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ELECTRICAL AND ELECTRONICS ENGINEERING
EEG 215 ASSIGNMENT

1a i NEEL TEMPERATURE

This is the characteristic temperature for antiferromagnetic systems. It is the temperature above which an anti-ferromagnetic substance loses its antiferromagnetism and becomes paramagnetic.

ii TRANSITION TEMPERATURE

This is the temperature at which a normal conductor loses its resistivity and becomes a superconductor.

iii CURIE LAW

This states that the susceptibility of a paramagnetic material is proportional to the reciprocal of temperature in Kelvin (K)

$$\chi \propto \frac{1}{T}$$

$$\chi = \frac{c}{T} \quad \text{where c is a constant}$$

iv MAGNETO-ELASTIC ENERGY

Also known as magneto-restrictive energy is the work done by the magnetic field against this elastic restoring force.

v INTRINSIC BREAKDOWN

This is the liberation of electrons from valence bands.

b ASSUMPTIONS OF QUANTUM FREE ELECTRON THEORY

- In a metal, the available free electrons are fully responsible for electrical conduction.

- The electrons move a constant potential inside the metal. They cannot come out of the metal surface / high potential barrier.

- Electrons distributed in various energy levels according to Pauli's exclusion principle.

c $\rho = 1.6 \times 10^{-8}\ \Omega\text{-}m$ $\qquad d = 16 \times 10^{-3}\ mm \Rightarrow 16 \times 10^{-6}\ m$

$E = 100\ Vm^{-1}$ $\qquad m_e = 9.1 \times 10^{-31}\ kg$

$A = 107.9\ kg$ $\qquad \text{density} = 1.05 \times 10^{4}\ kgm^{-3}$

i Electron relaxation time τ

$$\tau = \frac{\sigma m}{ne^2} \qquad \sigma = \frac{1}{\rho} = \frac{1}{1.6 \times 10^{-8}} = 6.25 \times 10^{7}$$

Carrier concentration, $n = \frac{\text{Avogadro's no.} \times \text{density}}{\text{weight}}$

$$\frac{6.023 \times 10^{23} \times 1.05 \times 10^{4}}{107.9} = 5.8611 \times 10^{25}\ m^{-3}$$

$$\tau = \frac{6.25 \times 10^{7} \times 9.1 \times 10^{-31}}{5.8611 \times 10^{25} \times (1.6 \times 10^{-19})^2}$$

$$= 3.79 \times 10^{-11}\ secs$$

ii Electron mobility μ

$$\mu = \frac{\sigma}{ne} = \frac{6.25 \times 10^{7}}{5.8611 \times 10^{25} \times 1.6 \times 10^{-19}}$$

$$= 6.6647\ m^2 V^{-1} s^{-1}$$

iii Drift velocity V_d

$$V_d = \mu E$$

$$= 6.6647 \times 100 = 666.47\ m/s$$

iv Mean free path

$$\lambda = \frac{1}{\pi d^2 n} = \frac{1}{\pi \cdot (1.6 \times 10^{-6})^2 \times 5.8611 \times 10^{25}}$$

$$= 2.1214 \times 10^{-17}$$

v Current

$$J = neV_d$$

$$= 1.6 \times 10^{-19} \times 5.8611 \times 10^{25} \times 666.47$$

$$= 6.25 \times 10^{9}\ Am^{-2} \rightarrow 6249995707\ Am^{-2}$$

$$A = \pi\left(\frac{d}{2}\right)^2 = \pi \cdot \left(\frac{16 \times 10^{-6}}{2}\right)^2 = 2.0106 \times 10^{-10}\ m^2$$

$$J = \frac{I}{A} \rightarrow I = JA = 6249995707 \times 2.0106 \times 10^{-10}$$

$$= 1.2566\ A$$

di In a different sheet

ii Probability function $F(E)$ of an electron

$E_F = 6.23eV$

$F(E) = 0.75$

$T = 77°C + 273 = 350K$

$6.23 \times 1.6 \times 10^{-19} = 9.968 \times 10^{-19}$ J

$K = 1.38 \times 10^{-23}$ JK^{-1}

$$F(E) = \frac{1}{1 + e^{\frac{(E-E_F)}{KT}}}$$

$$0.75 = \frac{1}{1 + e^{\left[\frac{E - 9.968 \times 10^{-19}}{1.38 \times 10^{-23} \times 350}\right]}}$$

$$0.75 = \frac{1}{1 + e^{\left[\frac{E - 9.968 \times 10^{-19}}{4.83 \times 10^{-21}}\right]}}$$

$$1 + e^{\left[\frac{E - 9.968 \times 10^{-19}}{4.83 \times 10^{-21}}\right]} = \frac{1}{0.75}$$

$$e^{\left[\frac{E - 9.968 \times 10^{-19}}{4.83 \times 10^{-21}}\right]} = \frac{1}{3}$$

$$\frac{E - 9.968 \times 10^{-19}}{4.83 \times 10^{-21}} = \ln \frac{1}{3}$$

$$E - 9.968 \times 10^{-19} = -5.306297354 \times 10^{-21}$$

$$E = 9.915 \times 10^{-19} \text{ J}$$

$$= 6.1968 \text{ eV}$$

e $\quad P = \frac{\text{charge}}{\text{volume}}$

$$= \frac{-ze}{\frac{4}{3}\pi R^3} = \frac{-3ze}{4\pi R^3}$$

Lorentz force

$F_1 = qE \quad = -zeE$

Columbic Force

$$F_c = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q + q_0}{x^2} \quad [P \times \text{volume of sphere}]$$

$$F_c = \frac{1}{4\pi\varepsilon_0} \frac{ze}{x^2} \left[-\frac{\cancel{3}}{\cancel{4}} \frac{ze}{\cancel{\pi} R^3} \times \frac{\cancel{4}}{\cancel{3}} \cancel{\pi} x^3 \right.$$

$$F_c = \frac{-1}{4\pi\varepsilon_0} \frac{z^2 e^2 x}{R^3}$$

At equilibrium

$$F_e = F_c$$

$$-zeE = \frac{1}{4\pi\varepsilon_0} \frac{z^2 e^2 x}{r^3}$$

$$x = \frac{4\pi\varepsilon_0 r^3 E}{ze}$$

$$\mu = \alpha E$$

$$\alpha_e = \frac{\mu}{E}$$

$$\mu = zex$$

$$\mu = \frac{\cancel{ze}\, 4\pi\varepsilon_0 r^3 E}{\cancel{ze}}$$

$$\mu = 4\pi\varepsilon_0 r^3 E$$

$$\alpha = \frac{4\pi\varepsilon_0 r^3 E}{E}$$

$$\alpha = 4\pi\varepsilon_0 r^3$$

DENSITY OF STATES

A parameter of interest in the study of conductivity of metals and semi-conductors is the density of state. The Fermi function F(E) gives only the probability of filling up of electrons on a given energy state. It does not give information about the no. of electrons that can be filled in a given energy state. To know this we should ~~ascertain~~ ascertain the no. of available energy state called DENSITY STATE.

Density of state is defined as the no. of energy state per unit volume in an energy interlude. It is used to calculate the no. of charge carriers per unit volume of any solid.

$$N(E)dE = \frac{\text{No. of energy states b/w } E \text{ and } E+dE}{\text{Volume of the metal}}$$

$$N(E)dE = \frac{\pi}{4h^3}(8m)^{3/2}E^{1/2}\,dE$$