MS 131, Problem Set #7

assigned 11/16/05
due 11/23/05

1. Consider the elements C, Si, Ge and Sn

   (a) Write down the electron configuration for each of these elements.

   (b) Why can each crystallize in the diamond structure type (with covalent bonding)?

   (c) Why can Sn also crystallize in a close-packed arrangement (with metallic bonding), but not the others?

2. There are five 2-dimensional lattice types: square, rectangular, hexagonal, diamond (with two lattice points per unit cell) and oblique. For each of these,

   (a) draw an example of the lattice,

   (b) draw the corresponding reciprocal space lattices, explicitly giving the directions and magnitudes of the reciprocal space lattice vectors, and

   (c) draw the first Brillion zone.

3. Consider a structure with a simple three-dimensional cubic lattice, one atom at each lattice point, and valence electrons an s-shell.

   (a) By analogy to the 1 and 2-dimensional problems, write the energy as a function of wave vector, $k = (k_x, k_y, k_z)$, for the LCAO approach. What assumption is made in this approach?

   (b) Draw the first Brillioun zone for this structure. The special points are at $\Gamma = (0,0,0)$, $X = \pi/a(1,0,0)$ and $L = \pi/a(1,1,1)$.

   (c) Draw the band structure of this solid (taking into consideration only the s-orbitals), $E = E(k)$ for a plot extending from Γ to X to L to Γ. Derive explicitly the functional form of $E(k)$ along the lines in k-space connecting these points.