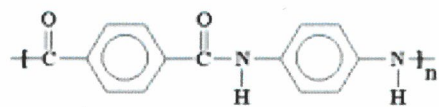
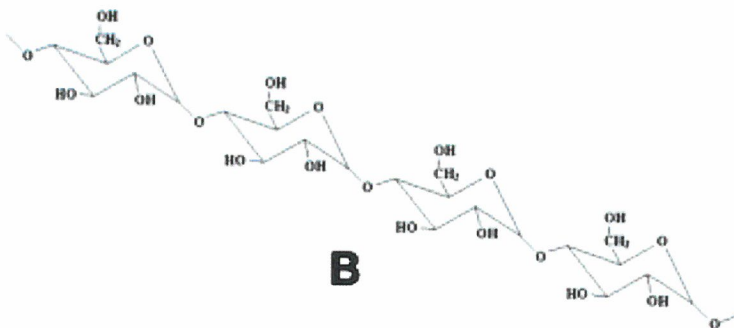


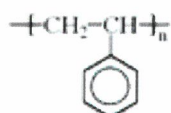
Part I: Multiple Choice Place the best answer on the answer sheet. Place all answers on the answer sheet.
 Answers placed on this page will not be graded.



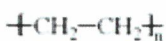
A



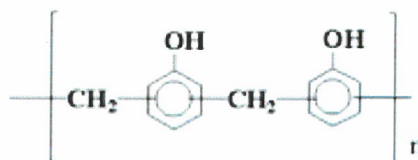
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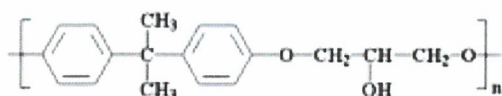
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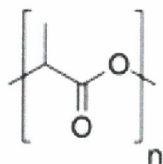
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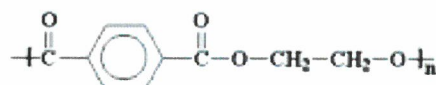
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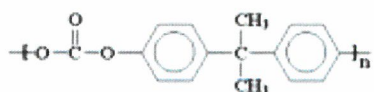
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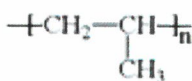
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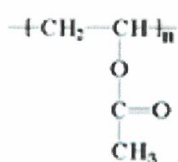
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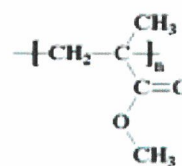
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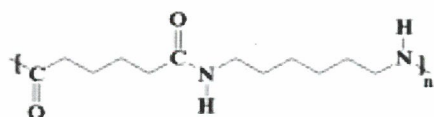
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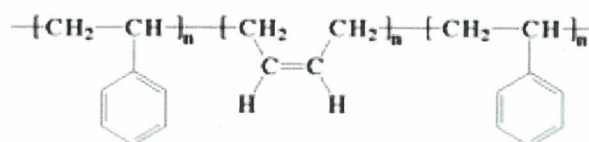
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L



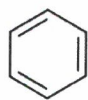
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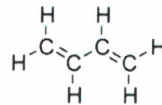
N

Question 1- 30 refer to the diagrams of polymer structures A-M above. **NOTE: NONE can be an answer**

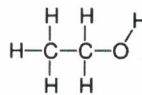
- 1) Which structure is polyethylene?
- 2) Which structure is nylon-6,6?
- 3) Which structure is polystyrene?
- 4) Which structure is a polycarbonate?
- 5) Which two structures are polyesters?
- 6) Which structure is PS?
- 7) Which structure is PVA?
- 8) Which structure is PMMA?
- 9) Which structure is PET?
- 10) Which structure has recycle code 1?
- 11) Which structure has recycle code 6?
- 12) Which structure has recycle code 5?
- 13) Which structure is used to make plexiglass?
- 14) Which structure is used to make plastic water bottles?
- 15) Which structure is used to make white school glue?
- 16) Which structure is used to make bullet proof vests?
- 17) Which structure is used to make billiard balls?
- 18) Which structure is used to make tennis shoe soles?
- 19) Which two structures are polyamides?
- 20) Which structure is biodegradable?
- 21) Which structure a bio-polymer?
- 22) Which two structures are thermosets?
- 23) Considering structures C, D and J, which one is most flexible?
- 24) Which structure is a block co-polymer made from three different polymers?
- 25) Which structure is made from an epoxy monomer?
- 26) Which structure is commonly foamed to make coffee cups ?
- 27) Considering structures A, G and M, which one is made from polymerization of ethylene units?
- 28) Considering structures B, G and M, which one is made with an amine monomer?
- 29) Which structure would be considered the most "rubbery?"
- 30) Considering structures C, D and F, which one is most hydrophilic?



