Crystalline Structures :

In crystalline materials , Atoms or ions of a solid are arranged in a pattern that repeats itself in three dimensions; they form a solid that is said to have a ***crystal structure***

• Atoms, arranged in repetitive 3-Dimensional pattern, in long range order (LRO) give rise to ***crystal structure***.

• Properties of solids depend upon crystal structure and bonding force.
• An imaginary network of lines, with atoms at intersection of lines, representing the arrangement of atoms is called ***space lattice***.

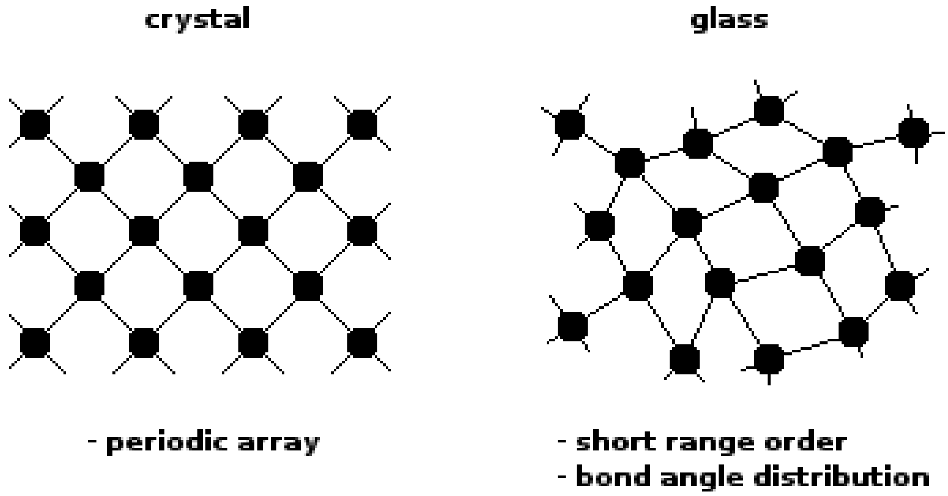
• Unit cell is that block of atoms which repeats itself to form space lattice.

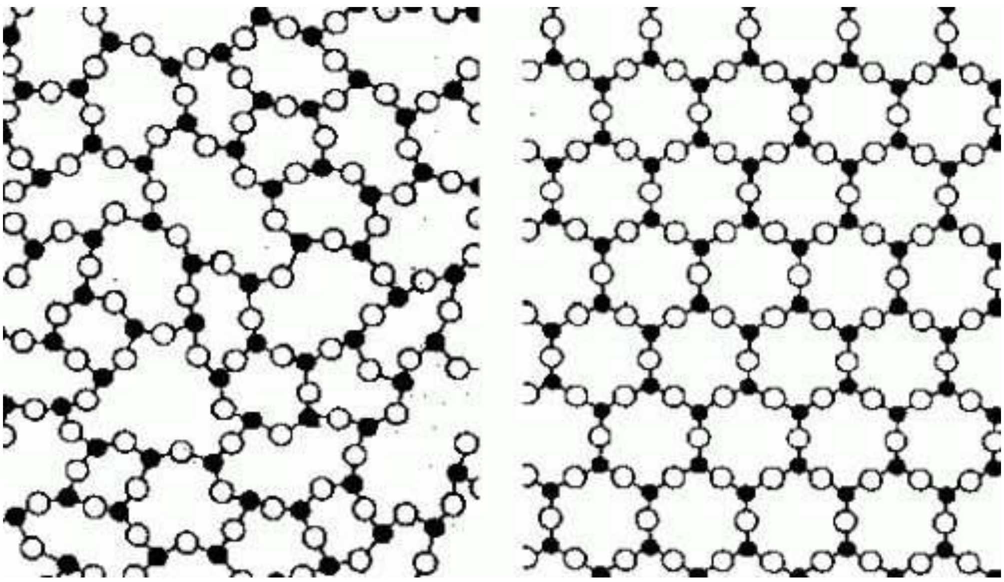
Many substances, including metals, have a crystalline structure in the solid state. Metal crystals from when the molten metals cools and solidifies, where as crystals of other substances, for example copper sulphate, and sodium chloride (salt), form when a saturated solution of compound evaporates causing the solid to crystallize out.
In crystalline structure , the atoms are located at regular and recurring positions in three dimension . The pattern may be replicated millions of times within a given crystal.

Noncrystalline (Amorphous) Structures:

The noncrystalline solids materials do not have their basic particles arranged in a geometric patter. Their particles have a random formation, and such as a result, such substances are said to be amorphous (without shape). • Materials arranged in short range order are called amorphous materials

Many important materials are noncrystalline: liquids and gases, for example. Water and air have a noncrystal structures. A metal loses its crystalline structure when it is melt. Such as glass, plastics and rubber are materials that fall into this category. While many important plastics are mixture of crystalline and noncrystalline forms.





Amorphous **Crystal**

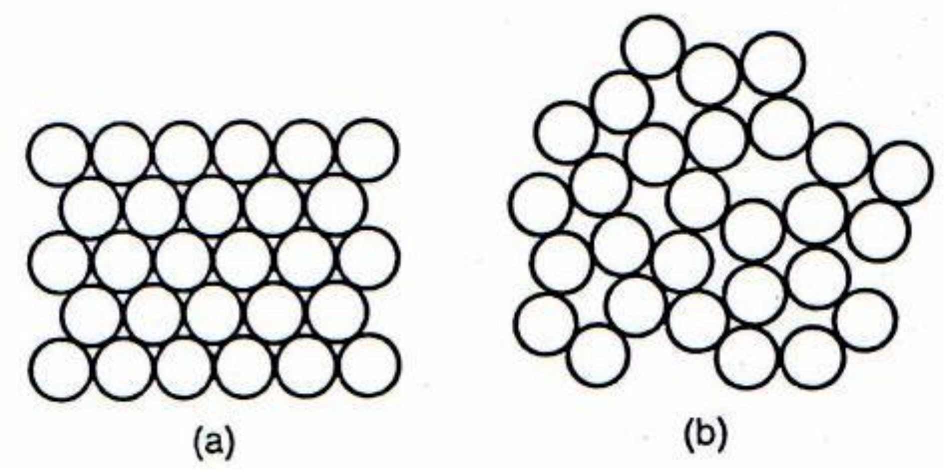
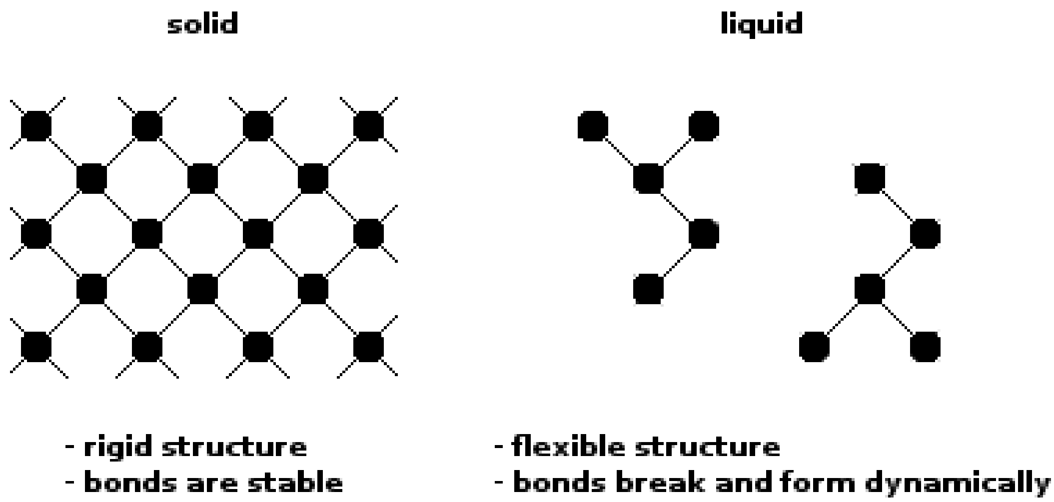


Fig (2) Difference in structure between (a) crystalline and (b) noncrystalline materials



The Unit Cell :

As we mention before, that all of the metals and its alloys have crystalline structure where the atoms are rearranged in an organized shapes which it is called as the crystal lattice. This lattice consisted of another smallest grouping of atoms each one is called the unit cell as shown in figure (3).

The unit cell is the smallest parallel surfaces of the crystalline structure that can be removed or repeated in different directions. It is also differ from each other in shape or size in the crystalline lattice from one material to another.

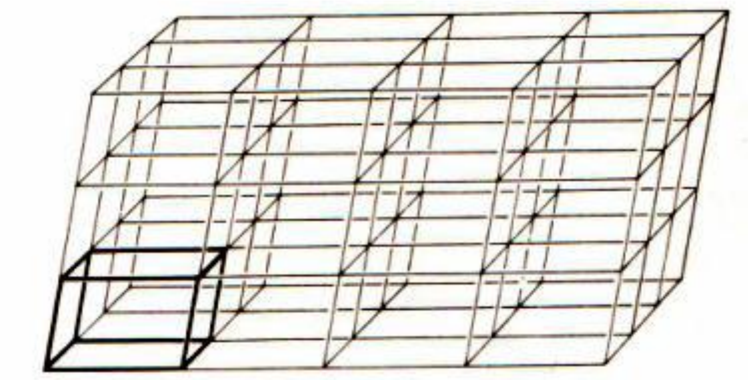


Fig (3) Representation of part of a space lattice with a unit cell outlined.

Crystal Systems and Bravais Lattice:

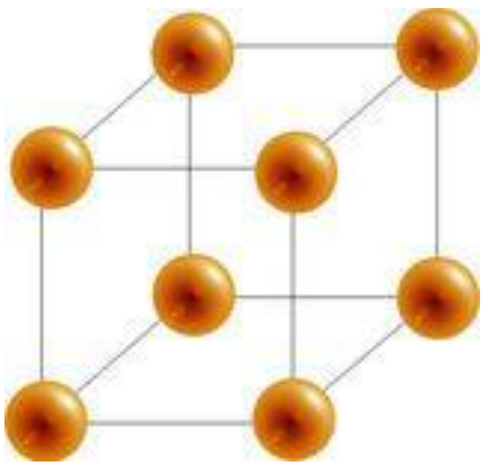
The structure can be viewed in the form of a *unit cell,* which is the basic geometric grouping of atoms that is repeated

could describe all possible lattice networks.

• **There are three basic types of unit cells:**

- **Simple cubic**
- **Body Centered**
- **Face Centered**

1- Simple Cubic



2- Body-Centered-Cubic [BCC]

As shown in figure below as an example of the materials for this type :
Chromium, Molybdenum, Tungsten, Iron.

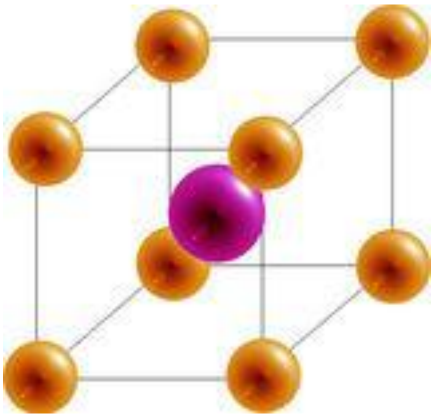
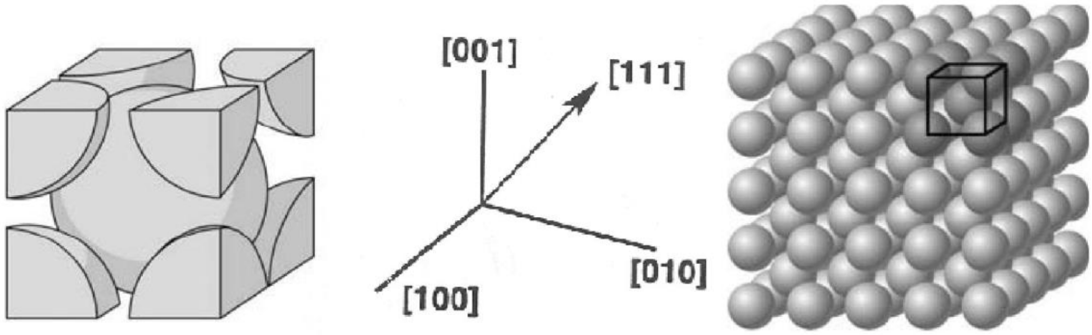


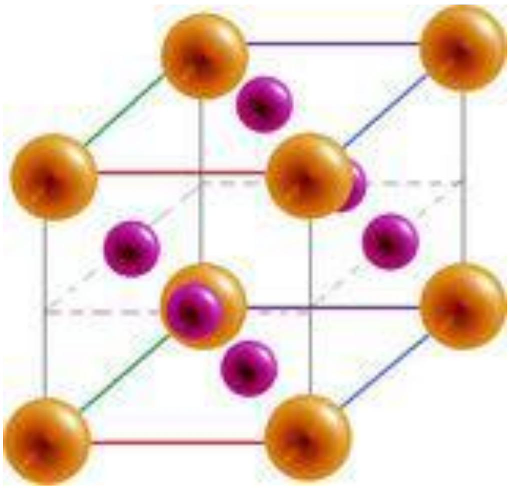
Fig. Body center cubic.

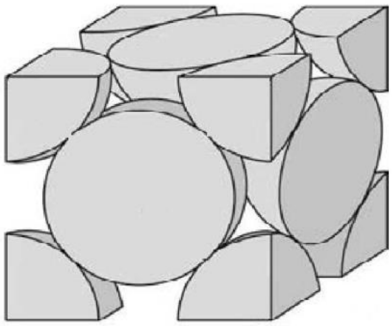


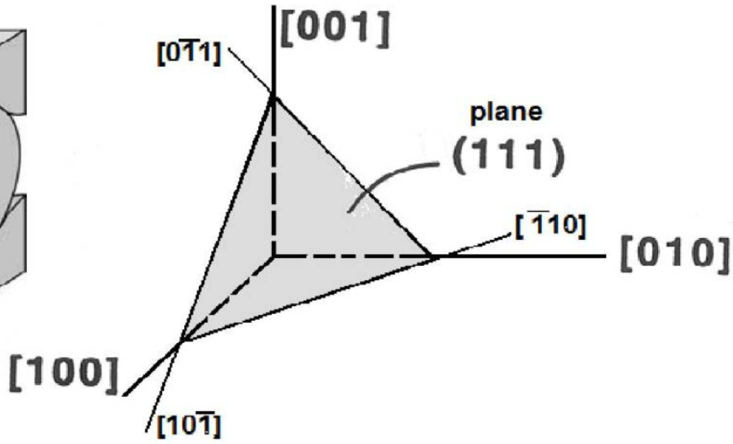
3- Face-Centered-Cubic [FCC]

As shown in figure below as an example of the materials for this type :

Aluminum, Copper, Lead, Nickel, Gold, Silver.





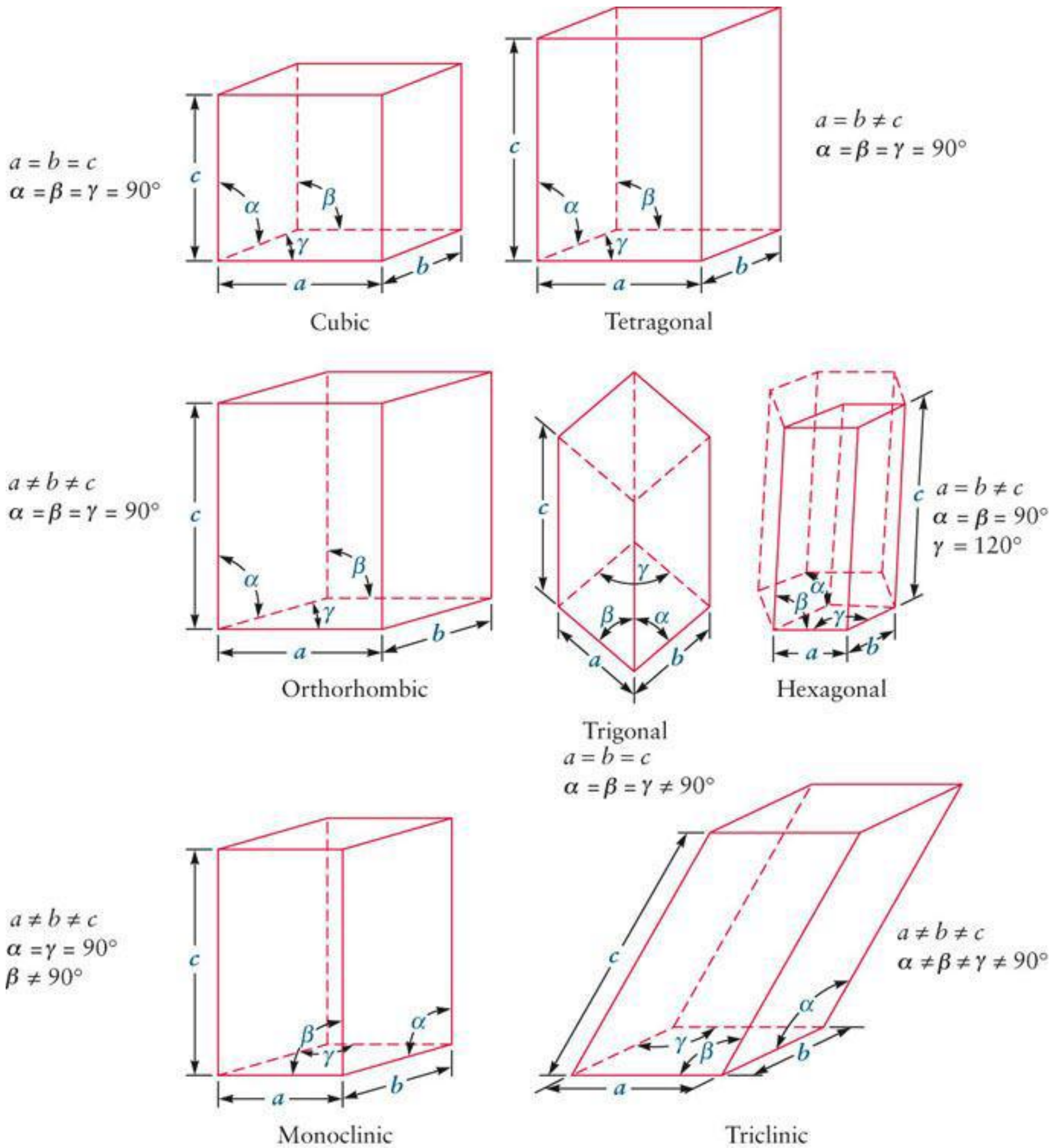


For the plane (111) the slip directions are: [$\bar{1}$10] , [0$\bar{1}$1] and [10$\bar{1}$].

There are several types of pattern in which metallic atoms can arrange them selves on solidification , but the most common is as follows :-

• Only seven different types of unit cells are necessary to create all point lattices.

Bravais (1811–1863). French crystallographer showed that 14 standard unit cells



Number of Atoms in Cubic :-

The atoms that belongs to the unit cell are called the basic atoms, its number is different from one shape of arrangement to another, this number can be found from the following equation:-

$$n = \frac{nc}{8} + \frac{nf}{2} + ni$$

Where **n** : is the number of the basic atoms in the unit cell.
nc : is the number of the atoms in the corners.
ni : is the number of the atoms in internal the cubic.
nf : is the number of the atoms in the center of the face.

