**MSE 214 (Polymers)**
**Exercise 1 — Introduction**
**17th September 2025**

**Question 1.**

In your own words, explain the following terms:

a. Monomer
b. Polymer
c. Repeating unit
d. Degree of polymerization

**Question 2.**

What is a copolymer? For a copolymer prepared from two monomers (A and B), give a schematic illustration for: statistical, alternate, block, and graft copolymers.

**Question 3.**

a) A sample of polystyrene is composed of a series of fractions of different sized molecules (see table below). From the table below, calculate the number-average and weight-average molecular weight of this polymer samples. From these values, calculate the dispersity of the sample

| Fraction | Number of moles ($N_x$) | Molar mass ($M_x$) (g/mol) |
|---|---|---|
| A | 0.1 | 12'000 |
| B | 0.19 | 21'000 |
| C | 0.24 | 35'000 |
| D | 0.18 | 49'000 |
| E | 0.11 | 73'000 |
| F | 0.08 | 102'000 |
| G | 0.06 | 122'000 |
| H | 0.04 | 146'000 |

b) Turns out there was an error in the data recording software: the "Number of moles ($N_x$) column was mislabeled. The actual heading was "Weight Fraction ($W_x$)".

| Fraction | Weight fraction ($W_x$) | Molar mass ($M_x$) (g/mol) |
|---|---|---|
| A | 0.1 | 12'000 |
| B | 0.19 | 21'000 |
| C | 0.24 | 35'000 |
| D | 0.18 | 49'000 |
| E | 0.11 | 73'000 |
| F | 0.08 | 102'000 |
| G | 0.06 | 122'000 |
| H | 0.04 | 146'000 |

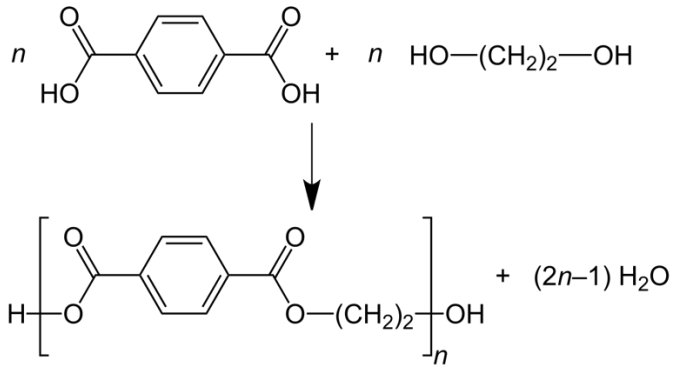
From this corrected table, calculate the number-average and weight-average molecular weight. Calculate the dispersity of the sample as well.

**Question 4.**

Classify the polymers that are formed from the reactions below:

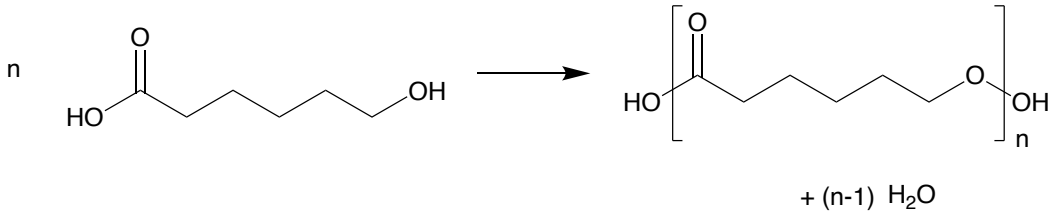
(Hints: i) Don't get too caught up in the complexity of the molecules — only the functional group matters. ii) Think back to the polymerization games we had in the lectures — can everyone take part in the reaction or only some people? iii) Are the total number of atoms conserved?)

Example:

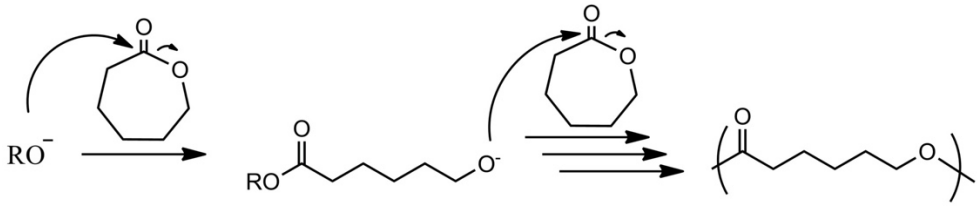



Ans: Two monomers used → Copolymer. Linear polymer. All monomers can react → Step-growth polymer. Water as byproduct → Condensation polymerization

a)

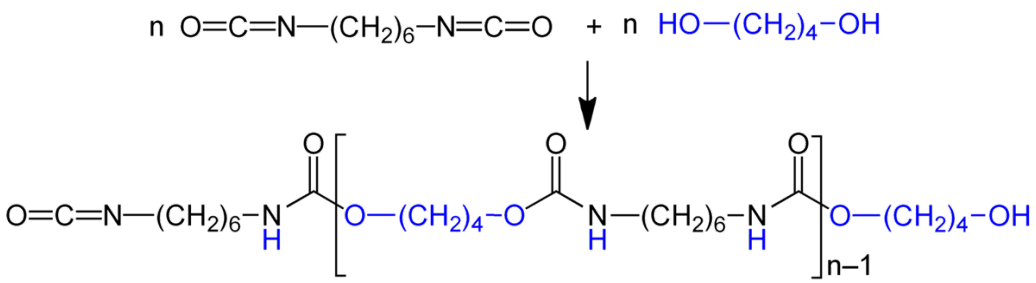



b)




Hint: Concentration of $RO^-$ is much lower than that of the cyclic monomer.
Hint 2: You can think of $RO^-$ as an "excited state"

c)



**Question 5.**

In determining engineering stress and engineering strain, we make the assumption that the cross-sectional area of the sample is not changing. But at sufficiently high strains, this assumption no longer holds true. To account for that, we can use true stress and true strain instead, these values are based on the instantaneous cross-sectional area and length of the sample.

Assuming that the volume of the sample is conserved and that deformation happens uniformly, **derive the equations for true stress and true strain as a function of engineering stress and strain respectively.**

Hint: Conservation of volume can be represented as $A_0L_0 = AL$, where $A_0$ is the initial cross-sectional area of the sample, $L_0$ is the initial length of the sample, A is the instantaneous cross-sectional area, and L is the instantaneous length of the sample.

**Question 6.**

A polymer is described in each of the paragraphs below. i) How would you classify the polymer? Please provide the reason for your classifications. ii) What were some classifications that you were unable to infer from the information given? Why were you unable to classify these polymers in those ways?

Example: Poly(lactic acid) (PLA) is one of the most popular polymers used in material extrusion additive manufacturing. PLA is heated up till its melting point and then extruded through a nozzle to deposit it.

Ans: Poly(lactic acid) → likely one monomer used → Homopolymer. Heated till melting point and extruded → thermoplastic. Not a crosslinked polymer.

No synthesis process described so cannot infer information about polymerization mechanism, chemical reaction, and the precise architecture. Cannot infer mechanical properties.

a) Polystyrene is one of the most widely used polymers in the world. Products made from polystyrene are often made via extrusion or injection molding. (Hint: both these manufacturing processes require high temperatures)

b) Bakelite (polyoxybenzylmethyleneglycolanhydride) is made by reacting formaldehyde and phenol together. It is one of the most commercially successful polymers of all time due to its high temperature resistance. Bakelite products do not flow even with significant heating.

c) Nylon 66 is often synthesized via the reaction between hexamethylenediamine and adipic acid. Water is formed during this reaction.