Name: ____**Solutions**_____ GTID: _____

MSE 2001 A: Principles and Applications of Engineering Materials

Midterm exam 1, June 3, 2013, 10am – 11am

Please read this cover sheet carefully before continuing with the exam.

Please remove everything from your desk except this test itself, writing instruments, and a calculator.

All pages are numbered at the bottom center of the page. Make sure that you have all 7 pages including this cover page (p.1). Work all problems in the spaces below the problem statement. You can use the back side of the pages for scratch, but I will not grade answers written on the back side. Do not remove the staple or tear out any pages.

I will not grade your exam if you fail to sign on the line below.

I acknowledge the above terms for taking this exam. I commit to uphold the ideals of honor and integrity by refusing to betray the trust bestowed upon me as a member of the Georgia Tech community. I pledge my honor that I have not violated the Honor Code during this examination.

Student's signature: _____

You may find the following formulas useful for this test:

$d(h\ k\ l) = \frac{a_0}{\sqrt{h^2+k^2+l^2}}$ $n\lambda=2d\sin(\theta)$

$density = \frac{M_{uc}}{V_{uc}}$ $M_{uc} = \frac{number\ of\ atoms}{unit\ cell} \times \frac{mass}{atom}$

$reaction\ rate = Ce^{-\frac{Q}{RT}}$ R = 8.314 J/mol-K

1. Match the correct pairs (10 points)

A. Amorphous	**_I_** bonding which involves electron transfer
B. Thermoset Polymer	**_E_** bonding which involves electron sharing
C. Liquid Crystal	**_J_** number of nearest neighbors
D. Diffraction	**_A_** materials without long range order
E. Covalent Bond	**_G_** the strongest type of secondary bond
F. Lattice Parameter	**_H_** linear polymers that form melts upon heating
G. Hydrogen Bond	**_B_** polymers with 3D network of bonds, no melt formed
H. Thermoplastic Polymer	**_F_** lengths of the unit cell edges
I. Ionic Bond	**_C_** fluids with some degree of long range order
J. Coordination Number	**_D_** constructive interference in an x-ray experiment

2. Fill in the Blank (10 points)

Word Bank

Metals	Thermodynamics	Octahedral	Composites	Electronegativity
Basis	Tetrahedral	Polycrystalline	Ceramics	Isotropic
Polymorphic	Lattice	Kinetics	Polymers	Anisotropic

1. A crystal structure is defined as the _____Lattice_____ + _____Basis_____.

2. _____Composites___ are 2 or more materials which are combined to achieve a unique combination of properties.

3. ___Thermodynamics_____ determines which process may occur while _____Kinetics_____ determines the rate of the process.

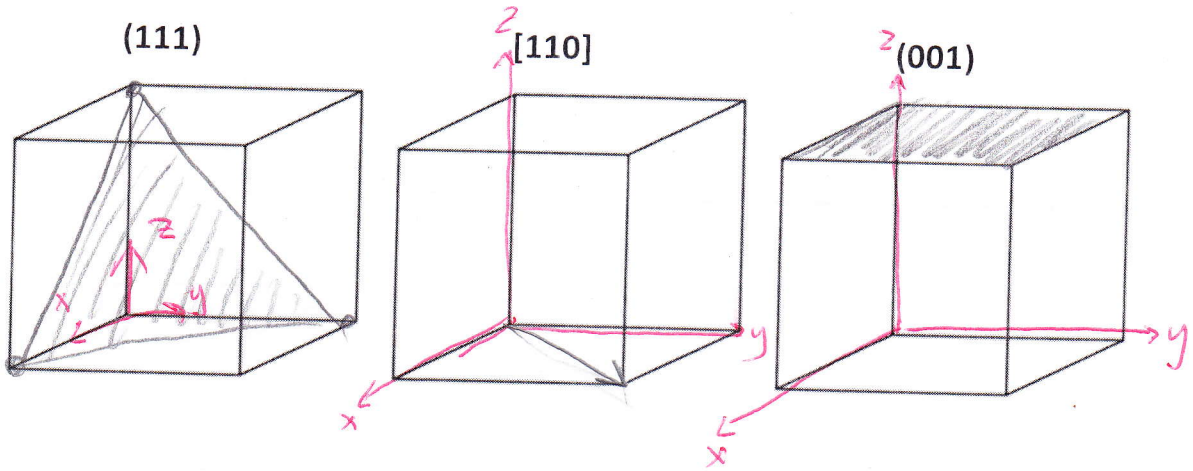
4. Materials properties which depend on the direction are ____Anisotropic____.

