MSE 170 B Midterm 11/2/2009 100pts. Total

Exam is closed book, closed notes, no collaborations with neighbors.

(Two sheets of letter-size paper is allowed)

Instructions:

1. *Write your name and student ID on the top of the page.*
2. *Read the questions carefully.*
3. *Read the questions carefully, again.*
4. *Make sure you are answering the right questions.*
5. *Write legibly.*
6. *Show work as needed to justify answers.*
7. *After you are done, hand in your work and as once a wise man said: " Do a little dance, ..."*

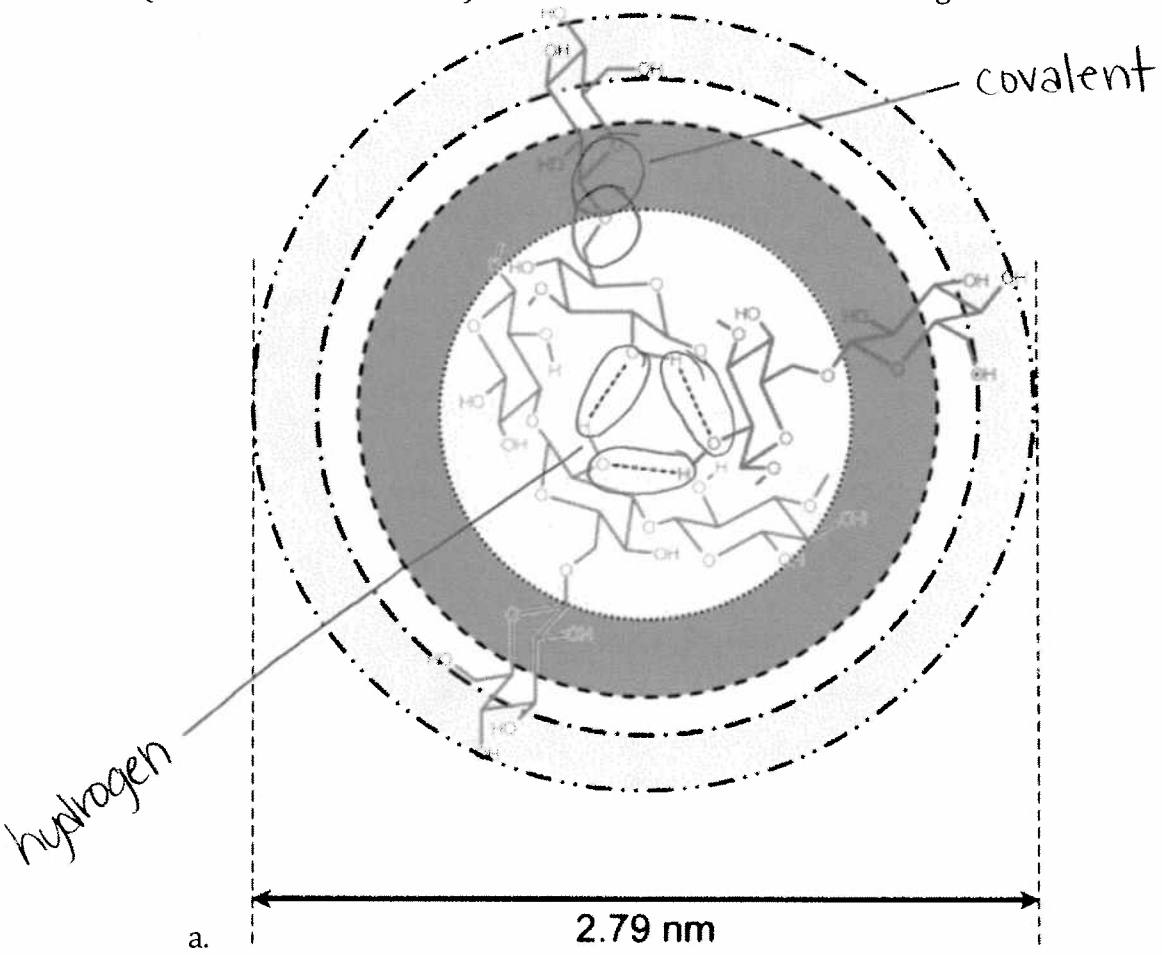
GOOD LUCK!