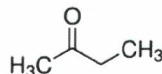
A



B



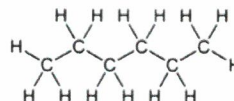
C



D



E



F

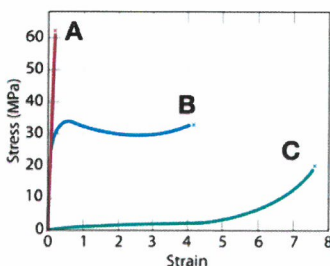
Question 31- 40 refer to the diagrams of organic structures above.

- 31) Which molecule is an alkane?
 - 32) Which molecule is an alcohol?
 - 33) Which molecule is a ketone?
 - 34) Which molecule is aromatic?
 - 35) Which molecule is an alkene?
 - 36) How many carbons are in molecule A?
 - 37) How many hydrogens are in molecule D?
 - 38) Which molecule is a carboxylic acid?
 - 39) Which molecule could be polymerized?
 - 40) Which molecule adds stiffness to polymers?
- 41) Regardless of whether you're using SI or English units, the units for stress are always identical to:
- a. Force
 - b. Torque
 - c. Pressure
 - d. Moment of inertia
 - e. Nothing – it's unitless

- 42) Your friend asks you what's the main difference between true stress / strain (σ and ϵ , respectively) and engineering stress / strain (s and e). What do you say?
- True stress and strain take into account external factors, such as what temperature and pressure; engineering stress and strain on the other hand, don't
 - Engineering stress and strain are unitless whereas true stress and strain aren't
 - True stress and strain are in reference to a log-scale, not a linear scale like engineering stress and strain are
 - True stress and strain are in reference to the instantaneous cross-sectional area of the sample, not the original length like engineering stress and strain are
 - True stress and strain are in English units; engineering stress and strain are in SI units.

- 43) Uniaxial tensile testers record the force required to produce a certain deformation given a constant strain rate. Why is it generally easier to accurately measure E for a rubbery sample than a metal (like steel)?
- It takes a lot more force to hold your sample in place when you're dealing with metals: slippage of your grips will screw up your readings
 - Metals hit plastic deformation at much lower strains than rubbers do
 - The linear slope of the stress-strain curve is much steeper for metals than for rubbers, thus small errors in where the yield strength s_y is leads to much larger errors in E
 - You should do multiple trials of a sample to get an average E , and rubber samples are typically much cheaper than metals
 - Rubbers tend to take a longer time to break

Questions 44 – 49 are about the following stress-strain curve for a linearly isotropic material. Oh come on, you knew one of these had to be on the test!



- 44) What's E for polymer C, approximately?
- 0.5 MPa
 - 5 GPa
 - 500 GPa
 - 50 MPa
 - 5 Pa
- 45) What's the yield strength for polymer B?
- 30 MPa
 - 50 MPa
 - 25 MPa
 - 35 MPa
 - 4 MPa
- 46) What's the ultimate tensile strength for C?
- 35 MPa
 - 33 MPa
 - 60 MPa
 - 10 MPa
 - 20 MPa
- 47) Which polymer is most "stretchy"?
- A
 - B
 - C
 - not enough information given
 - all equal
- 48) Which polymer is "toughest"?
- A
 - B
 - C
 - not enough information given
 - all equal
- 49) Which polymer is most "brittle"?
- A
 - B
 - C
 - not enough information
 - all equal

50) When a plasticizer is added to a polymer, the overall effect is to _____ the crystallinity of the polymer and _____ its T_g?

- a. reduce; lower
- b. increase; lower
- c. increase; raise
- d. reduce; raise
- e. eliminate; raise

51) _____ polymers result from rapid reaction of one molecule at a time with a growing polymer chain, usually with a reactive intermediate at the growing end of the chain.

- a. Addition
- b. Condensation
- c. Step-growth
- d. Amorphous

52) Low-density polyethylene is soft and flimsy because it has a _____ and _____ structure?

- a. highly branched; crystalline
- b. highly branched; amorphous
- c. unbranched; triglyceride
- d. unbranched; amorphous
- e. unbranched; crystalline

53) A polymer with a high degree of crystallinity is usually _____ than a similar polymer with a lower degree of crystallinity.

- a. denser but less rigid
- b. denser and more rigid
- c. less dense and less rigid
- d. less dense but more rigid
- e. less dense but stronger

54) The T_g of a polymer is its _____.

