Chem/ CBE C178: Spring 2020: Midterm 2

- You have **50 minutes to take the exam, plus 20 minutes** to upload your solution to Gradescope (and print the exam if you wish).

- You may use your course notes, anything downloaded from the bCourses website for this course, the course text, and any materials associated with this course such as homework. Use of other resources and contact with others is not permitted.

- **SHOW YOUR WORK.**

- **INCLUDE UNITS IN ALL YOUR ANSWERS.**

- **YOUR EXAM SHOULD HAVE <u>5 PAGES</u>, including this page.**

Useful Information:

Avogadro's number = 6.02×10^{23} T(in K) = T(in °C) + 273

Boltzmann constant k = 1.381×10^{-23} J/K

R = 8.314 J/K mol=1.987cal/K mol = 82.1 cm^3 atm/K mol

Length of C-C sigma bond = 0.154 nm. Length of C-H sigma bond = 0.11 nm.

Length of C-O sigma bond =0.143 nm

Problem	Points
1	/35
2	/20
3	/45
TOTAL	/100

As a member of the Berkeley community, I act with honesty, integrity, and respect for others. I pledge that I have neither given nor received assistance with this exam.

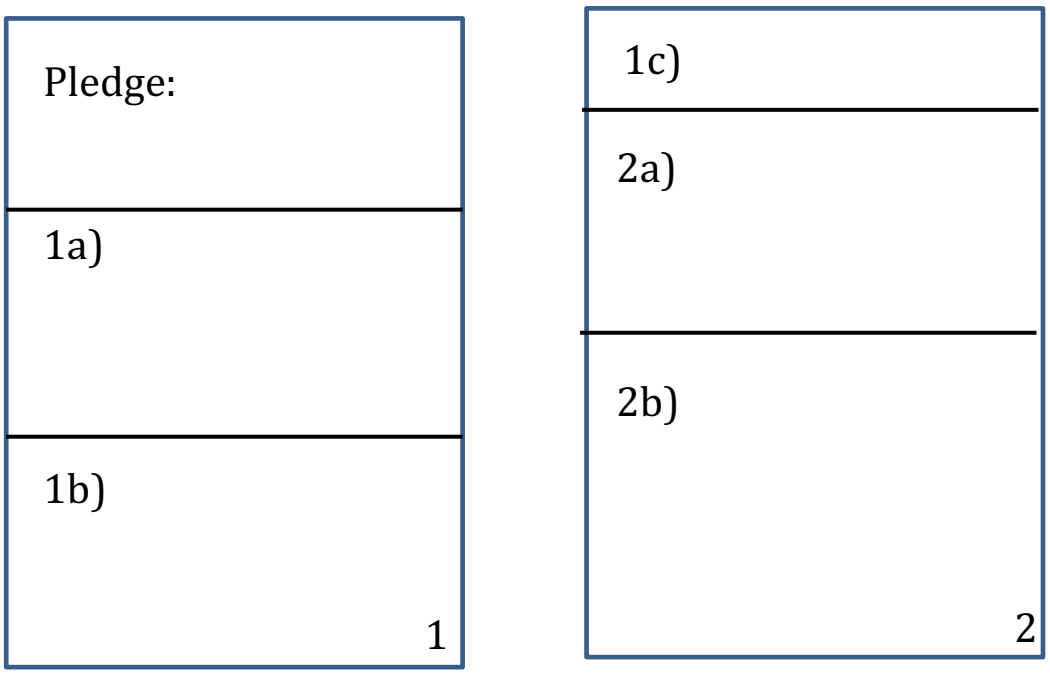
Signed: _____

SOLUTION FORMAT:

- Your solution may be written on **blank paper.** Be sure to **indicate what problem (e.g., 1a, 3c, etc.) your answer corresponds to.**

- **Please draw a solid line between answers to 1a and 1b, 1b and 1c, etc.**

Your solution should look like this:



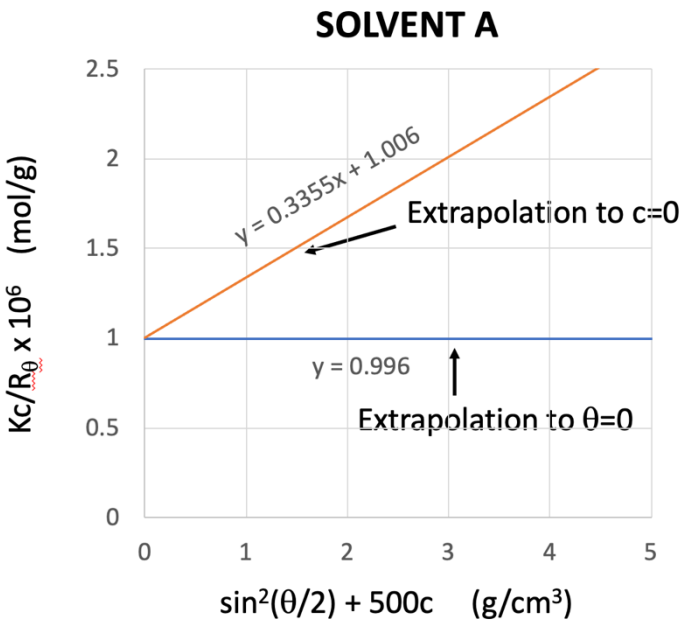
Please write the pledge below on the first page of your exam. You may write this in advance before the exam starts. Sign it at the end of the exam and submit it with your solution.

