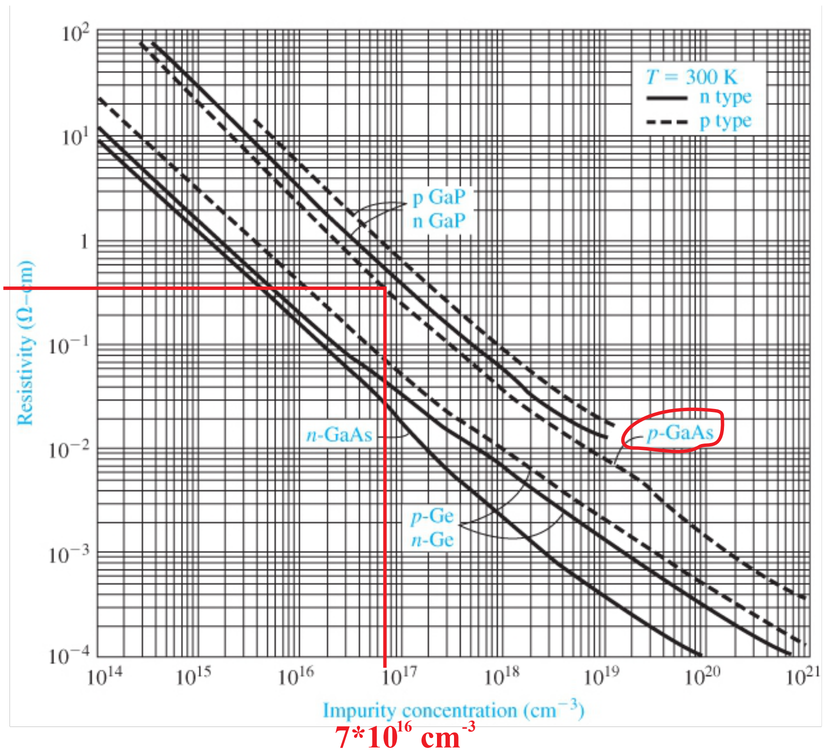
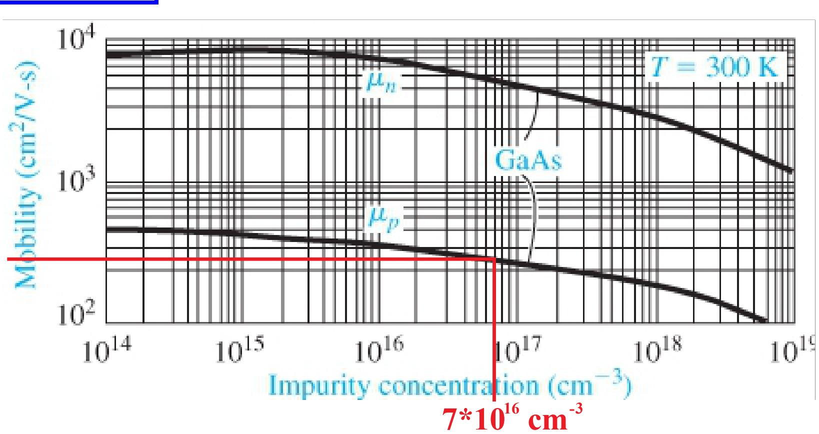
5.4 (*a*) The resistivity of a p-type GaAs material at $T = 300$ K is required to be $\rho = 0.35\,(\Omega\text{-cm})$. Determine the acceptor impurity concentration that is required. What is the hole mobility corresponding to this impurity concentration? (*b*) An n-type GaAs material is required to have a conductivity of $\sigma = 120\,(\Omega\text{-cm})^{-1}$. What donor impurity concentration is required and what is the corresponding electron mobility?

a) The intrinsic charge concentration, $n_i = 1.8 \times 10^6$ #/cm^3 (Table B.4), is negligible compared to N_a. So, $p \approx N_a$. We'll assume $N_d = 0$. Per (5.20), $\rho = 1/[e(\mu_n N_d + \mu_p N_a)] \cong 1/(e\,\mu_p N_a)$. Using Fig. 5.4b, the impurity concentration for *p*-type GaAs is $\boxed{N_a = 7 \times 10^{16}\ \#/\text{cm}^3}$.



