



*Exploring the World of Science*

# Materials Science

(EXAM)

**Test length:** 50 Minutes

**Team number:** \_\_\_\_\_

**School name:** \_\_\_\_\_

**Student names:** \_\_\_\_\_

*Directions:*

This exam is worth **110 points**. You are allowed two 8.5" x 11" notes sheets and two calculators. Tiebreakers, in order of precedence, are indicated in the test.

Answer all questions in the test book. **A periodic table is included at the end of this test.** You may separate the test, however, if you choose to do so, please write your team name and number at the top of each page (this is a good idea in any case!).

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.

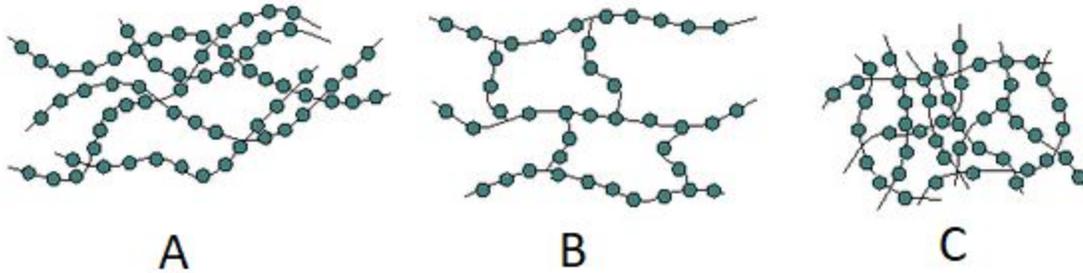
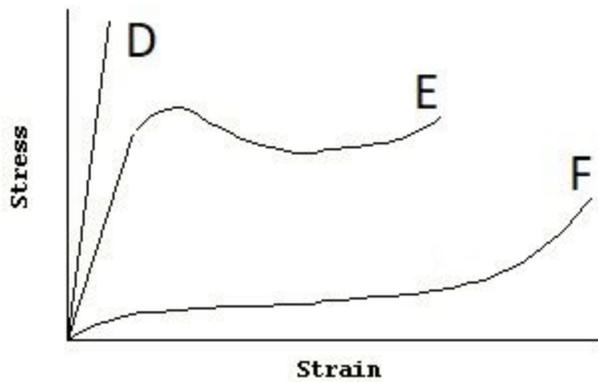


Diagram A:

Diagram B:

Diagram C:



Line D:

Line E:

Line F:

High impact toughness:

Extremely high elongation at break:

High elastic modulus:

Undergoes curing to form irreversible chemical bonds:

Physical properties are a result of chain entanglement:

Randomly, irregularly coiled under normal conditions:

Suitable for high-temperature applications:

Exhibit viscoelasticity:

Cannot be recycled:

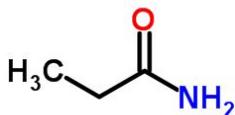
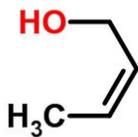
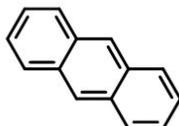
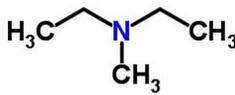
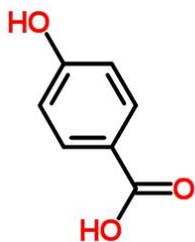
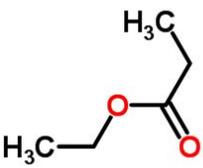
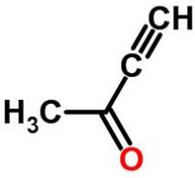
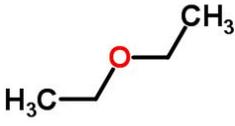
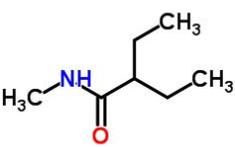
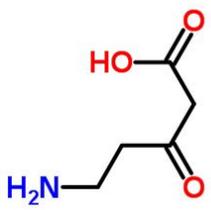
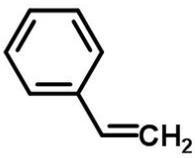
\_\_\_\_/15 pts

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.

