

Following is a collection of questions used by myself and others associated with material covered in **Polymer Chemistry**. They are somewhat intentionally broad because the course is often taught as an introduction covering many diverse topics. The questions are a combination of matching, short essay, short answers, etc. The points assigned to each problem is given as "( )" after the number of each problem and are based roughly on a 100 point exam.. This is at best a general guide and should be modified as you feel best. Good luck.

Charles Carraher, Jr.

### 1. (22 POINTS) DEFINITIONS

Match the following

AMORPHOUS \_\_\_\_\_

ATACTIC \_\_\_\_\_

BACKBONE \_\_\_\_\_

COPOLYMER \_\_\_\_\_

CRYSTALLINE \_\_\_\_\_

CROSSLINKS \_\_\_\_\_

DEGREE OF POLYMERIZATION \_\_\_\_\_

DSC (DIFFERENTIAL SCANNING CALORIMETRY) \_\_\_\_\_

ENTROPY OF MIXING \_\_\_\_\_

GLASS TRANSITION TEMPERATURE \_\_\_\_\_

HELIX AND PLEATED \_\_\_\_\_

HILDEBRAND'S EQUATION \_\_\_\_\_

HOMOPOLYMER \_\_\_\_\_

MARK-HOUWINK EQUATION \_\_\_\_\_

MELTING POINT OR RANGE \_\_\_\_\_

MER \_\_\_\_\_

PLASTICIZER \_\_\_\_\_

POLYMER OR MACROMOLECULE \_\_\_\_\_

PROTEIN \_\_\_\_\_

TGA OR TG (THERMAL GRAVIMETRIC ANALYSIS) \_\_\_\_\_

VINYL POLYMER \_\_\_\_\_

YOUNG'S MODULES \_\_\_\_\_

A. A COMPOUND THAT "SOLUBILIZES" ONLY A PORTION OF A POLYMER CHAIN; ADDED TO POLYMERS TO GIVE THEM FLEXIBILITY

B. REPEAT UNIT IN A POLYMER CHAIN

C. POLYMER DERIVED FROM THE POLYMERIZATION OF VINYL MONOMERS SUCH AS VINYL CHLORIDE.

D. TEMPERATURE RANGE OR POINT WHERE A POLYMER ACHIEVES FULL CHAIN MOBILITY.

E. TEMPERATURE RANGE WHERE ONLY LOCAL, SEGMENTAL MOBILITY

OCCURS; WHERE ONLY SMALL PORTIONS OF THE POLYMER CHAIN CAN MOVE.

F. POLYMER WHERE THERE IS A RANDOM ARRANGEMENT OF PENDANT GROUPS ON EACH SIDE OF THE POLYMER CHAIN.

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 POLYMER 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 SUCH AS VINYL CHLORIDE AND ETHYLENE.

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.  $\text{VISCOUSITY} = K M^a$

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. (6 POINTS) FOR THE FOLLOWING POLYMER CHAIN- CIRCLE (ONLY) A BRANCH POINT, DRAWN A DOTTED LINE AROUND (ONLY) THE TWO END GROUPS AND INDICATE BY A TWO HEADED LINE (<----->) THE END-TO-END DISTANCE.

3. (2 POINTS) CIRCLE ONLY WHICH WOULD BE MORE LIKELY TO SOFTEN AND MELT IF HEATED

A. UNCROSSLINKED POLYETHYLENE OR HIGHLY CROSSLINKED RUBBER

4. (5 POINTS) CIRCLE ONLY THOSE POLYMERS WHERE HYDROGEN BONDING

## OCCURS WITHIN OR BETWEEN THE CHAINS

NYLON/PROTEIN      POLYETHYLENE      CELLULOSE

POLYBUTYLENE      POLYESTER

5. (4 POINTS) A. WHAT IS THE MOLECULAR WEIGHT OF POLYETHYLENE ---  $-(CH_2CH_2)-$  WHICH HAS A DP OF 100? \_\_\_\_\_

B. WHAT IS THE DP OF A POLYETHYLENE WHICH HAS A MOLECULAR WEIGHT OF 56,000? \_\_\_\_\_

6. (4 POINTS) CIRCLE ONLY THOSE GROUPS THAT ARE APT TO ADD FLEXIBILITY TO A POLYMER CHAIN

$$\text{-CH}_2\text{-} \quad \text{AMIDE-C--N-} \quad \text{-CH}_2\text{-O-} \quad \text{1,4-PHENYLENE}$$

$$\begin{array}{c} \parallel \quad | \\ \text{O} \quad \text{H} \end{array}$$

7. (6 POINTS) A. AN ELASTOMER (RUBBER) IS FLEXIBLE ABOVE OR BELOW (CIRCLE ONLY THE CORRECT ANSWER) ITS GLASS TRANSITION TEMPERATURE.

