MSE 2001-B: Exam #2

Answer Key

<Printed Name>

October 13th, 2010

In taking this test, I agree that I will not participate in cheating or any other forms of academic fraud inconsistent of university policies. I understand that if I am caught participating in these types of actions, my exam grade will immediately default to 0% and I will be unable to retake the exam. AK

<initials> .

Part I: Conceptual

True/False/Maybe: 20 points (2 point each)
(The answer to the following questions are either true, false, or maybe)

(1) F Noble gases (i.e. the right-most column of the periodic table) are considered electronegative.

(2) F A hydrogren bond is a secondary bond that occurs when two hydrogen atoms come together.

(3) F A material with a face-centered cubic crystal structure has 6 full atoms associated per unit cell, one for each face of the cube.

(4) F A material with large grains is better at blocking dislocation ($\perp$) motion compared to the same material with smaller grains.

(5) F Atomic vibrations are not considered defects in a crystalline structure.

(6) F The yield strength of a material, σ_y, is highly dependent on the cross-sectional area of the material.

(7) T In cubic systems, the planes (213), (321), and (132) are equivalent and part of the {123} family.

(8) T Crystalline regions in semi-crystalline polymers restrict chain motion compared to amorphous regions.

(9) T Anisotropy exists when material properties, such as modulus (E), are dependent on the direction of an applied force.

(10) M Defects in the crystalline structure of a material will lower the material's properties.

Multiple Choice: 10 points (2 points each)
(Circle an answer that completes the following statements)

(1) The electron configuration of Sodium (Na), which has an atomic number of Z=11, can be written as:

a). $1s^2 2s^2 2p^6 3s^1$ b). $1s^2 2s^2 2p^6 3s^2 3p^6$ c). $1s^2 2s^2 3s^2 2p^5$

(2) Secondary bonds are _____ weaker than primary bonds.

a). 1 – 10x b). 10 – 100x c). 100 – 1000x

(3) Substitutional impurities tend to exist when the radius of the impurity atom is _____ of the radius of the solvent material atoms.

a). < 5% b). < 10% c). < 15%

(4) A piece of Iron (Fe) consisting of both FCC and BCC crystals would be considered a _____ material.

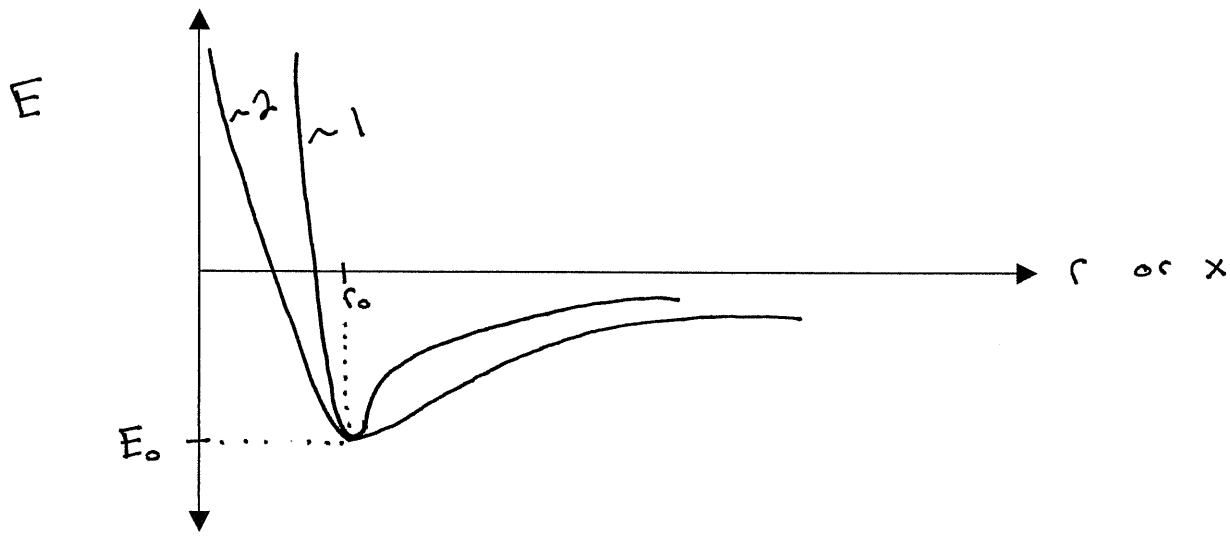
a). polycrystalline b). multi-phase c). composite

