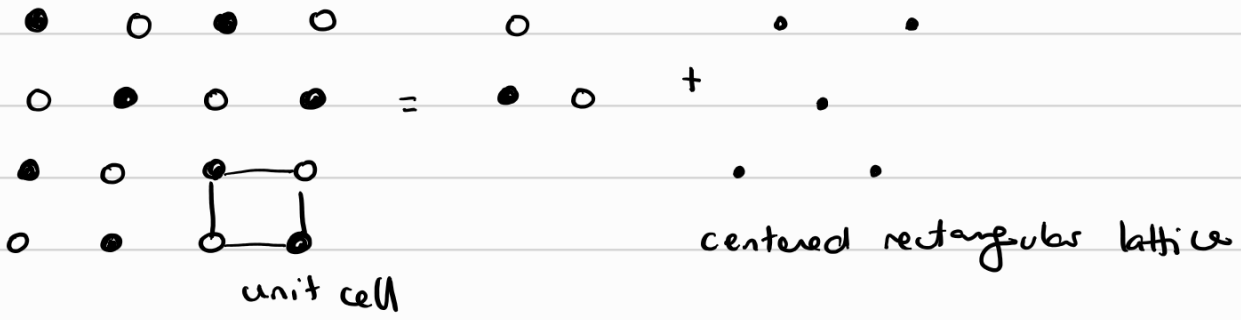
1) i)



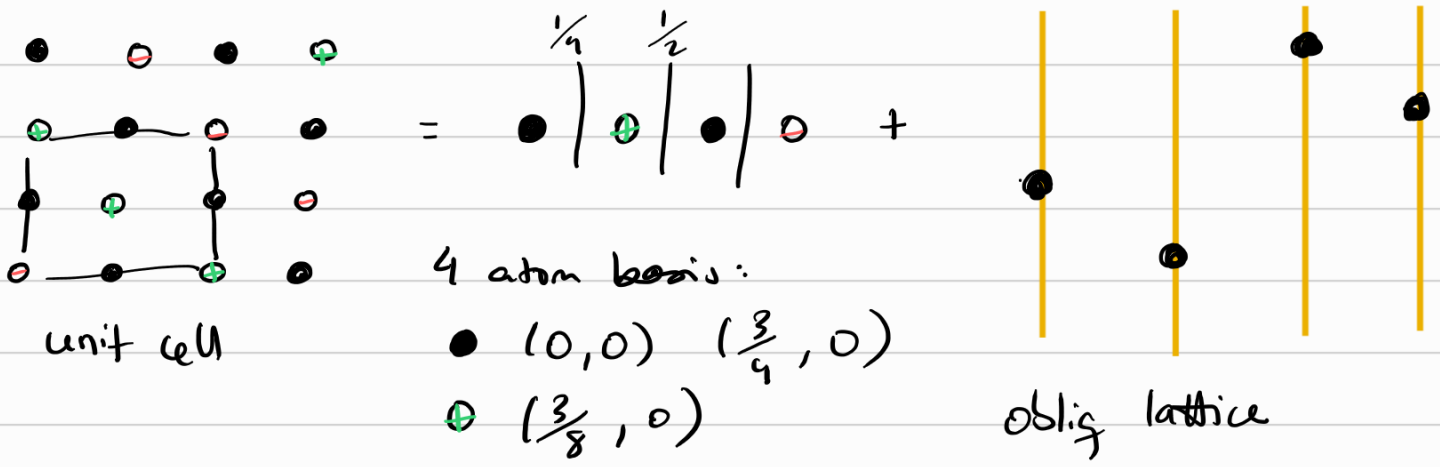
unit cell

centered rectangular lattice

3 atom basis: • (0,0)

o (1,0), (0,1)

ii)



unit cell

4 atom basis:

• (0,0) (3/4, 0)

⊕ (3/8, 0)

