Total: ______/100
Rank:_______

Names: KEY ____________________

____

Team Name: ____________________

Team Number: ____________________

Materials Science Test

KEY

DO NOT OPEN UNTIL INSTRUCTED

Please provide team number on all pages submitted with the test.

You will be provided with a periodic table. You are encouraged to start Question 1 (lab-based) as soon as your testing session begins.

You may separate the sheets, but be certain to write your team number on each if you do so.

Tie-Breakers:
Question 10e
Question 2a (if 10e tied)
Question 12 (if 2a tied)

--------------DO NOT WRITE BELOW THIS LINE ---------------

Supervisor/Assistant Check off Each Item

Lab Coat/Apron to Knees ________
Pants or Skirts to Ankles ________
Long-Sleeved Shirt
& Apron or Coat ________
Closed-Toe Shoes ________
Indirect Vent Goggles ________
Satisfactory Clean-Up ________

Unsafe procedures noted at any station:

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Team #__________

1. MATERIAL PERFORMANCE (16 pts total)

Note: This lab portion includes waiting times of five-minute intervals in which you are encouraged to work on other portions of the event.

You will be investigating the creep rate and composition of two recipes of silly putty. The silly putty includes:

- ¼ tsp borax (low concentration) **OR** 1 tsp borax (high concentration)
- 3 oz warm water, divided
- 2 oz Elmer's glue

Procedures:

1. Obtain two sheets of wax paper and label one "Low" and one "High."
2. Take the silly putty out of the Ziploc bags and form each sample into a Hershey kiss shape, with a relatively flat bottom as opposed to a spherical shape.
3. Place each kiss shape on its respective sheet of wax paper. Immediately draw a circle around the widest part of the silly putty.
4. Return every five minutes and draw a new circle around the putty.
5. Do this for 25 minutes (five measurements).
6. After 25 minutes, draw your final circle and place each sample back in its appropriate bag.
7. Measure the diameter of each circle and record it in your data table.
8. Calculate the creep for each 5-minute interval. Creep is here defined as the percent enlargement in the area of the base as compared to the initial area.
9. Create a graph of time vs. creep. Include both samples on the same plot.
10. Calculate the creep rate between the 5- and 10-minute measurements for each sample.

Data (2 pts): -1 if creep calculated incorrectly

	Low Concentration		High Concentration	
Time (min)	**Diameter (cm)**	**Creep**	**Diameter (cm)**	**Creep**
0		0		0
5				
10				
15				
20				
25				

Graph should have:
- 2 lines - 1 pt
- labeled axes - 1 pt
- Key or indication of which line is which - 1 pt
- data from table correctly plotted 2 pts

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***#1 cont'd* Graph (5 pts):**

Graph will depend on data from pg 1.

***#1 cont'd* Creep Rate (5 pts):**

2 pts each
-2 if not right time interval

	Low Borax Concentration	High Borax Concentration
Calculated Creep Rate		

Use slope of graph

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***#1 cont'd* Question (4 pts):** Based on your observations, how is the concentration of the borax related to the viscoelastic properties of the silly putty? Provide an explanation for this relationship based on the structural properties of the putty and its components.

Higher [borax], ~~Less~~ more viscous. +2

Borax cross-links the polymer chains of glue. +2

2. **MATERIAL PERFORMANCE (13 pts total)** Complete the following table and create a stress-strain curve for the data below. For this particular material, original length, L_0= 1.00 m and original cross-sectional area, A_0= 0.25 m^2.

Data (3 pts) -1 if either column calculated incorrectly

Length, L (m)	Force Required (N)	Stress (kPa)	Strain
1.01	112.5	0.45	0.01
1.02	224.8	0.90	0.02
1.03	337.7	1.35	0.03
1.04	329.8	1.32	0.04
1.05	392.5	1.57	0.05
1.06	466.6	1.87	0.06
1.07	505.0	2.02	0.07
1.08	502.4	2.01	0.08
1.09	472.7	1.89	0.09
1.10	415.1	1.66	0.10

