# University of Kentucky
# Department of Physics and Astronomy
## PHY 525: Solid State Physics II
## Fall 2000
## Test 2

Date: November 8, 2000 (Wednesday)

Time allowed: 50 minutes.

Answer all questions.

1. ***Hall coefficient of a semiconductor***. (a) Starting from drift velocity approximation, show that the Hall coefficient of a semiconductor is given by

$$R_H = \frac{1}{n_i ec}\,\frac{1-b}{1+b}$$

where $n_i$ is the intrinsic concentration, and b is the ratio of mobility in conduction and valance bands ($b=\mu_n/\mu_p$ ). (b) Consider two semiconductors A and B of with same energy gap. The following table gives the ratio of electron effective mass and relaxation time in the conduction and valance bands:

| | $m^*_n/m^*_p$ | $\tau_n/\tau_p$ |
|---|---|---|
| Semiconductor A | 0.3 | 30 |
| Semiconductor B | 0.8 | 15 |

Estimate the ratio of their Hall coefficients from Drude model. (c) For a semiconductor of energy gap equivalent to a temperature of 12500K, estimate the ratio of the Hall coefficient at 300K and 200K, $R_H(300K)/R_H(200K)$. Assume $\tau$ does not vary much in this temperature range.

2. ***Graded diode.*** In the depletion layer (width 2w) of a graded p-n junction, the doping level varies linearly with position: $N_D-N_A = kx$ for $-w \le x \le +w$. If the p- and n-semiconductors have doping level of $N_A$ and $N_D$ respectively. Let the effective density of state of the conduction and valance band be $N_C$ and $N_V$ respectively. Also let the energy gap of the intrinsic semiconductor be $E_g$. Assume all impurities are fully ionized. (a) Calculate chemical potential $\mu n$ and $\mu p$ in terms of $N_D$, $N_A$, $N_C$, $N_V$, and $E_g$, from this calculate the potential difference $\Delta\varphi$ across the depletion layer. (b) What should be the electric field E at the two sides of the depletion layer? Find the electric field E(x) within the depletion layer. (c) Find the electric potential $\varphi(x)$ within the depletion layer. (d) Determine the layer width 2w in term of $\Delta\varphi$.