Home Problem Set #5 Due : October 6, 2014

1. Calculate the time between two collisions and the mean free path for pure copper at room temperature. Discuss whether or not this result makes sense. (See the hint given in prob. 3 in page 113 of the text book)

$$\tau = 2.5\text{x}10^{-14}(s); l = 393(\text{Å})$$

2. Calculate the number of free electrons per cubic centimeter (and per atom) for sodium from resistance data (relaxation time $3.1\text{x}10^{-14}$ s).

N_a 의 $\sigma = \frac{1}{\rho} = \frac{1}{4.20\times10^{-6}\Omega cm} = 2.38\times10^{5}/\Omega cm$

$N_F = \frac{\sigma \cdot m}{\tau \cdot e^2} = \frac{(2.38\times10^{5})(9.11\times10^{-31})}{(3.1\times10^{-14})(4.803\times10^{-10})^2} = 3.03\times10^{7}$

$unit: \frac{(1/\Omega cm)(kg)}{s \cdot (cm^{1.5}g^{0.5}/s)^2} = \frac{9\times10^{11}/s \cdot kg}{s \cdot cm^3 \cdot g/s^2} = 9\times10^{14}/cm^3$

$\therefore N_F = 3.03\times10^{7}\times9\times10^{14}/cm^3 = 2.73\times10^{22}/cm^3$

3. Solve the differential equation

$$m\frac{dv}{dt} + \frac{eE}{v_F}v = eE$$

And compare your result with (7.11).

4.

$$m\frac{dv}{dt} + \frac{eE}{v_f}v = eE$$

$$\frac{dv}{dt} + \frac{eE}{mv_f}v = \frac{eE}{m}$$

$$v = \exp\left(-\int \frac{eE}{mv_f}\,dt\right)\cdot\left[\int \frac{eE}{m}\cdot\left(\exp\left(\int \frac{eE}{mv_f}\,dt\right)\right)dt + C\right]$$

$$= \exp\left(-\frac{eE}{mv_f}t\right)\cdot\left[\int \frac{eE}{m}\cdot\exp\left(\frac{eE}{mv_f}t\right)dt + C\right]$$

$$= \exp\left(-\frac{eE}{mv_f}t\right)\cdot\left[v_f\cdot\exp\left(\frac{eE}{mv_f}t\right) + C\right]$$

$$= v_f + C\cdot\exp\left(-\frac{eE}{mv_f}t\right)$$

when $t \to \infty$ $\quad v = v_f \quad \therefore C = -v_f$

$$\therefore v = v_f\left(1 - \exp\left(-\frac{eE}{mv_f}t\right)\right)$$