

Tutorial Sheet-10 (Even Semester, 2022) [Physics-2 (15B11PH211)][L33-L36]

(Assignment 7: Discuss the various drawbacks of classical free electron theory of metals)

Q1. The electrical resistivity of a certain copper sample with cube edge of 3.61 \AA is $1.77 \times 10^{-8} \Omega\text{-m}$.

Use the free electron theory to estimate (a) relaxation time and (b) average speed of electrons in a field of 100 V/m . [CO3, Ans: $2.37 \times 10^{-8} \text{ sec}$, 0.416 m/s]

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Q2. Determine the value of Fermi energy function for an energy kT above the Fermi level.

[CO2, Ans: 0.269]

Q3. Determine the temperature at which the probability that an energy state with an energy 0.1 eV above the Fermi level will be occupied by an electron is 5% . [CO3, Ans: 394 K]

Q4. Density of Aluminum metal is $2.7 \times 10^3 \text{ kg/m}^3$ and its atomic weight is 27 . The effective mass of electron in aluminum is $0.99 m_e$, calculate its Fermi temperature. [CO3, Ans: $1.368 \times 10^4 \text{ K}$]

Q5. Determine the degree of degeneracy of the energy level $\frac{38h^2}{8mL^2}$ of a particle in a cubical potential box of side L . [CO3, Ans: 9 fold]

Q6. (a) What are the assumptions of quantum free electron theory? Also discuss merits and demerits.

(b) Derive the expression for electrical conductivity on the basis of quantum free electron theory.

(c) Discuss Bloch theorem and Kronig Penny model qualitatively.

[CO1]

Q7. Prove that the Kronig-Penny potential with $P \ll 1$, the energy of the lowest band at $k=0$ is $E = \frac{\hbar^2 P}{ma}$.

Given $\frac{P \sin \alpha a}{\alpha a} + \cos \alpha a = 1$ for $k=0$ and $\alpha^2 = \frac{2mE}{\hbar^2}$.

[CO4]