Point Distribution (total=100)

Problem 1	*50*
Problem 2	*25*
Problem 3	*25*

Problem 1. Basic concepts (50 points): Answer the following questions:

1. What kind of atomic and intermolecular bonds exist in skyzophyllan (mushroom based fiber)? Comment on their relative strengths.



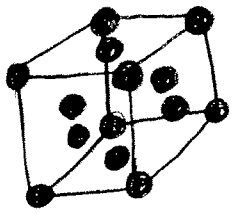
a.

Covalent bonds are stronger than hydrogen bonds.

2. What is the defining characteristic of a crystalline structure?

long range order

3. Draw a unit cell for a FCC structure.



4. Determine the Miller indices for the planes A and B shown in the following unit cell.

A intercepts: $-\frac{1}{2}$ $\frac{1}{2}$ ∞
reciprocals: -2 2 0
indicies: $(\bar{2}\ 2\ 0)$

B intercepts: 1 $\frac{1}{2}$ $\frac{1}{2}$
reciprocals: 1 2 2
indicies: $(1\ 2\ 2)$

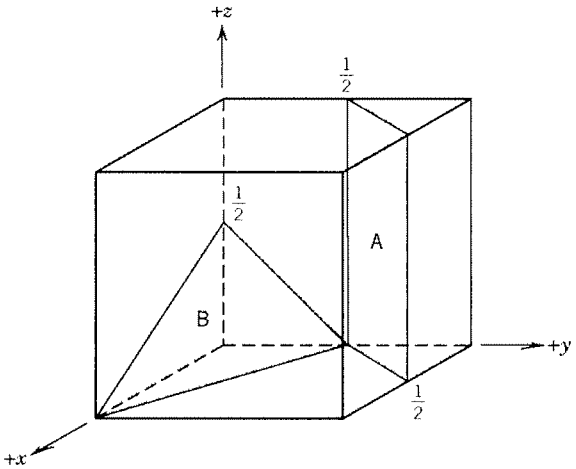


Figure 1

5. What happens to dislocations during plastic deformation of metals?

The dislocations move.

6. Referring to the periodic Table on page 12, determine what is the predominant type of bonding for Ge (Germanium), KI (Potassium Iodide), and solid V. Why?

Ge	covalent	same electronegativity numbers
KI	ionic	big difference in electronegativities
V	metallic	elemental metal donates electrons to "sea of electrons"

7. All other parameters being equal, how would you expect the ductility of a metal to relate to the grain size? Explain

Bigger grains → higher ductility. This is because the dislocations have more room to move.

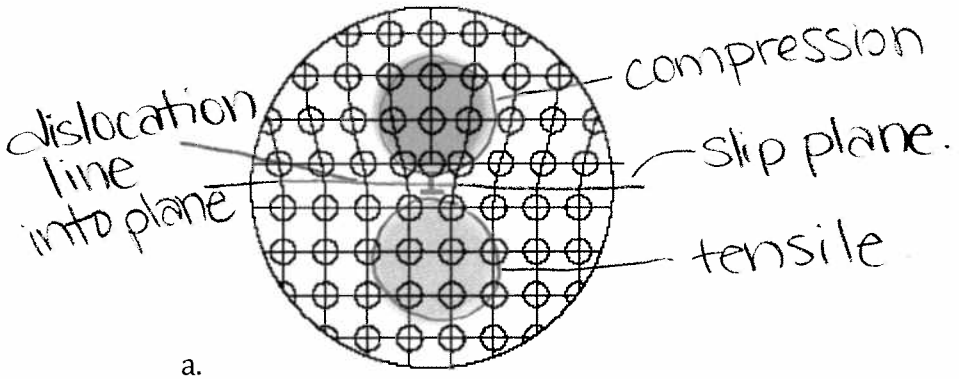
8. What do reducing grain size, and increasing the number of dislocations have in common as strengthening mechanisms? Explain.

