Percentage Composition, Avogadro's Number, Moles, and Grams

Chapter 2 Problem 58

A particular lead-cadmium alloy is 8.0% cadmium by mass. What mass of this alloy, in grams, must you weigh out to obtain a sample containing 6.50×10^{23} Cd atoms?

Solution:

First, define what 8.0% cadmium by mass means:

$$8.0\%\,{}^{\text{w}}\!/_{\text{w}} = \frac{8.0 \text{ g Cd}}{100 \text{ g alloy}}$$

Now, figure out what mass of Cd is represented by 6.50×10^{23} Cd atoms:

There's no direct conversion from numbers of atoms to mass. Avogadro's number will convert numbers of atoms to moles. The molar mass of the atom, then, can convert moles of Cd atoms to mass.

$$N = 6.50 \times 10^{23} \text{ atoms Cd}$$

$$n_{\text{Cd}} = 6.50 \times 10^{23} \text{ atoms Cd} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ atoms}} = 1.079 \text{ mol Cd}$$

$$m_{\text{Cd}} = 1.079 \text{ mol Cd} \times 112.41 \frac{\text{g Cd}}{\text{mol Cd}} = 121.33 \text{ g Cd}$$

Finally, calculate the amount of alloy that contains 121.33 g Cd using the percentage composition as the conversion factor:

$$m_{\text{alloy}} = 121.33 \text{ g Cd} \times \frac{100 \text{ g alloy}}{8.0 \text{ g Cd}} = \boxed{1520 \text{ g alloy}}$$