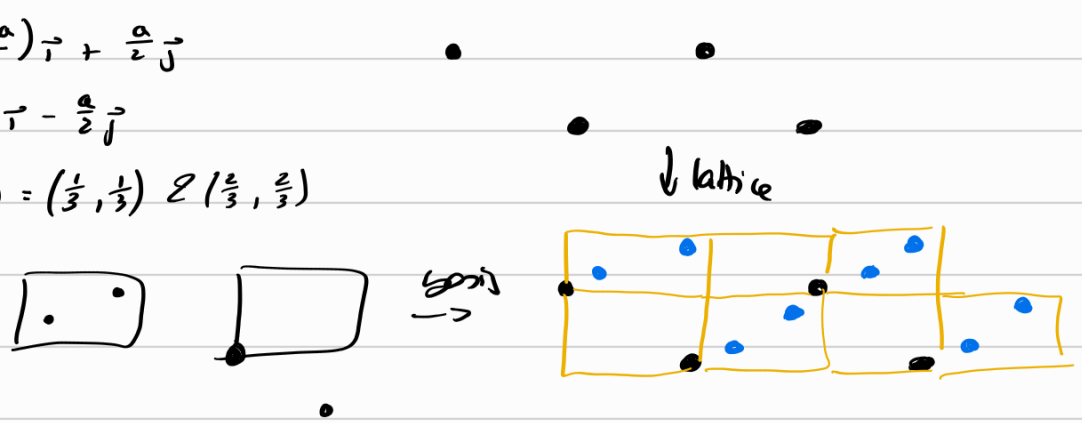
⊖ (1,0)

oblig lattice

2) $\vec{a} = \left(\frac{\sqrt{3}a}{2}\right)\vec{i} + \frac{a}{2}\vec{j}$

$\vec{b} = \frac{\sqrt{3}a}{2}\vec{i} - \frac{a}{2}\vec{j}$

basis $(u,v) = (\frac{1}{3}, \frac{1}{3})$ & $(\frac{2}{3}, \frac{2}{3})$

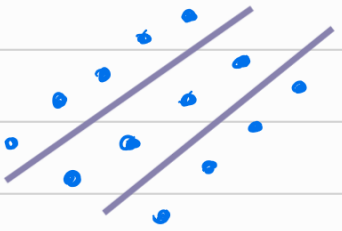


hexagonal

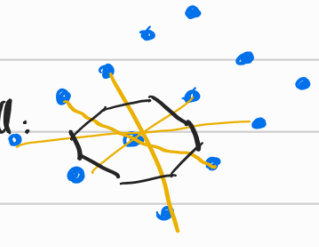
mirror plans

rotations 60°, 120, 180, ...

no inver° symetry

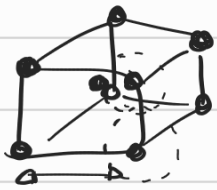


Weigner cell:



3) not in the mood

4) i) bcc



a) $R_{nn} = \frac{\sqrt{3}a}{2}$ → atomic rad = $\frac{\sqrt{3}a}{4}$ ✓

b) $V_{atom} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi \frac{3\sqrt{3}a^3}{4^3} = \frac{\sqrt{3}}{4^2}\pi a^3$

$V_{\square} = a^3$ $\quad \frac{V_{atom}}{V_{\square}} = \frac{\sqrt{3}}{16}\pi$

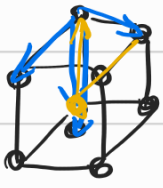
Good AY guidance

2 atoms bcc ∴ $PF = 2 \times \frac{\sqrt{3}}{16}\pi \approx 0.68$ ✓

c) $V_{atom} = \frac{\sqrt{3}}{16}\pi$

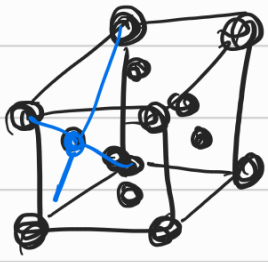
$2 \times V_{atom} = \frac{\sqrt{3}}{8}\pi$

d)



Coordinat° n° = 4

ii) fcc



a) $R_{nn} = \frac{a}{\sqrt{2}}$ $\quad r_{atom} = \frac{a}{2\sqrt{2}}$

b) $V_{atom} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi \frac{a^3}{2^4\sqrt{2}}$

