1. Callister, 9.13

This problem asks us to consider a specimen of ice I which is at -10°C and 1 atm pressure.

(a) In order to determine the pressure at which melting occurs at this temperature, we move vertically at this temperature until we cross the Ice I-Liquid phase boundary of Figure 9.33. This occurs at approximately 570 atm; thus the pressure of the specimen must be raised from 1 to 570 atm.

(b) In order to determine the pressure at which sublimation occurs at this temperature, we move vertically downward from 1 atm until we cross the Ice I-Vapor phase boundary of Figure 9.33. This intersection occurs at approximately 0.0023 atm.

2. Callister, 9.20

Upon heating a lead-tin alloy of composition 30 wt% Sn-70 wt% Pb from 150°C and utilizing Figure 9.7:

(a) the first liquid forms at the temperature at which a vertical line at this composition intersects the eutectic isotherm—i.e., at 183°C;

(b) the composition of this liquid phase corresponds to the intersection with the (\(\alpha + L\))-L phase boundary, of a tie line constructed across the \(\alpha + L\) phase region just above this eutectic isotherm—i.e., \(C_L = 61.9\) wt% Sn;

(c) complete melting of the alloy occurs at the intersection of this same vertical line at 30 wt% Sn with the (\(\alpha + L\))-L phase boundary—i.e., at about 260°C;

(d) the composition of the last solid remaining prior to complete melting corresponds to the intersection with \(\alpha-(\alpha + L)\) phase boundary, of the tie line constructed across the \(\alpha + L\) phase region at 260°C—i.e., \(C_\alpha\) is about 13 wt% Sn.

3. Callister, 9.23

The copper-gold phase diagram is constructed below.
4. Callister, 9.33

(a) This portion of the problem asks that we determine the mass fractions of $\alpha$ and $\beta$ phases for an 80 wt% Sn-20 wt% Pb alloy (at 180°C). In order to do this it is necessary to employ the lever rule using a tie line that extends entirely across the $\alpha + \beta$ phase field (Figure 9.7), as follows:

$$W_\alpha = \frac{C_\beta - C_\alpha}{C_\beta - C_\alpha} = \frac{97.8 - 80}{97.8 - 18.3} = 0.224$$

$$W_\beta = \frac{C_\alpha - C_\beta}{C_\beta - C_\alpha} = \frac{80 - 18.3}{97.8 - 18.3} = 0.776$$

(b) Now it is necessary to determine the mass fractions of primary $\beta$ and eutectic microconstituents for this same alloy. This requires us to utilize the lever rule and a tie line that extends from the maximum solubility of Pb in the $\beta$ phase at 180°C (i.e., 97.8 wt% Sn) to the eutectic composition (61.9 wt% Sn). Thus

$$W_{\beta'} = \frac{C_\alpha - C_{\text{eutectic}}}{C_\beta - C_{\text{eutectic}}} = \frac{80.0 - 61.9}{97.8 - 61.9} = 0.504$$

$$W_e = \frac{C_\beta - C_\alpha}{C_\beta - C_{\text{eutectic}}} = \frac{97.8 - 80.0}{97.8 - 61.9} = 0.496$$
(c) And, finally, we are asked to compute the mass fraction of eutectic $\beta$, $W_{e\beta}$. This quantity is simply the difference between the mass fractions of total $\beta$ and primary $\beta$ as

$$W_{e\beta} = W_\beta - W_{\beta}' = 0.776 - 0.504 = 0.272$$

5. Callister, 20.5

(a) The two sources of magnetic moments for electrons are the electron's orbital motion around the nucleus, and also, its spin.

(b) All electrons have a net magnetic moment, which arises from orbital and spin contributions.

(c) Not all atoms have a net magnetic moment. If an atom has completely filled electron shells or subshells, there will be a cancellation of both orbital and spin magnetic moments.

6. Callister, 20.7

(a) This portion of the problem calls for us to compute the magnetic susceptibility within a bar of some metal alloy when $M = 1.2 \times 10^6$ A/m and $H = 200$ A/m. This requires that we solve for $\chi_m$ from Equation (20.6) as

$$\chi_m = \frac{M}{H} = \frac{1.2 \times 10^6 \text{ A/m}}{200 \text{ A/m}} = 6000$$

(b) In order to calculate the permeability we must employ Equations (20.4) and (20.7) as follows:

$$\mu = \mu_0 (\chi_m + 1)$$

$$= (1.257 \times 10^{-6} \text{ H/m}) (6000 + 1) = 7.54 \times 10^{-3} \text{ H/m}$$

(c) The magnetic flux density may be determined using Equation (20.2) as

$$B = \mu H = (7.54 \times 10^{-3} \text{ H/m}) (200 \text{ A/m}) = 1.51 \text{ tesla}$$

(d) This metal alloy would exhibit ferromagnetic behavior on the basis of the value of its $\chi_m$ (6000), which is considerably larger than the $\chi_m$ values for diamagnetic and paramagnetic materials listed in Table 20.2.
7. Callister, 20.10

We are to determine the number of Bohr magnetons per atom of a hypothetical metal that has a simple cubic crystal structure, an atomic radius of 0.125 nm, and a saturation flux density of 0.85 tesla. It becomes necessary to employ Equations (20.8) and (20.11) as follows:

\[ M_s = \frac{B_s}{\mu_o} = \frac{n_B \mu_B}{V_C} \]

For the simple cubic crystal structure \( V_C = (2r)^3 \), where \( r \) is the atomic radius. Substituting this relationship into the above equation and solving for \( n_B \) yields

\[ n_B = \frac{B_s (8r^3)}{\mu_o \mu_B} \]

\[ = \frac{(0.85 \text{ tesla})(8)(0.125 \times 10^{-9} \text{ m})^3}{(1.257 \times 10^{-6} \text{ H/m})(0.27 \times 10^{-24} \text{ A} \cdot \text{m}^2 / \text{BM})} = 1.14 \text{ Bohr magnetons/atom} \]