系所組別： 微電子工程研究所

考試科目： 固態電子元件

※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

1. Gallium arsenide at T=300K contains acceptor impurity atoms at a density of $1\times10^{15}cm^{-3}$. Additional impurity atoms are to be added so that the Fermi level is 0.45eV below the intrinsic level. Determine the concentration and type of impurity atoms to be added. (if $n_i=1.8\times10^{6}$ cm^{-3}) (9%)

2. A geometry for measuring the Hall effect is shown in Fig. 1. A silicon Hall device at T=300K has the following geometry: $d=10^{-3}$cm, $W=10^{-2}$cm, and $L=10^{-1}$cm. The following parameters are measured: I_x=0.75mA, V_x=15V, V_H=+5.8mV, and B_Z=1000 gauss. Determine (a) the conductivity type, (b) the majority carrier concentration, and (c) the majority carrier mobility. (11%)

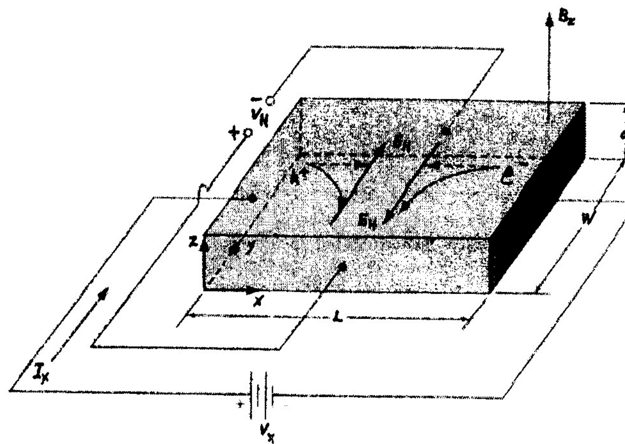

Fig. 1

3. The doping concentrations of a silicon p-n junction are $N_A = 10^{17}$ cm^{-3} on the p-side and $N_D = 10^{16}$ cm^{-3} on the n-side. Calculate the depletion layer widths in the p-side (x_p) and n-side (x_n) at 300 K when a 5 V reverse bias is applied. (if $n_i = 10^{10}$ cm^{-3}, silicon dielectric constant 11.9, and permittivity $\varepsilon_0 = 8.85\times10^{-14}$ F/cm) (10%)

4. The junction capacitance (C_j) of a silicon p-n^+ one-sided abrupt junction with junction area 10 μm^2 is shown in the table below.

reverse bias applied (V)	0	1	2	3
C_j (F)	3.07×10^{-15}	2.11×10^{-15}	1.71×10^{-15}	1.47×10^{-15}

Calculate the doping concentrations in the p-side (N_A) and n-side (N_D). (15%)

(背面仍有題目,請繼續作答)

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5. Qualitatively draw the energy band diagram (including Fermi-level E_F) of an n-p-n bipolar junction transistor under the (a) active, (b) saturation, and (c) cutoff modes of operation. Explain your answer. (15%)

6. Please sketch the current-voltage (I-V) characteristics of four different types of MOSFETs (n-channel enhancement, n-channel depletion, p-channel enhancement, and p-channel depletion). (10%)

7. Please derive an equation that relates the quantum efficiency (η) of a *p-i-n* photodiode to its responsivity (R) at a wavelength λ. (15%)

8. An InGaAs Fabry-Perot laser operating at a wavelength (λ) of 1.55 μm has a cavity length of 600 μm. The index of refraction (n) of InGaAsP is 3.39. Derive and then calculate the separation $\Delta\lambda$ between the allowed modes in the longitudinal direction, assuming $dn/d\lambda = 0.85\ \mu m^{-1}$. (15%)