They both reduce dislocation movement. Dislocations do not move at grain boundarie Smaller grains → less motion.

More dislocations impede dislocation motion.

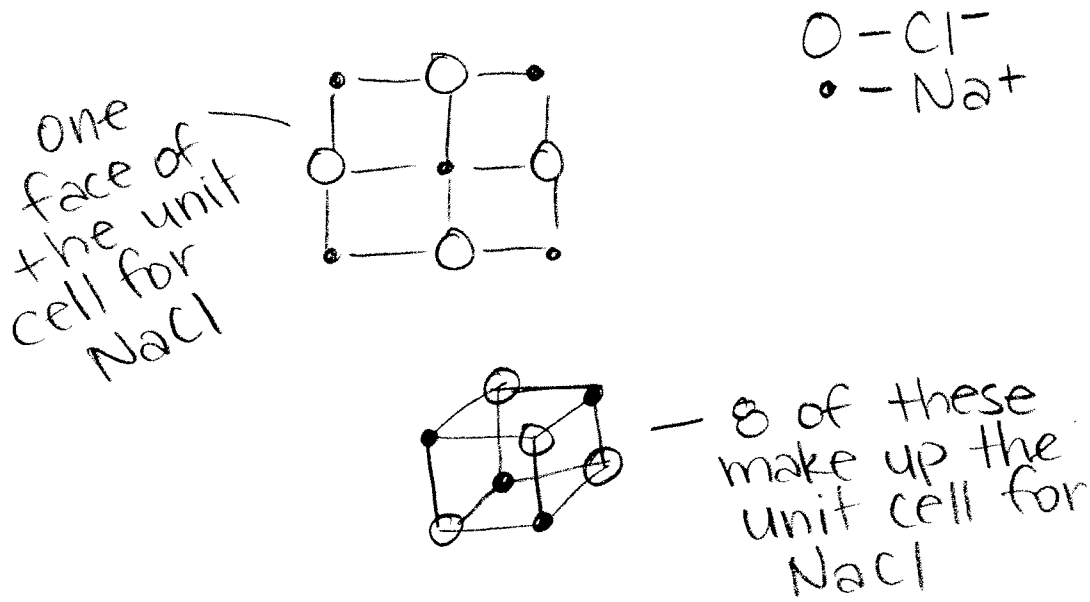
9. Indicate the type the dislocation below, and label the dislocation line and slip plane. Indicate the type of stress above and below the slip plane.

edge dislocation



a.

10. Draw the unit cell for NaCl.



Problem 2. (25 points) From the stress-strain plot for a brass specimen

a) Label in the following figure the yield strength, resilience, toughness, and ductility (10 points)