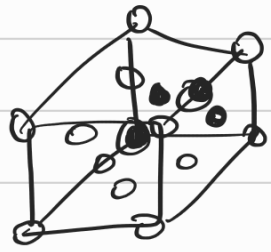
$\frac{V_{atom}}{V_{cell}} = \frac{\frac{\pi}{3}\frac{a^3}{4\sqrt{2}}}{a^3} = \frac{\pi}{3 \cdot 4\sqrt{2}}$

$4 \times \frac{V_{atom}}{V_{cell}} = \frac{\pi}{3\sqrt{2}} \approx 0.74 = PF$

c) $4 \times V_{atom} = \frac{\pi a^3}{3\sqrt{2}}$

d) 4 = coord n°

iii)



a) $R_{nn} = \frac{\sqrt{3}a}{4}$, $r = \frac{\sqrt{3}}{8}a$

b) $V_{at} = \frac{4}{3}\pi r^3 = \frac{4}{8}\pi \frac{3\sqrt{3}}{4\sqrt{2}\cdot 8^2}a = \frac{\pi\sqrt{3}\,a^3}{2\cdot 8^2}$

$8 \times \frac{V_{at}}{V_{FCC}} = \frac{\pi\sqrt{3}\,a^3}{2\cdot 8^2} = \frac{\pi\sqrt{3}}{2\cdot 8^2} \times 8 \simeq 0.384 = PF$

Diamond
8 atoms
basis

c) $V_{at} = \frac{\pi\sqrt{3}\,a^3}{2\cdot 8^2}$ $\frac{a^3}{2}$

$8 \times V_{at} = \frac{\pi\sqrt{3}\,a^3}{16}$

d) coord n° = 6 8

5) $\vec{a} = a\vec{i}$

$\vec{b} = \frac{a}{2}\vec{i} + \frac{\sqrt{3}a}{2}\vec{j}$

$\vec{c} = c\vec{k}$

$a = 2.461\ \text{Å}$

$c = 6.708\ \text{Å}$

at $(u,v,w) = (\frac{1}{3}, \frac{1}{3}, 0), (\frac{2}{3}, \frac{2}{3}, 0), (\frac{1}{3}, \frac{1}{3}, \frac{1}{2}), (0, 0, \frac{1}{2})$

density $\simeq 2.2\,g/cm^3$

i) $V = |\vec{a}\cdot(\vec{b}\times\vec{c})| = \left|\begin{pmatrix} a/2 \\ 0 \\ 0 \end{pmatrix} \cdot \left(\begin{pmatrix} a/2 \\ \sqrt{3}a/2 \\ 0 \end{pmatrix} \times \begin{pmatrix} 0 \\ 0 \\ c \end{pmatrix}\right)\right|$

$= \left(\begin{pmatrix} a/2 \\ 0 \\ 0 \end{pmatrix} \cdot \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ a/2 & \sqrt{3}\frac{a}{2} & 0 \\ 0 & 0 & c \end{vmatrix}\right)$

$= \left(\begin{pmatrix} a/2 \\ 0 \\ 0 \end{pmatrix} \cdot \begin{pmatrix} \frac{\sqrt{3}a}{2}c \\ \frac{a}{2}c \\ 0 \end{pmatrix}\right)$

redo

$= \frac{\sqrt{3}\,a^2}{4}c + \frac{a^2}{4}c$

$$= \frac{a^2}{4} c \left(\sqrt{3}+1\right)$$

$$V \simeq \cancel{27.73}\ 35.18\ \text{Å}^3$$

ii) 14.4 g $\quad 1\text{Å} = 10^{-10}\ m$

$$\text{density} = \frac{\text{weight}}{\text{vol}} = \frac{2.2\ g}{1\ cm^3}$$

✓ right tech wrong n° ply

$$\text{weight} = 14.4\ g \quad \therefore \text{vol} = \frac{14.4}{2.2} = 6.54\ cm^3$$

$$N^\circ \text{cells} = \frac{\text{Vol pen}}{\text{Vol cell}} = \frac{6.54}{27.73 \times 10^{-9}} \simeq 2.36 \times 10^{8}$$

Atoms/cell = 4 $\quad \therefore$ the pen contains 9.44×10^8 atoms

---

Retry (i)-(ii)

