Property	Si	GaAs
Dielectric constant	11.9	13
Energy gap, E_g (eV)	1.12	1.43

1. A silicon sample is doped with 10^{16} donor atoms/cm^3 at room temperature (300K).
   The intrinsic carrier density in Si is 9.65×10^9 cm^{-3}.
   (a) Find the carrier concentrations. (10%)
   (b) Find the Fermi level. (10%)
      (Note: Sketch the band diagram and mark E_C, E_V, E_F and E_i; indicate clearly the location of the Fermi level with respect to intrinsic level.)

2. Consider a GaAs PIN diode
   (a) Calculate the value of N_D with an intrinsic region thickness of 20 μm, and a permitted ΔE of 10^5 V/m. ΔE is the change in electric field across the depletion region. (10%)
   (b) An electric field of 3.5×10^5 V/m is needed to reach the saturation region.
      Find the bias voltage. (10%)

3. Calculate the maximum width of surface depletion region for a metal-SiO$_2$-Si capacitor having $N_A = 3 \times 10^{16}$ cm^{-3}. (20%)

4. A solar cell under an illumination of 80 W/m^2 has a short circuit current I_{sc} of 40 mA and an open circuit output voltage V_{oc} of 0.55V. What are the short circuit current and open circuit voltages when the light intensity is halved? (20%)

5. Consider the p$^+$n junction of a uniformly doped silicon n-channel JFET has doping concentrations of $N_A = 10^{18}$ cm^{-3} and $N_D = 7 \times 10^{15}$ cm^{-3} at T = 300K. The metallurgical channel thickness is 0.8 μm. Determine the built-in potential barrier and the pinchoff voltage of the JFET. (20%)