Atom Percentages and Alloys

Problem 2-80

An alloy that melts at about the boiling point of water has Bi, Pb, and Sn atoms in the ratio of 10:6:5, respectively. What mass of alloy contains a total of one mole of atoms?

Solution:

Calculate the atom percentages of each element;

$$\text{atom percentage Bi} = \frac{10 \text{ atoms Bi}}{21 \text{ atoms}} \times 100 = 47.62\% = 47.62 \frac{\text{atoms Bi}}{100 \text{ atoms alloy}}$$

$$\text{atom percentage Pb} = \frac{6 \text{ atoms Bi}}{21 \text{ atoms}} \times 100 = 28.57 \frac{\text{atoms Pb}}{100 \text{ atoms alloy}}$$

$$\text{atom percentage Sn} = \frac{5 \text{ atoms Bi}}{21 \text{ atoms}} \times 100 = 23.81 \frac{\text{atoms Sn}}{100 \text{ atoms alloy}}$$

Since numbers of atoms and moles differ only by Avogadro's number, we can rewrite each of these percentages...

$$\text{mole percentage Bi} = 47.62 \frac{\text{mol Bi}}{100 \text{ mol alloy}}$$

$$\text{mole percentage Pb} = 28.57 \frac{\text{mol Pb}}{100 \text{ mol alloy}}$$

$$\text{mole percentage Sn} = 23.81 \frac{\text{mol Sn}}{100 \text{ mol alloy}}$$

The problem specifies 1 mol of atoms in the alloy. We ultimately want mass. Let's get the mass of each element first:

$$m_{\text{Bi}} = 47.62 \frac{\text{mol Bi}}{100 \text{ mol alloy}} \times 1 \text{ mol alloy} \times 208.98 \tfrac{\text{g}}{\text{mol}} = 99.52 \text{ g Bi}$$

$$m_{\text{Pb}} = 28.57 \frac{\text{mol Pb}}{100 \text{ mol alloy}} \times 1 \text{ mol alloy} \times 207.2 \tfrac{\text{g}}{\text{mol}} = 59.20 \text{ g Pb}$$

$$m_{\text{Bi}} = 23.81 \frac{\text{mol Sn}}{100 \text{ mol alloy}} \times 1 \text{ mol alloy} \times 118.71 \tfrac{\text{g}}{\text{mol}} = 28.26 \text{ g Sn}$$

$$m_{\text{total}} = m_{\text{Bi}} + m_{\text{Pb}} + m_{\text{Bi}} = 187 \text{ g alloy}$$