Engineering Physics
06PHY12
Assignment 3

Answer the following questions

1. Explain the terms: drift velocity, relaxation time, mobility, mean collision time and mean free path for free electron. [5]
2. Bring out the salient features of Drude-Lorentz theory. [5]
3. State Mathiessien's rule and give an account of the nature of total resistivity bath at high and low temperatures. [5]
4. Define drift velocity, mobility and relaxation time for free electron, derive the expression for conductivity in terms of mean collision time. [10]
5. Based on free electron theory, derive an expression for electrical conductivity in metals and discuss the failures of classical free electron theory. [10]
6. Mention the assumptions of quantum free electron theory and based on it derive an expression for density of states for the electrons in a solid. [10]
7. Explain density of states. Derive an expression for number of allowed states for a unit volume of solid. [10]
8. Explain Fermi energy and Fermi factor. Discuss the variation of Fermi factor with temperature and energy. [8]
9. Describe Fermi-Dirac distribution and discuss the same for different temperature conditions. [6]
10. Define Fermi factor and hence discuss the probability of occupation of various energy states by electrons at $T = 0\,K$ and $T > 0\,K$. [7]
11. Show that occupation probability at $E = E_F + \Delta E$ is same as non-occupation probability at $E = E_F - \Delta E$, E_F is the Fermi energy. [5]
12. Show that if the probability of occupancy is x at an energy level ΔE below the Fermi level, then x is also probability of non occupancy at an energy level ΔE above the Fermi level. [5]
13. How does the electrical resistance of the metal change with impurity and temperature? [5]
14. Elucidate the difference between classical free electron theory and quantum free electron theory. Describe how quantum free electron theory has been successful in overcoming the failures of classical free electron theory. [9]
15. Elucidate the difference between classical free electron theory and quantum free electron theory. [6]

Solve the following problems

1. Calculate the drift velocity and thermal energy of electrons in a metal of thickness $1\,mm$ across which a potential difference of $1\,V$ is applied at the temperature of $300\,K$. The mobility of free electron is $40\,cm^2/Vs$. [5]

2. Find the relaxation time of conduction electrons in a metal of resistivity $1.54 \times 10^{-8} \Omega m$, if the metal has 5.8×10^{28} conduction electrons per m^3. [6]

3. A certain conductor has electron concentration 5.9×10^{28} per metre-cube. What current density in the conductor will correspond to a drift velocity of $(1/1.6)\, mm/s$. Calculate the mobility of the charge carriers. Given conductivity $= 6.22 \times 10^7\, /\Omega m$ [5]

4. Calculate the mobility of electrons in Copper assuming that each atom contributes one free electron for conduction. Resistivity of Copper is $1.7 \times 10^{-8}\, \Omega m$. Atomic weight is 63.54. Density $8.96 \times 10^3\, kg/m^3$. Avagadro's number $6.025 \times 10^{23}\, /mol$. [5]

5. At what temperature we can expect 1% probability that an energy level $0.5\, eV$ above Fermi level will be occupied. [5]

6. Find the probability with which an energy level $0.2\, eV$ below Fermi level being occupied at room temperature of $300\, K$ and $1000\, K$. [5]

7. The Fermi level in potassium is $2.1\, eV$. What are the energies for which the probabilities of occupancy at $300\, K$ are 0.99, 0.01 and 0.5? [5]

8. Find the electron density for a metal with Fermi energy $3\, eV$. [4]

9. Calculate the Fermi energy in eV for a metal at $0^\circ\, K$, given that its density is $10500\, kg/m^3$, atomic weight is 107.9 and it has only one conduction electron per atom. [5]

10. Calculate the Fermi energy in eV, Fermi velocity and Fermi temperature for Sodium, given that the density of Sodium is $971\, kgm^{-3}$. Its atomic weight is 23, and it has one conduction electron per atom. [5]

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