Condensed Matter Physics I
Final written test
academic year 2011/2012
January 23, 2012

(*Time: 3 hours*)

NOTE: Give all the steps necessary to understand in detail the solution procedure. Answers with the final result only or with insufficient details will not be considered valid.

Exercise 1: *Free electrons in hcp and triangular lattices*

1. The Zn atom has 2 valence electrons. Zn atoms aggregate giving a metal with hcp structure, ABAB... is the sequence of the close-packed planes. The nearest neighbor interatomic distance is 2.66 Å and the distance between two neighboring planes in the ABAB... sequence is $c/2$ with c=4.95 Å.
   Write the primitive translation vectors and the basis of Zinc.

2. Is it possible to have a hcp insulator? Justify your answer, and, in case of positive answer, explain in details when it would be possible.

3. Consider now only the 2D in-plane structure which forms a triangular lattice. Make a picture of the corresponding reciprocal lattice, together with the first Brillouin zone, and give its area.

4. Make a picture also of the second and third Brillouin zones, indicating them clearly. Give also their areas.

5. Consider again the case of 2 valence electrons per site. Calculate the radius of the Fermi sphere (which is a "circle" in this 2D case).

6. Draw the Fermi sphere in comparison with the first, second and third Brillouin zones. In which Brillouin zone is the Fermi sphere lying? Translating the portions of the Fermi sphere lying in the n-th Brillouin zone through reciprocal lattice vectors, draw the branches of the Fermi sphere corresponding to the n-th band.

Exercise 2:

1.

Exercise 3:

1.

1. Which planes in fcc and bcc structures have the highest density of atoms? Calculate this density for Cu and Fe, knowing that the structure and lattice parameter of the two elemental solids are FCC with a_0=3.61 Å for Cu and BCC with a_0=2.86 Å for Fe respectively.