(5) Hexagonal crystal structures use ____ integers to define a direction or plane.

a). 3 b). 4 c). 6

Conceptual: 40 points (Questions 1-5: 10 points each. Question 6: 5 points)

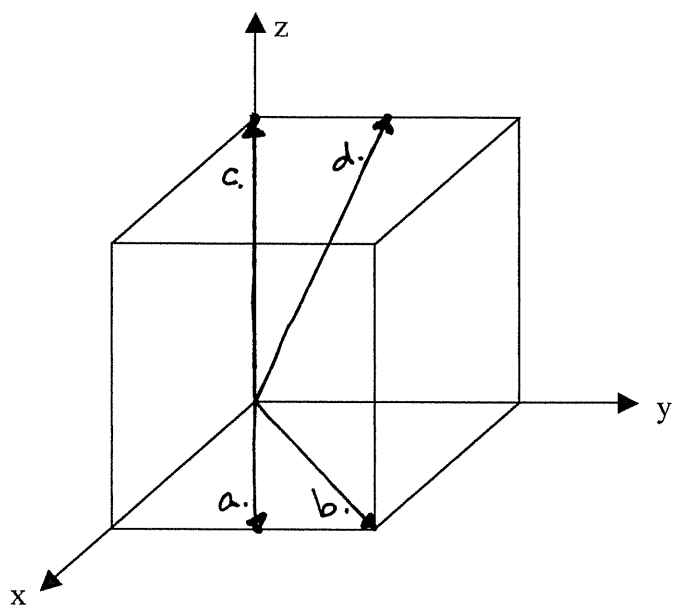
(1) Sketch the bond energy curves for 2 different materials. Material 1 has a high modulus and low coefficient of thermal expansion, while Material 2 has a low modulus and high coefficient of thermal expansion; however, both materials have equal bond energies and bond lengths. (Note: label each axis and curve appropriately).



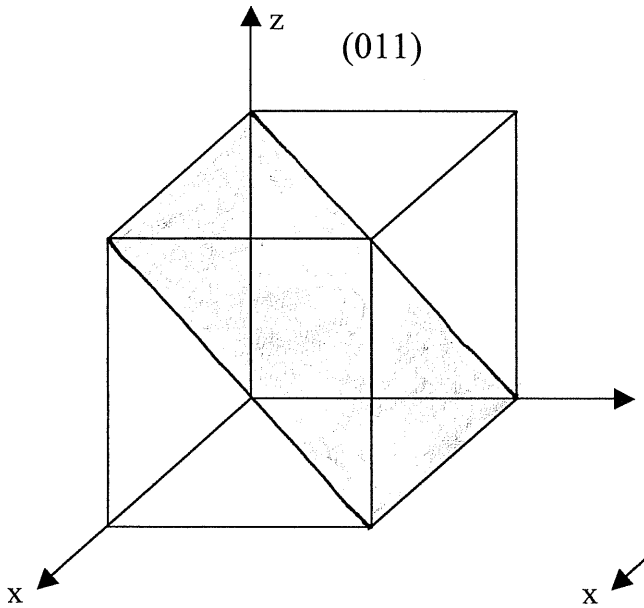
(2) Sketch the following directions in the unit cell (*label each direction*):

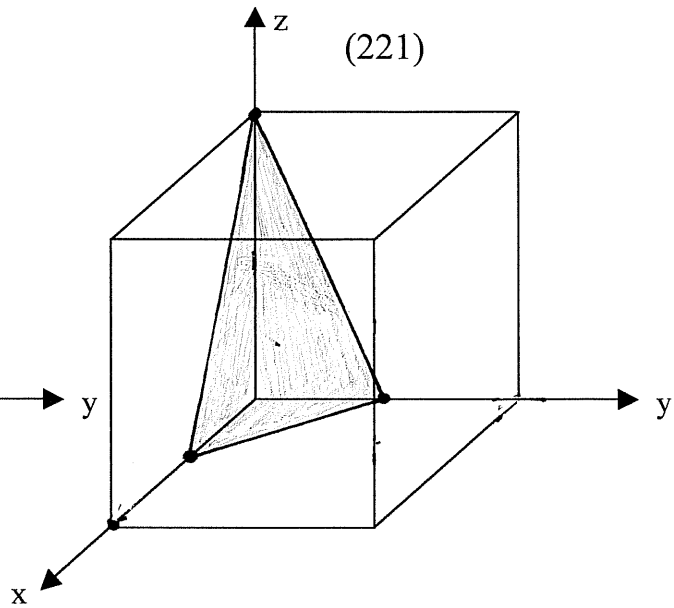
(2.5 pts each)