B. CIRCLE 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. (8 POINTS )FOR POLYETHYLENE, AS VISUALIZED BELOW, DO THE FOLLOWING.

A. CIRCLE THE POLYETHYLENE CHAIN (BELOW) THAT SHOULD HAVE THE LOWER GLASS TRANSITION TEMPERATURE

B. DRAW A BOX AROUND THE POLYETHYLENE THAT SHOULD BE STRONGER

C. DRAW A TRIANGLE ABOUT THE POLYETHYLENE THAT SHOULD BE MORE POROUS AND SUSCEPTIBLE TO ULTRAVIOLET DEGRADATION AND MOST UNSTABLE TO CHEMICAL ATTACK

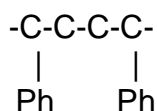
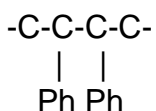
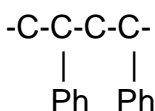
D. DRAW A DASHED "----" LINE ABOUT THE POLYETHYLENE THAT SHOULD HAVE THE HIGHER DENSITY.

9. (4 POINTS) COMPUTE THE FOLLOWING AVERAGE DISTANCES FOR A POLYETHYLENE CHAIN OF 100 UNITS WHERE EACH ETHYLENE UNIT IS 4 ANGSTROMS.

CONTOUR LENGTH = \_\_\_\_\_ A

ROOT-MEAN-SQUARED AVERAGE END-TO-END DISTANCE= \_\_\_\_\_ A

10. (2 POINT) CIRCLE ONLY WHICH OF THE FOLLOWING REPRESENTS A HEAD-TO-TAIL REPRESENTATION OF POLYSTYRENE.



11. (6 POINTS) a. CIRCLE (ONLY) THE FOLLOWING THAT IS A MAXWELL MODEL;  
b. DRAW (ONLY) A SQUARE ABOUT THE MODEL FOR A "HOOKEAN" SPRING  
c. DRAW (ONLY) A TRIANGLE ABOUT THE VOIGT-KELVIN MODEL

12. (6 POINTS) VISCOSITY RELATIONSHIPS

- A. CIRCLE (ONLY) THE EQUATION DESCRIBING THE RELATIVE VISCOSITY OR VISCOSITY RATIO  
B. DRAW A BOX (ONLY) ABOUT THE EQUATION DESCRIBING THE INTRINSIC VISCOSITY OR LIMITING VISCOSITY NUMBER  
C. DRAW A TRIANGLE (ONLY) ABOUT THE EQUATION DESCRIBING THE REDUCED VISCOSITY OR VISCOSITY NUMBER

13. (12 POINTS) A. GIVE THE RELATIONSHIP BETWEEN NUMBER OF CHAINS AND THE MOLECULAR WEIGHT OF EACH FOR THE FOLLOWING IN TERMS OF THE NUMBER OF EACH CHAIN,  $N_i$ , AND THE MOLECULAR WEIGHT OF EACH CHAIN,  $M_i$ .

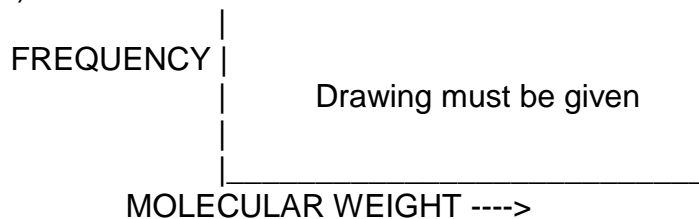
WEIGHT-AVERAGE MOLECULAR WEIGHT =

NUMBER-AVERAGE MOLECULAR WEIGHT =

B. GIVE ONE TECHNIQUE THAT WILL COMMONLY GIVE YOU A WEIGHT-AVERAGE MOLECULAR WEIGHT \_\_\_\_\_

C. GIVE ONE TECHNIQUE THAT WILL COMMONLY GIVE YOU A NUMBER-AVERAGE MOLECULAR WEIGHT \_\_\_\_\_

D. FOR THE FOLLOWING MOLECULAR WEIGHT DISTRIBUTION PLOT IDENTIFY "A" AND "B" AS MOST LIKELY BEING THE WEIGHT-AVERAGE MOLECULAR WEIGHT (CIRCLE ONLY) AND NUMBER-AVERAGE MOLECULAR WEIGHT (BOX ONLY).



