3.12 This problem asks that we calculate the theoretical densities of Al, Ni, Mg, and W.

Since Al has an FCC crystal structure, $n = 4$, and $V_C = 16R^3\sqrt{2}$ (Equation 3.4). Also, $R = 0.143$ nm (1.43 x 10^{-8} cm) and $A_{\text{Al}} = 26.98$ g/mol. Employment of Equation 3.5 yields

$$\rho = \frac{nA_{\text{Al}}}{V_C N_{\text{A}}}$$

$$= \frac{(4 \text{ atoms/unit cell})(26.98 \text{ g/mol})}{\left\{\left[(2)(1.43 \text{ x } 10^{-8} \text{ cm})(\sqrt{2})\right]^3/(\text{unit cell})\right\}(6.023 \text{ x } 10^{23} \text{ atoms/mol})}$$

$$= 2.71 \text{ g/cm}^3$$

The value given in the table inside the front cover is 2.71 g/cm^3.

Nickel also has an FCC crystal structure and therefore

$$\rho = \frac{(4 \text{ atoms/unit cell})(58.69 \text{ g/mol})}{\left\{\left[(2)(1.25 \text{ x } 10^{-8} \text{ cm})(\sqrt{2})\right]^3/(\text{unit cell})\right\}(6.023 \text{ x } 10^{23} \text{ atoms/mol})}$$

$$= 8.82 \text{ g/cm}^3$$

The value given in the table is 8.90 g/cm^3.

Magnesium has an HCP crystal structure, and from the solution to Problem 3.6,

$$V_C = \frac{3\sqrt{3}\, a^2 c}{2}$$

and, since $c = 1.624a$ and $a = 2R = 2(1.60 \text{ x } 10^{-8} \text{ cm}) = 3.20 \text{ x } 10^{-8}$ cm

$$V_C = \frac{(3\sqrt{3})(1.624)(3.20 \text{ x } 10^{-8} \text{ cm})^3}{2} = 1.38 \text{ x } 10^{-22} \text{ cm}^3/\text{unit cell}$$

Also, there are 6 atoms/unit cell for HCP. Therefore the theoretical density is

$$\rho = \frac{nA_{\text{Mg}}}{V_C N_{\text{A}}}$$