

Chapter 1

Problem Solutions

1.1

- (a) fcc: 8 corner atoms $\times 1/8 = 1$ atom
6 face atoms $\times 1/2 = 3$ atoms
Total of 4 atoms per unit cell

- (b) bcc: 8 corner atoms $\times 1/8 = 1$ atom
1 enclosed atom $= 1$ atom
Total of 2 atoms per unit cell

- (c) Diamond: 8 corner atoms $\times 1/8 = 1$ atom
6 face atoms $\times 1/2 = 3$ atoms
4 enclosed atoms $= 4$ atoms
Total of 8 atoms per unit cell

1.2

- (a) 4 Ga atoms per unit cell

$$\text{Density} = \frac{4}{(5.65 \times 10^{-8})^3} \Rightarrow$$

$$\underline{\text{Density of Ga} = 2.22 \times 10^{22} \text{ cm}^{-3}}$$

4 As atoms per unit cell, so that

$$\underline{\text{Density of As} = 2.22 \times 10^{22} \text{ cm}^{-3}}$$

- (b)

8 Ge atoms per unit cell

$$\text{Density} = \frac{8}{(5.65 \times 10^{-8})^3} \Rightarrow$$

$$\underline{\text{Density of Ge} = 4.44 \times 10^{22} \text{ cm}^{-3}}$$

1.3

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

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

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

Then

$$\text{Ratio} = \frac{\left(\frac{4\pi r^3}{3} \right)}{8r^3} \times 100\% \Rightarrow \underline{\text{Ratio} = 52.4\%}$$

- (b) Face-centered cubic lattice

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

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

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

Then

$$\text{Ratio} = \frac{4 \left(\frac{4\pi r^3}{3} \right)}{16\sqrt{2}r^3} \times 100\% \Rightarrow \underline{\text{Ratio} = 74\%}$$

- (c) Body-centered cubic lattice

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

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

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

Then

$$\text{Ratio} = \frac{2 \left(\frac{4\pi r^3}{3} \right)}{\left(\frac{4}{\sqrt{3}}r \right)^3} \times 100\% \Rightarrow \underline{\text{Ratio} = 68\%}$$

- (d) Diamond lattice

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

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

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

Then

$$\text{Ratio} = \frac{8 \left(\frac{4\pi r^3}{3} \right)}{\left(\frac{8}{\sqrt{3}}r \right)^3} \times 100\% \Rightarrow \underline{\text{Ratio} = 34\%}$$

1.4

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

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

Problem Physics Manual

**United States. Department of the
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