3.091 Fall Term 2009
Homework Quiz #6A
solution outlines

Chemical analysis of a silicon (Si) crystal reveals boron (B) at a level of 0.0003 atomic percent.

(a) Assuming that the concentration of thermally excited charge carriers from the Si matrix is negligible, calculate the density of free charge carriers (carriers/cm^3) in this Si crystal.

each B atom will attract an electron and thus create a "mobile hole"; we only have to determine the number of B atoms/cm^3 of Si. The atomic volume of the host crystal (Si) is given on your PT as 12.05 cm^3/mole.

$$\#\ \text{Si atoms/cm}^3 = \frac{6.02\times10^{23}\ atoms}{1\ mole}\times\frac{1\ mole}{12.05\ cm^3} = 5.00\times10^{22}\ \text{atoms/cm}^3$$

$$\therefore\ \#\ \text{B atoms/cm}^3 = 5.00\times10^{22}\times0.0003\times10^{-2} = 1.50\times10^{17}\ \text{B/cm}^3$$

thus, the number of free charge carriers ("holes") is 1.50×10^{17}/cm^3; they are created through the acquisition of one electron by each B atom from the valence band of the host Si crystal.

(b) Draw a schematic energy band diagram for this material and label the valence band, conduction band, band gap, and the energy level associated with the B impurity.