(i) $V = |\vec{a} \cdot (\vec{b} \times \vec{c})| = \left| \begin{pmatrix} a/2 \\ 0 \\ 0 \end{pmatrix} \cdot \left(\begin{pmatrix} a/2 \\ \sqrt{3}a/2 \\ 0 \end{pmatrix} \times \begin{pmatrix} 0 \\ 0 \\ c \end{pmatrix} \right) \right|$

$$\vec{b} \times \vec{c} = \begin{pmatrix} a/2 \\ \sqrt{3}a/2 \\ 0 \end{pmatrix} \times \begin{pmatrix} 0 \\ 0 \\ c \end{pmatrix} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ a/2 & \sqrt{3}a/2 & 0 \\ 0 & 0 & c \end{vmatrix} = \frac{\sqrt{3}a}{2} c\vec{i} - \frac{a}{2} c\vec{j}$$

$$V = \vec{a} \cdot (\vec{b} \times \vec{c}) = \begin{pmatrix} a \\ 0 \\ 0 \end{pmatrix} \cdot \frac{a}{2} c \begin{pmatrix} \sqrt{3} \\ 1 \\ 0 \end{pmatrix} = \frac{a}{2} c \left(\sqrt{3}a\right)$$

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

$$V \simeq \frac{(2.461)^2}{2} 6.708 (\sqrt{3})$$

$$= 35.18\ \text{Å}^3$$

$\text{Å} \xrightarrow{10^{-8}} cm$

$\text{Å}^3 \xrightarrow{(10^{-8})^3} cm^3 \quad 10^{-24}$

ii) 14.4 g $\quad 1\text{Å} = 10^{-10}\ m$

$$\text{density} = \frac{\text{weight}}{\text{vol}} = \frac{2.2\ g}{1\ cm^3}$$

$$\text{weight} = 14.4\ g \quad \therefore \text{vol} = \frac{14.4}{2.2} = 6.54\ cm^3$$

$$N^\circ \text{ cells} = \frac{\text{Vol pen}}{\text{Vol cell}} = \frac{6.54}{35.18 \times 10^{-10}} \simeq 1.86 \times 10^{23} \text{ cm}^3$$

Atoms / cell = 4 ∴ the pen contains 7.44×10^{23} atoms

(iii) $A = |\vec{a} \times \vec{b}|$

$$= \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ a & 0 & 0 \\ a/2 & \sqrt{3}a/2 & 0 \end{vmatrix}$$

$$= a^2 \frac{\sqrt{3}}{2} \vec{k}$$

$$= 5.24 \text{ Å}^2$$

(iv) Carbon

$A = 5.24 \text{ Å}^2$ / unit cell

7.44×10^{23} atom ÷ 2 atom / unit cell $= 3.72 \times 10^{23}$ unit cells

$A_{\text{unit cell}} \times N^\circ_{\text{unit cells}} = A = 1.95 \times 10^{24} \text{ Å}^2$

MAKE SURE U WORK WITH AREAS / VOLS OF ONLY ATOMS OR ONLY UNIT CELLS

v) $1500 \mu m^2 - 500 \S$

$A = 1.95 \times 10^{24} \text{ Å}^2$

$= 1.95 \times 10^{24} \times (10^{-8})^2$

$= 1.95 \times 10^{8} \text{ cm}^2$ → D

$= 1.95 \times 10^{22} \mu m^2$

$\frac{1.95 \times 10^{4}}{1500 \times 10^{-12}}$

$1500 \mu m^2 - \S 500$

1.95×10^{22} — $\S 6.5 \times 10^{12}$

6) fcc $a = 3.615\ \text{Å}$

4 atom basis

$V = 1\ cm^3$

$$V_{fcc} = \frac{a^3}{4} = 11.81\ \text{Å}^3$$

$$= 11.81 \times 10^{-24}\ cm^3$$

seem to be doing a lot of unit conversion mistakes in 1st the following

$$N°\ fcc\ cells = \frac{V_{Cu}}{V_{fcc}} = 8.47 \times 10^{22}$$

$\therefore$ N cells x Atoms per cell = Atoms in Cu $= 3.39 \times 10^{23}$

$$\text{Density} = \frac{\text{Mass}}{\text{Vol}} = \frac{\text{Atoms}}{}$$

Na

atomic weight $23 = 3.818 \times 10^{-26}$

bcc

$a = 4.23\ \text{Å}$

$$\text{Density} = \frac{\text{mass}}{\text{vol}}$$

$$Vol_{bcc} = \frac{a^3}{2} = \frac{(4.23 \times 10^{-8})^3_m}{2} = 3.78 \times 10^{-23}\ m^3$$

