

3.091 Fall Term 2009  
**Homework Quiz #6B**  
 solution outlines

Chemical analysis of a germanium (Ge) crystal reveals antimony (Sb) at a level of 0.0002 atomic percent.

- (a) Assuming that the concentration of thermally excited charge carriers from the Ge matrix is negligible, calculate the density of free charge carriers (carriers/cm<sup>3</sup>) in this Ge crystal.

each Sb atom will donate an electron to the conduction band; we have only to determine the number of Sb atoms/cm<sup>3</sup> of Ge. The atomic volume of the host crystal (Ge) is given on your PT as 13.57 cm<sup>3</sup>/mole.

$$\# \text{ Ge atoms/cm}^3 = \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mole}} \times \frac{1 \text{ mole}}{13.57 \text{ cm}^3} = 4.44 \times 10^{22} \text{ atoms/cm}^3$$

$$\therefore \# \text{ Sb atoms/cm}^3 = 4.44 \times 10^{22} \times 0.0002 \times 10^{-2} = 8.87 \times 10^{16} \text{ Sb/cm}^3$$

thus, the number of free charge carriers is  $8.87 \times 10^{16}/\text{cm}^3$ ; they are created by the donation of one electron by each Sb atom to the conduction band of the host Ge 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 Sb impurity.