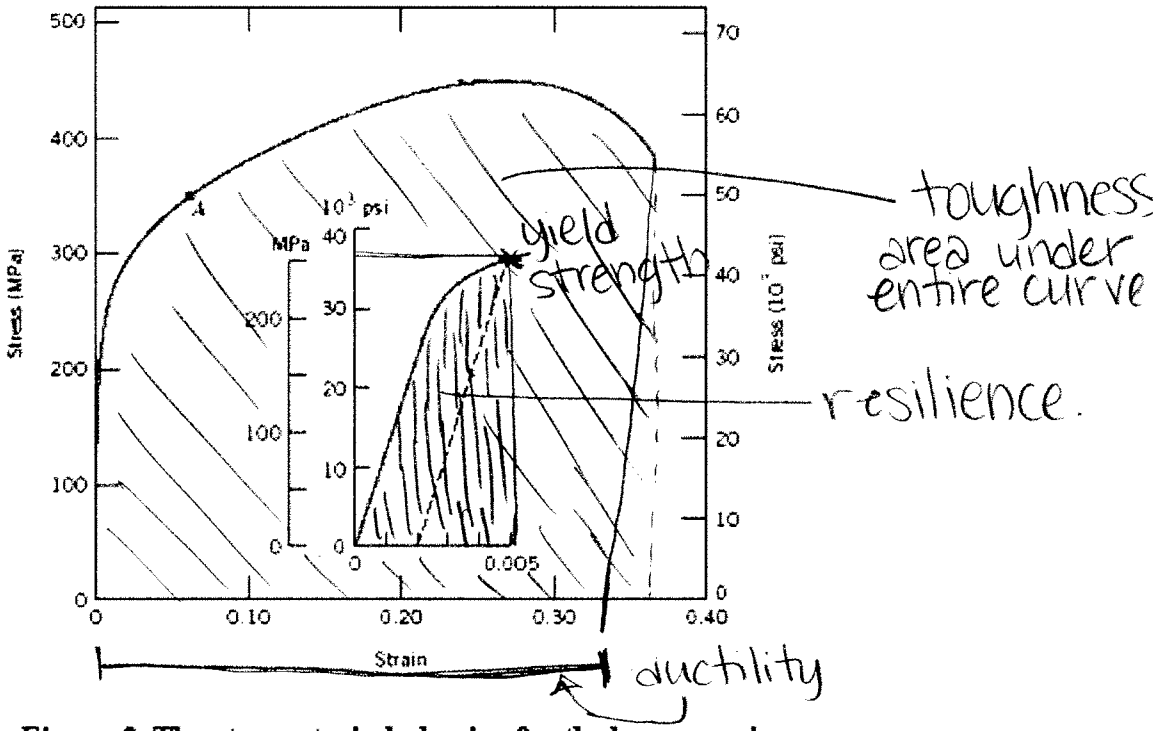


Figure 2. The stress-strain behavior for the brass specimen

b) Determine the elastic and plastic strains when a tensile load 250 MPa is applied on a cylindrical specimen. If the specimen is 120 mm long, how long can it be elongated before it witnesses plastic deformation?
(10 points)

250 MPa ⇒ 0.005 strain

0.003 plastic strain
0.002 elastic strain

For plastic deformation.

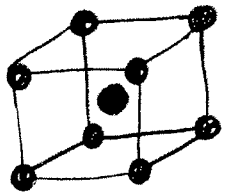
$d > 120\,mm \cdot 0.005 = 600\,\mu m$

c) Calculate the elastic modulus from the figure (5 points)

≈ 75 GPa.

Problem 3 (25 points) Crystal Structures

a. Draw a BCC unit cell and determine the number of atoms per unit cell (10 points).



$1 + 8(\frac{1}{8}) = 2$ atoms per unit cell

b. Derive the relationship between a (lattice parameter) and r (atomic radius) (7 points)

atoms touch along cube diagonal. (4r along cube diagonal)

face diagonal = $a\sqrt{2}$

cube diagonal = $a\sqrt{3}$

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

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

c. Define atomic packing factor and calculate the APF for the BCC structure. (8points)