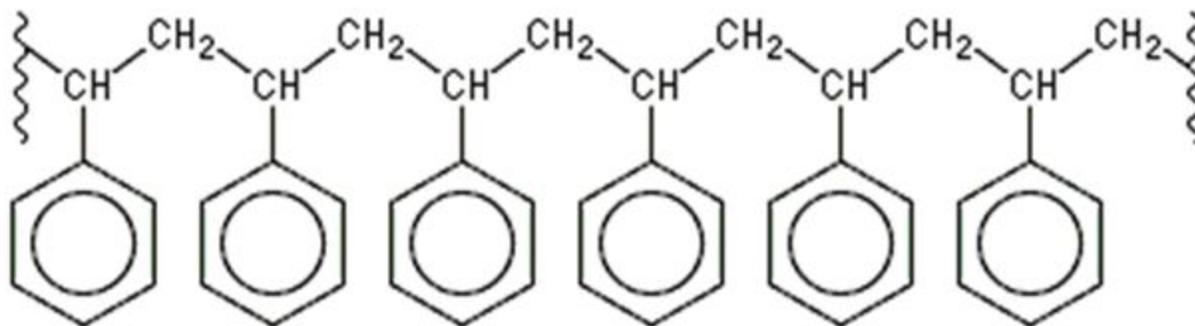
*Note:* Some types may not be used. Some types may be used more than once. Some molecules will fall into multiple categories - please list all appropriate types.

- A. Alkenes    B. Alkynes    C. Alcohols    D. Esters    E. Ethers  
 F. Aromatics    G. Ketones    H. Amides    I. Amines    J. Carboxylic acids

					
			TB 4:		
					
	TB 5:				

\_\_\_\_/20 pts TB4? \_\_\_\_ TB5? \_\_\_\_

Tiebreaker 2: 3A. (3) Draw the monomer unit of the following polymer in the box below:



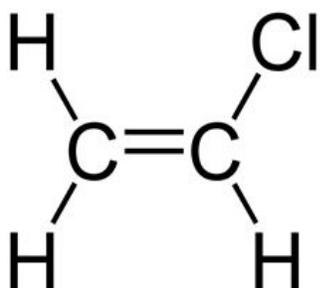
3B. (1) What is the common name of this monomer?

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

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

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

\_\_\_\_/8 pts TB2?\_\_\_\_



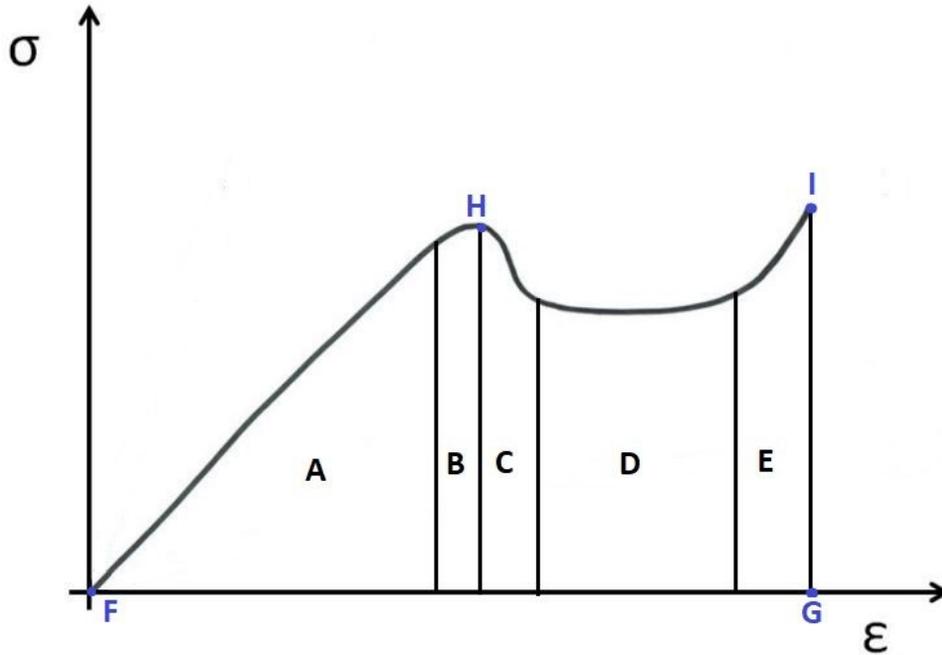
4A. (1). What is the common name of this monomer?

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

*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.



\_\_\_\_/7 pts TB3?\_\_\_\_



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

A:

B:

C:

D:

E:

What is the term for the slope of region A?