14. (3 POINT) FOR A DOUBLE-HELIX DNA SHOW THE CORRECT COUPLING OF THE ADJACENT CHAIN  
(WHERE A=ADENINE, G=GUANINE, T=THYMINE AND C=CYTOSINE)

START= C-A-G-T-T-C

ANSWER= \_\_\_\_\_

15. (7 POINTS) CIRCLE (ONLY) THE FOLLOWING THAT ARE OR ARE MAINLY COMPOSED OF POLYCARBOHYDRATES (POLYSACCHARIDES)

AMYLOSE      LIGNIN      DNA      CELLULOSE

WOOD      SAWGRASS (A PLANT; DRY PART)      STARCH

16. (3 POINTS) DRAW THE REPEAT UNIT STRUCTURE FOR ANY THREE OF THE FOLLOWING-BE SURE TO INDICATE WHICH THREE THEY ARE-PLEASE.

POLYSTYRENE    POLYETHYLENE    PET    POLYURETHANE    POLYESTER

NYLON      POLYPROPYLENE    PROTEIN      NUCLEIC ACID

17. (6) DESCRIBE THE TWO MAJOR COMPONENTS OF STARCH AND

STRUCTURALLY DISTINGUISH BETWEEN THE TWO.

18. (6) COMPARE THE STRUCTURES OF CELLULOSE AND STARCH. WHY CAN HUMANS DIGEST STARCH AND NOT CELLULOSE?

19. (6) WHAT DOES IT MEAN THAT THE STRUCTURES OF POLYSACCHARIDES CAN BE DESCRIBED IN ONLY GENERAL OR APPROXIMATE TERMS?

20. (8) GIVE THE NAMES AND REPEAT-UNIT FOR FOUR POLYMERS THAT ARE PREPARED BY THE STEP-GROWTH MECHANISM.

21. (8) GIVE THE NAMES AND REPEAT-UNIT FOR FOUR POLYMERS THAT ARE PREPARED BY THE CHAIN-GROWTH MECHANISM.

22. (12) SUPPLY THE REPEAT-UNIT FOR ANY SIX OF THE FOLLOWING AND NOTE WHETHER THE POLYMER IS CONSIDERED A VINYL OR CONDENSATION POLYMER.

POLYSTYRENE    POLYESTER    POLYAMIDE POLYETHYLENE  
POLYPROPYLENE POLY(ETHYLENE OXIDE)    POLYURETHANE  
ABS    NATURAL RUBBER    POLYISOPRENE

23. (16) RECOGNITION OF ABBREVIATIONS IS IMPORTANT WHEN COMMUNICATING WITH OTHERS. PLEASE TELL WHAT EIGHT OF THE FOLLOWING ABBREVIATIONS REPRESENT.

$M_w$

DP

PP

HDPE

PVC

LVN

HPLC

SEM

PET

NYLON 6,6

24. (6) A USABLE PRODUCT, BAKELITE WAS FORMED FROM THE REACTION OF PHENOL AND FORMALDEHYDE BECAUSE BAEKELAND RECOGNIZED THE FUNCTIONALITY OF PHENOL AND FORMALDEHYDE. WHAT DOES "FUNCTIONALITY", SPECIFICALLY WHAT DOES IT MEAN WITH RESPECT TO PHENOL AND FORMALDEHYDE?

25. (6) OTHER SCIENTISTS HAD GOTTEN ONLY “GOOPS” AND “GLIMES” FROM REACTION OF FORMALDEHYDE AND PHENOL, BUT BAEKELAND WAS ABLE TO MAKE USABLE SOLID PRODUCTS. HOW DID HE DO THIS?

26 (4) SOME POLYMERS ARE CALLED “ENGINEERING PLASTICS” OR “ENGINEERING MATERIALS”. WHAT DOES THIS MEAN, THAT IS WHAT IS AN ENGINEERING MATERIAL?

27. (6) DESCRIBE THE INFLUENCE OF SECONDARY FORCES ON POLYMERS.

COMPARE THE EFFECT OF THESE SECONDARY FORCES ON THE PROPERTIES OF SMALL MOLECULES AND POLYMERS.

NAME THREE OF THESE SECONDARY FORCES.

28. (4) CONTRAST THE BEHAVIOR OF POLYMERS ABOVE AND BELOW THEIR GLASS TRANSITION TEMPERATURE.