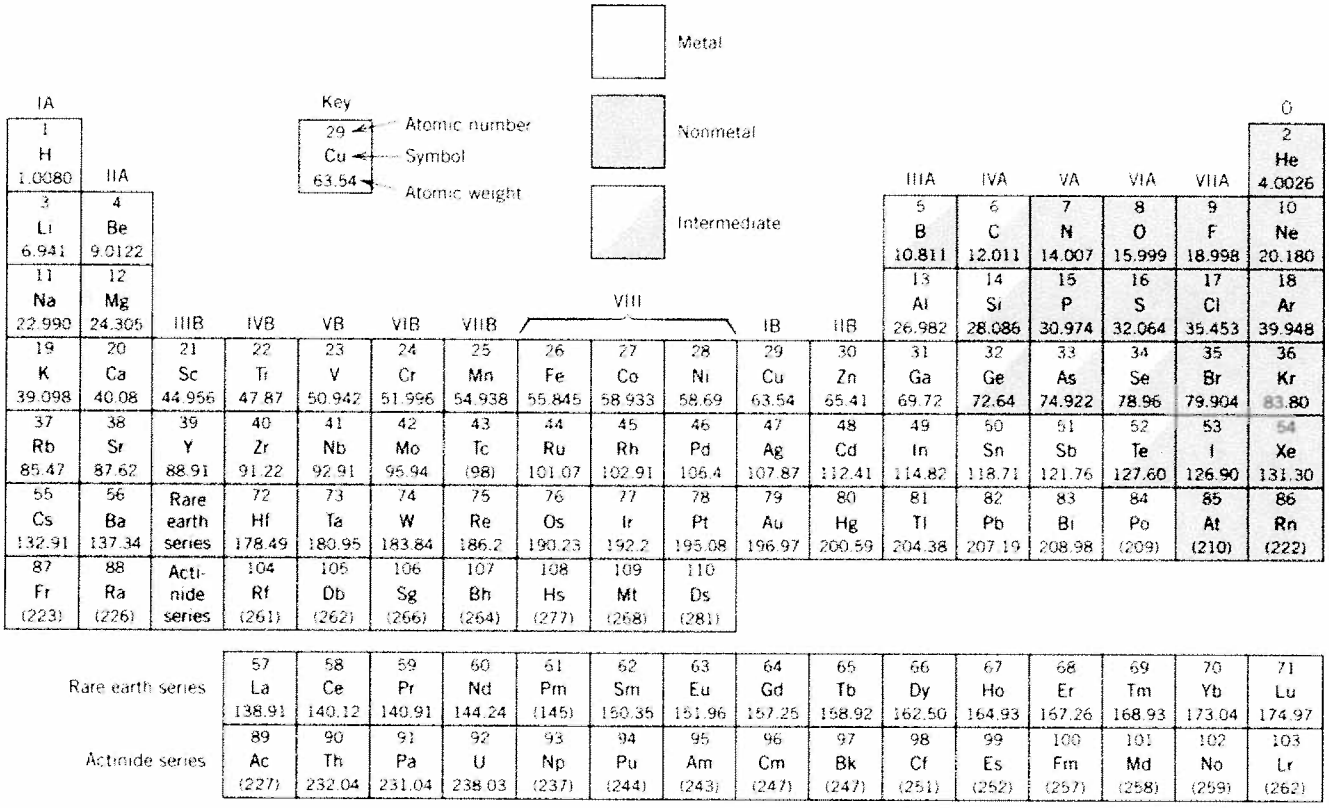
$$APF = \frac{\text{volume occupied by atoms}}{\text{volume of unit cell}}$$

$$APF = \frac{2\left(\frac{4}{3}\pi r^3\right)}{\left(\frac{4}{\sqrt{3}}\right)^3 r^3}$$

$$APF = \frac{\sqrt{3}\,\pi}{8}$$

$$APF = 0.68$$

Periodic Table



IA							VIII					IIIA	IVA	VA	VIA	VIIA	0
1 H 1.0080	IIA									IB	IIB						2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305	IIIB	IVB	VB	VIB	VIIB				IB	IIB	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.87	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.69	29 Cu 63.54	30 Zn 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.30
55 Cs 132.91	56 Ba 137.34	Rare earth series	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.2	76 Os 190.23	77 Ir 192.2	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.19	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	Acti-nide series	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)								

Rare earth series	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
Actinide series	89 Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	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)

Electronegativity

IA							VIII					IIIA	IVA	VA	VIA	VIIA	0
H 2.1	IIA									IB	IIB						He –
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne –
Na 0.9	Mg 1.2	IIIB	IVB	VB	VIB	VIIB				IB	IIB	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar –
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr –
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe –
Cs 0.7	Ba 0.9	La–Lu 1.1–1.2	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2	Rn –
Fr 0.7	Ra 0.9	Ac–No 1.1–1.7															