Total of 100 points. Each question is worth of 5 points, unless otherwise noted.

1. (a) Draw the structure of syndiotactic poly(vinyl chloride).
   (b) Would the glass transition temperature of syndiotactic PVC be lower than, the same to, or higher than atactic PVC? Explain your answer.
   (c) If atactic PVC is crosslinked somehow, would the glass transition temperature be lower than, the same to, or higher than linear (<u>un</u>crosslinked) PVC? Explain your answer.
   (d) Polyethylene terephthalate (PET) is prepared from ethylene glycol ($HO\text{-}CH_2\text{-}CH_2\text{-}OH$) and terephthalic acid ($HOOC\text{-}Ph\text{-}COOH$). Draw the structure of PET.
   (e) PET is not soluble in organic solvent, and is soluble only in pretty strong acid like trifluoroacetic acid or phenol. Explain.
   (f) Cellulose acetate is soluble in either acetic acid or pyridine, but is not soluble in a mixture of the two. Explain.

2. In Flory-Huggins lattice theory for polymer solutions, the entropy of mixing is given as:
$$\Delta S_m = k \ln [\Omega_{12}/\Omega_1\Omega_2].$$
   (a) What are Ω_{12}, Ω_1, and Ω_2, respectively? Answer in your own words. No equations.
   (b) Is Ω_2 larger, the same, or smaller than Ω_1? Why?

3. Answer the following questions for χ.
   (a) What is it called?
   (b) How is the polymer/solvent system with higher χ compared to the system with lower χ?
   (c) What does it mean by $\chi = 0.5$?
   (d) If a polymer/solvent system has negative χ value, what does it mean?
   (e) χ of polystyrene in toluene at 25 °C is 0.37. Would χ at 40 °C be higher than, lower than, or the same to 0.37? Why?
   (f) Would χ of polystyrene in acetone at 25 °C be higher than, lower than, or the same to 0.37? Why?

4. [10 points] You want to determine the theta temperature of a polymer in a certain solvent. You are given with the polymer samples with a few different known molecular weights and the solvent. Design and explain your experiment that determines the theta temperature.

5. (a) Name the methods, as many as you can, that can be used in the molecular weight determination of polymers.
   (b) Categorize the methods of your answer to (a) into three groups; methods measuring M_n, M_w, and molecular size.

6. Using the table given below, answer the following questions.

   (a) For a polystyrene solution in cyclohexane at 34.5 °C, a relative viscosity of 1.60 was measured at the concentration of 1.0 g/dL. Estimate the viscosity average molecular weight of the polymer.

   (b) The use of 'universal calibration' in GPC is based on the observation that the hydrodynamic volume is the same for all the polymers at the same retention volume. If a monodisperse cis-polybutadiene standard with molecular weight of 100000 eluted at the retention volume of 100 mL in the GPC experiment with benzene at 30 °C, what would be the molecular weight of the fraction of polyvinyl acetate eluted at the same retention volume at the same condition?

Table 3.10 Selected intrinsic viscosity–molecular weight relationship

Polymer	Solvent	$T(°C)$	$K \times 10^{3a}$	a^b
cis-Polybutadiene	Benzene	30	33.7	0.715
it-Polypropylene	1-Chloronaphthalene	139	21.5	0.67
Poly(ethyl acrylate)	Acetone	25	51	0.59
Poly(methyl methacrylate)	Acetone	20	5.5	0.73
Poly(vinyl acetate)	Benzene	30	22	0.65
Polystyrene	Butanone	25	39	0.58
Polystyrene	Cyclohexane	34.5	84.6	0.50
Polytetrahydrofuran	Toluene	28	25.1	0.78
Polytetrahydrofuran	Ethyl acetate hexane	31.8	206	0.49

^{a} K in mL/g