

1. DEFINITIONS

Match the following

Amorphous ____H

Atactic ____F

Backbone ____N

Copolymer ____M

Crystalline ____G

Crosslinks ____K

Degree of polymerization J ____

DSC (Differential scanning calorimetry) ____S

Entropy of mixing ____P

Glass transition temperature E ____

Helix and pleated ____U

Hilderband's equation ____O

Homopolymer ____L

Mark-Houwink equation ____Q

Melting point or range ____D

Mer ____B

Plasticizer A ____

Polymer or macromolecule ____I

Protein ____V

TGA OR TG (Thermal gravimetric analysis) T ____

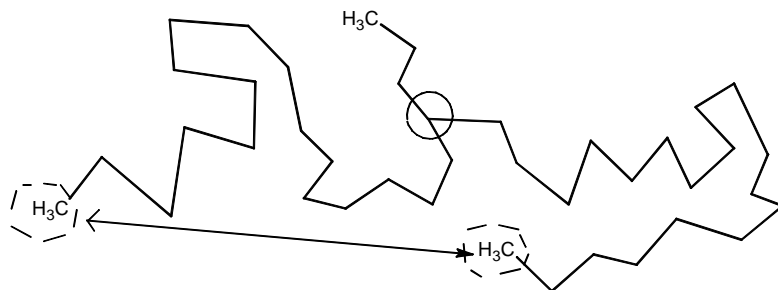
Vinyl polymer ____C

Young's modules ____R

- A. A compound that "solubilizes" only a portion of a polymer chain; added to give flexibility.
- B. Repeat unit in a polymer chain.
- C. Polymer derived from the polymerization of vinyl monomers.
- D. Temperature range or poliont where a polymer achieves full chain mobility.
- E. Temperature range where only local, gegmental mobility occurs; where only relatively small portions of the polymer can move.
- F. Polymer where there is a random arrangement of pendant groups on each side of the polymer backbone.
- G. Polymer portion with a highly ordered structure
- H. Polymer portion with a (highly) disorganized structure
- I. Molecule composed of many mers or repeat units; a very large molecule.
- J. Number of units within a polymer .
- K. Covalent or physical bonds between two or more linear polyer chains.
- L. Polymer composed of only one repeat unit.
- M. Polymer composed of more than one repeat unit; usually employed to describe a vinyl polymer derived from two different vinyl molecules
- N. Principal chain in a polymer molecule.
- O. Describes the forces holding a material together; CED; used to help predict solubility
- P. Major force that encourages (drives) solubility

- Q. Viscosity = KM^a
- R. Stress/Strain
- S. Measures energy (heat) changes typically as a function of temperature
- T. Measures weight changes typically as a function of temperature
- U. Most common shapes of polymers
- V. Natural "nylon"; composed of amino acid units

2. For the following polymer chain circle only a branch point; draw a dotted line about the two end groups; and indicated by a two headed line (\longleftrightarrow) the end-to-end distance.



3. Underline only which would be more likely to soften and melt if heated.

A. UNCROSSLINKED POLYETHYLENE OR HIGHLY CROSSLINKED RUBBER

4. Underline only those polymers where hydrogen bonding occurs within and/or between polymer chains.

NYLON/PROTEIN POLYETHYLENE CELLULOSE

POLYBUTYLENE POLYESTER

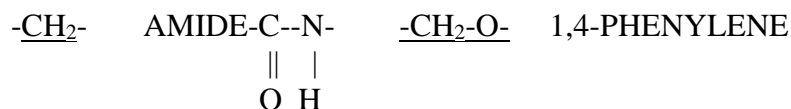
5. A. What is the molecular weight of polyethylene, $-(CH_2CH_2)-$, which has a DP of 100?

$$100 \text{ units} \times 28 \text{ amu/unit} = 2800$$

B. What is the DP of a polyethylene which has a molecular weight of 56,000 Da?

$$56,000 \text{ amu} / 28 \text{ amu/unit} = 2,000 \text{ units}$$

6. Underline only those groups that are apt to add flexibility to a polymer chain.



7. A. An elastomer (rubber) is flexible above or below (underline only the correct answer) its glass transition temperature.

B. Underline only those properties/conditions that (generally) describe an elastomer (rubber).

WELL ORDERED HIGHLY DISORIENTED CHAINS IN UNSTRETCHED FORM

LARGELY HYDROCARBON MINIMAL INTERACTION BETWEEN CHAINS

ORIGINALLY A LOT OF ELONGATION FOR A LITTLE STRAIN

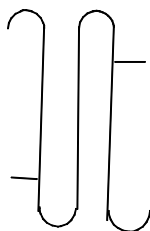
8. For polyethylene, as visualized below, underline the correct answer.

A. The polyethylene chain, below, that should have the lower glass transition temperature is a or b.

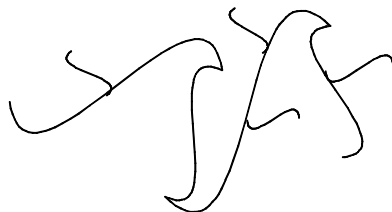
B. The polyethylene that should be stronger is a or b.

