

## Polymer Science 2025/26

### Exercise 6

1. From the following multiple-choice questions, only one answer is correct. In the exam, each such question will be worth 2 points.

Which statement is *true*?

- a) *trans*-1,4-polyisoprene is a soft, amorphous material that crystallizes only under large deformation.
- b) For a polycondensation driven to high conversion, a dispersity of 2 and a Poisson-type distribution of the molecular weight are expected.
- c) In the free-radical polymerization of ethylene, an increase in initiator concentration increases the polymerization rate but decreases the average molecular weight.
- d) Bisphenol-A polycarbonate (PC) cannot crystallize because of irregularities in its chemical structure.

Which polymerization conditions do you expect to result in a thermoset?

- a) The polymerization of 2-aminoterephthalic acid (2-aminobenzene-1,4-dicarboxylate) at high temperature.
- b) Reaction between ethylene glycol (ethane-1,2-diol) and 1,6-hexandiamine in the presence of catalytic amounts of an acid.
- c) The reaction between phosgene and bisphenol A at high temperature.
- d) The reaction of benzene-1,3,5-triisocyanate and ethylene glycol (ethane-1,2-diol) in the absence of water.

Which is the best description of poly(tetrafluoroethylene)?

- a) Petroleum-derived polymer that crystallizes preferably in an orthorhombic unit cell.
- b) Perfluorinated polymer that crystallizes preferably via a helical conformation.
- c) Polymer with high chemical resistance and high melting temperature due to strong dipolar interactions between the polymer chains.
- d) Material with a very high friction coefficient that is industrially produced via the free radical polymerization of tetrafluoroethane.

Which of the following statements about polymer chain conformations is *correct*?

- a) The “freely rotating chain” model allows greater flexibility than the “freely jointed chain” model, resulting in a smaller root-mean-square end-to-end distance,  $R_n$ , for a given chain length  $n$ .
- b) Flory’s characteristic ratio  $C_\infty$  quantifies the deviation of a real polymer chain from the ideal chain model and is defined as the ratio of the actual bond length to the bond length of a fully extended, infinitely stiff polymer chain.
- c) The size of a polymer chain, represented by the root-mean-square end-to-end distance,  $R_n$ , depends on the bond length,  $l$ , and the number of bonds in the chain,  $n$ , and it scales as  $n^{1/2}$ .
- d) For a freely jointed chain, the radius of gyration,  $R_g$ , is always larger than the root-mean-square end-to-end distance,  $R_n$ , regardless of chain length.

Which polymer is least suitable for microwave heating due to significant microwave absorption?

- a) Polyethylene (PE)
- b) Poly(vinyl chloride) (PVC)
- c) Poly(ethylene-co-tetrafluoroethylene)
- d) Polytetrafluoroethylene (PTFE).

Which polymer is most likely to undergo crystallization upon slow cooling from the melt?

- a) Polycarbonate produced by polycondensation of bisphenol A and phosgene.
- b) Polystyrene produced by living anionic polymerization of styrene.
- c) Polypropylene produced by free radical polymerization of propylene.
- d) Poly(lactic acid) obtained by ring-opening polymerization of stoichiometric amounts of L-lactide and D-lactide.

2. The melting temperature of a crystalline lamella formed by a polymer is given by

$$T_m = T_{m0} \left( 1 - \frac{2\sigma_e}{l\Delta H} \right)$$

- a) Explain the meaning of each term in this equation with reference to a schematic representation of a lamella, and discuss the physical origin of this relationship.
- b) In a semi-crystalline polymer, the lamellae are organized in the form of spherulites. What is a spherulite, and which mechanisms lead to the formation of spherulites from lamellar nuclei within a molten polymer when  $T_g < T < T_{m0}$ ?
- c) During injection molding, a highly stretched molten polymer comes into contact with the walls of a cold mold. What are the consequences for its morphology, assuming that the polymer can crystallize?

3. a) What is the glass transition and how can it be measured? For a given polymer, do different measurement techniques give the same value for  $T_g$ ? Explain briefly.
- b) Show schematically the shear modulus  $G$  as a function of temperature  $T$  for an amorphous polymer. Indicate the approximate orders of magnitude of  $G$  as well as the influence of molar mass  $M$  and measurement speed (or frequency). Add to the same graph the corresponding behavior of a semi-crystalline polymer and an elastomer.
- c) Briefly explain the principle of free volume theory. How does this theory account for the dependence of  $T_g$  on molar mass for linear chains? What is the effect of chain branching on  $T_g$ , and why?