5.1 The concentration of donor impurity atoms in silicon is $N_d = 10^{15}$ cm^{-3}. Assume an electron mobility of $\mu_n = 1300$ cm^2/V-s and a hole mobility of $\mu_p = 450$ cm^2/V-s. (*a*) Calculate the resistivity of the material. (*b*) What is the conductivity of the material?

a) Per (5.20), $\rho = \dfrac{1}{\sigma} = \dfrac{1}{e(\mu_n n + \mu_p p)}$.

Assume $N_a = 0$. Table B.4 gives an intrinsic charge concentration $n_i = 1.5 \times 10^{10}$ #/cm^3 at 300 K for silicon. This is negligible compared to N_d. So, $n \approx N_d$. This also implies that p is negligible compared to n. For these approximations, this gives a resistivity of

$$\rho \simeq \frac{1}{e\,\mu_n\,N_d} = \frac{1}{1.602176634\times10^{-19}\,(1300)10^{15}} \quad \Rightarrow \underline{\boldsymbol{\rho = 4.80116\ \Omega\text{-cm} = 0.048012\ \Omega\text{-m}}}.$$

b) Since $\sigma = 1 / \rho = 1 / 0.048012$ $\Rightarrow$ $\underline{\boldsymbol{\sigma = 20.828\ \text{S/m} = 0.20828\ \text{S/cm}}}$.