Worksheet #3

solid state & electrical properties

1) What would the packing efficiency of a hypothetical cubic unit cell be if it contained 5 net atoms per unit cell and its edge length was equal to \((\frac{5\sqrt{2}}{2}) r\)?

2) Draw a z-diagram for this unit cell.

3) A high strength alloy can be made by adding beryllium and cobalt to copper. If a unit cell of this alloy has cobalt atoms on all corners, copper atoms on all faces, and two central beryllium atoms, what is the correct formula for this alloy?

4) Silver crystallizes in a unit cell with a 74% packing efficiency.
   a) What type of cubic unit cell does silver adopt?
   b) How many atoms are in a silver unit cell?

5) Given the following z-diagram, determine the number of X and Y atoms in each z-layer, and from this determine the empirical formula for the following compound.
   Assume the white spheres are X and the black spheres are Y.

   \(z=0.1\quad z=0.33\quad z=0.67\)
6) A compound has the following band diagram, with the shading representing occupancy by electrons. This solid has a completely filled lower energy band and a partially filled higher energy band. The energy gap between the two lower bands is equivalent to 1.72 eV.

\[ \text{\textendash} \]

a) Predict the electrical properties of this solid on the basis of this band diagram. That is, would you expect it to be a conductor, a semiconductor or an insulator?

b) What would happen to the electrical properties of this compound if all of the electrons were removed only from the upper band? Why?

7) What wavelength of light, in nm, would promote electrons across the band gap for ZnSe, which has a band gap of 2.70 eV?

b) Is this in the visible region? If not, in what region of the EMR spectrum is it?

8) Predict the effect on conductivity of each of the following.

a) Increasing temperature of a semiconductor will _________________ its conductivity.

b) Increasing temperature of a metal will _________________ its conductivity.

c) Adding P to Si will _________________ its conductivity.

d) Adding P to Cu will _________________ its conductivity.
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9) Define p-type and n-type semiconductors.

b) List which elements would be appropriate to add to Si (or Ge) to make each type of doped semiconductor.

c) Describe how the band structure of Si is affected by addition of the above elements to make p-type and n-type semiconductors. Draw pictures of band structures to illustrate these changes.

10) Gallium nitride (GaN) is a material used in LEDs. Based on the trends you saw in laboratory, how would you expect the wavelength of light emitted by a GaN LED to compare with that emitted by GaP & GaAs LEDs?