-1 wrong unit

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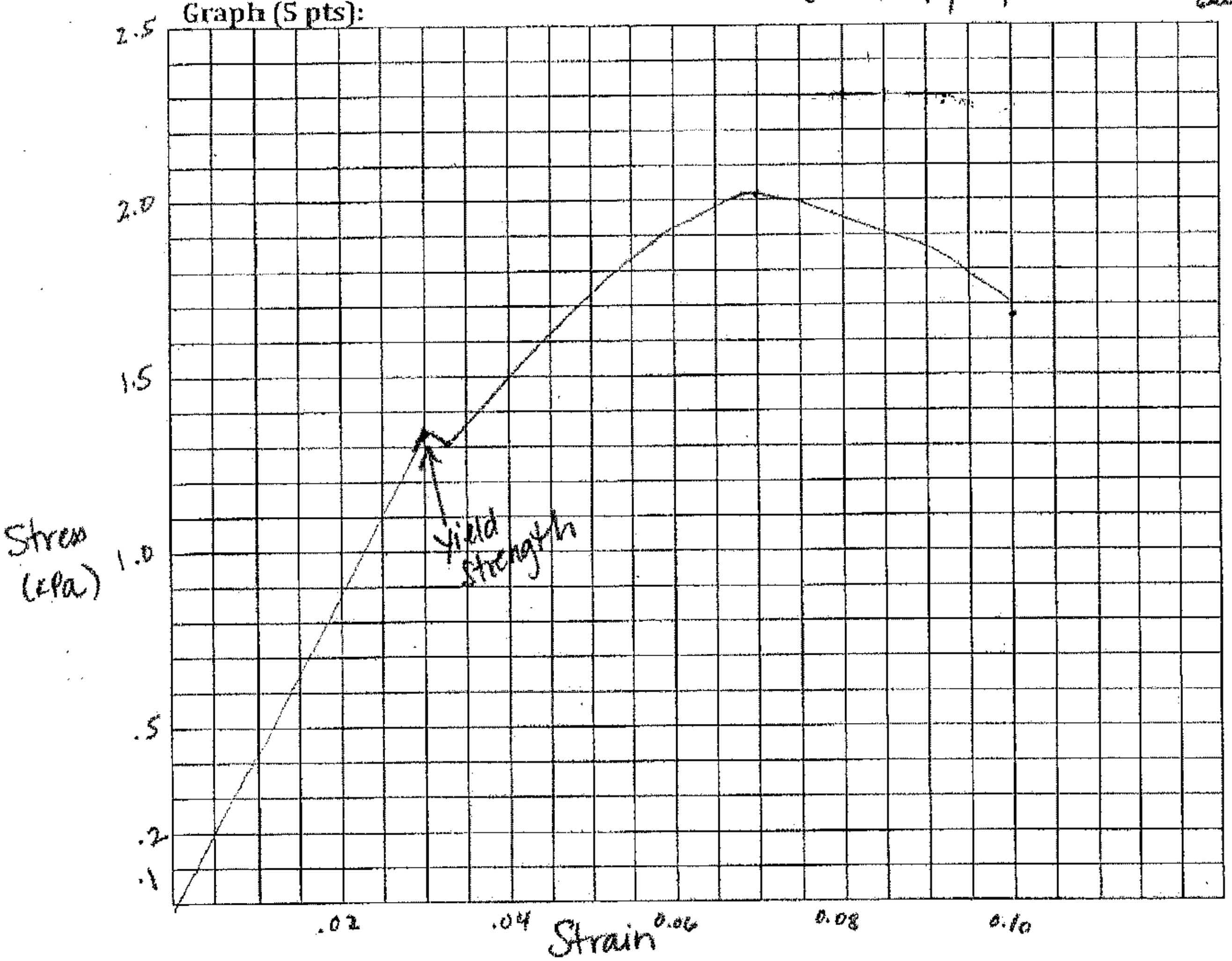
labeled axes - 1 pt
Correct x & y 1 pt. 3 pts graphed data

Graph (5 pts):



a. **(3 pts)** Calculate Young's Modulus for the material. Provide justification for your answer.

2 ways - slope of linear part of graph
or
Eq'n in that range

-2 no work/justification

E = 45 kPa

b. **(2 pt)** On your graph, label the yield strength of the material.

