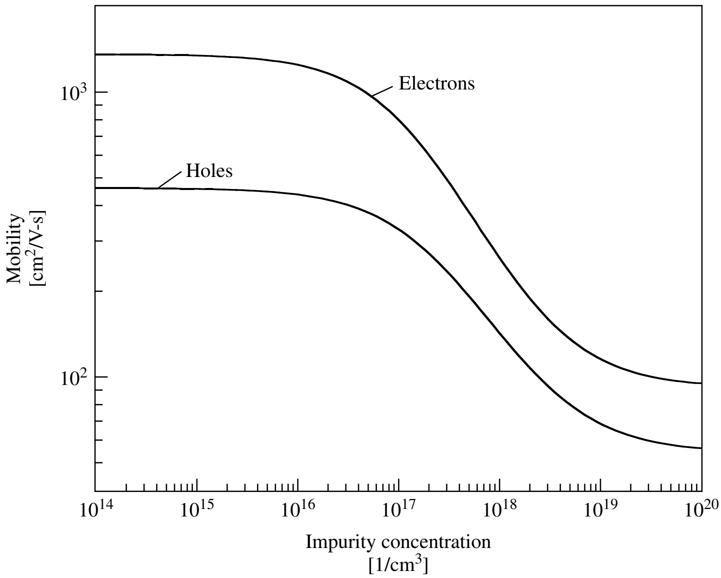

Figure 3.12 Electron and hole mobilities in silicon for $T = 300$ K

$$\mu_p = 54.3 + \frac{406.9}{1 + \left(\frac{N_D^+ + N_A^-}{2.35 \times 10^{17}}\right)^{0.88}} \text{cm}^2/\text{V-s} \tag{3.60}$$

and are plotted in Figure 3.12. At low impurity levels, the mobility is governed by intrinsic lattice scattering, while at high levels the mobility is governed by ionized impurity scattering.

Electrons and holes in semiconductors tend, as a result of their random thermal motion, to move (diffuse) from regions of high concentration to regions of low concentration. Much like how the air in a balloon is distributed evenly within the volume of the balloon, carriers, in the absence of any external forces, will also tend to distribute themselves evenly. This process is called *diffusion* and the diffusion current densities are given by

$$\vec{J}_p^{\text{diff}} = -qD_p \nabla p \tag{3.61}$$

$$\vec{J}_n^{\text{diff}} = qD_n \nabla n \tag{3.62}$$

where D_p and D_n are the hole and electron diffusion coefficients, respectively. Note that they are driven by the gradient of the carrier densities.

In thermal equilibrium, there can be no net hole current and no net electron current – in other words, the drift and diffusion currents must exactly balance. In nondegenerate materials, this leads to the Einstein relationship

$$\frac{D}{\mu} = \frac{kT}{q} \tag{3.63}$$