4.2 Determination of the number of vacancies per cubic meter in gold at 900°C (1173 K) requires the utilization of Equations 4.1 and 4.2 as follows:

$$N_v = N \exp\left(-\frac{Q_v}{kT}\right) = \frac{N_{\mathrm{A}}\,\rho_{\mathrm{Au}}}{A_{\mathrm{Au}}} \exp\left(-\frac{Q_v}{kT}\right)$$

$$= \frac{(6.023 \times 10^{23}\ \text{atoms/mol})(18.63\ \text{g/cm}^3)}{196.9\ \text{g/mol}} \exp\left[-\frac{0.98\ \text{eV/atom}}{(8.62 \times 10^{-5}\ \text{eV/atom}-\text{K})(1173\ \text{K})}\right]$$

$$= 3.52 \times 10^{18}\ \text{cm}^{-3} = 3.52 \times 10^{24}\ \text{m}^{-3}$$

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4.7 In order to compute composition, in atom percent, of a 92.5 wt% Ag-7.5 wt% Cu alloy, we employ Equation 4.6 as

$$C'_{\mathrm{Ag}} = \frac{C_{\mathrm{Ag}} A_{\mathrm{Cu}}}{C_{\mathrm{Ag}} A_{\mathrm{Cu}} + C_{\mathrm{Cu}} A_{\mathrm{Ag}}} \times 100$$

$$= \frac{(92.5)(63.55\ \mathrm{g/mol})}{(92.5)(63.55\ \mathrm{g/mol}) + (7.5)(107.87\,\mathrm{g/mol})} \times 100$$

= 87.9 at%

$$C'_{\mathrm{Cu}} = \frac{C_{\mathrm{Cu}} A_{\mathrm{Ag}}}{C_{\mathrm{Ag}} A_{\mathrm{Cu}} + C_{\mathrm{Cu}} A_{\mathrm{Ag}}} \times 100$$

$$= \frac{(7.5)(107.87\ \mathrm{g/mol})}{(92.5)(63.55\ \mathrm{g/mol}) + (7.5)(107.87\,\mathrm{g/mol})} \times 100$$

= 12.1 at%

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4.10 The concentration of an element in an alloy, in atom percent, may be computed using Equation 4.5. However, it first becomes necessary to compute the number of moles of both Cu and Zn, using Equation 4.4. Thus, the number of moles of Cu is just

$$n_{m_{\text{Cu}}} = \frac{m'_{\text{Cu}}}{A_{\text{Cu}}} = \frac{33 \text{ g}}{63.55 \text{ g/mol}} = 0.519 \text{ mol}$$

Likewise, for Zn

$$n_{m_{\text{Zn}}} = \frac{47 \text{ g}}{65.39 \text{ g/mol}} = 0.719 \text{ mol}$$

Now, use of Equation 4.5 yields

$$C'_{\text{Cu}} = \frac{n_{m_{\text{Cu}}}}{n_{m_{\text{Cu}}} + n_{m_{\text{Zn}}}} \times 100$$

$$= \frac{0.519 \text{ mol}}{0.519 \text{ mol} + 0.719 \text{ mol}} \times 100 = 41.9 \text{ at\%}$$

Also,

$$C'_{\text{Zn}} = \frac{0.719 \text{ mol}}{0.519 \text{ mol} + 0.719 \text{ mol}} \times 100 = 58.1 \text{ at\%}$$

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4.14 This problem calls for a determination of the number of atoms per cubic meter for lead. In order to solve this problem, one must employ Equation 4.2,

$$N = \frac{N_A \rho_{Pb}}{A_{Pb}}$$

The density of Pb (from the table inside of the front cover) is 11.35 g/cm^3, while its atomic weight is 207.2 g/mol. Thus,

$$N = \frac{(6.023 \text{ x } 10^{23} \text{ atoms/mol})(11.35 \text{ g/cm}^3)}{207.2 \text{ g/mol}}$$

$$= 3.30 \text{ x } 10^{22} \text{ atoms/cm}^3 = 3.30 \text{ x } 10^{28} \text{ atoms/m}^3$$

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4.16 We are asked in this problem to determine the approximate density of a Ti-6Al-4V titanium alloy that has a composition of 90 wt% Ti, 6 wt% Al, and 4 wt% V. In order to solve this problem, Equation 4.10a is modified to take the following form:

$$\rho_{ave} = \frac{100}{\dfrac{C_{Ti}}{\rho_{Ti}} + \dfrac{C_{Al}}{\rho_{Al}} + \dfrac{C_{V}}{\rho_{V}}}$$

And, using the density values for Ti, Al, and V—i.e., 4.51 g/cm^3, 2.71 g/cm^3, and 6.10 g/cm^3—(as taken from inside the front cover of the text), the density is computed as follows:

$$\rho_{ave} = \frac{100}{\dfrac{90 \text{ wt\%}}{4.51 \text{ g/cm}^3} + \dfrac{6 \text{ wt\%}}{2.71 \text{ g/cm}^3} + \dfrac{4 \text{ wt\%}}{6.10 \text{ g/cm}^3}}$$

$$= 4.38 \text{ g/cm}^3$$

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4.20 This problem asks us to determine the number of molybdenum atoms per cubic centimeter for a 16.4 wt% Mo-83.6 wt% W solid solution. To solve this problem, employment of Equation 4.18 is necessary, using the following values:

$C_1 = C_{Mo} = 16.4$ wt%
$\rho_1 = \rho_{Mo} = 10.22$ g/cm^3
$\rho_2 = \rho_W = 19.3$ g/cm^3
$A_1 = A_{Mo} = 95.94$ g/mol

Thus

$$N_{Mo} = \frac{N_A C_{Mo}}{\frac{C_{Mo} A_{Mo}}{\rho_{Mo}} + \frac{A_{Mo}}{\rho_W}\left(100 - C_{Mo}\right)}$$

$$= \frac{\left(6.023 \times 10^{23} \text{ atoms/mol}\right)(16.4 \text{ wt\%})}{\frac{(16.4 \text{ wt\%})(95.94 \text{ g/mol})}{10.22 \text{ g/cm}^3} + \frac{95.94 \text{ g/mol}}{19.3 \text{ g/cm}^3}\left(100 - 16.4 \text{ wt\%}\right)}$$

$$= 1.73 \times 10^{22} \text{ atoms/cm}^3$$

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Dislocations—Linear Defects

4.26 The Burgers vector and dislocation line are perpendicular for edge dislocations, parallel for screw dislocations, and neither perpendicular nor parallel for mixed dislocations.

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Interfacial Defects

4.27 The surface energy for a crystallographic plane will depend on its packing density [i.e., the planar density (Section 3.11)]—that is, the higher the packing density, the greater the number of nearest-neighbor atoms, and the more atomic bonds in that plane that are satisfied, and, consequently, the lower the surface energy. From the solution to Problem 3.53, planar densities for FCC (100) and (111) planes are $\frac{1}{4R^2}$ and $\frac{1}{2R^2\sqrt{3}}$, respectively—that is $\frac{0.25}{R^2}$ and $\frac{0.29}{R^2}$ (where *R* is the atomic radius). Thus, since the planar density for (111) is greater, it will have the lower surface energy.

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