Chapter 1 Homework: Introduction
Available points: 50

1. **Define the following terms (6 points)**

a. Polymer – Large Molecule comprised of many repeat units derived from monomers

b. Oligomer – A Low Molecular weight Polymer.

c. Copolymer – A macromolecule formed when two or more different monomers react to each other to form a polymer.

d. Polydispersity Index – The measure of breadth of distribution of a polymer's molecular weight, given as $PDI = \frac{M_w}{M_n} \geq 1$.

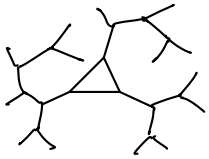
e. Thermoplastic – A polymer which will soften and eventually liquify upon heating to a sufficient temp. This can be repeated so these polymers can be easily reshaped and recycled

f. Thermoset – Presence of cross-linked networks results in these polymers being permanently solid upon heating, and will not flow upon reheating. Generally very chemically and thermally resistant.

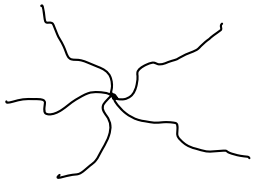
2. **Briefly explain the most significant similarity between dendrimer and star polymer structures. Draw a schematic diagram of both structures. (3 points)**

Dendrimers and star polymers are very similar in that they both are special hyperbranched polymers, in that they have a common growth point where chains grow.

Dendrimer:



Star:



3. **True or False. <u>Correct the false statements</u>. (12 points)**

a. F Herman Staudinger originally studied the hydrogenation of benzene. → Polyindene

b. T Crystalline polymers can melt when heated.

c. F Staudinger faced difficulty convincing fellow scientists because he used colligative property measurements, which are only useful for large molecular weight polymers. → Inaccurate for

d. F A random copolymer is a copolymer of W and Z monomers that shows an average property of homopolymer W and homopolymer Z. → An alternating

e. F When cooling a semicrystalline polymer from the melt, it will typically have a much higher degree of crystallinity if it is quenched (rapidly cooled). → allowed to slowly cool to room temperature

f. T Common examples of thermosets are phenolic resin and epoxy resin.

g. T A thermoplastic polymer will soften and liquefy at a high temperature and a thermoset is permanently solid.

h. F Atactic → Syndiotactic and Isotactic polymers tend to be crystalline, while syndiotactic → Atactic polymers tend to be amorphous.

i. T Monosubstituted monomers prefer Head-to-Tail sequence isomerization.

j. T Polymer morphology models include Fringe-Micelle Model, Chain-folded Model, and Spherulite Model. (and combinations of them) ← still not false

k. T Additives are added to polymer products to improve polymer properties including processability, weather resistance, and recyclability.

l. T Dynamic bonds break when exposed to elevated temperatures and reform upon cooling. ex: Vitrimers!

4. Suppose that a protein sample consists of 45% of molecules of MW = 10,000, 15% of molecules of MW = 14,000, and 40% of molecules of MW = 32,000. What is the z-average molecular weight (Mz) and the PDI? Show your work for full credit. (6 points)

$$M_z = \frac{\sum N_x M_x^3}{\sum N_x M_x^2}, \quad PDI = \frac{M_w}{M_N} \quad \text{where } M_w = \frac{\sum N_x M_x^2}{\sum N_x M_x} \text{ and } M_N = \frac{\sum N_x M_x}{\sum N_x}$$

Assume a basis of 1 mol of the sample

↳ $1\,mol \cdot 0.45 = 0.45\ mol$ of $M_w = 10{,}000$ $x=1$

$1\,mol \cdot 0.15 = 0.15\ mol$ of $M_w = 14{,}000$ $x=2$

$1\,mol \cdot 0.40 = 0.40\ mol$ of $M_w = 32{,}000$ $x=3$

$$M_N = \frac{0.45 \times 10{,}000 + 0.15 \times 14{,}000 + 0.40 \times 32{,}000}{0.45 + 0.15 + 0.40} = 19{,}400$$

$$M_w = \frac{0.45 \times 10{,}000^2 + 0.15 \times 14{,}000^2 + 0.40 \times 32{,}000^2}{0.45 \times 10{,}000 + 0.15 \times 14{,}000 + 0.40 \times 32{,}000} = 24948.45$$

