Ranjan Singh
Chemistry Classes
JEE (Main & Advanced)• NEET• XI • XII

Study Package

Ranjan Singh
M.Sc. Bio-Chemistry(P.U)
Ex-Faculty : Narayana & Goal

PHYSICAL
CHEMISTRY

SOLID STATE

Director's Message

Ranjan Singh

M.Sc.(Biochemistry), P.U.

Chemistry plays a central and important role in all competitive examinations as well as in day to day life. For last so many years, I have constantly been in touch with students, guiding them in Chemistry and looking into their difficulties for them to succeed in their board as well as competitive examinations JEE(Mains & Advance) | NEET.

I have felt a need for a good coaching centre to fulfil the requirements of students. Students need a highly experienced and qualified faculty in chemistry, who can guide them well, clear their doubts, provide them the effective & tricky notes, and make them do much needed practice. More importantly they should also be provided Classroom Monitoring, Periodical & Surprise Tests to guide them in the proper direction. I realize that, it is very important to diagnose the basic weaknesses and problems of students not succeeding in JEE(Mains & Advance) | NEET and Board exams. In fact, as question patterns are changing, now they need to have a different approach for these Examinations.

At RANJAN SINGH CHEMISTRY CLASSES, we have our own way to prepare students for Competitive Examinations as well as Board Examination at a time so they can crack the entrance exam like JEE(Mains & Advance) and NEET as well as 12th Board simultaneously. We act as a medium to provide the simplest, easiest and a comfortable way to make students achieve their target. At RANJAN SINGH CHEMISTRY CLASSES(RSCC), we guide our students with the best motivational classes so weak students are also able to believe that, They can do it.

When you join RANJAN SINGH CHEMISTRY CLASSES you become a part of the powerful force which propels you towards your goal and if you get a position among the rankers with my excellent guidance, I will think that our efforts have borne fruits.

Ranjan Singh

M.Sc(Biochemistry), P.U.
Ex-faculty : Narayana IIT Academy
& Goal Institute

Solids

Solids are characterised by the state of matter in which particles are closely packed and held together by strong inter molecular attractive force.

Properties of solids

- In solid state the particles are not able to move randomly.
- They have definite shape and volume.
- Solids have high density. .
- Solids have high and sharp melting point which depend on the strength or value of binding energy.
- They are very low compressible.
- They show very slow diffusion.

Types of Solids

Solids

Crystalline Solids — Amorphous Solids

Crystalline solids

- In this type of solids the atoms or molecules are arranged in a regular pattern in the three dimensional network.
- They have well defined geometrical pattern, sharp melting point, definite heat of fusion and anisotropic nature.
- Anisotropic means they exhibit different physical properties in all directions.
  eg. The electrical and thermal conductivities are different in different directions.
- They are generally incompressible. .
- The general examples of crystalline solids are as Quartz, diamond etc.

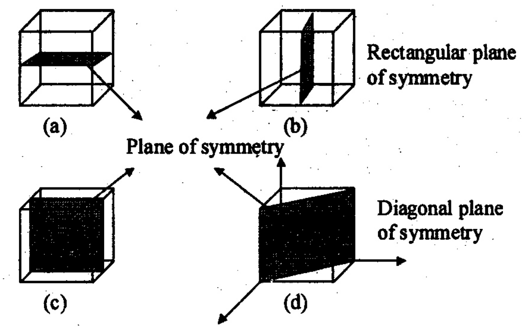
Amorphous Solids

- In this type of solids, the arrangement of building constituents is not regular.
- They are regarded as super cooled liquids with high viscosity in which the force of attraction holding the molecules together are so great, that the material becomes rigid but there is no regularity in structure.
- They do not have sharp melting points.
- They are isotropic as they exhibit same physical properties in all the directions.
- The general examples of this solids are as glass, Rubber, plastics etc.

Study of Cyrstals

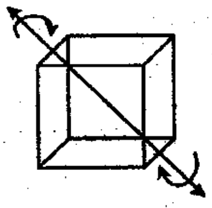
- **Crystal -** A crystal is a homogenous portion of a solid substance made by regular pattern of structural units bonded by plane surface making definite angles with each other.
- **Space lattice: -** The arrangement of constituents like atom, ions and molecules in different sites in three dimensional space is called space lattice.
- **Unit cell : -** The smallest repeating unit in space lattice which when repeats over and over again, results in a crystal of the given substance called unit cell.
- **Face:-** The plane surface of the crystal are called faces.
- **Edge:-** An edge is formed by the intersection of two adjacent faces.
- **Interfacial angles:-** The angle between the perpendiculars intersecting faces called interfacial angles.
- **Plane of symmetry**

  It is an imaginary plane which passes through the centre of a crystal & can divide it into two equal portions which are exactly the mirror images to each other.

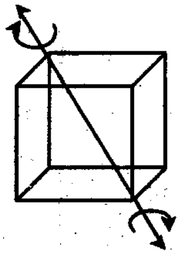


Axis of symmetry

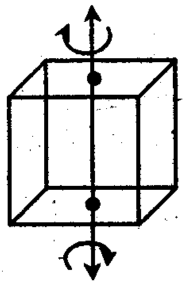
- It is an imaginary line about which the crystal may be rotated so that it presents the same appearance more than once in a complete rotation through 360°.
- The axes of symmetry are called diad, triad, tetrad and hexad respectively. It is the original appearance and is repeated twice (180°), thrice (120°), four times (90°) and six times (60°) in one rotation.
- These axes of symmetry are also called as two fold, three fold, four fold and six fold respectively.
- Five fold symmetry is not found in crystals.



