from: written test, May 2011, Cond Matt Phys II

Carrier densities in a two-dimensional semiconductor

Consider a 2 dimensional crystal at $T = 0$ with some full energy bands, the others being empty. The energy gap between the uppermost full energy band and the first empty one is $E_g = 1eV$. Let's treat this system as an intrinsic 2 dimensional semiconductor, neglecting the effect of impurities.

The energy dispersion at the top of the valence band is è

$$\epsilon_v(\mathbf{k}) = \epsilon_v - \frac{\hbar^2}{2m_v}(\mathbf{k} - \mathbf{k}*)^2 + ...$$

and at the bottom of the conduction band

$$\epsilon_c(\mathbf{k}) = \epsilon_c + \frac{\hbar^2}{2m_c}(\mathbf{k} - \mathbf{k}*)^2 + ...$$

1. Calculate the energy density of states at the top of the valence band.
2. Calculate the energy density of states at the bottom of the conduction band.
3. Assume the non-degenerate regime and temperature K_BT much smaller of the bands width, in order to be able to use eqs. (28.12-13) of the textbook and the energy density of states obtained earlier. Calculate $N_c(T)$.
4. Calculate $P_v(T)$.
5. Knowing that $m_v = 0.38m_e$ and $m_c = 0.067m_e$, evaluate numerically $N_c(T)$ e $P_v(T)$ at room temperature ($T = 300\,^oK$).
6. Evaluate numerically the intrinsic carrier density $n_i(T)$ at room temperature.