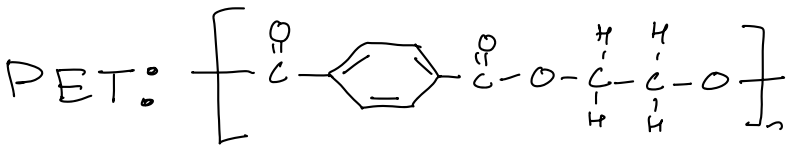
$$M_z = \frac{0.45 \times 10{,}000^3 + 0.15 \times 14{,}000^3 + 0.40 \times 32{,}000^3}{0.45 \times 10{,}000^2 + 0.15 \times 14{,}000^2 + 0.40 \times 32{,}000^2} = 59{,}906{,}446.28$$

$$PDI = \frac{24948.45}{19{,}400} = 1.286$$

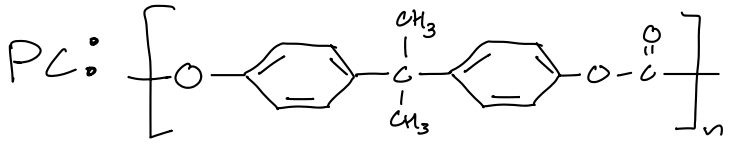
$\therefore M_z = 59{,}906{,}446.28$ and $PDI = 1.286$

5. Draw the polymer structures of the following polymers. (2 points) Pg. 13 Book

a. Poly(ethylene terephthalate)



b. Polycarbonate



6. Classify the following as a Thermoset, Thermoplastic, or Elastomer and give one example of an application of that polymer (5 points)

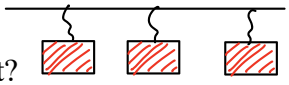
a. Thermoplastic Polystyrene
   i. Ex: Styrofoam
b. Thermoplastic ABS Resin
   i. Ex: Gaskets
c. Thermoset Benzoxazine Resin
   i. Ex: Electronic Packaging
d. Elastomer Silicone Rubber
   i. Ex: Medical Flexible Tube
e. Thermoplastic Poly(methylmethacrylate)
   i. Ex: Contact lens

7. LC polymers can be differentiated in 3 different ways. Explain/describe/draw the following (6 points)

Allow  to be an LC chromophore

a. Main-chain LC vs Side-chain LC

Main-chain LC: LC chromophores placed in main chain of polymer 

Side-chain LC: LC chromophores placed in side chain of polymer 

b. Viscosity of polymer in LC state vs isotropic state. Why is the viscosity different?

Viscosity is lower in LC state because the bundles of molecules rotate as a unit/at the same time instead of individually, resulting in less molecular friction occuring.

c. Thermotropic vs Lyotropic polymer

Thermotropic: LC polymers that show LC phase by melting

Lyotropic: LC polymers that show LC phase in certain solution concentration ranges

8. List and describe two principles of green chemistry (4 points) Pg. 26

(i) Atom Economy: Synthetic methods should be designed such that the process uses all materials to create the final product. This minimizes waste and maximizes efficiency

(ii) Inherently Safer Chemistry: In order to prevent accidents, substances and their derivatives should be chosen such that, in the event of an accident, chemical severity is low and risk of more serious accidents like releases, explosions, and fires are minimized.

Multiple Choice. Circle the correct answer. (2 points)

9. Which of the following is NOT a copolymer structure?

A. Alternating ✓

B. Block ✓

C. Branched ← This is a type of polymeric structural isomer.

D. Graft ✓

E. Random ✓

10. Which of the following is a type of isomer?

A. Structural ✓ ex: Linear, branched, Ladder, star, etc.

B. Sequence ✓ ex: Head-to-Head vs. Head-to-Tail

C. Geometric ✓ ex: cis/trans about a double bond

D. All of the above

11. Correct the statement. If a statement is true, write "True". (4 points)

a. The fringed micelle model is the model to describe the molecular arrangement of a semicrystalline polymer. In this model, well-aligned molecular chains are forming local order representing the crystalline portion of the polymer. Connecting the crystalline portion of the polymer with more randomly coiled molecular chains is the amorphous portion of the polymer. The degree of crystallinity is the fraction of the crystalline portion of the polymer.

Small crystalline regions, called micelles, are formed in local order representing regions of high crystallinity.

b. At the Goodyear factory in Akron, I want to produce car tires. After completely polymerizing the polybutadiene, I am left with a sturdy hoop. The tire was heated above the glass transition temperature of the butadiene, which was 170 deg K. The polymer softened and eventually melted/flowed around 220 deg K. Therefore, the tire should only be used below the glass transition temperature.

The tire should be used above its glass transition temperature, but below its melting temperature. This is because the tire will be rigid and most likely more brittle below its T_g.