As for Simple Cubic (S.C) , No. Of atoms calculated by the equation above:-

$$n = 8 * 1/8 + 0 + 0 = 1 \text{ atom.}$$

For the Body-centered-cubic (BCC), it is obvious that the unit cell have just two atoms the first one in the corner of the cube and the second in the center of the cube (that share the unit cell with each atom in the corner) as in the equation

$$n = 8 * 1/8 + 1 + 0 = 2 \text{ atoms.}$$

As for the Face-centered-cubic (FCC) it is calculated by the equation above :

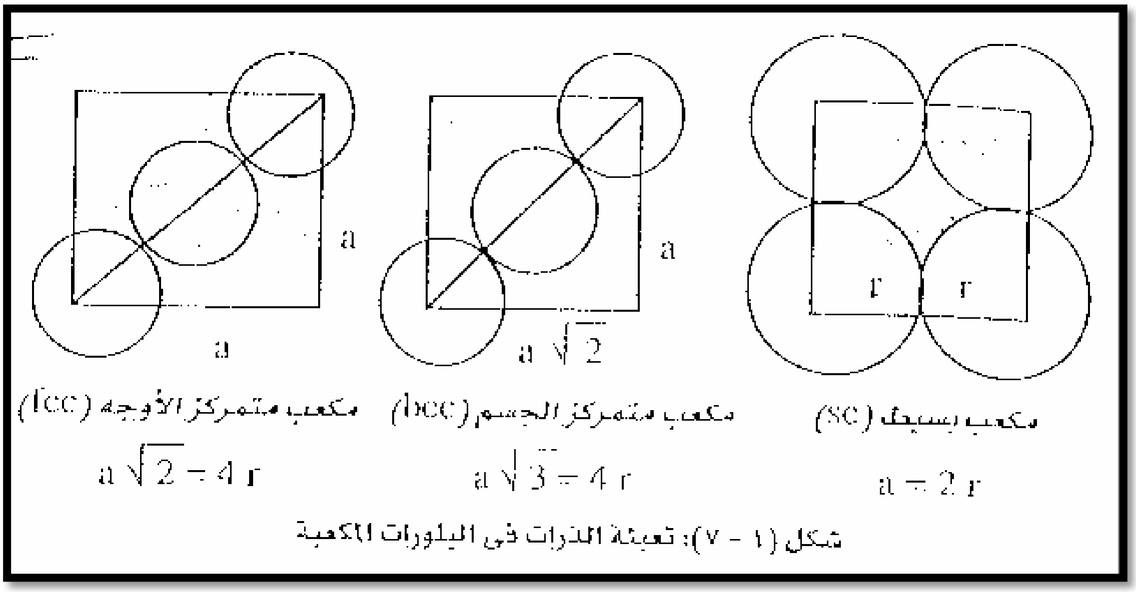
$$n = 8 * 1/8 + 6 * 1/2 + 0 = 4 \text{ atoms.}$$

Riadus of Atoms

to calcaulate the riadus of atoms , we must assume that:−

1 – the atoms with contact.

2− the shape of atoms is spherical .



شكل (١ - ٧): تعبئة الذرات في البلورات المكعبة

1-Riadus of simple cubic

A = 2r , $r = \frac{a}{2}$

Where ,(r) riadus of atom , (a) the distance between centers tow nieghbouring atoms .

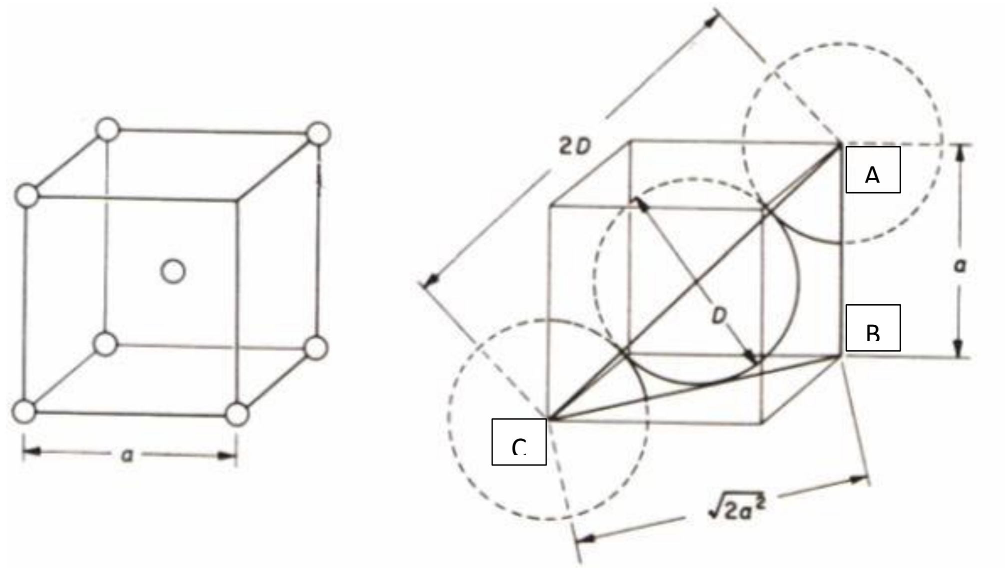
Note :-

The riadus of atoms measured in angstrom (A^0)

1(A^0) = (10^{-10}) meter.

2- Riadus of BCC

From the following fig . and by using pythagoras theory ,



Fig(4) Body centered cubic unit cell. Relation between a and D.

$(AC)^2 = (AB)^2 + (BC)^2$

$(4r)^2 = a^2 + (a\sqrt{2})^2$

$(4r)^2 = a^2 + 2a^2$

$(4r)^2 = 3a^2$

$4r = a\sqrt{3}$

$$r = \frac{a\sqrt{3}}{4}$$

Hom e Work :-

How to obtianed on the amount ($a\sqrt{2}$) in BCC cubic.

3. Face-centered-cubic (FCC)

Similarly, for face centered cubic as shown in figure , the length of a face diagonal = 2D and by Pythagoras:

$(AC)^2 = (AB)^2 + (BC)^2$

$(4r)^2 = a^2 + a^2$

$(4r)^2 = 2a^2$

$4r = a\sqrt{2}$

$$r = \frac{a\sqrt{2}}{4} = \frac{a}{2\sqrt{2}}$$

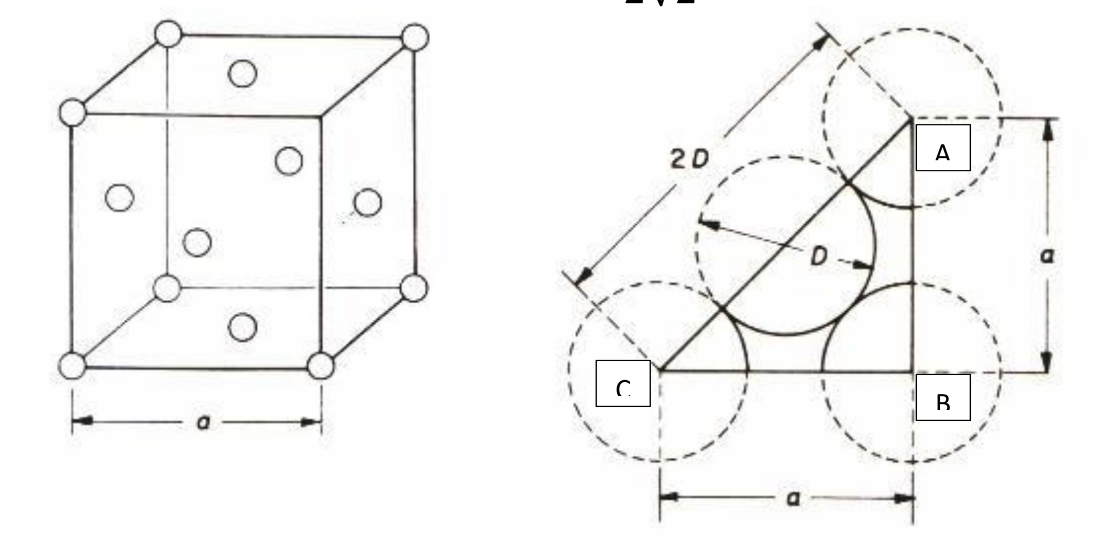


Fig (5) Face centered cubic unit cell. Relation between a and D.