a. [2 1 0]
b. [1 1 0]
c. [0 0 1]
d. [0 1 2]

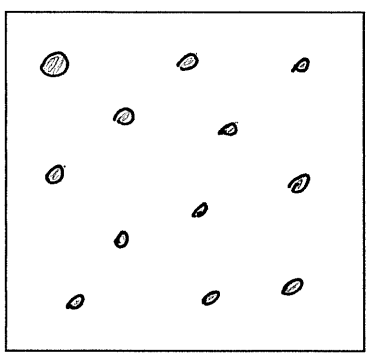


(3) Draw and shade the following planes in the unit cells: (5 pts each)

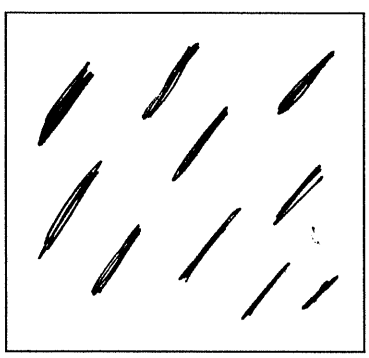




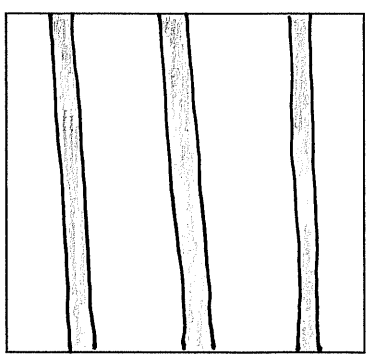
(4) In the boxes below, draw and label the 3 different types of composites. (3 pts each)



Particulate



Discontinuous



Continuous

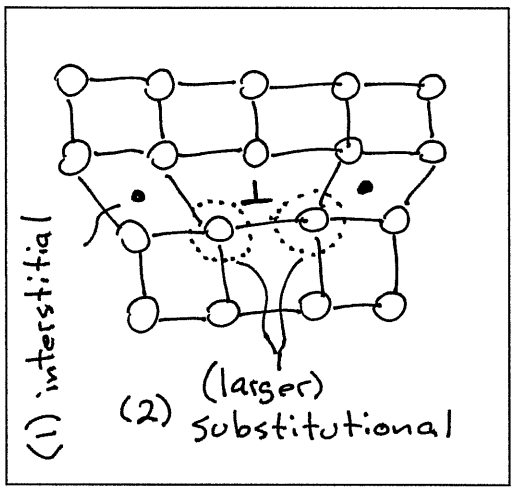
Give an example of a composite and identify which type it belongs to. (Note: Only give 1 example) (1pt)

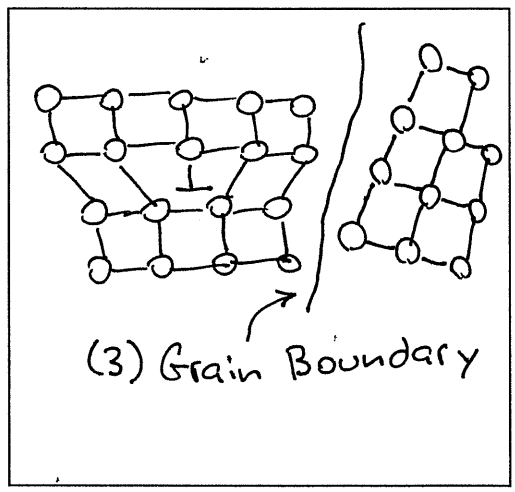
↑ Bone Cement

↑ Fiberglass

↑ Rebar Concrete

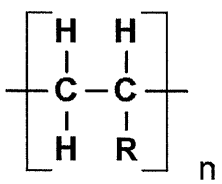
(5) In the boxes below, draw 2 mechanisms that will impede or limit dislocation (⊥) motion. Start by drawing a dislocation (⊥) and then add "something" to limit motion. (5 pts each)





~need 2 of 3.

