**HW#1 of IET 307: Materials Science**

Due by September 11, 2010, before 11.55 PM on Blackboard

5 points for each problem, 75 points in total

1. What is metallic bonding? How is it formed? What are its characteristics?

Metallic bonding is found in metals and their alloys. It involves the nondirectional sharing of nonlocalized valence electrons that are mutually shared by all the atoms in the metallic solid. Metals are good conductors of both electricity and heat. Also at room temperature, most metals and their alloys fail in a ductile manner. A fracture will occur after the materials have experienced a significant degree of permanent deformation.

2. What is ionic bonding? How is it formed? What are its characteristics?

Ionic bonding is found in compounds that are composed of both metallic and nonmetallic elements. Atoms of metallic elements easily give up their valence electrons to nonmetallic atoms. In the process all the atoms acquire stable or inert gas configurations and an electrical charge. Ionic bonding is nondirectional; the magnitude of the bond is equal in all directions around an ion. They are characteristically hard and brittle, and electrically and thermally insulative.

3. What is covalent bonding? How is it formed? What are its characteristics?

Covalent bonding is when stable electron configurations are assumed by the sharing of electrons between adjacent atoms. Two atoms that are covalently bonded will each contribute at least one electron to the bond. The shared electrons will be considered to belong to both atoms. Covalent bonds are directional, which means that it is between specific atoms and may exist only in the direction between one atom and another that participates in electron sharing. They may be very strong or very weak.

4. What is Van der Waals bonding? How is it formed? What are its characteristics?

Van der Waals bonds are a secondary interatomic bonding between adjacent molecular dipoles, which may be permanent or induced. The bonding results from the coulombic attraction between the positive end of the dipole and the negative region of an adjacent one. Melting and boiling temperatures are extremely low in materials when induced dipole bonding is occurring. Melting and boiling points are extremely high in things like water because of their low molecular weights.

5. What are unit cell, lattice constant and the number of atoms per unit cell? What is the number of atoms of BCC, FCC and HCP?

Unit cells are the basic structural units of a crystal structure. It is generally defined in terms of atom (or ion) positions within a parallelepiped volume. The lattice constant is the regular geometrical arrangement of points in a crystal space. The number of atoms per cell is determined by the coordination number. In the FCC and HCP there are 12 atoms, and in BCC there are 8 atoms.

6. What is the atomic packing factor? What are the atomic packing factors of BCC, FCC and HCP? Does the volume increase or decrease when FCC iron changes to BCC iron? Why?

Atomic packing factor is the fraction of solid sphere volume in a unit cell. The atomic packing factor of FCC is 0.74, BCC is 0.68, and HCP is 0.74. The volume is less dense with the BCC iron because the atomic packing factor is lower.

7. What are the families of crystal directions and planes?

The families of crystal directions and planes are denoted through the use of square brackets. They are equivalent directions that are grouped together.

8. What are the closest packed crystalline direction and plane of BCC and FCC?

FCC=ABCABCA (Every third layer is the same.)

HCP=ABABABA (Every other layer is the same.)

9. What are the similarity and difference between FCC and HCP crystal structures?

FCC and HCP crystal structures have the same coordination number (12) and the same atomic packing factor (0.74). They differ in their specific shapes. The FCC is a cube and the HCP is hexagonal in shape. They also differ in their stacking sequences.

10. What is the Miller index of the crystal plane in the following figure?

11. If the atomic radius of aluminum is 0.143 nm, calculate the volume of its unit cell in cubic meters.

12. Calculate the radius of an Iridium atom, given that Iridium has a FCC crystal structure, a density of 22.4 g/cm3, and an atomic weight of 192.2 g/mol.

13. Rhenium has an HCP crystal structure, an atomic radius of 0.137 nm, and a c/a ratio of 1.615. Compute the volume of the unit cell for Re.

14. Explain why the properties of polycrystalline materials are most often isotropic?

For many polycrystalline materials, the crystallographic orientations of the individual grains are totally random. Under these circumstances, even though each grain may be anisotropic, a specimen composed of the grain aggregate behaves isotropically.

15. Why are covalently bonded materials generally less dense than ionically or metallically bonded ones?

Covalently bonded materials are less dense than ionically bonded ones because of the direction that the atoms bond in. Ionically bonded materials are nondirectional, which means that the bonds can form in more places. This means that the ionically bonded materials are more closely packed and therefore are denser than the covalently bonded materials.