C. The polyethylene that should be more porous and susceptible to ultraviolet degradation is a or b.

D. The polyethylene that should be denser is a or b.



a.



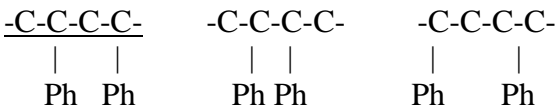
b.

9. Compute the following average distances for a polyethylene chain of 100 units where each ethylene unit is 0.25 nm (for a zigzag structure). Contour length is 0.25 nm/ethylene unit x 100 units = 25 nm.

Root-mean-squared average end-to-end distance = _____.

Root mean-squared end-to-end distance = $0.25 \text{ nm} \times (100)^{1/2} = 0.25 \times 10 = 2.5 \text{ nm}$

10. Underline which of the following represents a head-to-tail polystyrene structure.

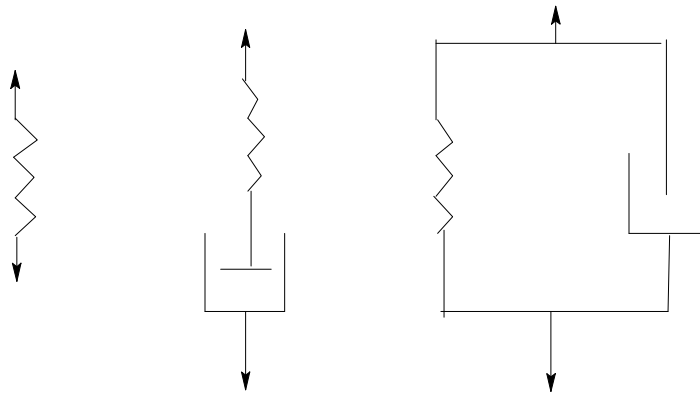


11. Underline only the correct answer for each.

a. Which, a, b, or c, is a Maxwell Model?

b. Which, a, b, or c, is a "Hookean" spring model?

c. Which, a, b, or c, is a Voigt-Kelvin model.



a. Hookean
Spring

b. Maxwell
Model

c. Voigt-Kelvin
Model

12. Viscosity relationships.

A. Give an equation that describes the relative viscosity or viscosity ratio.

$$\eta/\eta_0$$

B. Give an equation that describes the intrinsic viscosity or limiting viscosity number.

$$\lim_{c \rightarrow 0} (\eta_{sp}/c)$$

C. Give an equation that describes the reduced viscosity or viscosity number.

$$\eta_{sp}/c$$

13. A. Give the relationship between number of chains and the molecular weight for each in terms of number of each chain, N_i , and molecular weight of each chain, M_i .

Weight-average molecular weight =

$$\overline{M}_w = \frac{\sum W_i M_i}{\sum W_i} = \frac{\sum M_i^2 N_i}{\sum M_i N_i}$$

Number-average molecular weight =

$$\overline{M}_n = \frac{\text{total weight of sample}}{\text{number of molecules of } N_i} = \frac{W}{\sum N_i} = \frac{\sum M_i N_i}{\sum N_i}$$

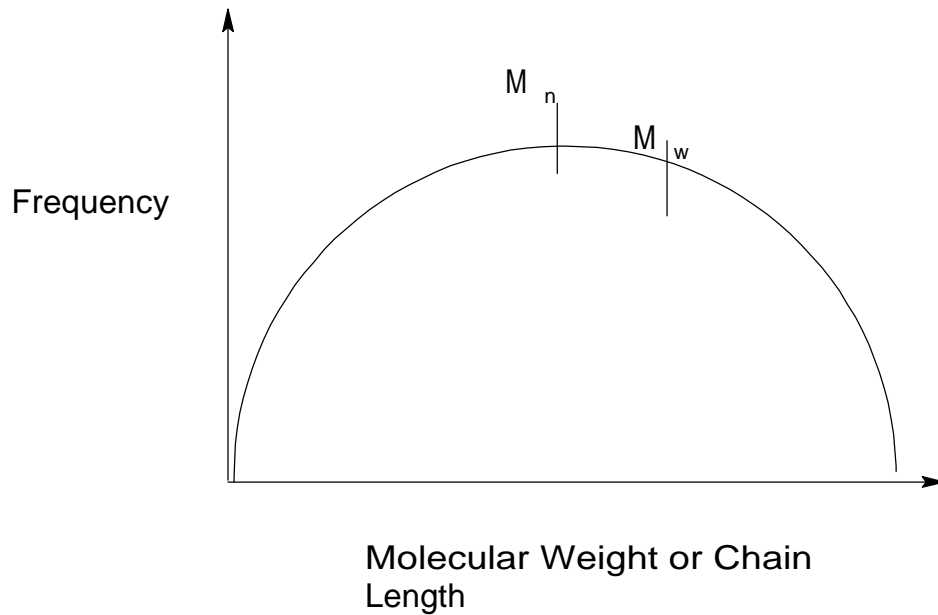
B. Give one technique that will generally give you a weight average molecular weight.

Light scattering photometry

C. Give one technique that will generally give you number average molecular weight.

Membrane osmometry, vpo, end-group, boiling point elevation, melting point depression, light scattering under the right conditions, etc.

