MATRL 100A: Structure and Properties I, Problem Set 3

This problem set is due in lecture on **Wednesday, Oct 24**th as hard copy. Write neatly, show your work, clearly, and include units in all answers. While you are free to discuss this problem set with your classmates, the product that you turn in must be your own work. Do not copy or paraphrase each other's work.

Chapter 3

1. Determine the linear density (atoms *per* unit length) for BCC [100], [110], and [111] directions in terms of atomic radius R. [3]
2. For the BCC (100) and (110) planes, [6]
   (a) Make a sketch of the plane.
   (b) Determine the planar density (atoms *per* unit area) in terms of atomic radius R.
   (c) Which of the $\{100\}$, $\{110\}$, and $\{111\}$ direction families fall within the plane?
3. Aluminum is FCC with an atomic radius of R = 0.184 nm.
   (a) Compute the interplanar spacing d_{111} for the (111) set of planes. [1]
   (b) When monochromatic x-radiation with a wavelength of 0.1542 nm is used, what is the diffraction angle 2θ for the first-order reflection of the (111) plane? [2]
4. The metal iridium has an FCC crystal structure. An x-ray diffraction peak for the (220) set of planes occurs at $2\theta = 69.2°$ (first-order reflection) when Cu K-α radiation is used (wavelength of λ = 0.1542 nm), compute
   (a) The interplanar spacing, d, of the (220) set of planes (Bragg Law) [2]
   (b) The lattice constant (Equation 3.21 in 10th edition) [2]
   (c) The radius of an iridium atom [2]
   (d) The mass of an iridium atom given that the density of iridium is 22.56 g/cm^3 [2]

Chapter 4

1. Calculate the activation energy for vacancy formation in aluminum, given that the equilibrium number of vacancies at 500°C (773 K) is $7.57 \times 10^{23}\ m^{-3}$.The atomic weight and density (at 500 °C) for aluminum are, respectively, 26.98 g/mol and 2.62 g/cm^3. [3]
2. What is the composition, in atom percent, of an alloy that consists of 30 wt% Zn and 70 wt% Cu? *Hint:* The molar masses of Zn and Cu are 65.41 g mol^{-1} and 63.55 g mol^{-1}, respectively. [3]
3. Atomic radius, crystal structure, electronegativity, and the most common valence are tabulated below (1) for several elements; for those that are nonmetals, only atomic radii are indicated.

   Which of these elements would you expect to form the following with copper. Briefly explain your reasoning [6]
   (a) A substitutional solid solution having complete solubility
   (b) A substitutional solid solution of incomplete solubility
   (c) An interstitial solid solution

Element	*Atomic Radius (nm)*	*Crystal Structure*	*Electro-negativity*	*Valence*
Cu	0.1278	FCC	1.9	+2
C	0.071			
H	0.046			
O	0.060			
Ag	0.1445	FCC	1.9	+1
Al	0.1431	FCC	1.5	+3
Co	0.1253	HCP	1.8	+2
Cr	0.1249	BCC	1.6	+3
Fe	0.1241	BCC	1.8	+2
Ni	0.1246	FCC	1.8	+2
Pd	0.1376	FCC	2.2	+2
Pt	0.1387	FCC	2.2	+2
Zn	0.1332	HCP	1.6	+2

Figure 1: Problem 4.3 Data