MATERIALS SCIENCE ANSWER KEY

1. (1 point each) Match each description with the appropriate category of polymer: Thermoplastic, thermoset, and elastomer. Each category will be used more than once.
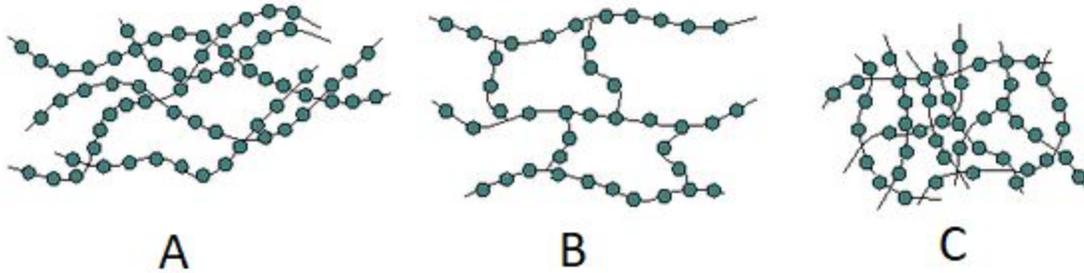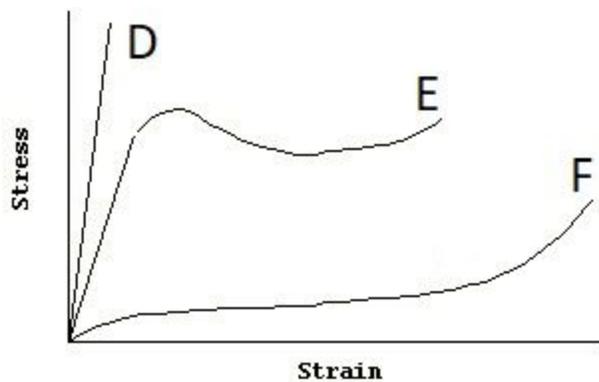

A   B   C

Diagram A: Thermoplastic

Diagram B: Elastomer

Diagram C: Thermoset

Line D: Thermoset

Line E: Thermoplastic

Line F: Elastomer

High impact toughness: Thermoplastic

Extremely high elongation at break: Elastomer

High elastic modulus: Thermoset

Undergoes curing to form irreversible chemical bonds: Thermoset

Physical properties are a result of chain entanglement: Thermoplastic

Randomly, irregularly coiled under normal conditions: Elastomer

Suitable for high-temperature applications: Thermoset

Exhibit viscoelasticity: Elastomer

Cannot be recycled: Thermoset

_____/15 pts

2. (20 points total) Organic chemistry nomenclature:
In the space to the right of each diagram, write the letter(s) of the corresponding molecule types.
Note: Some types may not be used. Some types may be used more than once. Some molecules will fall into multiple categories - please list all appropriate types.

A. Alkenes B. Alkynes C. Alcohols D. Esters E. Ethers

F. Aromatics G. Ketones H. Amides I. Amines J. Carboxylic acids

	H		A C		F
	I		TB 4: C F J		D
	B G		E		H
	TB 5: E I J		A B		A F

Graders: Award 1 point per correct letter. Subtract 1 point per incorrect letter. Do not add / subtract points for answers not given Lowest score possible for the page is zero.

