PRINT NAME: George P. Burdell

MSE 2001
Fall 2011
Midterm Exam #1
September 14, 2011

100!

I have neither received nor given help in taking this exam.

Signature: George P. Burdell

Fill in the blanks with the appropriate word or words (please print). Questions 1 - 8 count 4 points each.

1. The ground electronic state of a neutral Pb atom (Z = 82) is
   $1s^2\ 2s^2$ $2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^2$
   (List in order of increasing energy.)

2. < 1 1 0 > are close packed type directions in FCC and lies on a { 1 1 1 } type planes, which are close packed.

3. Mixed bonds may involve a combination of metallic and covalent bonds or a mix of covalent and ionic bonds.

4. The primary bonds in Si are covalent bonds, while the primary bonds in Fe are metallic bonds.

5. The HCP crystal structure has a hexagonal Bravais lattice and a basis consisting of two identical atoms.

6. Graphite consists of sheets of carbon atoms bonded to each other by sp^2 hybridized covalent bonds. Adjacent sheets are bonded together by relatively weak secondary bonds.

7. Solids that are non-crystalline (thus, not polycrystalline) are amorphous in structure and are known as glasses.

8. In general, increasing the strength of a material decreases the material's ductility, while increasing a material's ductility decreases its strength.

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Fill in the blanks with the appropriate letter **and** circle the printed answer. Questions 9 - 15 count 4 points each.

c 9. An atom in the simple cubic structure (SC lattice, 1 atom basis) has a coordination number (CN) of:
a) 2, b) 4, (c) 6, d) 8, e) 12

b 10. The equilibrium state of a system (at constant temperature and pressure) is that state which minimizes the system's:
a) Entropy, (b) Gibbs free energy, c) Enthalpy, d) Helmholtz free energy

b 11. An octahedral interstitial site has a coordination number (CN) of:
a) 4, (b) 6, c) 8, d) 12

f 12. Which is a close packed direction in the FCC structure?
a) [100], b) (110), c) {100}, d) (111), e) [111], (f) [110], g) (110)

b 13. Along with polymorphic, means capable of more than one crystal structure:
a) Isotactic, (b) Allotropic, c) Atactic, d) Syndiotactic

d 14. Each cubic unit cell of the zinc blende structure is associated with how many atoms?
a) 1, b) 2, c) 4, (d) 8, e) 12

c 15. The Miller indices of the close packed planes in FCC are:
a) {100}, b [110], (c) {111}, d) [111], e) [100], f) <110>

Questions 16 - 19 count 10 points each. **SHOW YOUR WORK** and **CIRCLE YOUR ANSWERS**.

16. Compute the packing factor (PF) for the body centered cubic structure (BCC lattice, one atom basis).

$$PF = \frac{2 \cdot \frac{4}{3}\pi R^3}{a_0^3}, \quad 4R = \sqrt{3}\,a_0 \Rightarrow R^3 = \left(\frac{\sqrt{3}}{4}\right)^3 a_0^3$$

$$PF = 2 \cdot \frac{4}{3}\pi \left(\frac{\sqrt{3}}{4}\right)^3 = 0.68$$

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17. An x-ray diffraction pattern of copper (FCC) using Cu Kα radiation (λ = 0.1542 nm) produces a diffraction maximum (diffraction spot) at a scattering angle of 2θ = 50.5° corresponding to diffraction from (2 0 0) planes. Calculate the lattice parameter in nm. (Hint: assume n = 1 and note the relationship between the distance between (hkl) planes, d_{hkl}, and a_o (lattice parameter) for cubic materials given in the attached *Formula and Data* sheet.)

$\lambda = 2 d_{200} \sin\theta, \quad \theta = 25.25^\circ$

$d_{200} = \dfrac{\lambda}{2\sin(25.25^\circ)} = \dfrac{0.1542}{2\sin(25.25^\circ)}$

$d_{200} = 0.1807 \text{ nm} = \dfrac{a_o}{(h^2+k^2+l^2)^{1/2}}$

$\Rightarrow a_o = (0.1807)(2^2)^{1/2} = 0.361 \text{ nm}$

18. Identify the indicated features (planes, directions, etc.) of the cubic unit cell in the blanks (use correct notation):

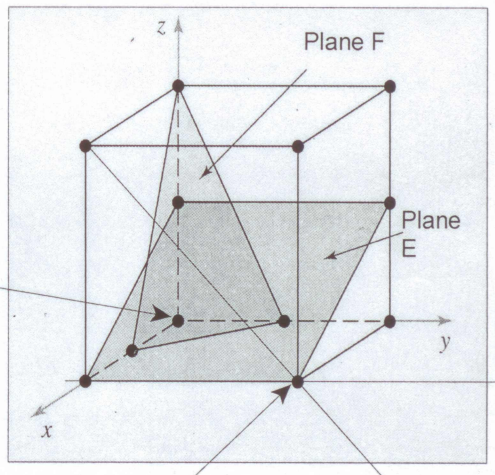
a) Plane E (102)

b) Plane F (221)

c) Point A 1, 1, 0

d) Direction B [0 1 $\bar{1}$]

e) Family of all directions equivalent to Direction C <100>



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19. Compute the minimum radius ratio, r/R, for which an atom of radius r will simultaneously touch three larger atoms of radius R (R > r). (Hint: The centers of all four atoms lie in a plane.)

$$\cos 30^\circ = \frac{R}{R+r} = \frac{\sqrt{3}}{2}$$

$$\frac{\sqrt{3}}{2} r = R\left(1 - \frac{\sqrt{3}}{2}\right) \Rightarrow \frac{r}{R} = \frac{2\left(1 - \frac{\sqrt{3}}{2}\right)}{\sqrt{3}} = 0.154$$