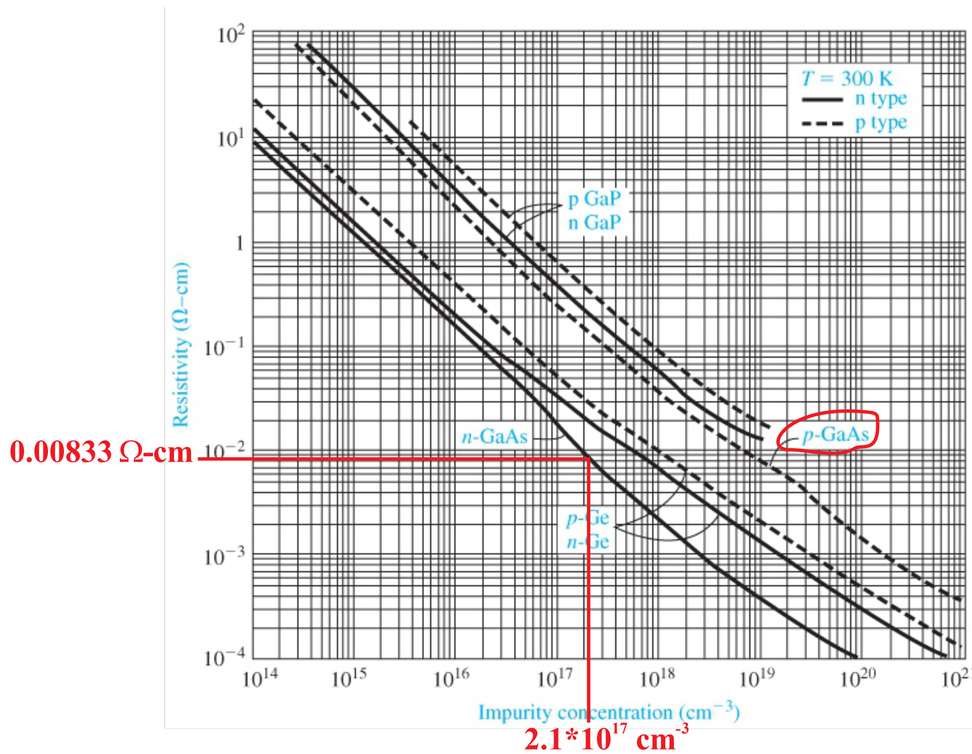
From Semiconductor Physics and Devices: Basic Principles (4th Edition), Donald A. Neamen, McGraw Hill, 2012, ISBN 978-0-07-352958-5.

Going to Figure 5.3 (bottom graph for GaAs), we read the electron mobility for this impurity concentration is $\boxed{\mu_p \approx 250\ \text{cm}^2/\text{V-s}}$.



Check- $\rho \cong 1/(e\,\mu_p N_a) = 1/[1.6022\times10^{-19}(250)7\times10^{16}] =$ **0.357 Ω-cm**. [decent agreement]

b) The intrinsic charge concentration, $n_i = 1.8 \times 10^6$ #/cm^3, is negligible compared to N_d. So, $n \approx N_d$. Assume $N_a = 0$. Per (5.23), $\sigma = e\,(\mu_n N_d + \mu_p N_a) \cong e\,\mu_n N_d = 120\,(\Omega\text{-cm})^{-1}$ and $\rho = 1/\sigma = 1/120 = 0.00833\ \Omega$-cm. Using Fig. 5.4b, the impurity concentration for the *n*-type GaAs is $\boxed{N_d = 2.1 \times 10^{17}\ \#/\text{cm}^3}$.



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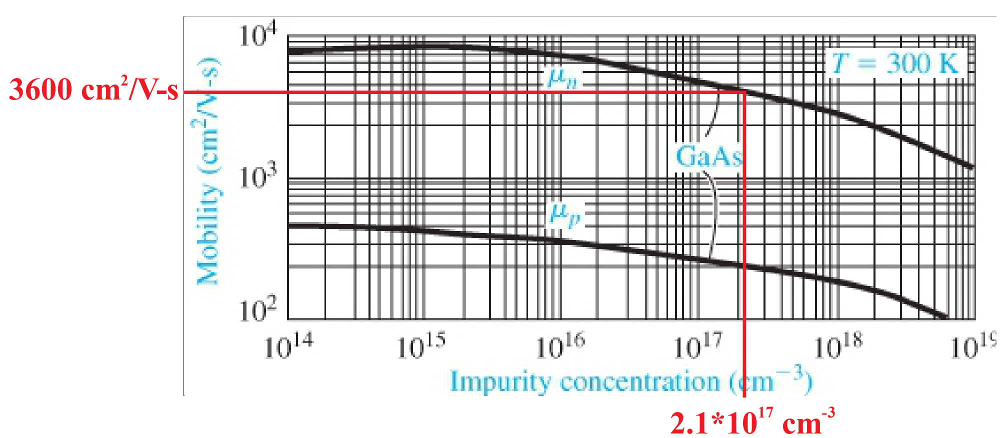
Going to Figure 5.3 (bottom graph for GaAs), we can read what the electron mobility for this impurity concentration is $\boxed{\mu_n \approx 3600\ \text{cm}^2/\text{V-s}}$.



Check- $\sigma \cong e\,\mu_n N_d = 1.6022\times10^{-19}\,(3600)\,2.1\times10^{17} =$ **121.1** $(\Omega\text{-cm})^{-1}$. [decent agreement]