Physics 8510

Problem Set 4

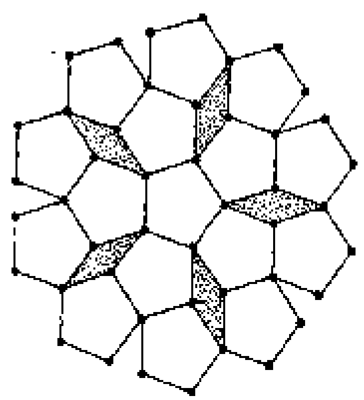
1) Suppose that identical solid spheres are placed in space so that their centers lie on the atomic points of a crystal and the spheres on the neighbouring sites touch each other. Find the packing fraction for diamond structure. ($\sqrt{3}\pi/16$) (We did fcc, bcc and sc in class. Hint: Find the radius of the sphere in terms of a, i.e. the volume, and then find how many spheres per a^3.)

2) In high purity Si crystals, defect densities can be reduced to levels of 10^{13} cm $^{-3}$. On average, what is the spacing between defects in such crystals? In heavily doped Si, the defect density can approach 10^{19} cm $^{-3}$. What is the average spacing between defects for such doped semiconductors?

3) Metallic Na crystallizes in body centered cubic form, the length of the cube being 4.25 x 10^{-8} cm. Find the concentration of conduction electrons assuming one conduction electron per atom. Adopting the free electron Fermi gas model for the conduction electrons, derive an expression for the Fermi energy (at 0 K). (Does this depend on the mass of the crystal?)

4) Show that the c/a ratio for an ideal hexagonal closed- pack (hcp) structure is $(8/3)^{1/2}$ = 1.6333.

5) Find the spacing d between adjacent (100) and (111) planes (i.e. $d_{\{100\}}$and $d_{\{111\}}$).



(b)

Fig. 1.7.(a) Lattice points in a plane normal to the symmetry axis n passing through O. (b) Regular pentagons cannot fill planar space.

Note: The figure shows a quasicrystal tiling in 2-d, after the work of Penrose. The long range orientational order and the long-range nonperiodic order are shown. (First observation of Quasi crystals: D Levine and P Steinhardt , PRL 53, 2477 (1984) and D Schechtman et.al. PRL 53, 1951, 1984.)