PART – II

CHAPTER-4

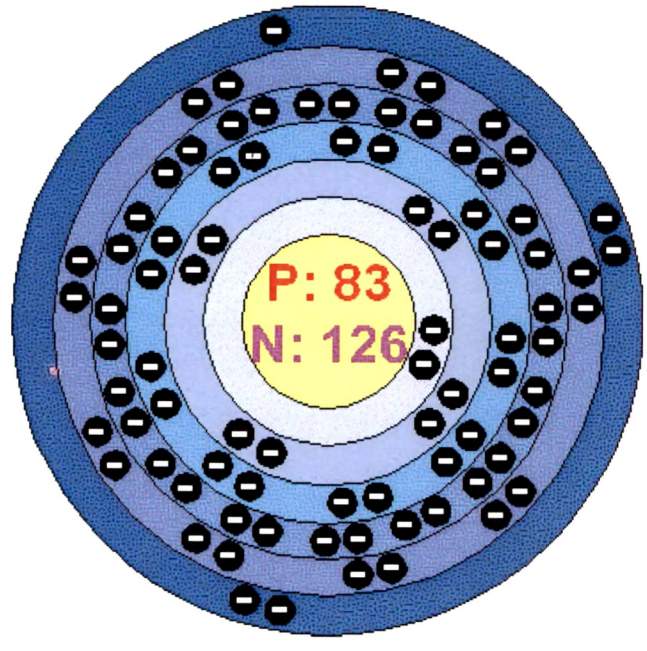
GENERAL INFORMATION ABOUT Bi-Sb

The basic information on bismuth and antimony, the constituent of the materials system under study and some important reports on the alloy system by earlier workers are presented below.

Bismuth (Bi):

- → At. wt. 208.98,
- → At. no. 83, .
- → At. radius 1.55 A^0
- → Melting Point 271.3^0 C
- → Sp.gr.9.747 – at 20^{0}C,
- → Valence 3 or 5

Bismuth belongs to group V period 6 of the periodic table with five electrons in the outer most shell ($6s^2$ - $6p^3$). It is the most diamagnetic of all metals. It is termed to be an electrically semi metal though, it is the most metallic in its group.



Atomic Structure (Bismuth)

Boiling Point: 1560.0 °C (1833.15 K, 2840.0 °F)

Crystal Structure: Rhombohedral

Density @ 293 K: 9.8 g/cm^3

Color: white

Name Origin: From the German word *wissmuth* (white mass)

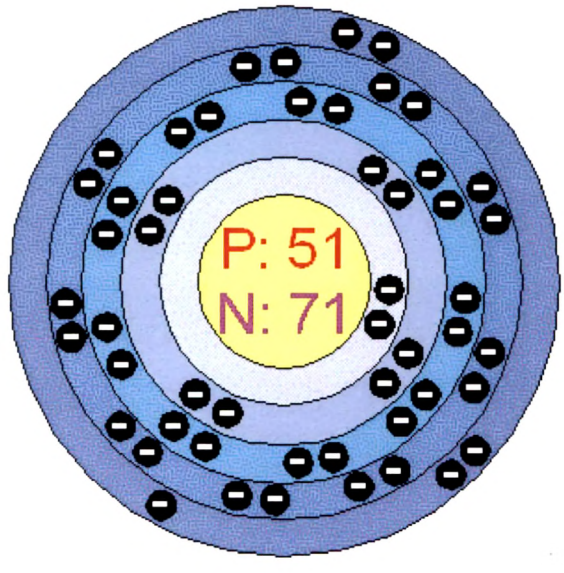
Uses: pharmaceuticals, fuses

Obtained From: bismuthine

ANTIMONY:

Antimony (Sb) is like bismuth, with a rhombohedral structure and so far as the crystallography is concerned, it is similar to bismuth. It belongs to the group V period 5 with five electron in the outer most orbit($5s^2 - 5p^3$). Like Bismuth it forms alloy with other metals such as lead, tellurium, sodium, tin etc.,