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3. **MATERIAL PERFORMANCE (2 pts)** Which class of materials generally has the highest Young's Modulus?
    a. Metals
    b. Polymers
    (c) Ceramics

4. **MATERIAL PERFORMANCE (2 pts)** Write the following in order of *increasing* Young's Modulus: **Concrete, Nickel, Nylon, Silicon Carbide**

    Nylon < Concrete < Nickel < Silicon Carbide

5. **MATERIAL PERFORMANCE (1 pt each)** Identify each of the following as a metal **(M)**, composite **(CO)**, ceramic **(CE)** or polymer **(P)**.

    a. polyvinyl chloride P
    b. silicon nitride CE
    c. tungsten M
    d. fiberglass CO
    e. proteins P
    f. aluminum oxide CE

6. **MATERIAL PERFORMANCE (1 pt each)** *Select the word choice for each statement that correctly completes the sentence.*

    a. If the size of an object decreases, its surface area: volume ratio *increases/decreases*.

    b. As the viscosity of a liquid increases, the flow rate *increases/decreases*.

    c. Ceramics are *more/less* dense than most metals and alloys.

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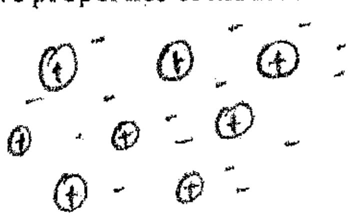
7. **MATERIAL PERFORMANCE (2 pts)** Which of the following is NOT a characteristic property of a ceramic material?
   a. high temperature resistance
   b. wear-resistant
   c. malleable
   d. high mechanical strength

8. **MATERIAL PERFORMANCE (2 pts)** Viscoelasticity is generally greater in which class of materials?
   a. Metals
   b. Polymers
   c. Ceramics
   d. Composites

9. **MATERIAL PERFORMANCE (4 pts)** Illustrate the bonding between metallic atoms in the space below. Then describe how this bonding allows for the conductive properties of metals.

+2 pic
+2 explain



Sea of electrons
metal cations w/
delocalized electrons

Electrons can move - not bound to any particular atom, flow of electrons is conductivity!

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10. IMF/SURFACE CHEM

a. **(3 pts)** Construct a body-centered cubic (BCC) cell from the toothpicks and marshmallows available at the lab station. Once constructed, leave it on the plate with your team number.

1 in middle attached to 8 others which are attached in cube shape

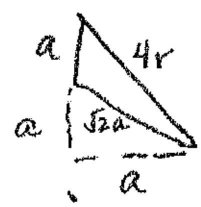
b. **(2 pts)** How many atoms are in one BCC unit cell?

2

c. **(2 pts)** What is the coordination number for the BCC structure?

8

d. **(5 pts)** Molybdenum forms the BCC structure. Its atomic radius is 139 pm. Calculate the lattice constant (in angstroms, Å) of molybdenum.



$a^2 + (\sqrt{2}a)^2 = (4r)^2$

$a^2 + 2a^2 = (4r)^2$

$3a^2 = (4r)^2$

$\sqrt{3}a = 4r$

$a = \frac{4r}{\sqrt{3}}$

321 pm

3.21 Å

-3 no work

e. **(5 pts)** Calculate the density of molybdenum. Show work to support your answer.

Mo 95.94 g/mol

-3 no work

$\frac{2 \text{ atoms}}{} \times \frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ atoms}} \times \frac{95.94 \text{ g}}{1 \text{ mole}} \times \frac{}{3.31 \times 10^{-23}}$

9.63 g/cm³

$V = (3.21 \times 10^{-8} \text{ cm})^3 = 3.31 \times 10^{-23} \text{ cm}^3$

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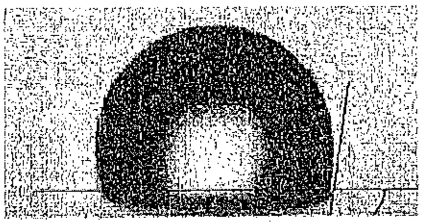
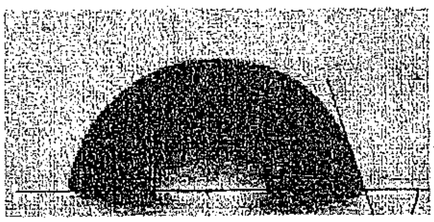
11. IMF/SURFACE CHEM

