isothermally, how much heat is exchanged with the surroundings?

Name: