Chemistry Study Materials for Class 12
(NCERT Based Notes of Chapter- 01)
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The Solid State

Close packing in solids

In solids the particles are closely packed. In close packed structures the particles are considered as hard spheres. Solids are three dimensional and the 3 dimensional structures can be obtained by the following three steps:

1. **Close packing in One Dimensions**

   Here the spheres are arranged in a row touching each other. In this arrangement each sphere is in contact with 2 adjacent spheres. Therefore, co-ordination number of each sphere is 2.

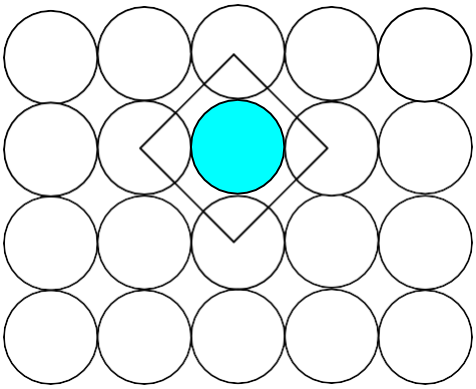
2. **Close packing in Two Dimensions**

   Here the spheres are arranged in two directions – length-wise and breadth-wise. This can be done in two different ways.

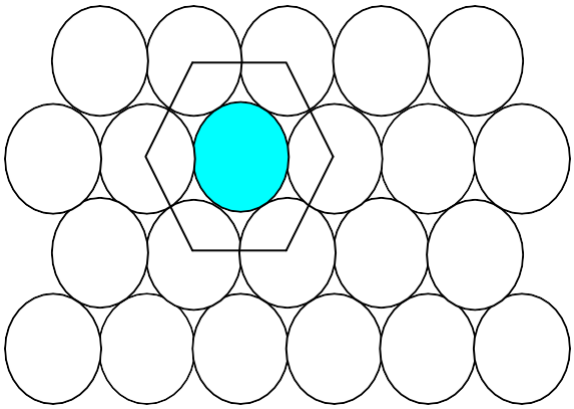
   i. ***Square close packing***: Here the spheres of second row are placed exactly above those of the first row. In this arrangement, each sphere is in contact with four adjacent spheres. So the co-ordination number of each sphere is 4. When we join the centers of these spheres, we get a square. So this close packing is called square close packing in two dimensions.

   ii. ***Hexagonal close packing***: Here the spheres of the second row are placed in the depressions of the first row; the spheres of the third row are placed in the depressions of the second row and so on. In this arrangement, each sphere is in contact with six adjacent spheres. So the co-ordination number of each sphere is 6. When we join the centers of these spheres, we get a hexagon. So this close packing is called hexagonal close packing in two dimensions.

   Hexagonal close packing is more efficient than square close packing in two dimensions. This is because in Hexagonal close packing maximum space is occupied by spheres.



SQUARE CLOSE PACKING



HEXAGONAL CLOSE PACKING

3. Close packing in Three Dimensions

Here the particles are arranged in layers. This can be possible in two ways.

i. *Three dimensional close packing from two dimensional square close-packed layers:*

Here the spheres of the second layer are placed exactly above those of the first layer. In this arrangement spheres of both the layers are perfectly aligned horizontally as well as vertically. The spheres of the third layer are placed exactly above those of the second layer and so on. If the arrangement of the spheres in the first layer is denoted as 'A', all the layers are of 'A' type. So this arrangement forms AAA….. type pattern. The lattice thus generated is the simple cubic lattice and its unit cell is the primitive cubic unit cell.

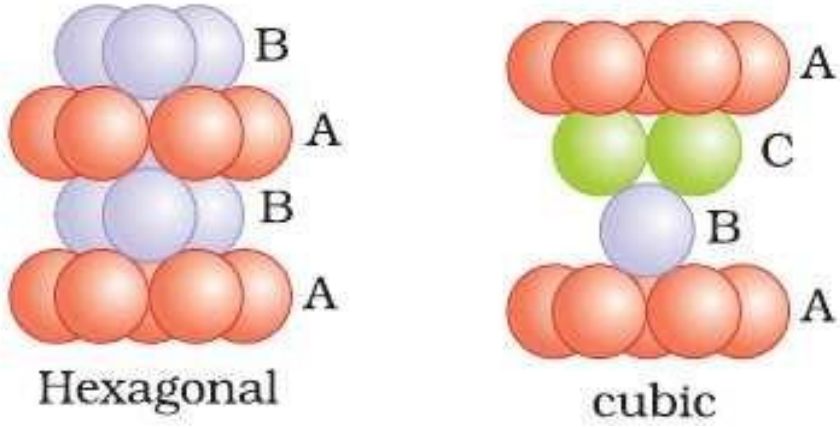
ii. *Three dimensional close packing from two dimensional hexagonal close-packed layers:*

Here the first layer is arranged as hexagonal manner. The second layer is placed above the depressions of the first layer.

On placing the second layer there arises two types of voids (vacant spaces) above the second layer – tetrahedral voids and octahedral voids. Thus when we place the third layer over the second there are two possibilities:

- *Covering tetrahedral voids*: Here the spheres of the third layer are placed above the tetrahedral voids of the second layer. In this arrangement, the spheres of the third layer are vertically above those of the first layer, i.e. the first layer and the third layer are identical. If we call the first layer as 'A' and the second layer as 'B', then the third layer will be 'A', the fourth layer will be 'B' and so on. This will form the pattern ABAB…… This type of close packing is called ***Hexagonal close packing (hcp) in three dimensions***. This type of arrangement is found in metals like Mg, Zn etc.

➢ *Covering octahedral voids:* Here the spheres of the third layer are placed above the octahedral voids of the second layer. In this arrangement, the third layer is different from the first or the second layer. But the spheres of the fourth layer are vertically above those of the first layer, i.e. the first layer and the fourth layer are identical. If we call the first layer as 'A', the second layer as 'B', and the third layer as 'C', then the fourth layer will be 'A', the fifth layer will be 'B' and so on. This will form the pattern ABCABC…… This type of close packing is called ***Cubic close packing (ccp)*** **or** ***face-centred cubic(fcc) packing in three dimensions***. This type of arrangement is found in metals like Cu, Ag etc.



In both hcp and ccp 74% of the available space is occupied by spheres. So both are equally efficient.

Co-ordination Number

In a close packed arrangement the number of nearest neighbours with which a given sphere is in contact is called *the co-ordination number* of that sphere. In both hcp and ccp each sphere is in contact with 12 adjacent spheres. Thus the co-ordination number in both hcp and ccp is *12*.

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