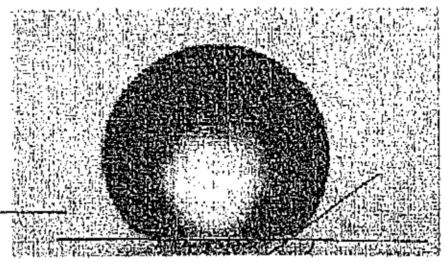
a. **(4 pts)** Find the contact angle for each liquid below:



I. 95° 91°

II. 45°





III. 70°

IV. 145° 150°

b. **(2 pts)** Assume that each of these samples is the same liquid on different surfaces. Rank the surfaces from most hydrophobic to most hydrophilic.

IV I III II

hydrophobic hydrophilic

c. **(2 pts)** Assume instead that these are samples of different liquids on the same surface. What two liquids could be mixed together in equal proportions to yield a contact angle of 120°?

IV & I

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12. **IMF/SURFACE CHEM (5 pts)** A single drop of soap is dropped into a tray of water from a pipette. The soap creates a circle with a diameter of 12.6 cm. Calculate the thickness of a single soap molecule. *(Note: 1 mL = 18 drops)*

-3 (no work)

$A=\pi(6.3)^2$ r = 6.3 cm

$A=124.69\ cm^2$ $\frac{1mL}{18}=0.06\ mL$ in one drop

$\frac{0.06\ cm^3}{124.69\ cm^2}=$ 0.00048 cm

13. **IMF/SURFACE CHEM (5 pts)** Referencing their respective bonding patterns and/or atomic packing, explain why diamond is so hard while graphite can be used as a lubricant, despite both being made of only carbon atoms.

1 pt - Differences cited

must reference both substances or else -3

2pts Graphite is hexagonally packed carbon atoms, where hexagonal sheets are held together by van der Waals forces. These sheets can easily slide against one another. Diamond has all electrons tied up in a rigid covalent network of single bonds, creating its characteristic hardness 2 pts.

14. **IMF/SURFACE CHEM (2 pts)** Glass is an example of a(n)________ structure.

a. Ionic
b. Covalent
c. Crystalline
(d.) Amorphous

15. **IMF/SURFACE CHEM (2 pts)** If a face-centered cubic cell, body-centered cubic cell and simple cubic cell were all made of the same atoms, which would have the highest density?

(a.) face-centered cubic
b. body-centered cubic
c. simple cubic

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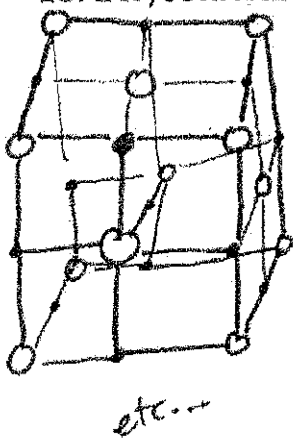
16. IMF/SURFACE CHEM (3 pts) Draw a unit cell of sodium chloride.



face centered cubic WRT Cl^-

Na^+ fills octahedral holes

17. IMF/SURFACE CHEM (2 pts) As water temperature increases from 0°C to 100°C, what happens to the surface tension?

a. Increases
(b.) Decreases
c. Stays the Same
d. Fluctuates

18. IMF/SURFACE CHEM (2 pts) Which of the following is NOT a hexagonal close packed (HCP) metal?

a. Indium
b. Nickel
c. Rhodium
(d.) Vanadium

19. IMF/SURFACE CHEM (4 pts) Match each compound to its predominant force that keeps its molecules together:

__C__ I. C_2H_5OH	A. Covalent Network
__A__ II. SiO_2	B. Ionic
__B__ III. $CaCl_2$	C. Hydrogen bonding
__D__ IV. C_2H_6	D. London dispersion forces