Q.110

Rough estimation of free electron contribution to specific heat assuming that only electrons below kT of ε_F get excited and gain energy $\sim \frac{3}{2} kT$

$$\text{Fraction} = \frac{\int_{\varepsilon_F - kT}^{\varepsilon_F} \varepsilon^{1/2} d\varepsilon}{\int_0^{\varepsilon_F} \varepsilon^{1/2} d\varepsilon} = \frac{\varepsilon_F^{3/2} - (\varepsilon_F - kT)^{3/2}}{\varepsilon_F^{3/2}}$$

$$= \left[1 - \left(1 - \frac{kT}{\varepsilon_F}\right)^{3/2}\right]$$

$$\approx \frac{3}{2} \frac{kT}{\varepsilon_F}$$

For Cu at 30K this is $\sim 0.5\%$

at 1360K this is $\sim 2.5\%$

Specific heat contribution

$$= \frac{d}{dT}\left[\frac{3}{2} kT \times \frac{3}{2} \frac{kT}{\varepsilon_F}\right] N_A$$

$$= \frac{9}{2} \frac{kT}{\varepsilon_F} R$$

Actual contribution $\frac{\pi^2}{2} \frac{kT}{\varepsilon_F} R$

Q.111

$$E_y = R_H J_x B_z$$

$$\frac{V_y}{3 \times 10^{-2}} = -0.84 \times 10^{-10} \times \frac{25}{3 \times 10^{-2} \times 0.1 \times 10^{-3}} \times 1.4$$

$$V_y = 29.4 \, \mu V$$

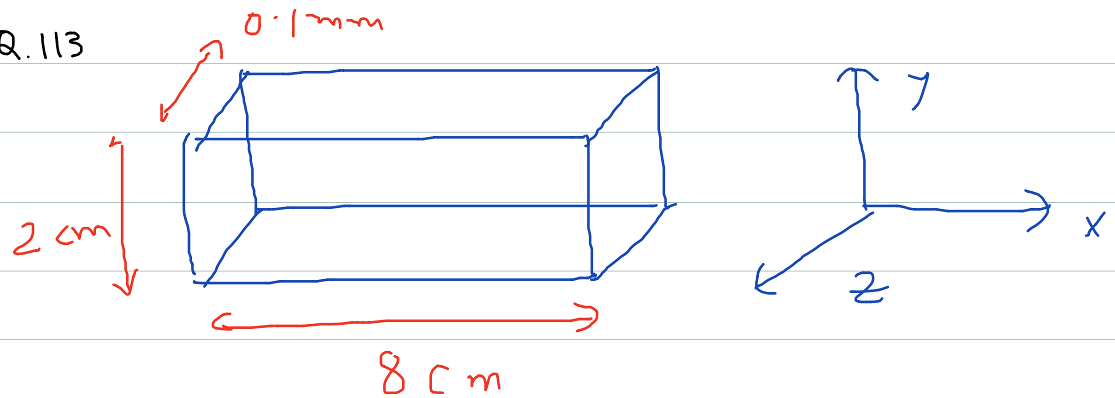
Hall angle ϕ is defined as

$$\tan\phi \equiv \frac{E_y}{E_x} = \frac{\sigma E_y}{J_x} = \frac{R_H J_x B_z \sigma}{J_x} = R_H B_z \sigma$$

$$\Rightarrow \phi \approx 0.46^0$$

$$\mu \equiv \frac{e\tau}{m} = R_H \sigma = 5.712\times 10^{-3}\ m^2/V.s$$

Q.113



Let the current flow in x - dir. and mag field be applied in z - dir.

$$E_x = \frac{10^{-2}}{8\times 10^{-2}} = \frac{1}{8} V/m$$

$$R_H = \frac{1}{ne}$$

In order to find 'n', we have to use the value of Fermi Energy

$$E_F = \frac{\hbar^2 k_F^2}{2m} = \frac{\hbar^2 (3\pi^2 n)^{2/3}}{2m} = 5\ eV$$

$$\Rightarrow (3\pi^2 n)^{2/3} = 1.321\times 10^{20} \text{ and } n = 5.126\times 10^{28} \text{ and } R_H = 1.219\times 10^{-10}$$

The electric field in y - direction is given by

$$E_y = R_H J_x B_z = \frac{32\times 10^{-6}}{2\times 10^{-2}} = 1.6\times 10^{-3}\ V/m$$

$$\therefore\ J_X = \frac{1.6\times10^{-3}}{2\times1.219\times10^{-10}} = 6.56\times10^{6}\ A/m^2$$

Thus the current in the x-dir. is given by

$$I = 6.56\times10^{6}\times1\times10^{-4}\times2\times10^{-2} = 13.12\ A$$

The conductivity is given by

$$\sigma = \frac{J_x}{E_y} = 6.56\times10^{6}\times8 = 5.25\times10^{7}\ (\Omega m)^{-1}$$

The relaxation time is given by

$$\tau = \frac{\sigma R_H m}{e} = 3.64\times10^{-14}\,s$$

Or

$$\tau = \frac{\sigma m}{ne^2} = 3.64\times10^{-14}\,s$$