(1.) GaAs, $N_a = 2\times10^{17}\,cm^{-3}$ $T = 300K$

Silicon is added to Ga sites

Silicon has 4 valence electrons where Ga only has 3. ∴ Si has one extra electron which will be donated to the lattice. Si is a donor.

Therefore, the problem is to find N_d such that $n = N_d - N_a$ causes the Fermi level to be exactly $3kT$ from E_c ⟹ the onset of degeneracy.

$$N_d - N_a = N_c e^{-(E_c - E_f)/kT}$$

$$= N_c e^{-3kT/kT} = N_c e^{-3}$$

$$\underline{N_d = N_a + N_c e^{-3}}$$

$$= 2\times10^{17}\,cm^{-3} + 2\left(\frac{2\pi m_n^* kT}{h^2}\right)^{3/2} e^{-3}$$

For GaAs $m_n^* = .06\,m_0$

$N_d = 2\times10^{17} + 3.7\times10^{17}(.05)$

$$\boxed{N_d \approx 2.2\times10^{17}\,cm^{-3}}$$

2

$$np = N_c e^{-(E_c - E_F)/kT} N_v e^{-(E_F - E_v)/kT} = n_i^2$$

$$= N_c N_v e^{-E_g/kT} = n_i^2$$

$$N_c = 2\left(\frac{2\pi m_n^* kT}{h^2}\right)^{3/2} \quad N_v = 2\left(\frac{2\pi m_p^* kT}{h^2}\right)^{3/2}$$

$$n_i^2 = 4\left(\frac{2\pi kT}{h^2}\right)^3 m_n^{*\,3/2} m_p^{*\,3/2} e^{-E_g/kT}$$

For Si $\quad m_n^* = 1.08\, m_0$

$\qquad\quad m_p^* = .56\, m_0$

at $T = 100K$

$$n_i^2 = \left[4\left(\frac{2\pi}{h^2}\right)^3 m_n^{*\frac{3}{2}} m_p^{*\,3/2}\right] e^{-E_g/kT} (kT)^3$$

$$\underline{n_i^2 = 1.7\times 10^{43} (kT)^3 e^{-E_g/kT} \quad cm^{-6}}$$

$n_i = 3\times 10^{-19}$, thus $\boxed{n_i \approx 0 \text{ at } T = 100K}$

at $T = 300K$

$$\boxed{n_i \simeq 1.1\times 10^{10}\, cm^{-3}}$$