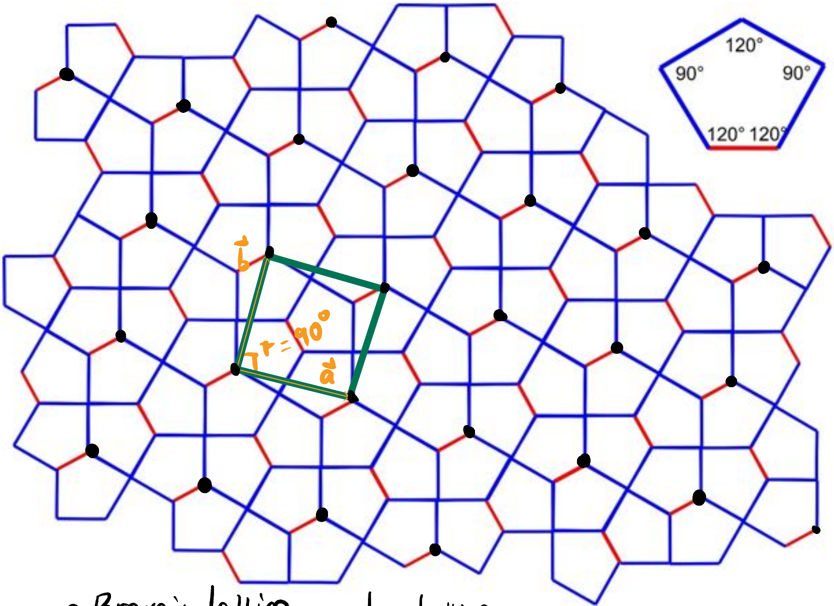
1.1 In a Cairo tiling, a two-dimensional plane is fully filled by pentagons. The geometry of a single pentagon is formed by four identical side length (blue) and one different side length (red) and angles of 90° and 120°.

(a) Determine the 2D Bravais lattice of the Cairo tiling.

(b) Draw the unit cell vectors **a** → and **b** → and the enclosed angle γ.

(c) Determine γ.

(d) How many tiles are within one unit cell?



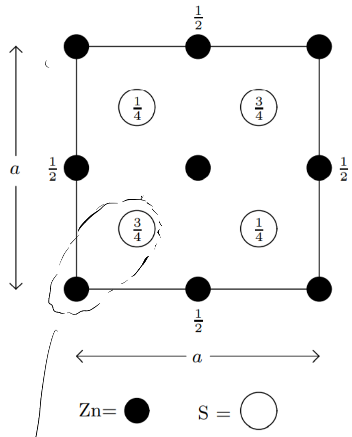
(a) • Bravais lattice, cubic lattice.

(b)(c). As I shown in the figure. $\gamma = 90°$

(d) 4. tiles,

1.2 The diagram of Figure shows a plan view of a structure of cubic ZnS (zincblende) looking down the z axis. The numbers attached to some atoms represent the heights of the atoms above the z = 0 plane expressed as a fraction of the cube edge a. Unlabeled atoms are at z = 0 and z = a.

(a) What is the Bravais lattice type?
(b) Describe the basis.



(c) Given that a = 0.541 nm, calculate the nearest neighbor Zn–Zn, Zn–S, and S–S distances.

(a) FCC

(b) Zn(0, 0, 0)
S$(\frac{1}{4}, \frac{1}{4}, \frac{3}{4})$

(c) $\Delta^{min}_{Zn\text{-}Zn} = \left[\left(\frac{a}{2}\right)^2 + \left(\frac{a}{2}\right)^2\right]^{\frac{1}{2}} = \frac{a}{\sqrt{2}} \doteq 0.3827\,nm$

$\Delta^{min}_{Zn\text{-}S} = \left[\left(\frac{a}{4}\right)^2 + \left(\frac{a}{4}\right)^2 + \left(\frac{a}{4}\right)^2\right]^{\frac{1}{2}} = \frac{\sqrt{3}a}{4} \doteq 0.2345\,nm$

$\Delta^{min}_{S\text{-}S} = \left[\left(\frac{a}{2}\right)^2 + \left(\frac{a}{2}\right)^2\right]^{\frac{1}{2}} = \frac{a}{\sqrt{2}} \doteq 0.3827\,nm.$

1.3 Fluorine can crystalize into a so-called beta phase at temperatures between 45 and 55 Kelvin. Figure below shows the cubic conventional unit cell for beta phase fluorine in three-dimensional form along with a plan view.

