Self-Assessment: Electronic Materials

Weekly Homework Quiz – Solution Outlines

1. Indium phosphide (InP) is a semiconductor with a band gap, E_g, of 1.27 eV. Calculate the value of the absorption edge of this material. Express your answer in meters.

For absorption of incoming radiation, the following must be true:

$$E_{radiation} = E_g$$

Using the Planck relationship gives the wavelength of the absorption edge:

$$E_{radiation} = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E_g} = \frac{6.6\times10^{-34}\times3\times10^{8}}{1.27\times1.6\times10^{-19}} = 9.74\times10^{-7}\ \text{m}$$

1. 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^3) in this Ge crystal.

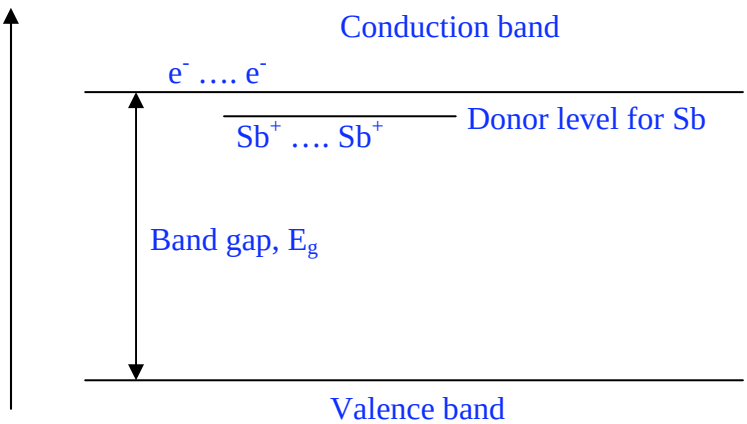
   Each Sb atom will donate an electron to the conduction band; we have only to determine the number of Sb atoms/cm^3 of Ge. The atomic volume of the host crystal (Ge) is given on your PT as 13.57 cm^3/mole.

$$\#\ \text{Ge atoms/cm}^3 = \frac{6.02\times10^{23}\ \text{atoms}}{1\ \text{mole}}\times\frac{1\ \text{mole}}{13.57\ \text{cm}^3} = 4.44\times10^{22}\ \text{atoms/cm}^3$$

$$\#\ \text{Sb atoms/cm}^3 = 4.44\times10^{22}\times0.0002\times10^{-2} = 8.87\times10^{16}\ \text{Sb/cm}^3$$

   Thus, the number of free charge carriers is 8.87 x 10^{16}/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.



3.091SC Introduction to Solid State Chemistry

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