D. For the following molecular weight distribution plot identify "A" and "B" as to type of molecular weight-either number or weight average.



14. For a double-helix show the correct coupling of the adjacent chain (Where A=ADENINE, G=Guanine, T=Thymine and C=Cytosine)

Fragment= C-A-G-T-T-C
 remember Gee-CAT
 Answer= G-T-C-A-A-G

15. Underline only the following that are or are mainly composed of polycarbohydrates (polysaccharides).

AMYLOSE LIGNIN DNA CELLULOSE

WOOD SAWGRASS (A PLANT; DRY PART) STARCH

16. Draw the repeat unit for any three of the following-be sure to indicate which three.

Polystyrene $-\text{CH}_2-\text{CHPh}-$

Polyethylene $-\text{CH}_2-\text{CH}_2-$

PET $-\text{C}(\text{O})-\text{PHENYLENE}-\text{C}(\text{O})-\text{OOCH}_2-\text{CH}_2-$

Polyurethane $-\text{C}(\text{O})-\text{NH}-\text{R}-\text{NH}-\text{C}(\text{O})-\text{O}-\text{R}'-\text{O}-$

Polyester $-\text{C}(\text{O})-\text{R}-\text{C}(\text{O})-\text{O}-\text{R}'-\text{O}-$

Nylon $\text{-NH-R-NH-C(O)-R'-C(O)-}$

Polypropylene $\text{-CH}_2\text{-CH(Me)-}$

Protein general unit -NH-CH(R)-C(O)-

Nucleic acid general unit $\text{-P=O(OR)-SUGAR(BASE)-}$

17. Describe the two major components of starch and structurally distinguish between the two.

Both amylose (largely linear) and amylopectin (more branched) are mainly α 1- \rightarrow linked glucose units. Amylose forms a helical structure whereas amylopectin is more free flowing.

18. Compare the structures of cellulose and starch. Why can humans digest starch and not cellulose?

Cellulose has its glucosyl units attached in what is called a β 1- \rightarrow 4 linkage whereas starch has the units connected in 1- \rightarrow 4 α unit. We have stomach enzymes that lyse or break the β linkages while termites have enzymes that lyse the α linkages.

19. What does it mean that the structures of polysaccharides can be described in only general or approximate terms?

While polysaccharides are often mainly one repeat unit, they contain other repeat units. In particular, branching occurs at different intervals resulting in only some approximate structure being present.

20. Give the names and repeat units for four polymers that are prepared by the step-growth mechanism.

Examples include the following.

polyesters $\text{-C(O)-R-C(O)-O-R'-O-}$

nylons $\text{-NH-R-NH-C(O)-R'-C(O)-}$

polyurethanes, $\text{-C(O)-NH-R-NH-C(O)-O-R'-O-}$

polyimides $\text{-C(O)-NH-R-NH-C(O)-NH-R'-NH-}$
etc.

21. Give the name and repeat unit for four polymers that are prepared by the chain-growth mechanism.

Polypropylene $-C-C(C)-$ poly(vinyl chloride) $-C-C(Cl)-$
 polystyrene $-C-C(Ph)-$ Polyethylene $-C-C-$

22. Supply the repeat unit for any six of the following and note whether the polymer is considered a vinyl or condensation polymer.

POLYSTYRENE $-C-CPh-$ VINYL

POLYESTER $C(O)-R-C(O)-O-$ COND

POLYAMIDE $-NH-R-NH-C(O)-R'-C(O)-$ COND

POLYETHYLENE $C-C-$ VINYL

POLYPROPYLENE $C-C(Me)-$ VINYL

POLY(ETHYLENE OXIDE) $C-C-O-$ COND

POLYURETHANE $-C(O)-NH-R-NH-C(O)-O-R'-O-$ COND

ABS $(C-C(CN)-)(C-C=C-C-)(C-CPh-)$ VINYL

NATURAL RUBBER COMBINATION OF STRUCTURES $-C-C(C)=C-C-$ VINYL

POLYISOPRENE COMBINATION OF STRUCTURES $C-C(C)=C-C-$ VINYL

23. Recognition of abbreviations is important when communicating with other polymer scientists. What do the following abbreviations represent?

M_w -weight average molecular weight

DP-degree of polymerization; number of repeat units

PP-polypropylene

HDPE-high density polyethylene

PVC-poly(vinyl chloride)

LVN-limiting viscosity number

HPLC-high pressure liquid chromatography

SEM- scanning electron microscopy

PET- poly(ethylene terephthalate)

Nylon 6,6-polyamide-backbone structure of N-C-C-C-C-C-C-N-C(O)-C-C-C-C-C(O)-

24. A usable product, Bakelite, is formed from the reaction of phenol and formaldehyde because Bakeland recognized the functionality of phenol and formaldehyde. What does "functionality" mean with respect to phenol and formaldehyde?

The number of reactive sites for the particular reaction and reaction conditions studied. Here, formaldehyde reacts as if it has two reactive sites and the phenol as though it had three-thus the product will be cross-linked. It is a thermoset.