_____/20 pts TB4?_____ TB5?_____

Tiebreaker 2: 3A. (3) Draw the monomer unit of the following polymer in the box below:
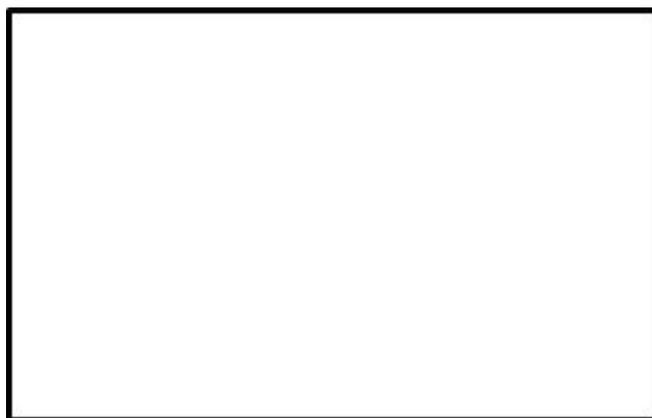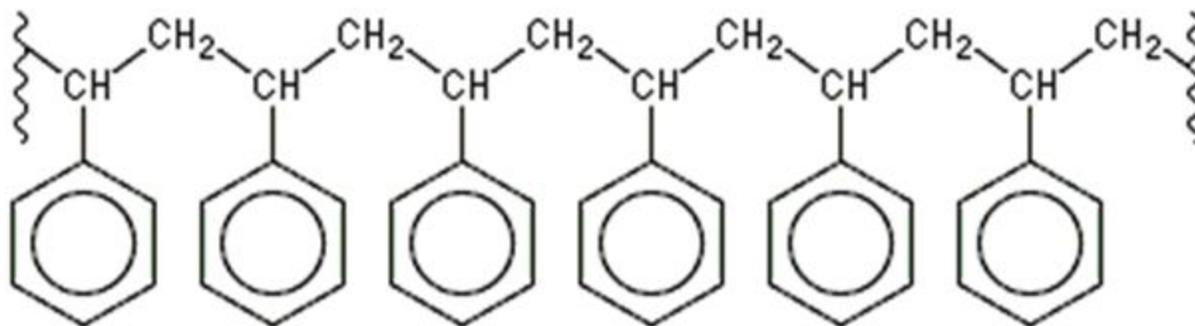
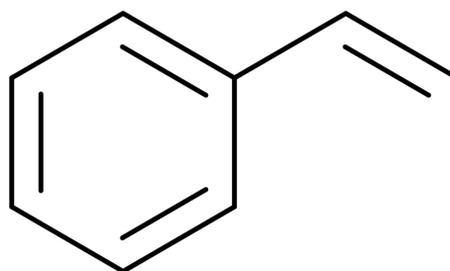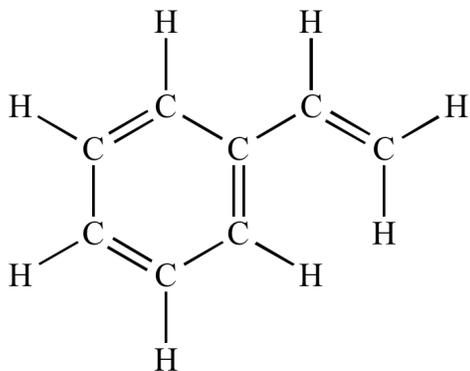3B. (1) What is the common name of this monomer?

Styrene

3C. (2) What is the IUPAC systematic name of this monomer?