(6) A linear polymer chain has the following mer unit structure, where **R** represents a side group. How can the size and arrangement of the side groups affect the amount of crystallinity in a polymer? (5 pts)

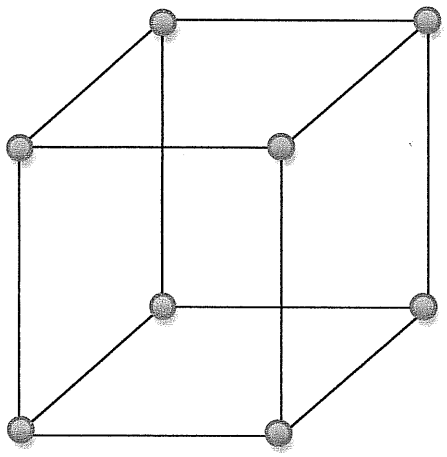


Bulkier / Larger R ⇒ reduce crystallinity

Even / Uniform Arrangement ↳ increase crystallinity

Part II: Quantitative

(1) Calculate the Atomic Packing Factor (APF) of a Simple Cubic Unit Cell. Show <u>all</u> assumptions, starting equations, relationships, and work! (15 pts)

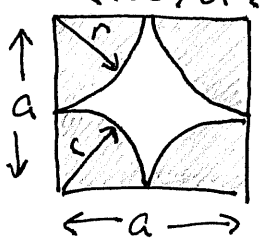


a

$V_{sphere} = 4/3 \cdot \pi \cdot r^3$

Find a-r relationship.

(100) or {100}



$\Rightarrow a = 2r$ (3pts)

Atoms per Cell

$\sim \frac{1}{8}$ atom per edge

↳ 8 edges $\times \frac{1 \text{ atom}}{8 \text{ edge}}$

↳ 1 atom

(2pts)

Calculate APF = $\frac{\text{Volume Spheres}}{\text{Volume Cell}}$ (5pts)

$$= \frac{(1\text{atom})(\frac{4}{3}\pi r^3)}{(a^3)}$$

$$= \frac{4}{3}\pi \cdot \frac{r^3}{(2r)^3}$$

$$= \frac{4}{3}\pi \cdot \frac{r^3}{8r^3}$$

$$= \boxed{\frac{\pi}{6}} \text{ or } \boxed{0.52} \leftarrow \text{APF}$$

(5pts.)

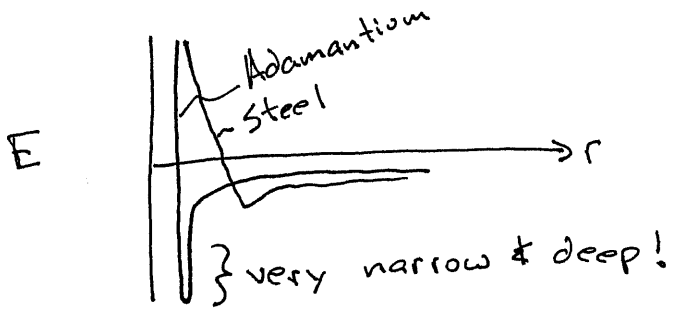
Extra Credit (*make sure you are finished the exam before attempting these!)*

(1) Regarding Conceptual Question 4, give an example for the remaining two types of composites. (½ point each)

(see question 4)

(2) Wolverine is an American comic book superhero whose skeleton has been reinforced and thoroughly coated with an imaginary metal called Adamantium. Adamantium is virtually indestructible as it has never been bent, melted, or plastically deformed.

Draw a bond-energy diagram of Adamantium compared to steel similar to Conceptual Question 1. (1 pt)



What fundamental concept gives Adamantium its extremely high strength? (1 pt)

limited dislocation motion

What type of composite is Wolverine's skeleton? (1 pt)

continuous