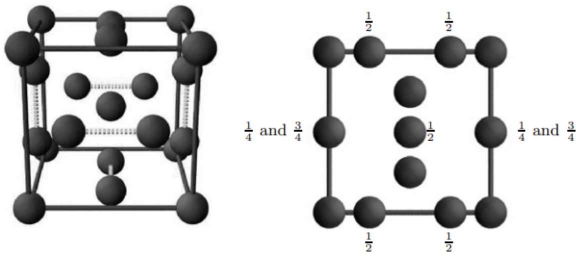


Figure. A conventional unit cell for fluorine beta phase. All atoms in the picture are fluorine. Lines are drawn for clarity Top: Three-dimensional view. Bottom: Plan view. Unlabeled atoms are at height 0 and 1 in units of the lattice constant.

(a) How many atoms are in this conventional unit cell? (a) $8\times\frac{1}{8}+12\times\frac{1}{2}+1=8$

(b) What is the lattice type? (b) Simple cubic (SC)

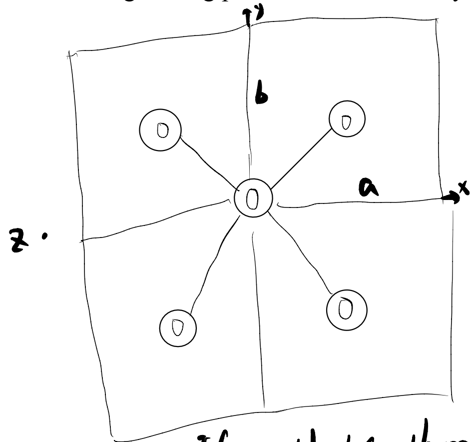
(c) What is the basis for this crystal?

(c) basis: $[0,0,0]$ $[0,\frac{1}{2},\frac{1}{4}]$ $[0,\frac{1}{2},\frac{3}{4}]$ $[\frac{1}{4},0,\frac{1}{2}]$ $[\frac{3}{4},0,\frac{1}{2}]$ $[\frac{1}{2},\frac{1}{4},0]$ $[\frac{1}{2},\frac{3}{4},0]$. $[\frac{1}{2},\frac{1}{2},\frac{1}{2}]$

1.4 Neighbors in the Face-Centered Lattice.

(a) Show that each lattice point in an fcc lattice has twelve nearest neighbors, each the same distance from the initial point. What is this distance if the conventional unit cell has lattice constant a?

(b) Now stretch the side lengths of the fcc lattice such that you obtain a face-centered orthorhombic lattice where the conventional unit cell has sides of length a, b, and c which are all different. What are the distances to these twelve neighboring points now? How many nearest neighbors are there?



(a) $D=\left[(\frac{a}{2})^2+(\frac{a}{2})^2\right]^{\frac{1}{2}}=\frac{a}{\sqrt{2}}$

(b) $D_{x\text{-}y}=\left[(\frac{a}{2})^2+(\frac{b}{2})^2\right]^{\frac{1}{2}}=\frac{\sqrt{a^2+b^2}}{2}$

$D_{x\text{-}z}=\frac{\sqrt{a^2+c^2}}{2}$

$D_{y\text{-}z}=\frac{\sqrt{b^2+c^2}}{2}$

x-y, x-z, y-z denote the corresponding plane.

If $a\neq b\neq c$, there are 4 nearest neighbors now.

And $D=\min\{D_{x\text{-}y}, D_{x\text{-}z}, D_{y\text{-}z}\}$.