Ethenylbenzene or Vinylbenzene

3D. (1) What is the standard abbreviation of the *polymer*? PS

3E. (1) What is the recycling code of the *polymer*? #6

Any style of drawing is correct, provided the molecule drawn is recognizable as styrene. Two different possibilities are shown in the box above. Brackets and n are optional. -1 for every error, e.g. Missing double bond, too many bonds on a carbon, etc. Examples:
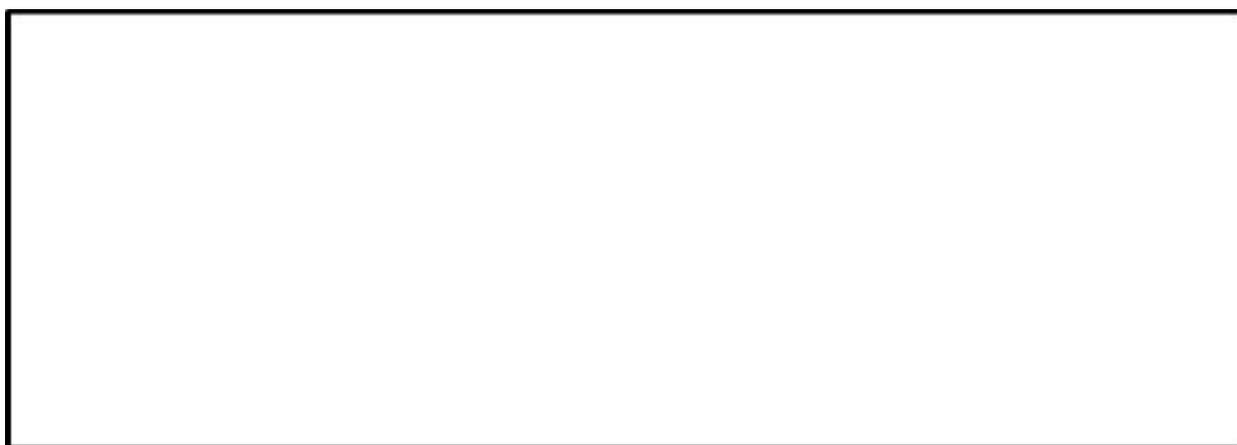

_____/8 pts TB2?_____
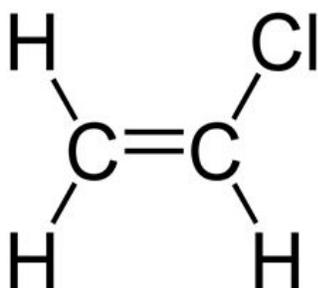
H   Cl   4A. (1). What is the common name of this monomer?

Vinyl chloride

C=C

4B. (2) What is the IUPAC systematic name of this monomer?

H   H   Chloroethene

Tiebreaker 3: 4C. (4) Draw the molecule as a polymer in the box below. Include at least 3 repeat units and draw brackets around the center repeat unit.

Any style of drawing is correct, provided the repeat unit is recognizable as CH2. Cl molecules can be drawn in any position, provided they are attached to alternating carbon atoms. -2 if brackets are incorrectly placed. -1 for every other error in the molecule, e.g. missing Cl atom, too many bonds on a carbon atom, not enough repeat units, etc.

_____/7 pts TB3?_____

σ

H

I

A   B C   D   E

F   G
                        ε
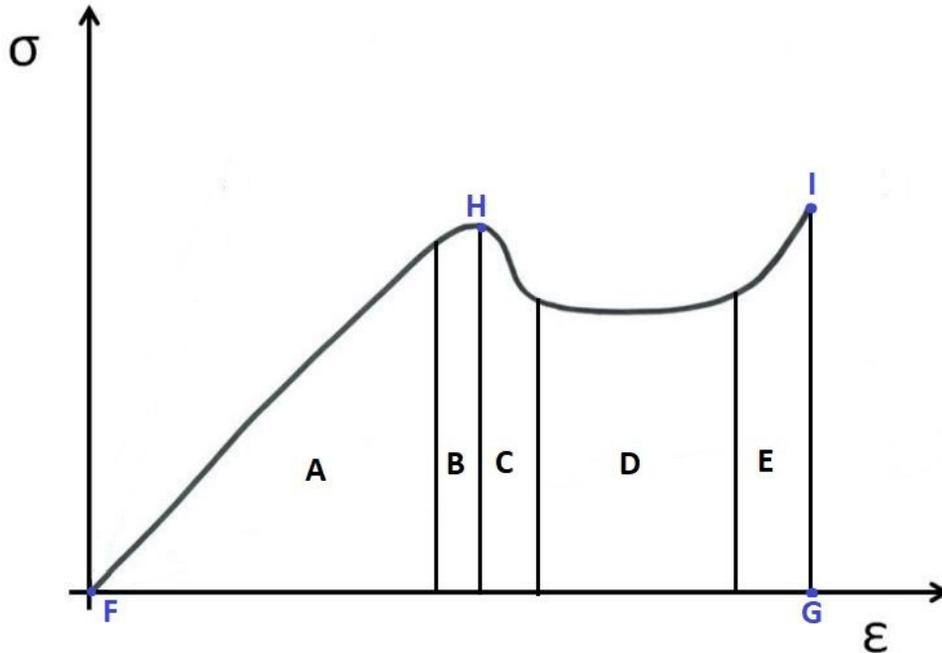
5. (1 each) Identify the phenomena in each region above for a polymer stress-strain curve:

A: Elastic region, linear region, elastic behavior, linear behavior, Hooke's Law behavior

B: Yield

C: Necking

D: Cold drawing, neck extension

E: Strain hardening

What is the term for the slope of region A? Elastic modulus, Young's modulus

What is the term for the stress at point H? Yield strength

What is the term for the stress at point I? (Ultimate) tensile strength

What is the term for the phenomena occurring at point I? Fracture

What is the term for the difference in strain between F and G? Ductility, elongation

What is the term for the area under the curve? Toughness

_____/11 pts

6. Consider a thin rod with length 1 meter, circular cross section, and radius 0.1 m.

Tiebreaker 1: 6A. (5) The material is clamped and a force of 550,000 N is applied, causing the material to stretch to a final length of 1.21 m. Assuming all deformation is elastic, what is the Young's modulus for this material?

5 points for a correct answer: 83.3 MPa.

If the answer is incorrect:
1 point for a correct calculation of strain: ϵ = (L-L(0))/L(0) = (1.21 m-1 m)/1 m = 0.21 or 21%.
1 point for a correct calculation of stress: σ = F/A(0) = 550000 N/(pi*(0.1 m)^2) = 17.5 MPa.
1 point for a correct expression of Young's Modulus: E = σ/ϵ. Rearrangements of this equation are also acceptable.
Maximum 3 points for an incorrect answer.

6B. (3) While the material is stretched, you notice that the radius of this material has decreased to 0.08 m. What is the Poisson's Ratio of this material?

3 points for a correct answer. 0.952

If the answer is incorrect:
1 point for a correct calculation of transverse strain: ϵ(t) = dr/r = (0.08 m-0.1 m)/0.1 m = -0.2
1 point for a correct expression of Poisson's Ratio: μ = -ϵ(t)/e(l)
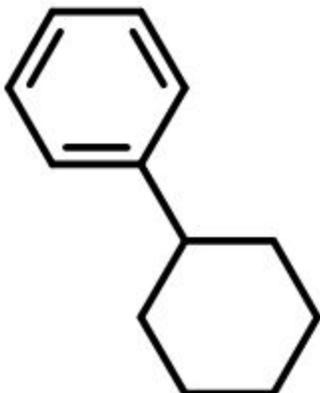Maximum 2 points for an incorrect answer.

6C. (2) What would the Poisson's Ratio be if the radius had instead increased to 0.12 m?

2 points for a correct answer. -0.952

0 points for an incorrect answer.

6D. (1) What is the name of a material exhibiting the type of behavior described in 7C? Hint: think about the Poisson's Ratio.

Auxetic

_____/11 pts TB1?_____

7A. (3) What is the molecular weight of the molecule to the left?

3 points for a correct answer: 160.255 g/mol.

If incorrect, 1 point for correct identification of the molecular formula: C12H16.

7B. (2) What is the IUPAC name of the molecule?

Cyclohexylbenzene.

8. (3) A transparent polymer has a refractive index of 1.5. You shine a laser into the polymer from air (n = 1) at an angle of 45 degrees. What is the angle of refraction, in degrees?

3 points for a correct answer: 28.13 degrees.

If incorrect, 1 point for correct statement of Snell's Law: sin(i)n(1) = sin(r)n(2)

9. (1) What is the angle of reflection, in degrees, off of a perfectly reflective polymer if the light is incident at a 60 degree angle?

2 points for a correct answer: 60 degrees.

10. (2) Plastics, like polystyrene, can crack when molded. This process, "crazing", happens when a material is improperly prepared. What might cause crazing when it is extremely humid?

