Chapter 1

Problem Solutions

1.1

(a) fcc: 8 corner atoms × 1/8 = 1 atom
6 face atoms × ½ = 3 atoms
Total of 4 atoms per unit cell

(b) bcc: 8 corner atoms × 1/8 = 1 atom
1 enclosed atom = 1 atom
Total of 2 atoms per unit cell

(c) Diamond: 8 corner atoms × 1/8 = 1 atom
6 face atoms × ½ = 3 atoms
4 enclosed atoms = 4 atoms
Total of 8 atoms per unit cell

1.2

(a) 4 Ga atoms per unit cell

$$\text{Density} = \frac{4}{(5.65\times10^{-8})^3} \Rightarrow$$

$$\underline{\text{Density of Ga}} = 2.22\times10^{22}\ cm^{-3}$$

4 As atoms per unit cell, so that

$$\underline{\text{Density of As}} = 2.22\times10^{22}\ cm^{-3}$$

(b) 8 Ge atoms per unit cell

$$\text{Density} = \frac{8}{(5.65\times10^{-8})^3} \Rightarrow$$

$$\underline{\text{Density of Ge}} = 4.44\times10^{22}\ cm^{-3}$$

1.3

(a) Simple cubic lattice; $a = 2r$

$$\text{Unit cell vol} = a^3 = (2r)^3 = 8r^3$$

$$\text{1 atoms per cell, so atom vol.} = (1)\left(\frac{4\pi r^3}{3}\right)$$

Then

$$Ratio = \frac{\left(\frac{4\pi r^3}{3}\right)}{8r^3}\times100\% \Rightarrow \quad \underline{Ratio = 52.4\%}$$

(b) Face-centered cubic lattice

$$d = 4r = a\sqrt{2} \Rightarrow \quad a = \frac{d}{\sqrt{2}} = 2\sqrt{2}\,r$$

$$\text{Unit cell vol} = a^3 = \left(2\sqrt{2}\,r\right)^3 = 16\sqrt{2}\,r^3$$

$$\text{4 atoms per cell, so atom vol.} = 4\left(\frac{4\pi r^3}{3}\right)$$

Then

$$Ratio = \frac{4\left(\frac{4\pi r^3}{3}\right)}{16\sqrt{2}\,r^3}\times100\% \Rightarrow \quad \underline{Ratio = 74\%}$$

(c) Body-centered cubic lattice

$$d = 4r = a\sqrt{3} \Rightarrow a = \frac{4}{\sqrt{3}}r$$

$$\text{Unit cell vol.} = a^3 = \left(\frac{4}{\sqrt{3}}r\right)^3$$

$$\text{2 atoms per cell, so atom vol.} = 2\left(\frac{4\pi r^3}{3}\right)$$

Then

$$Ratio = \frac{2\left(\frac{4\pi r^3}{3}\right)}{\left(\frac{4r}{\sqrt{3}}\right)^3}\times100\% \Rightarrow \quad \underline{Ratio = 68\%}$$

(d) Diamond lattice

$$\text{Body diagonal} = d = 8r = a\sqrt{3} \Rightarrow a = \frac{8}{\sqrt{3}}r$$

$$\text{Unit cell vol.} = a^3 = \left(\frac{8r}{\sqrt{3}}\right)^3$$

$$\text{8 atoms per cell, so atom vol.} = 8\left(\frac{4\pi r^3}{3}\right)$$

Then

$$Ratio = \frac{8\left(\frac{4\pi r^3}{3}\right)}{\left(\frac{8r}{\sqrt{3}}\right)^3}\times100\% \Rightarrow \quad \underline{Ratio = 34\%}$$

1.4

From Problem 1.3, percent volume of fcc atoms is 74%; Therefore after coffee is ground,

$$\text{Volume} = 0.74\ cm^3$$

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Joacim Rocklöv

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