MINOR I

PYL 102: Principles of Electronic Materials

(30 AUGUST 2016)

$F(\varepsilon) = \frac{1}{e^{\left(\frac{\varepsilon - \varepsilon_F}{k_B T}\right)} + 1}$

Answer all questions | Time One Hour | Maximum Marks 20

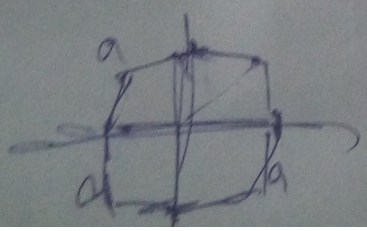
1. State the following statements as True or False with justification (in the absence of justification no marks will be given).
   (a) Metals A and B have cubic structure and they are monovalent. The lattice parameter of A is smaller than that of B. With these informations, it can be concluded that the Fermi energy of A is larger than that of B.
   (b) Bivalent cubic structure solid with no overlap of bands will be an insulater.
   (c) Raciprocal lattice of two dimensional square space lattice (a x a) is square lattice with lattice parameter as π/a.
   (d) Results of Hall measurements for metals fully supports the free electron model.
   (e) As per the quantum mechanical approach of the free electron model, a monovalent solid with body centre cubic structure will be an insulator. [1 x 5]

2. (a) Draw the first three bands in reduced zone scheme (between k=0 to π/a) for electrons in periodic potential and for free electron. [2]
   (b) For a metal at temperature T = 0K, the conduction electrons at the bottom of the band have energy E= 0 and the conduction electrons with the highest energy have an energy $E=E_F$. Assuming that the density of states for electrons is given by $D(E) = 3n\sqrt{E}\ (2E_F^{3/2})$, what is the average energy of the conduction electron (here n is number of electron per unit volume). [3]

3. For a hexagonal space lattice, the primitive translation vectors may be taken as
   $\bar{a}_1 = \frac{\sqrt{3}\,a}{2}\hat{x} + \frac{a}{2}\hat{y}$, $\bar{a}_2 = -\frac{\sqrt{3}\,a}{2}\hat{x} + \frac{a}{2}\hat{y}$, $\bar{a}_3 = c\hat{z}$

   where a is lattice constant, $\hat{x}$, $\hat{y}$, $\hat{z}$ are unit vectors along X, Y, Z directions.
   (a) Obtain primitive translation vectors of reciprocal lattice.
   (b) Name the structure of this raciprocal lattice.
   (c) Draw first Brillouin Zone of the two dimensional hexagonal space lattice. [2+1+2]

4. (a) Sketch Fermi surface in 2-dimension for metals (i) monovalent cubic structure. (ii) bivalent cubic structure.
   (b) Sketch third Brillouin zone of 2-dimensional square lattice (a x a). Obtain the number of available electron states in the third Brillouin zone. [2] [3]



$R = a_1 b_1 + a_2 b_2 + a_3 b_3$

$b_1 = b_2 \times b_3$