※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

1. Solve the Schrodinger wave equation $-\frac{\hbar^2}{2m}\nabla^2\psi = E\psi$ to find the energy levels for a semiconductor with volume of V, where m is the electron mass. Then show that the electron concentration can be expressed as $n = 2\left(\frac{2\pi mkT}{h^2}\right)^{3/2} e^{(E_F - E_c)/kT}$, where k is the Boltzmann's constant, T the absolute temperature, E_F the Fermi level and E_c the bottom of the conduction band. [Hint: the Fermi-Dirac distribution can be approximated as $e^{(E_F - E_c)/kT}$ and you may use the integral result $\int_0^\infty x^{1/2} e^{-ax} dx = \frac{\sqrt{\pi}}{2a\sqrt{a}}$.] (20%)
2. The Hall effect is used to measure the resistivity of a sample of Si doped with 10^{17} phosphorus atoms/cm^3. The applied magnetic flux density field is 10^{-5} Wb/cm^2 along z-direction and the flowing current is 1 mA along the sample. What are the Hall voltage and resistivity of the sample if its thickness in the z-direction is 100 μm and the electron mobility is 700 cm^2/(V-sec)? (15%)
3. An n-type Si sample with $N_d = 10^{15}$ cm^{-3} is exposed to a steady optical generation rate of 10^{21} EHP/cm^3 – sec. If the carrier lifetimes are $\tau_p = \tau_n = 10^{-6}$ sec for this excitation, calculate the separation in the quasi-Fermi levels $F_n - F_p$ and draw the corresponding band diagram. (15%)
4. For a silicon at room temperature (kT=0.0259 eV), it doped with 10^{16} arsenic atoms/cm^3 on one side and doped with 10^{15} boron atoms/cm^3 on the other side to form an abrupt p-n junction. Calculate the build-in potential, depletion region length for both n and p sides, and also draw the energy band diagram at thermal equilibrium, indicating Fermi level, conduction and valence bands for this p-n junction.[Use n_i = 1.5×10^{10} cm^{-3}, dielectric constant = 11.7 for Si and free-space permittivity $\varepsilon_0 = 8.85\times10^{-14}$ F/cm] (15%)

(背面仍有題目,請繼續作答)

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5. Sketch the space charge density, electric field and electric potential of a p-n junction with uniformly doping concentrations of N_a and $N_d = 10N_a$, respectively. (Assuming abrupt junction and no applied voltage) (15%)
6. For a MOS capacitor, (a) what is the definition of flat band voltage? (b) what factors can affect the value of the flat band voltage? (20%)