- → At. wt. 121.75,
- → At. no. 51, .
- → At. radius 1.43 A^0
- → Melting Point 650.5^0 C
- → Sp.gr.6.691 – at 20^0C,
- → Valence 3 or 5



Atomic Structure (Antimony)

Boiling Point: 1750.0 °C (2023.15 K, 3182.0 °F)

Classification: Metalloid

Crystal Structure: Rhombohedral

Density @ 293 K: 6.684 g/cm^3

Color: bluish

Bismuth has semimetal nature with a carrier concentration of about 10^{18} cm^{-3}. Its band structure has been obtained from measurements of de Haas-van Alphen effect[1], cyclotron resonance[2] , galvenomagnetic effect[3]., and elastoresistance[4]. The results have been interpreted in terms of the conduction band overlapping upon the valence band by 0.0184 eV. This overlap gives rise to the small number of holes in the valence band. Mean effective mass of holes to be $m_h^* \approx 2.5\ m_0$ which is very large compared to that electron $me^* \approx 0.05\ m_0$ given by shoenberg [1] . The group IV elements Pb and Sn act as acceptors much as do group III elements in the silicon or germanium type of semiconductor. Similarly group VI elements act as donors. Abeles and Meiboom[3] have effetely exploited this concept in their experimental study of galvanomegnetic effects and Heine[5] has analyzed the measurements of Shoenberg and Uddin[6] on magnetic susceptibility of Bi-Sn, Bi-Pb, and Bi-Te alloy at low temperatures on the same basis. According to Blunt and Cohen[10] The difference in the properties of Bi-Sn and Bi-Pb alloys[6,7] illustrate the former effect. The addition of group V element, however, can be expected to modify the band structure without destroying the equality of electron and hole concentrations.

Thus a comparison of the properties of alloys containing group V element with those containing group IV or VI should help to unravel the two

effects. Of the group V elements, Sb forms a complete range of solid solution with Bi. Shoenberg and Uddin[6] suggest on the basis of de Haas-van Alphen measurement on Bi-Sb alloys that the Fermi energy decrease with addition of Sb. Heine[5] has pointed out that a decreased Fermi energy implies a decreased overlap and that, consequently, Bi-Sb alloys may become semiconductor at concentration of Sb greater than 4%. The $Bi_{1-x}sb_x$ alloys is semiconducting in the composition range $0.07<x<0.22$ [8]

The temperature dependence of internal friction of this alloy has been studied by Maksimyuk and Onanko[9] employing pulse echo method. The liquid diffusion coefficient of the alloy containing 5 to 14 at%. Antimony was measured by Brown and Heumann[10]. Gopinathan and Pandmini[11] have reported the anomaly in the elastic properties of polycrystalline alloy system with increasing concentration of antimony. Similarl results were reported by Varkey and Padmini[12].

Yim and Amith[13] investigated the thermoelectric and thermo magnetic properties of undoped Bi-Sb alloy using highly homogeneous single crystals throughout the entire alloy composition range as function of temperature, magnetic field and crystallographic direction. The undoped n-type $Bi_{85}Sb_{15}$ alloy gave the largest magneto-thermal electrical figure of merit, 11×13^{-3} deg.$^{-1}$ at 100 ^{0} K and the same value at 80^0 K in transverse fields of 3000 Oe and 1300 Oe respectively. This is the largest figure of merit reported so far.

The galvanomagnetic and thermo electrical measurements were performed on doped and undoped $Bi_{85}Sb_{15}$ alloy single crystal by Brown and Silverman[14]. The thermal gap obtained from the temperature variation of resistivity of high purity samples was 0.024± 0.003 eV. The lattice parameter c and normal energy gap were found to be a functions of antimony concentration[15]. The megnetoresistance study of Bi-Sb alloy at high magnetic field was carried out by Hirnuma et al[16] and thermo electric power of $Bi_{91.5}Sb_{8.5}$ alloy in longitudinal quantizing magnetic field was reported by Galev et al[17].

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