CHAPTER I
THE CRYSTALLINE STATE

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4. ATOMIC PACKING FACTOR (APF)

Definition: It is the ratio of volume of atoms in unit cell to the total volume of unit cell.

APF = \frac{\text{volume of atoms in unit cell}}{\text{total volume of unit cell}}

APF for SC

Number of atoms per unit cell = z = 1

Side of the unit cell = a = 2r

Volume of one atom = \frac{4}{3} \cdot \pi r^3

Volume of unit cell = a^3

APF = 1 \times \left(\frac{4}{3} \cdot \pi r^3\right) / a^3 = \frac{\pi}{6} = 0.52

Hence APF for SC = \frac{\pi}{6} = 0.52
**ATOMIC PACKING FACTOR (APF) FOR BCC**

- **Definition:** It is the ratio of volume of atoms in unit cell to the total volume of unit cell.
- **APF** = volume of atoms in unit cell/ total volume of unit cell

**APF for BCC:**

- Number of atoms per unit cell = \( z = 2 \)
- Side of the unit cell = \( a = \frac{4r}{\sqrt{3}} \)
- Volume of one atom = \( \frac{4}{3} \pi r^3 \)
- Volume of unit cell = \( a^3 \)

\[
\text{APF} = \frac{2 \times \left( \frac{4}{3} \pi r^3 \right)}{\left( \frac{4r}{\sqrt{3}} \right)^3} = \frac{\sqrt{3} \pi}{8} = 0.68
\]

Hence APF for SC = \( \sqrt{3} \pi / 8 = 0.68 \)

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**Definition:** It is the ratio of volume of atoms in unit cell to the total volume of unit cell.

APF = volume of atoms in unit cell/ total volume of unit cell

APF for FCC:

Number of atoms per unit cell = z = 4

Side of the unit cell = a = 4r/√2

Volume of one atom = 4/3. Πr³

Volume of unit cell = a³

APF = 4x(4/3. Πr³)/(4r/√2)³ = √2. Π/6 = 0.74

Hence APF for SC = √2. Π/6 = 0.74
5. DENSITY OF CRYSTAL (\(\rho\))

- As unit cell possesses all the structural properties of a bulk crystal, the density of unit cell must be same as the bulk crystal density.
- We knew that \(\rho = \text{mass}/\text{volume}\)
- \(\rho = \frac{z \cdot w}{V}\)
- Where \(z\) is number of atoms per unit cell
- \(w = \text{mass of each atom}\)
- \(V = \text{volume of unit cell}\)
- As, \(w = \frac{\text{Molecular weight of the material}}{N_a}\)
- Where, \(N_a = \text{Avogadro’s constant}\)
5. DENSITY OF CRYSTAL ($\rho$)....

\[ w = \frac{M}{N_a} \]
\[ \rho = \frac{z \cdot M}{N_a \cdot V} \]

1. Density of SC: \( z = 1 \), \( V = a^3 \)
\[ \rho = \frac{z \cdot M}{N_a \cdot V} \]
\[ \rho = \frac{M}{N_a} \cdot a^3 \]

2. Density of BCC: \( z = 2 \), \( V = a^3 \)
\[ \rho = \frac{2M}{N_a \cdot A^3} \]

3. Density of FCC: \( z = 2 \), \( V = a^3 \)
\[ \rho = \frac{4M}{N_a \cdot a^3} \]