NAME ______________________

1) [10 pts] Sketch (2-dimensionally) and describe what is meant by “substitutional solid solution.” What are the two primary characteristics that would determine if one element is to be highly soluble in another.

2) [15 pts] Draw the following directions and planes for a cubic system unit cell. Be sure to show the x, y, z axes. It must be clear where your lines and directions are. **Show your work!**
   a) [0 1 1] direction  
   b) [2 2 1] direction  
   c) (0 2 1) plane

3) [15 pts] What are the indices for the following planes and directions? **Show your work!**
   (a)  
   (b)  
   (c)
For problems 4, 5, and 6 you may provide a short explanation or sketch if you think it will help.

4) [20 pts] Fill in the blanks with the correct word(s).

A. A type of grain boundary that has “mirror image” symmetry about the boundary is referred to as: _______________________.

B. Another word for “grain” is ______________________.

C. Body Centered Cubic (BCC), Face Centered Cubic (FCC), and Hexagonal Close Packed (HCP) are three types of ______________________ (hint: NOT “unit cells”).

D. The term used to describe the number of “nearest neighboring” atoms is __________ ______________________.

E. A primary inter atomic bond involving the non-directional sharing of non-localized valence electrons (“sea of electrons”) that are mutually shared by all the atoms in the solid is referred to as: ______________________.

5) [20 pts] Multiple Choice. Pick the single answer that best matches the description.

A. If a material’s properties are independent of the test direction, the material is:
   a) an alloy
   b) crystalline
   c) anisotropic
   d) isotropic

B. The atomic packing factor (APF) for a Face Centered Cubic (FCC) crystal structure is 0.74. What is it for a hexagonal close-packed (HCP)?
   a) 0.63
   b) 0.74
   c) 0.96
   d) 1.00

C. The crystal structure shown here is
   a) Face-Centered Cubic (FCC)
   b) Body-Centered Cubic (BCC)
   c) Hexagonal Close-Packed (HCP)
   d) None of the above

D. The basic, simplest, unit of a crystal structure is referred to as a:
   a) grain
   b) unit cell
   c) lattice
   d) cubic structure

E. The highest linear atomic density (a.k.a. linear density) possible is:
   a) 0.63 (63%)
   b) 0.74 (74%)
   c) 0.96 (96%)
   d) 1.00 (100%)
F. Of the four following bonds, which is the weakest?
   a. van der Waals
   b. covalent
   c. ionic
   d. metallic

6) [10pts] True or False:
   A. If the atomic radius of a solute atom is much larger than the radii of the solvent it will not be likely to have complete solubility.  T  F
   B. van der Waal bonds are a secondary inter atomic bond between adjacent molecular dipoles.  T  F
   C. Crystal structure and crystal system are synonymous (mean the same thing).  T  F
   D. A dislocation is a type of interfacial defect in a crystal.  T  F
   E. For something to be considered an alloy it must contain at least two different elements and at least one of these must be a metallic element.  T  F

7) [10 pts] Determine the ASTM grain size number (n) of the image shown below (100X), where
   \[ n = 3.32 \log(N) + 1 \]
   
   ![Image of grain structure](image.png)