1 point for mentioning water filling empty areas of a material.
1 point for mentioning expansion of the material when heated.
Both must be mentioned for full credit.

11. (3) How and why do extremely acidic environments affect the viscosity of proteins?

2 points for describing a decrease in viscosity.
1 point for mentioning denaturing of proteins.

____/14 pts

12. (1 point each) Write the appropriate classification of material under each picture below. Each classification should be used exactly once.

Foam   Fiber   Film

Coating   Adhesive   Resin

Film	Resin	Coating
Fiber	Foam	Adhesive

1 point for each correct answer.

13. (2) Silly putty is a viscoelastic material. It may be modeled as a combination of a spring and a dashpot (a device used to diminish the motion of the spring). The constants k and C respectively describe the stiffness of the spring and the viscosity of the material. Initially, silly putty has a C/k value of 0.1 seconds. Which answer best describes what happens when the silly putty is smashed with a hammer?
    A) C/k decreases, the silly putty becomes more viscous
    B) C/k decreases, the silly putty becomes less viscous
    C) C/k decreases, the silly putty becomes more stiff
    D) C/k decreases, the silly putty becomes less stiff
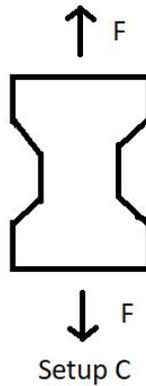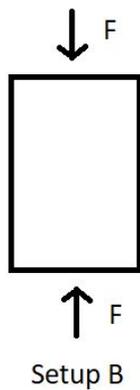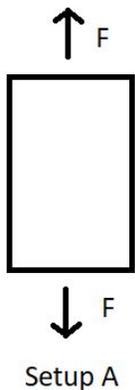   E) C/k stays the same, the elasticity or viscosity do not change

____/8 pts

14. (2) Which of the following types of materials typically exhibits cross-linkage?
   A) Thermoplastic
   B) Thermoset
   C) Elastomer
   D) Fiber

15. (2) Which of the following test setups would most likely result in crazing?
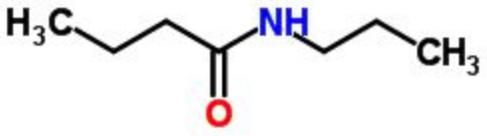

   A) Setup A

   B) Setup B

   C) Setup C

16. (4) Which of the following properties would decrease a polymer's solubility in hexane? Multiple answers may be correct.
   A) Branched alkyl groups
   B) Cross-linkage
   C) Low molecular weight
   D) High entanglement
   E) Hydrogen bonding
   F) Nonpolar substituents
   G) High degree of crystallinity
   H) High temperature

_____/8 pts

Tiebreaker 6: 17. (2 points each) Write the *systematic* name below each molecule.
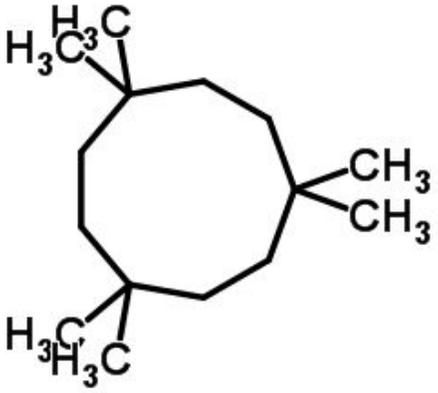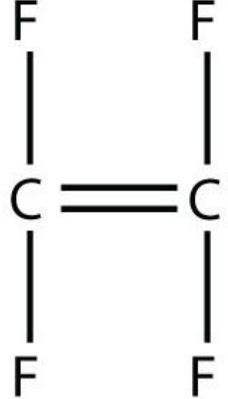
1,1,4,4,7,7-hexamethylcyclononane	tetrafluoroethene 1 point for tetrafluoroethylene
N-propylbutanamide	
1,5-pentanediol pentane-1,5-diol	1,3,5-cyclooctatrien-7-yne cycloocta-1,3,5-trien-7-yne

_____/10 pts