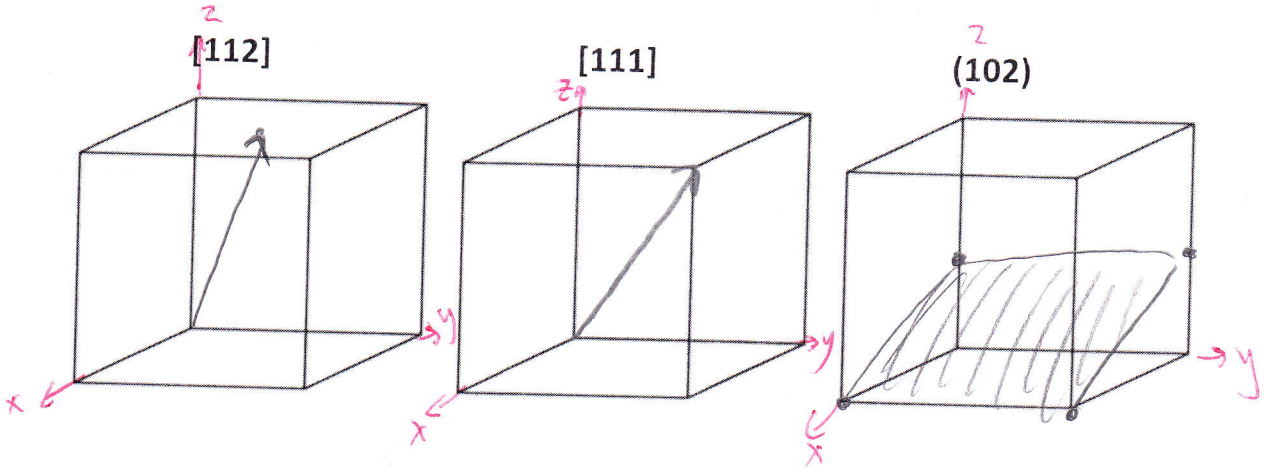
5. _____Octahedral___ sites have a coordination number of 6 while ___Tetrahedral_____ sites have a coordination number of 4.

6. Compounds which change from one unit cell to another at specific temperatures are called polymorphic.

7. The relative tendency of an element to attract electrons is called electronegativity

3. Draw the Direction or Plane (18 points)
Note: Define your coordinate system on each cube.

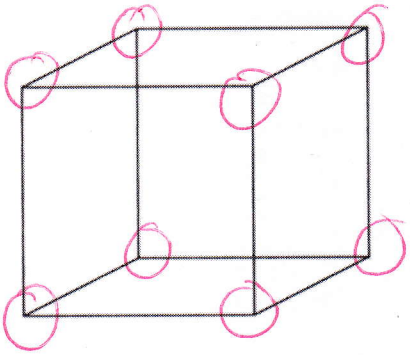




4. Cubic Unit Cells (12 points)

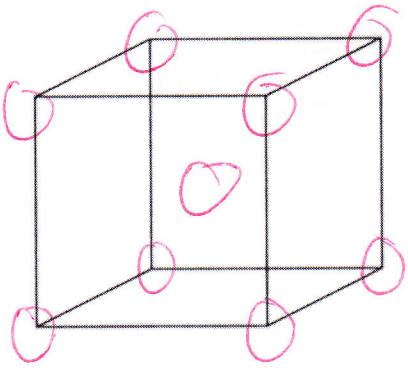
Draw the unit cell for simple cubic, body centered cubic, and face centered cubic structures. How many atoms are contained in each unit cell?