Mass = N° atoms x atomic weight

N° atoms bcc cell = 2

$V_{measured} = a^3$

not needed

$$N_{cells} = \frac{V_{measured}}{V_{bcc}} = \frac{a^3}{\frac{a^3}{2}} = 2$$

rounds!

N° atoms = N cells × N atoms per cell

= 4

Mass = ~~½~~ × 3.818×10^{-26} Kg = 1.53×10^{-25} Kg

RED ex (6)

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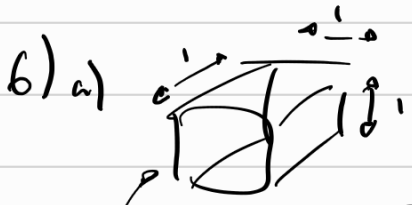
6) a)



? a = 3.615 Å

n° atom

Fcc 4 atoms / basis

vol fcc = a^3

$\frac{V_{tot}}{V_{fcc}} = \frac{(0.01)^3}{(3.615 \times 10^{-10})^3}$

$= 2.12 \times 10^{22} = \frac{n^\circ fcc}{V_{tot}}$

Tot at = $\frac{n^\circ fcc}{V_{tot}} \times$ fcc basis (4) = 8.47×10^{22} ✓

$V_{struct} \neq V_{cell}$

$\geq$ Vol occ atoms

b) Atomic weight 23 amu = 3.82×10^{-26} Kg

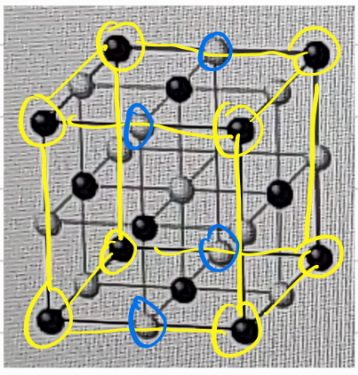
bcc ∴ 2 atoms per basis

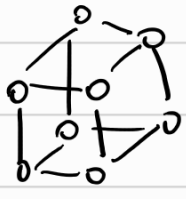
a = 4.23 Å

Density = $\frac{mass}{vol} = \frac{2 \times 3.82 \times 10^{-26}}{(4.23)^3} = 1.01 \times 10^{3}$ ~~m Kg~~ $^{-1}$ ✓

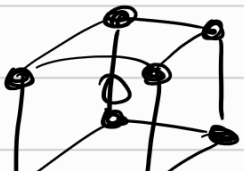
Kg / m^3

7)





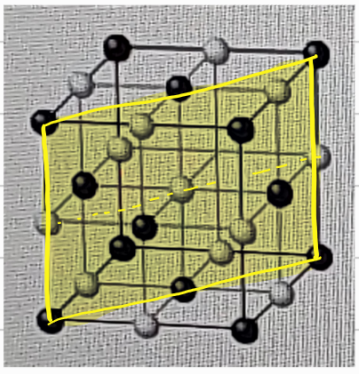
8) Cs Cl

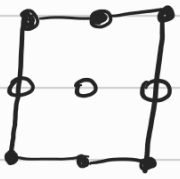


[111] Cl ✓

[210] Cs ✓

9)





• (0,0) $(\frac{1}{2}, 0)$ (1, 0)

(0,1) $(\frac{1}{2}, 1)$ (1,1)

o $(\frac{1}{2}, 0)$ $(\frac{1}{2}, \frac{1}{2})$ $(1, \frac{1}{2})$

basis + lattice

2 atom ✓

• (0,0)

o $(0, \frac{1}{2})$ ½

rectangular ✓

10) [d]