Properties of Polymers Midterm Exam 01 May 2019

1. [2 + 2 + 3 x 3 pts] **Answer the following questions.**

(a) Draw the structure of poly(styrene-*alt*-vinyl acetate).
(b) Draw the structure of syndiotactic polystyrene.
(c) Why is (atactic or syndiotactic) polystyrene insoluble in methanol, while styrene is soluble?
(d) Why is syndiotactic polystyrene insoluble in xylene, while atactic polystyrene is soluble?
(e) What would you do to dissolve syndiotactic polystyrene in xylene? Explain your answer.

2. [3 x 3 points] **Answer the following questions.**

(a) Is the solvent in an ideal solution always a good solvent? Why or why not?
(b) Actually, a polymer solution cannot be an ideal solution. Why?
(c) A polymer solution can behave as an ideal solution, though. How?

3. [3 x 3 points] **For polyethylene chains with the molar mass of 140000, the bond angle of 110°, and the bond length of 0.15 nm, answer the following questions.**

(a) If the chains take the most preferred conformation for all of their bonds, what would be the root-mean-square end-to-end distance?
(b) If the chains are freely rotating, what would be the root-mean-square end-to-end distance of the chain?
(c) If the characteristic ratio determined by SANS at 140 °C was 6.8, what would be the unperturbed root-mean-square radius of gyration?

4. [2 + 2 + 3 + 3 points] **For DSV and GPC for measuring molar mass of polymers, answer the following questions.**

(a) Spell out DSV and GPC.
(b) Both of DSV and GPC are 'relative' methods. Why are they 'relative?'
(c) What is the equation used in DSV practice to get molar mass from your raw data? Write the name of the equation, and describe the equation in <u>one sentence</u>.
(d) What is the concept (or observation) used in GPC practice to get molar mass from your raw data? Describe it in one sentence.

5. [5 x 3 points] **There are three theories explaining the glass transition of polymers.**

(a) What are they? Name the three.
(b) How is the glass transition defined by each of the theories? Limit your answer to <u>one sentence</u> for each theory.
(c) Would the glass transition temperature appear at a higher or a lower temperature when you increase the heating rate of the DSC experiment? Explain your answer using one of the theories above.
(d) Would the glass transition temperature appear at a higher or a lower temperature when you increase the crosslinking density of the same polymer? Explain your answer using one of the theories above.
(e) Would the glass transition temperature appear at a higher or a lower temperature when you 'age' the polymer sample? Explain your answer using one of the theories above.

6. [10 x 2 points] **Fill the blanks in the description of polymer crystals below.**

By slowly lowering the temperature of a polyethylene solution, the plate-like single crystal, called (a)_____ is formed. The unit cell crystallographic structure the crystal is (b)_____, in which the c-axis [chain axis] is perpendicular to the a-b plane. The crystal grows by crystallization of the chains on (c)_____ plane (which is called fold-plane; write down the Miller index), and folding at (d)_____ plane (which is fold surface; write down the Miller index). By the discovery of this polyethylene single crystal, the idea of folded-chain model, in contrast to the earlier (e)_____ model, of polymer semicrystalline state was developed.

By lowering the temperature of a polyethylene melt, a ball-like crystal, called (f)_____, is formed. This type of crystal formed in thin film shows characteristic (g)_____ pattern under polarized light. Examining this type of crystal formed in the bulk, the crystal is actually (a), and the chain axis is (h) radial or tangential (choose one) to the ball. The mode of re-entry to (a) is (i)_____ rather than adjacent, and the region between (a)s contains (j)_____ that holds the (a)s together.

7. [5 x 3 points] **Consider the three crystallizable polymers; Polymer 1 with T_g of –50 °C, Polymer 2 with T_g of 10 °C, and Polymer 3 with T_g of 100 °C.**

(a) Estimate or guess the melting temperature of Polymer 1, 2, and 3.

(b) After the polymers were cooled to room temperature from their melt state, it was found that Polymer A had very low degree of crystallinity and Polymer B showed continuous after-shrinkage for weeks. Match the polymers 1, 2, and 3 to A, B, and C.

(c) Explain your answer to (b).

(d) If you want to get the product of Polymer A with a higher crystallinity, what would you do? Explain.

(e) If the Avrami exponents for the crystallization of Polymer B and C are the same, which polymer would have larger crystals? Explain.

8. [3 x 3 points] **TPU and TPO are two examples of TPE.**

(a) Spell out TPU, TPO, and TPE.

(b) Define TPE in one sentence.

(c) What is the difference in the structure of crosslinking point between TPU and TPO?