Fairfax Science Olympiad Tryouts 2018
Name: _____
Score: _____/75

MATERIALS SCIENCE TEST

Part 1: Structure & Synthesis Topics

In questions 1-6, draw a diagram of the named functional group. Use "R" to denote the rest of the molecule. (2 points each)

1) Alcohol

2) Ester

3) Ketone

4) Alkene

5) Amine

6) Carboxylic Acid

7) Which of the functional groups in questions 1-6 are considered carboxyl compounds? (3 points)

8) Differentiate between a *bifunctional* monomer and *trifunctional* monomer. (2 points)

9) Differentiate between *conformation* and *configuration*. (2 points)

In questions 10-15, write the appropriate polymer structure (i.e. linear, branched, crosslinked, or network) matching the given description. (1 point each)

10) Formed by trifunctional mer units

_____

11) Most common structure of thermoplasts

_____

12) Formed in rubbers via *vulcanization*

_____

13) Epoxies and phenol formaldehyde belong to this group

_____

14) Includes star polymers, brush polymers, and dendrimers

_____

15) Has highest chain packing efficiency

_____

In questions 16-25, match the polymer with the appropriate description/structure. (1 point each)

16) PVC _____

17) PTFE _____

18) Phenol-formaldehyde _____

19) PMMA _____

20) nylon 6,6 _____

21) PC _____

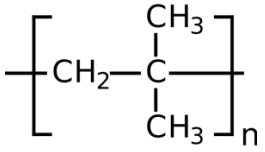
22) PDMS _____

23) PAN _____

24) PP _____

25) PIB _____

a) Plexiglas
b) Glass transition temperature is ~147 ºC
c) $(C_2H_6OSi)_n$
d) Teflon
e) Produced industrially by polycondensation of 1,6-hexamethylenediamine and adipic acid
f) Network thermoset
g) Mer molecular weight of 42.08 g/mol
h) First synthesized in 1872 by Eugen Baumann
i) $(C_3H_3N)_n$
j)



In questions 26-30, write the recycling code number corresponding to the stated plastics. (1 point each)

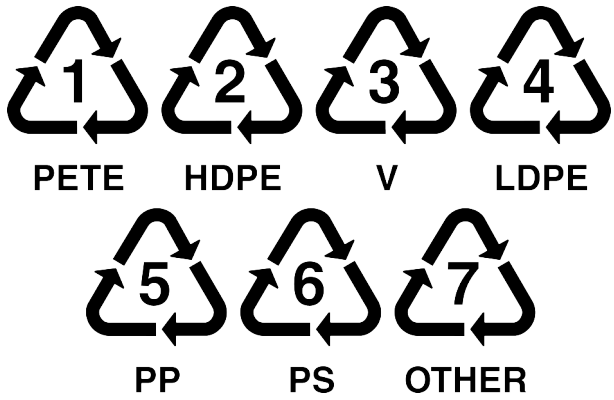
26) Soft drink bottles and water bottles _____

27) CD cases and styrofoam _____

28) Milk jugs and shampoo bottles _____

29) Nylon and fiberglass _____

30) Crushed bottles and shopping bags _____



31) Differentiate between the mechanical behavior of *thermoplastic polymers* and *thermosetting polymers* when heat is applied. Make sure to describe both macroscopic properties and molecular-level processes responsible for this difference. Also state which polymer structures (i.e. linear, branched, crosslinked, or network) are common to each type. (6 points)

Part 2: Characterization, Performance, Processing, and Application Topics

Show all calculations for full credit. Round all decimal answers to the hundredths place unless instructed otherwise. MAKE SURE TO INCLUDE APPROPRIATE UNITS!!!

Use the following table containing molecular weight data for polymer X for questions 32-35.

Molecular Weight Range (g/mol)	***Number Fraction, x***	***Weight Fraction, w***
8,000-16,000	0.05	0.02
16,000-24,000	0.16	0.10
24,000-32,000	0.24	0.20
32,000-40,000	0.28	0.30
40,000-48,000	0.20	0.27
48,000-56,000	0.07	0.11

32) What is the number-average molecular weight of polymer X? (2 points)

33) What is the weight-average molecular weight of polymer X? (2 points)

34) If polymer X is polyvinyl chloride, which has a mer molecular weight of 62.50 g/mol, then based on your answer to question 32, what is the average number of mer units per chain of polymer X to the nearest whole number? (2 points)

35) If polymer X has a weight-average degree of polymerization of 160, then based on your answer to question 33, what is the molecular weight of one mer unit of polymer X? (2 points)

For questions 36-41, fill in the blank with the appropriate characteristic of polymer stress-strain curves. (1 point each)

36) Yielding only occurs in _____ polymers.

37) The point marking shift from elastic to plastic deformation is called the _____.

38) Polymers that have a very low modulus of elasticity are called _____.

39) The capacity of a material to absorb energy when deformed elastically and, upon unloading, recover this energy is called _____.

40) The ratio of axial strain to lateral strain is known as _____. In polymers, this value is usually around 0.40.

41) _____ deformation exhibits characteristics of both viscous flow and elastic deformation.

For questions 42-46, state whether an increase in temperature causes an increase or a decrease in the corresponding measurement. (1 point each)

42) Young's Modulus _____

43) Tensile strength _____

44) Ductility _____

45) Relaxation Modulus _____

46) Creep Modulus _____

47) Briefly decribe why a polymer's tendency to crystallize decreases as molecular weight increases. (2 points)

48) What is the percent crystallinity of a sample of polymer X given the following data? (2 points)

- Density of the sample is 0.84 g/cm^3
- Density of completely crystalline polymer X is 0.98 g/cm^3
- Density of completely amorphous polymer X is 0.75 g/cm^3

49) Draw a schematic plot showing how the modulus of elasticity of an amorphous polymer depends on the glass transition temperature. Assume that molecular weight is held constant. (2 points)

50) The tensile strength and number-average molecular weight data for two polymethyl methacrylate materials are as follows:

Tensile Strength (MPa)	***Number Average Molecular Weight (g/mol)***
107	40,000
170	60,000

Using the data provided above, estimate the tensile strength at a number-average molecular eight of 30,000 g/mol. (2 points)

51) Plot and label schematic stress-strain curves on the same graph for the following polymers: (2 points)

- Branched polyethylene having a number-average molecular weight of 90,000 g/mol
- Heavily crosslinked polyethylene having a number-average molecular weight of 90,000 g/mol