Assignment #5 Solutions

Materials 100A: Assignment 5
Assignment 5
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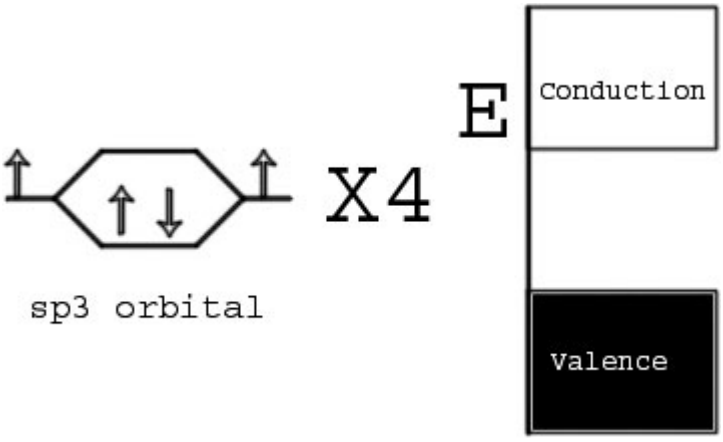
Submit to Paul by Thursday 11/18/2004.

1. Why is Si in the diamond structure an insulator ? Explain using molecular orbital and energy band diagrams. When Si melts, the density of the liquid is slightly larger than the density of the crystal. In other words, the density increases a little, and the volume decreases (like when ice melts). Liquid Si is a metal. Can you explain why ?

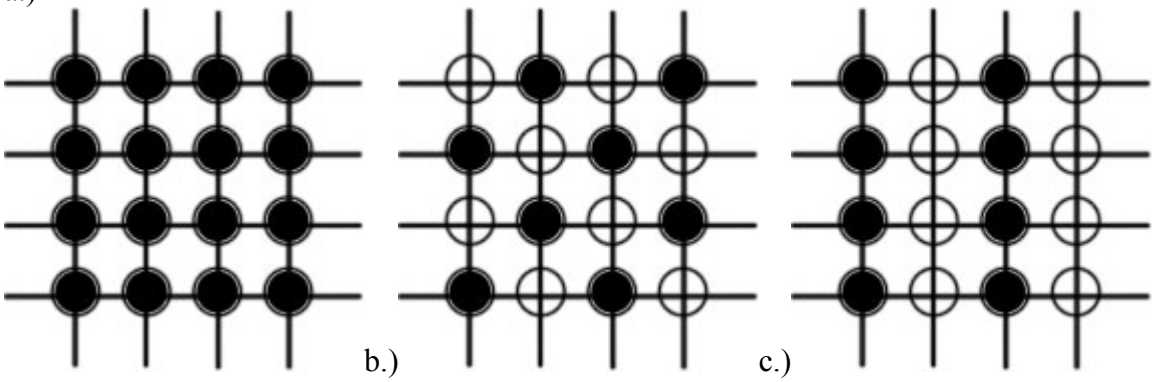
Si in the diamond structure is an insulator in the diamond structure because the valence band is full as each Si has 4 valence electrons and 4 nearest neighbors so the shared sp^3 hybrid orbitals each have 2 electrons.



Liquid Si is a metal because electrons have been thermally excited out of the valence band, and with the decrease in volume upon melting it can be assumed that the coordination number goes up so that the 4 valence electrons of Si are shared between more atoms leaving some bonding orbitals half full.

2. You have been taught how to form bonding and antibonding combinations for a chain of s orbitals. Can you do the same for a square lattice of s orbitals ? The question is, how would you shade the orbitals (circles) to form (a) the most bonding case, (b) the most antibonding case, and (c) the intermediate case(s) which are non-bonding (bonds = antibonds).

a.)



b.)

c.)

3. Would the square lattice of s orbitals be a metal if: (a) there is 1 electron per orbital ? (b) there are 2 electrons per orbital ?

a.) It would be a metal if there were 1 electron per orbital
b.) It would not be a metal if there were 2 electrons per orbital

4. Which elements would you chose to n-dope Si, and which would you chose to p-dope Si.

n-dope – group 5 elements
p-dope – group 3 elements

5. A cylindrical piece of copper has a diameter of 1 cm and a length of 5 cm. Its resistivity is ρ. This piece of copper is now extended so that it is 10 cm long. How does the resistance change, assuming that ρ does not. Do you expect ρ to change ? Why ?

The resistance will double, and ρ is not expected to change as it is a material property and not dependant on extensive properties such as mass or dimension.

6. Indicate using an illustration, of how the valence and conduction bands bend at the point of contact of a p and an n type semiconductor.

This is in the hardcopy of notes handed out on 11/9