What is the term for the stress at point H?

What is the term for the stress at point I?

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

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

What is the term for the area under the curve?

\_\_\_\_/11 pts

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

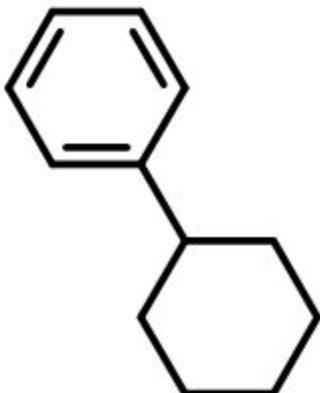
*Tiebreaker 1: 6A.* (5) The material is clamped and a force of 550,000 N is applied, causing the material to stretch to a final length of 1.21 m. Assuming all deformation is elastic, what is the Young's modulus for this material?

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?

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

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

\_\_\_\_/11 pts TB1?\_\_\_\_



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

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

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?

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?

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?

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

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?

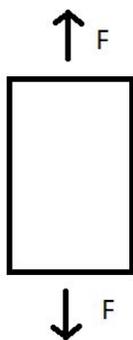
- A)  $C/k$  decreases, the silly putty becomes more viscous
- B)  $C/k$  decreases, the silly putty becomes less viscous
- C)  $C/k$  decreases, the silly putty becomes more stiff
- D)  $C/k$  decreases, the silly putty becomes less stiff
- E)  $C/k$  stays the same, the elasticity or viscosity do not change

\_\_\_\_/8 pts

14. (2) Which of the following types of materials typically exhibits cross-linkage?

- A) Thermoplastic
- B) Thermoset
- C) Elastomer
- D) Fiber

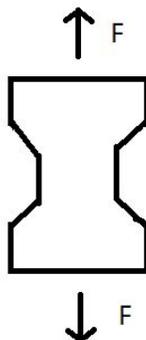
15. (2) Which of the following test setups would most likely result in crazing?



Setup A



Setup B



Setup C

A) Setup A

B) Setup B

C) Setup C

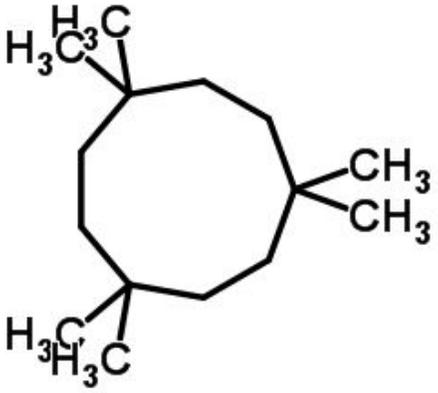
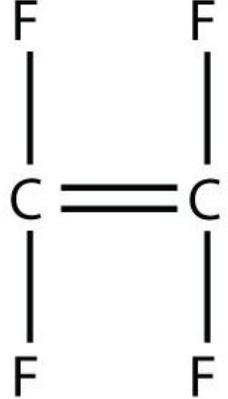
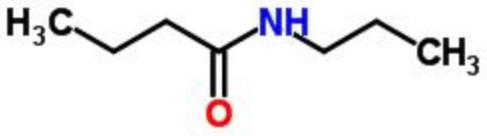
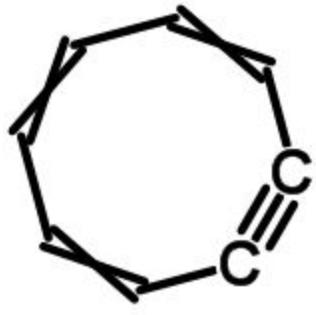
16. (4) Which of the following properties would decrease a polymer's solubility in hexane?

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.

\_\_\_\_/10 pts TB6?\_\_\_\_

1 H 1.00794																	2 He 4.002602
3 Li 6.941																	9 F 18.9984032
4 Be 9.012182																	10 Ne 20.1797
11 Na 22.989770																	17 Cl 35.4527
12 Mg 24.3050																	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6534	29 Cu 63.545	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.504	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 196.56655	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.56655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.58038	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Uu (269)	111 Uub (272)	112 Uuc (277)	114 Uuq (287)	116 Uuq (289)				

58 Ce 140.116	59 Pr 140.50765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967
90 Th 232.0381	91 Pa 231.035888	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)