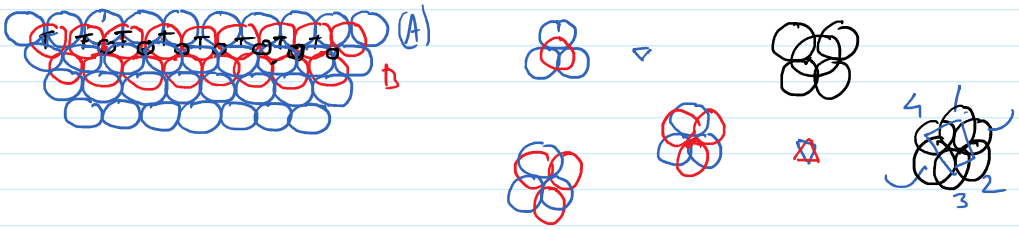
Three dimensional close packing from two dimensional hexagonal close packed layers



a) Placing second layer over the first layer

i) Take a two dimensional hexagonal close packed layer 'A' and place a similar layer above it such that the spheres of the second layer are placed in the depressions of the first layer.

ii) The spheres of the two layers are aligned differently let us call the second layer as 'B'.

iii) Not all the triangular voids of the first layer are covered by the spheres of the second layer. This gives rise to different arrangements:

- Whenever a sphere of the second layer is above the void of the first layer (or vice versa) a tetrahedral void is formed (marked as T in figure). These voids are called tetrahedral voids because a tetrahedron is formed when the centres of these four spheres are joined.
- At other places, the triangular void in the second layer are above the triangular voids in the first layer, and the triangular shapes of these do not overlap. One of them has the apex of the triangle pointing

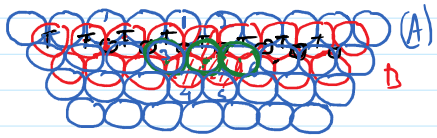
upwards and the other downwards. Such voids are surrounded by six spheres and are called octahedral voids. (marked as O in figure).

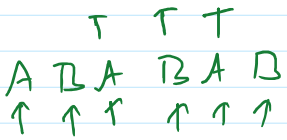
ii) Let the number of close packed spheres be N, then:
The number of octahedral voids generated = N.
the number of tetrahedral voids generated = 2N.

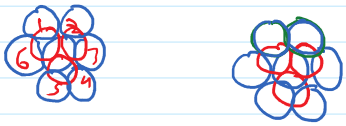
(b) Placing third layer over second layer

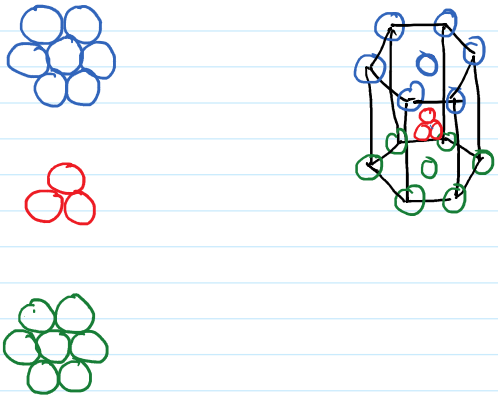
When third layer is placed over the second layer, there are two possibilities:

i) Covering tetrahedral voids.









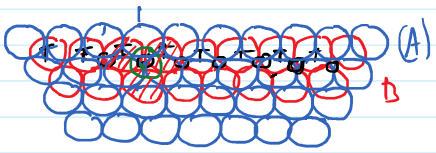
Tetrahedral voids of the second layer may be covered by the spheres of the third layer. In this case, the spheres of the third layer are exactly aligned with those of the first layer. Thus, the pattern is often written as ABAB -- pattern. This structure is called hexagonal close packed (hcp) structure. This sort of arrangement of atoms

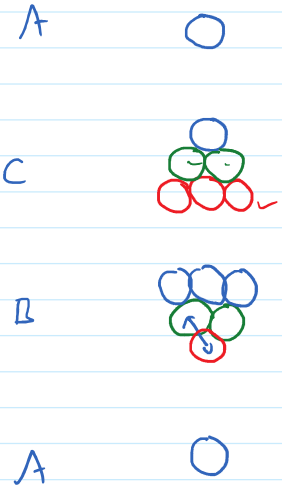
is found in many metals like magnesium and zinc.

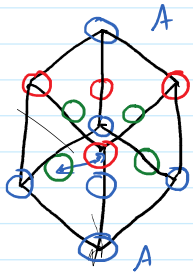
An atom is surrounded by 6 atoms in the same place, 3 atoms below the plane and three atoms above the above. Thus coordination number of hcp is 12.

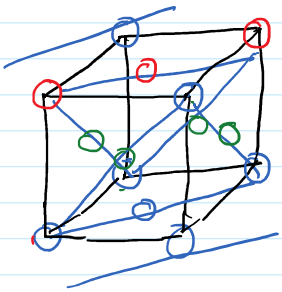
ii) Covering octahedral voids:

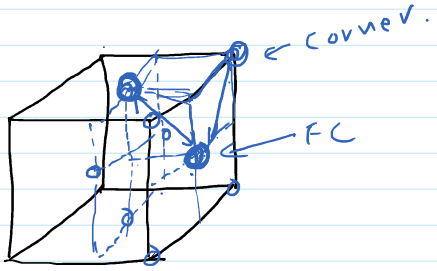
The third layer may be placed above the second layer in a manner such that its spheres cover the octahedral voids. When placed in this manner, the spheres of the third layer are not aligned with those of first layer. This pattern of layers is often written as ABCABC-- type packing. This structure is called cubic close packed (ccp) or face-centred cubic (fcc) structure. Metals such as copper and silver crystallise in this structure.

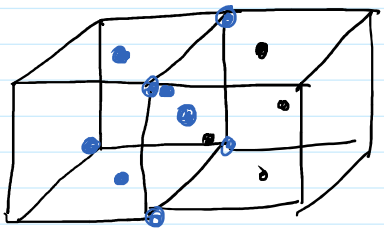












Coordination number for fcc is 12.

iii) Packing efficiency in both fcc and hcp is same i.e. 74%.