Polymer Chemistry Exam #1 10 April 2014

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

1. You are to prepare nylon 46 from an acid and an amine.
   (a) Write down the chemical equation showing the structure of the monomers and polymer.
   (b) [4 x 2 points] You want to obtain the polymer with high molar mass. One thing you can do is to use high-purity monomers. What are the other four [4] things?
   (c) The practical method to obtain high molar mass is to use ‘nylon salt’. Describe the method.
   (d) You can prepare the same polymer via interfacial polymerization. How should the monomer be changed? Explain.
   (e) In interfacial polymerization of polyester or polycarbonate, NaOH should be added continuously to the system. For nylon you need not. Explain why. [Hint: This is a general chemistry question.]

2. You are to prepare a polyurethane [PU].
   (a) Give a general equation for the formation of PU.
   (b) The type of the polymerization reaction for PU is different from that for nylon. How is it distinguished?
   (c) If you want your PU to be elastomeric, i.e. highly stretchable and recoverable, what kind of monomer would you use? Explain.
   (d) If you want fabricate PU foam, what would you do? Explain.

3. For dendrimer and hyperbranched polymer [HBP] answer the following questions.
   (a) You want to prepare a second-generation dendrimer with one molecule of tetrafunctional core. How many molecules of AB_2-type (or ARB_2-type) monomer are needed? What is the branching factor of this dendrimer?
   (b) If you prepare HBP with the same number of AB_2 molecules, what would be the minimum and maximum branching factor you can get?
   (c) If you prepare HBP with the same number of moles (not molecules), you would get the branching factor of 0.5. What would you do, if you want to obtain a higher branching factor?

4. For a radical polymerization of poly(methyl methacrylate) [PMMA] with the monomer concentration of 1 mol/L and the initiator (with the efficiency of 0.5) concentration of 0.01 mol/L, the following values are determined at steady-state.
   $k_d = 2 \times 10^{-5}\ s^{-1}$ $\quad$ $k_p = 1 \times 10^3$ L/mol-s $\quad$ $k_t = 1 \times 10^7$ L/mol-s
   Neglecting chain transfer reactions, answer the following questions.
   (a) Estimate the steady-state rate of polymerization.
   (b) Estimate the average lifetime of radical at steady state.
   (c) [6 points] It is analyzed that the retrieved PMMA at 10% conversion contains an average of 1.2 initiator fragment per chain. Estimate the number average molar mass of this PMMA.
   (d) If you want to cut down the molar mass by half, how much CBr_4 (with the chain transfer constant of 2) should be added? [If you are not sure of your answer to (c) above, you may use 100000 as the original molar mass, taking 1 point deduction. Take your chance.]

5. A reagent can retard or inhibit the propagation in radical polymerization.
   (a) How is a retardation distinguished from an inhibition in terms of rate of polymerization?
   (b) Each of (A) quinone, (B) di-*t*-butylphenol, and (C) DPPH can be used as retarder/inhibitor. They retard/inhibit the polymerization by (1) chain transfer, (2) termination, or (3) lowering radical reactivity. Match A, B, and C to 1, 2, and 3.
   (c) [3 x 2 points] Show how each of A, B, and C above inhibit or retard the propagation by writing chemical equations.