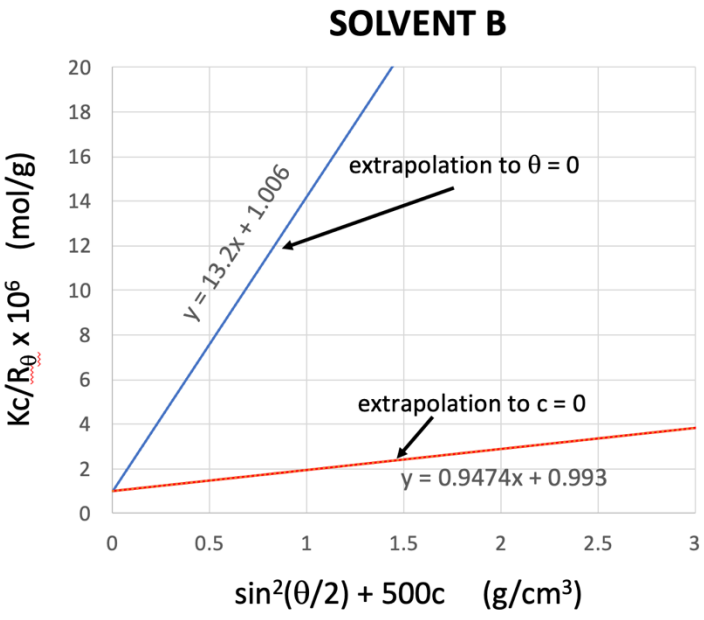
As a member of the Berkeley community, I act with honesty, integrity, and respect for others. I pledge that I have neither given nor received assistance with this exam.

Signed: _____

1. A sample of polystyrene (PS, M_o = 104 g/mole) is characterized using static light scattering in two different solvents, solvent A and solvent B, at the same temperature. The data for each solvent are plotted in the form of Zimm plots. For clarity, only the extrapolations of the data to zero concentration and zero scattering angle are shown below.

The wavelength of the incident light is 488 nm for both sets of experiments. The refractive index of solvent A is 1.45 and dn/dc = 0.120 ml/g. For solvent B, the refractive index is 1.39 and dn/dc = 0.112 ml/g. (Note: R_θ is the Rayleigh ratio as defined in the text; in lecture, we used to symbol ΔR_Θ for this quantity to highlight that it corresponds to the difference between the solution and the solvent.)





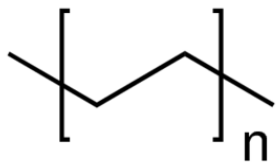
a) Which is the better solvent? Explain briefly.
b) Is either solvent a theta solvent? Explain briefly.
c) Using the data above, determine the radius of gyration of the polymer in solvent A.
d) Using the data above, determine the radius of gyration of the polymer in solvent B.
e) Determine the coil expansion factor, α.
f) Determine the characteristic ratio, C_∞, for polystyrene based on the data given above.
g) Using the value of C_∞ calculated above, determine the radius of gyration of the polymer, and comment on whether your result agrees with the light scattering data (and if so, for which solvent).

2. The following data for the osmotic pressure of a polymer solution are available:
Osmotic pressure = 300 dyne/cm^2; polymer concentration = 0.00133 g/cm^3; T = 30 °C.
You are told to estimate the molecular weight of the polymer given this information only.

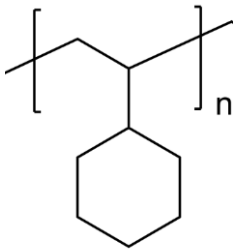
a) What assumption must you make to perform this calculation?
b) Compute the molecular weight of the polymer given this assumption.
c) You are told that the solvent for the experiment is a good solvent for the polymer. Do you expect the value computed in part b) is greater than, less than, or equal to the true molecular weight of the polymer? Why?
d) If the dissolved polymer is polydisperse, what molecular weight average should be assigned to your answer from part (b)?
e) A different polymer is dissolved in the same solvent and at the same concentration and temperature. The osmotic pressure measured is twice that reported for the first polymer. What can you say about this polymer versus the original polymer and why? Explain.

3. You are running experiments on a binary blend of polyethylene (PE, ρ = 0.784 g/cm^3) and poly(cyclohexylethylene) (PCHE, ρ = 0.92 g/cm^3) with $M_{n,PCHE}$ = 2600 g/mol. Their structures are below

Polyethylene



Poly(cyclohexylethylene)



a) You determine that $\phi_{c,PE} = 0.4$. What is $M_{n,PE}$? To simplify your calculations, use a four-carbon unit of PE ($-CH_2CH_2CH_2CH_2-$) for the reference volume.
b) Determine χ_c

Using samples with the same values of M_n obtained above for PE and PCHE, you prepare a beaker of a 20 g sample which is 30% PE by volume. You determine that at 220 °C the mixture phase separates into two phases with $\phi_{PE,1} = 0.15$ and $\phi_{PE,2} = 0.65$.

c) What phase is at the bottom of the beaker?
d) What are the total volume and masses of the PE and PCHE components?
e) What is the volume of PE and PCHE in each phase?

PLEASE NOTE ON THE LAST PAGE YOU UPLOAD ANY REQUEST FOR CONSIDERATION DUE TO UNEXPECTED ISSUES SUCH AS INTERNET ISSUES, SCANNING ISSUES, ETC.

BE SURE TO WRITE AND SIGN THE PLEDGE.

STAY SAFE & HEALTHY!