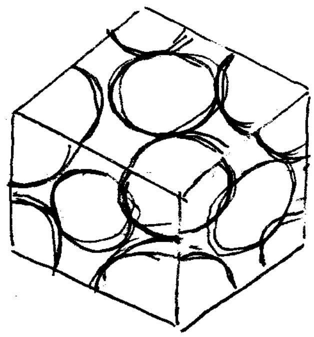
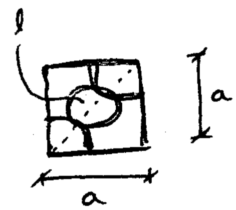
Sep. 17/18

Show the APF for the FCC unit cell is 0.74





$l^2 = a^2 + a^2 \Rightarrow l = \sqrt{2}a$

$\Rightarrow 4R$

$R = \sqrt{2}/4\,a = \frac{1}{2\sqrt{2}}a - \nu a$

$= 2\sqrt{2}R$

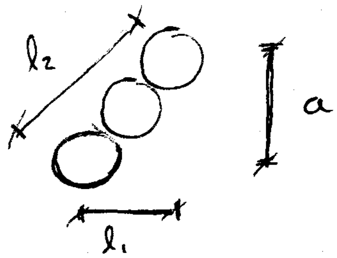
$$APF = \frac{4 \times \frac{4}{3}\pi R^3}{(2\sqrt{2}R)^3} = 0.74$$

Body-centered cubic (BCC) : atoms located at center and at the corners

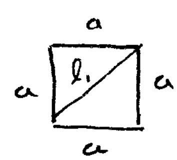
$N = 1 + (8 \times 1/8) = 2$

$CN = 8$ (touching 8 atoms)

Show that the APF for BCC unit cell is 0.68



(diagonally, along point of contact)



$\Rightarrow l_1^2 = a^2 + a^2$

$l_1 = \sqrt{2}a$

$l_2^2 = (\sqrt{2}a)^2 + a^2$

$l_2^2 = 2a^2 + a^2 \Rightarrow l_2^2 = 3a^2$

$l_2 = \sqrt{3}a$

$l_2 = \sqrt{3}a = 4R$

$\rightarrow a = 4R/\sqrt{3}$

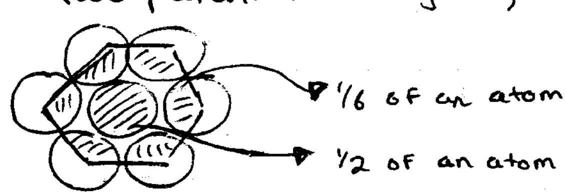
$$APF = \frac{2 \times \frac{4}{3} \times \pi \times R^3}{(4R/\sqrt{3})^3} = \frac{\pi\sqrt{3}}{8}$$

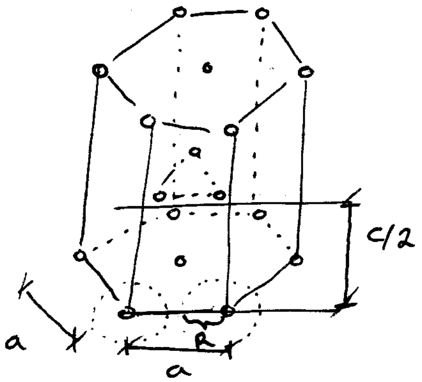
$= 0.68$

Hexagonal close-packed (HCP) : two parallel hexagons, (with atom in center) mid-plane with 3-atoms

$N = 3 + (1/6 \times 12) + (1/2 \times 2) = 6$

$CN = 12$ (touching 12 atoms)



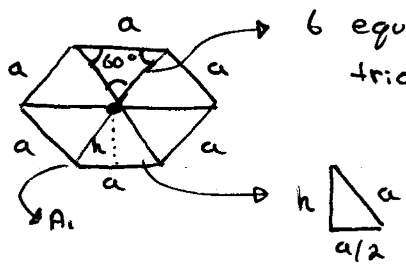


a, c, R

$a = 2R$

$c = 1.63\overline{3}$

Calculate the volume of an HCP unit cell



$A_1 = \dfrac{a \times h}{2}$

$a^2 = h^2 + \left(\frac{a}{2}\right)^2 \longrightarrow h = \left(\sqrt{3}/2\right)a$

$A_1 = \sqrt{3}/4\, a^2$

$A_t = 6 \times A_1 = 6\left(\sqrt{3}/4\right)a^2 = 3\left(\sqrt{3}/2\right)a^2$

$A_t = \dfrac{3\sqrt{3}}{2}(2R)^2 = 6\sqrt{3}R^2$

$V = A_t \times c = 6\sqrt{3}R^2 c$

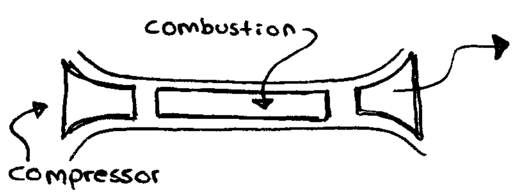
1.633

$APF = \dfrac{6 \times 4/3\, \pi R^3}{6\sqrt{3}R^2 c}$

apf = 0.74

(Problems 3.4 and 3.6 deal with this)

Crystal Structures / Single Crystals



Cr
W → creep resistance
Co

anisotropic – directionality of properties

two or more distinct crystal structures for the same materials (allotropy / polymorphism)

↳ elemental solids

Steel: (≈ 1% C) Cast Iron (< 4.5% C)

Austenite

→ Slow cooling : pearlite

medium cooling : bainite

Fast cooling : Martensite