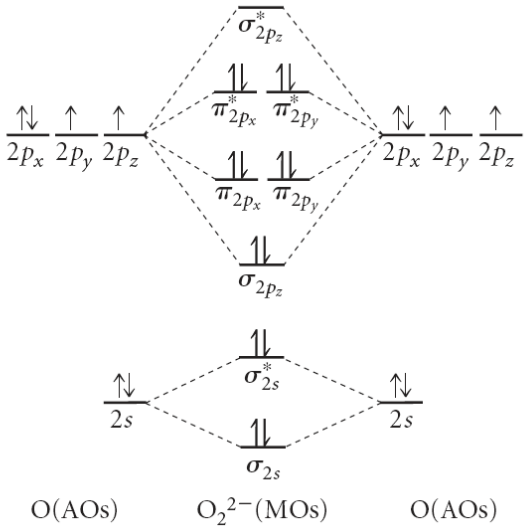
Self-Assessment: Bonding and Molecules

Weekly Homework Quiz – Solution Outlines

Problem #1

(a) Draw the energy level diagram that shows that the linear combination of atomic orbitals from two atoms of oxygen (O) results in the formation of the stable molecule, O_2^{2-}. The molecular orbitals in O_2^{2-} increase in energy according to the sequence σ_{2s}, σ_{2s}^*, σ_{2p_z}, $\pi_{2p_{x,y}}$, $\pi_{2p_{x,y}}^*$, $\sigma_{2p_z}^*$.



(b) 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

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

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

Problem #2

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.

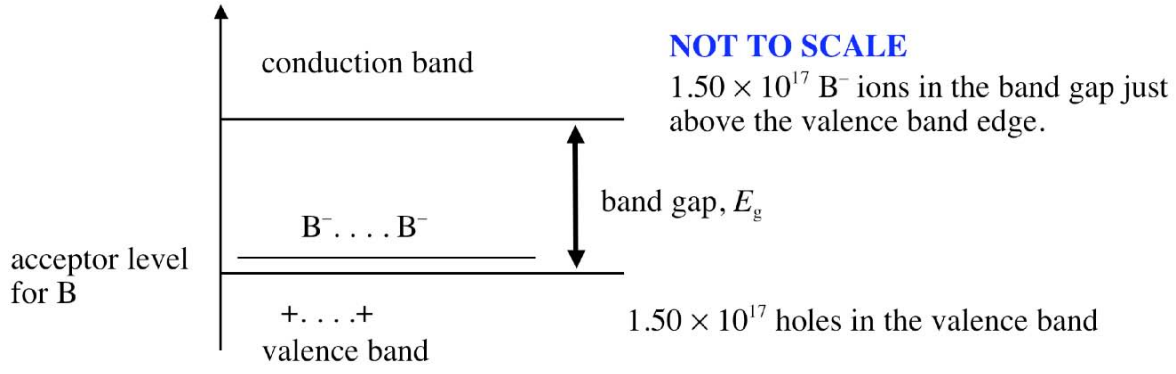
each B atom will attract an electron and thus create a "mobile hole"; we only have to determine the number of B atoms/cm^3 of Si. The atomic volume of the host crystal (Si) is given on your PT as 12.05 cm^3/mole.

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

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

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.



3.091SC Introduction to Solid State Chemistry

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