SC



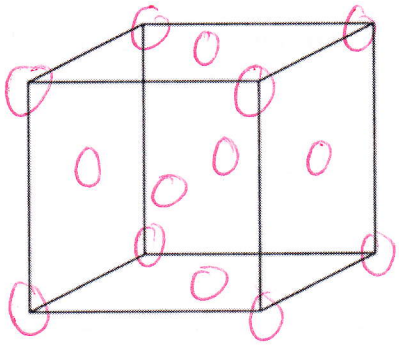
atoms = $\frac{1}{8}(8) = 1$

BCC



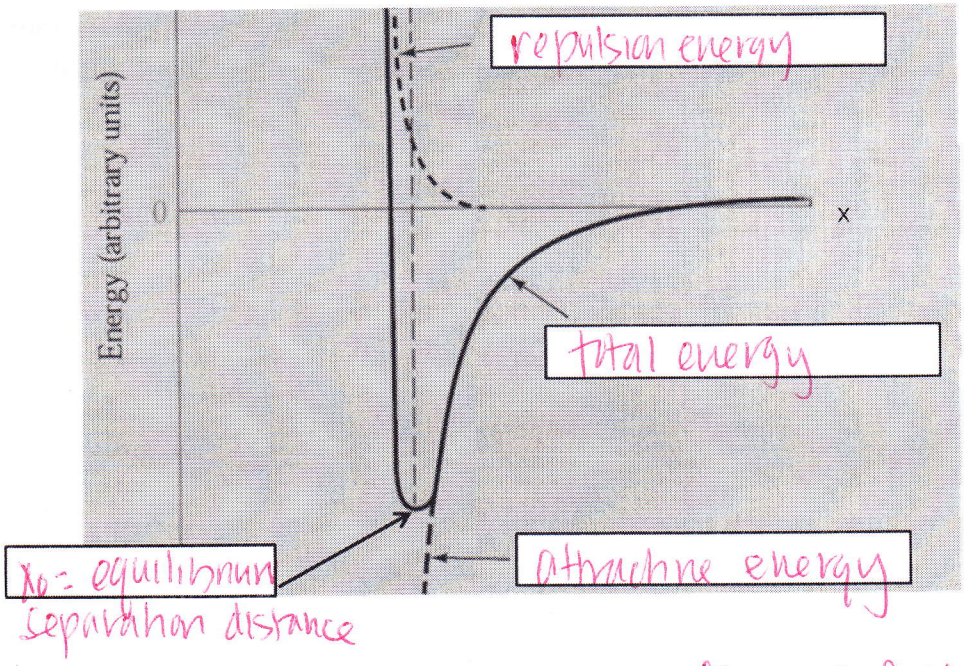
atoms = $\frac{1}{8}(8) + 1(\text{body}) = 2$

FCC



atoms = $\frac{1}{8}(8) + \frac{1}{2}(6) = 4$ (faces)

5. Bond Energy Curve (10 points)
Fill in the boxes with the components of the bond energy curve



Which materials property can be derived from this curve? coefficient of thermal expansion

6. Electronic Configuration (10 points)
Determine the electronic configuration for the following atoms:

Si $1s^2 2s^2 2p^6 3s^2 3p^2$

K $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

Cl $1s^2 2s^2 2p^6 3s^2 3p^5$

Kr $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$

Be $1s^2 2s^2$

7. Calculate the theoretical density of BCC Fe (~~10~~ points)

Note that 1 mol = 6.02×10^{23} atoms.
The atomic weight = 55.85g/mol
r = 1.24×10^{-8} cm

$$M_{uc} = \frac{\#\text{ of atoms}}{\text{unit cell}} \times \frac{\text{mass}}{\text{atom}} = \frac{2 \text{ atoms}}{\text{unit cell}} \cdot \left[55.85 \text{ g/mol Fe} \cdot \left(\frac{1 \text{ mol Fe}}{6.02 \times 10^{23} \text{ atoms}}\right)\right]$$

$$= 1.85 \times 10^{-22} \text{ g/unit cell}$$

$$V_{uc} = a_0^3 = \left(\frac{4r}{\sqrt{3}}\right)^3 = \left(\frac{4 \cdot 1.24 \times 10^{-8} \text{ cm}}{\sqrt{3}}\right)^3 = 2.35 \times 10^{-23} \frac{\text{cm}^3}{\text{unit cell}}$$

$$\text{density} = \frac{M}{V} = \frac{1.85 \times 10^{-22} \text{ g/unit cell}}{2.35 \times 10^{-23} \text{ cm}^3/\text{unit cell}} = 7.87 \text{ g/cm}^3$$

8. X-Ray Diffraction (~~20~~ points)

Copper has an FCC crystal structure with a lattice parameter of 3.61 A. Calculate the interplanar spacing for the (111) plane.

$$d = \frac{3.61}{\sqrt{1^2+1^2+1^2}} = \frac{3.61}{\sqrt{3}} = 2.08\ A$$

Assuming n=1 and λ = 1.54 A, calculate the value of 2θ corresponding to the (111) plane for copper diffraction.

$$n\lambda = 2d\sin\theta$$

$$\sin\theta = \frac{n\lambda}{2d}$$

$$\theta = \sin^{-1}\left(\frac{1 \cdot 1.54}{2 \cdot 2.08}\right) = 21.73^\circ$$

$$2\theta = 43.46^\circ$$

What is the selection rule for a <u>body cenetered cubic</u> structure for determining whether a crystallographic plane will be present or missing?

$(h+k+\ell)$ = even to be present