- a. gum transition temperature
- b. growth temperature
- c. Gaussian thermocouple
- d. lattice relaxation time
- e. glass transition temperature

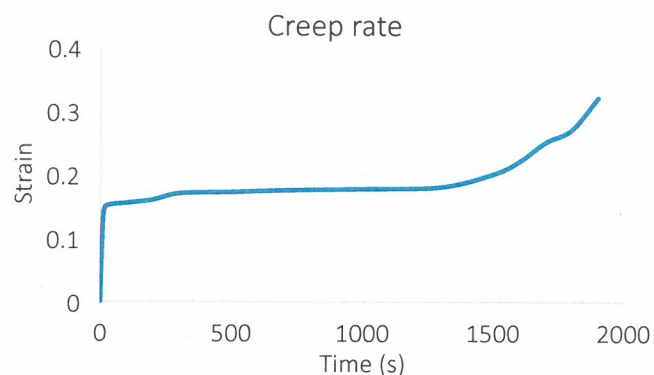
55) Below T_g, crystalline polymers exist as _____.

- a. thermoplastics which are flexible and moldable
- b. liquids which are flexible and moldable
- c. glasses of low flexibility
- d. thermoplastics which are readily extruded to form fibers
- e. liquids which are readily extruded to form fibers

56) Which of the following types of microscopy measures fine topographies via the deflection of a cantilever?

- a. SEM
- b. TEM
- c. AFM
- d. Confocal microscopy
- e. Light microscopy

Questions 57 – 60 are about creep, specifically about the creep depicted on the graph I've drawn down here. Note the scale.



57) Graphs depicting creep are typically plotted on what type of scale (this one might not be "typical")?

- a. Linear
- b. Log-log
- c. Semi-log
- d. Exponential
- e. Stress-time

58) What is the creep rate $\frac{d\varepsilon}{dt}$ of our sample (blue curve)?

- a. $1.3 \times 10^{-4} \text{ s}^{-1}$
- b. $1.7 \times 10^{-4} \text{ s}^{-1}$
- c. $8.7 \times 10^{-4} \text{ s}^{-1}$
- d. $2.3 \times 10^{-5} \text{ s}^{-1}$
- e. $9.0 \times 10^{-5} \text{ s}^{-1}$

59) We like to calculate $\frac{d\varepsilon}{dt}$ during which stage of creep?

- a. Primary
- b. Secondary
- c. Tertiary
- d. Quaternary
- e. Initial strain

60) Would this polymer be a good choice to cover the wires leading to cell-phone ear buds?

- a. Yes
- b. No
- c. Maybe
- d. Not enough information given

Part II: Place all answers on the answer sheet. Answers placed on this page will not be graded.

Activity: Crosslinking of Polymer Chains (50 points)

– Four solutions are provided for your team to conduct an experiment related to crosslinking of polymer chains. The composition of the solutions is unknown to the teams. Closely follow the instructions below to properly react the solutions and answer the corresponding questions.

Experimental Procedure and Materials: Provided for your use are four plastic Ziplock bags and 4 solutions. Solutions A and B contain similar polymer chains at different concentrations. Solutions C and D contain two different types of cross-linkers. Prepare four polymer systems in the bags following the procedure and quantities listed below. Add solutions quantities listed below with the use of a graduated cylinder. Once the solutions are added, remove the air from the bag by flattening the bag and then seal the bag tightly.

Mixing is very important for proper cross-linking reactions. Rub the bag with the solutions between your hands for one complete minute. Make sure the liquids are very well mixed! After mixing, allow the bag to rest for one minute before making observations. Once all of the polymer systems are prepared, proceed to the questions. Teams make take the polymers out of the bags to observe and touch. They may be messy!

Polymer System 1:

20 mL of Solution A and 15 mL of Solution C

Polymer System 2:

20 mL of Solution A and 15 mL of Solution D

Polymer System 3:

20 mL of Solution B and 15 mL of Solution C

Polymer System 4:

20 mL of Solution B and 15 mL of Solution D

Tasks/Questions related to the four solutions (A, B, C, D) and the four polymer systems (1, 2, 3, 4).

- 61) Which of the solutions is most viscous?
- 62) Which of the solutions (C or D) is a more effective cross-linker?
- 63) Which of the polymer systems is most viscous?
- 64) Which polymer system would be clearly considered viscoelastic?
- 65) Which of the polymer systems has the lowest creep rate?
- 66) Which polymer system dissipates the least amount of energy (heat) when a load is applied (squeezed).
- 67) Which polymer system has the greatest Young's Modulus?
- 68) Is the Poisson's Ratio of polymer system 1 +, - or 0?
- 69) Which solution has a greater concentration of polymer chains?
- 70) Which polymer system has a greater yield strength?
- 71) Identify one polymer system that is thixotropic.
- 72) Which polymer system has stronger adhesive properties?
- 73) When polymer system 1 is quickly stretched, is the strain large or small?
- 74) When polymer system 1 is broken, can the two pieces come back together and "heal" itself?
- 75) Can polymer systems 1 and 3 be blended to form a new polymer system?