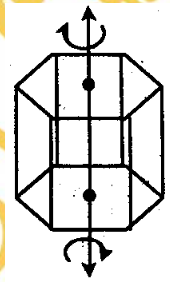
(i) Axis of two fold symmetry



(ii) Axis of three fold symmetry



(iii) Axis of four fold symmetry



(iv) Axis of six fold symmetry

Centre of symmetry

- It is a point in the crystal so that any line drawn through it intersects the surface of the crystal at equal distance on either side.

Note : Only simple cubic system have one centre of symmetry. Other system do not have centre of symmetry.

ELEMENTS OF SYMMETRY

- The total number of planes, axes and centre of symmetries possessed by a crystal is termed as elements of symmetry.
- A cubic crystal possess total 23 elements of symmetry

(i)	Plane of symmetry	(3 + 6)	=	9
(ii)	Axes of symmetry	(3 + 4 + 6)	=	13
(iii)	Centre of symmetry	(1)	=	1
	Total symmetry		=	23

Study of Structure of Crystalline Solids To study crystalline solids we need some mathematical and geometrical tools.Lets get familier with them.

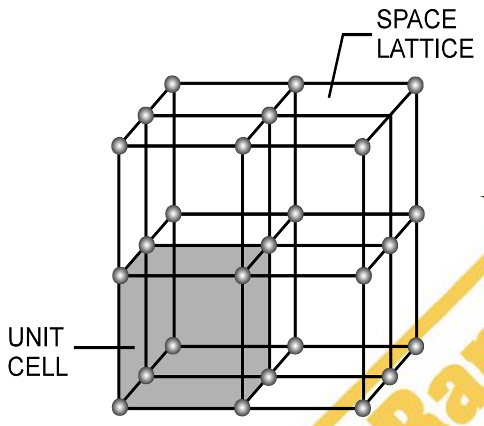
- **Space lattice :** It is the regular arrangement of points in space and forms the basis of classification of all structures.This regular arrangement spread over whole space in the **long range order**.
- **Unit cell:** Unit cell is the smallest arrangement of points which on repetition generates the whole space lattice. It is the *building block* of the whole structure.

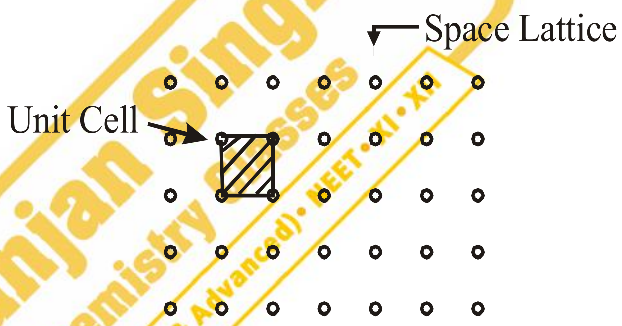
(a) Unit cell contains the *minimum information* in terms of edge lengths and angles sufficient to determine the structure of the lattice.

(b) Generally unit cell is the smallest element of the space lattice. But sometimes a slightly bigger Various types of unit cells can be chosen within a particular lattice:

(i) *Primitive*:When lattice points are found only at the corners of the unit cell.

(ii) *Centered/Non-primitive*:When lattice points are found at the corners and as well as inside the unit cell.





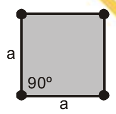
- **1–DIMENSIONAL SPACE LATTICE**

Uniformly separated lattice points in 1–dimension will represent 1–D lattice.Only **one parameter** is needed to describe it.

2 DIMENSIONAL SPACE LATTICE

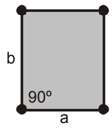
It is the regular arrangement of points in a plane.Only **three parameters** are needed to describe the lattice.Two sides a and b and angle between them(γ).

(i) **Square unit cell:** $a = b$, $\gamma = 90^\circ$



(Primitive Type)

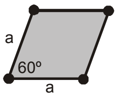
(ii) **Rectangle:** $a \neq b$, $\gamma = 90^\circ$



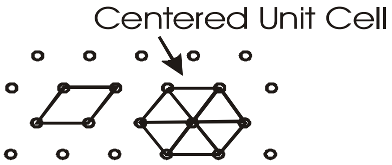
(Primitive Type)

(iii) **Hexagonal unit cell:** $a = b$, $\gamma = 60^\circ$

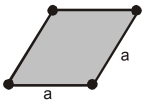
Unit cell can be chosen in more than one way.



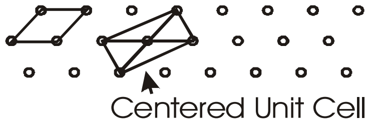
(Primitive Type)



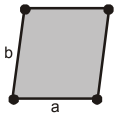
(iv) **Rhombic unit cell:** a = b, $\gamma \neq 90^\circ, 60^\circ$
Unit cell can be chosen in more than one way (since the diagonals of rhombus are perpendicular)



(Primitive Type)



(v) **Parallelogram:** a ≠ b, $\gamma \neq 90^\circ$
This is the most unsymmetric case.



(Primitive Type)

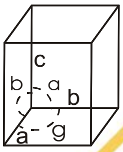
◆

3 DIMENSIONAL SPACE LATTICE

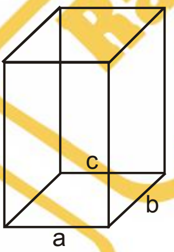
It is the regular arrangement of points in space.
Six parameters are required to completely describe the unit cell: **3** edge lengths and **3** angles.
a, b, c : edge lengths of unit cell (also known as the *crystallographic axes*.)
α, ,β ,γ are known as the *crystallographic angles*.

Seven Primitive unit cells in crystals

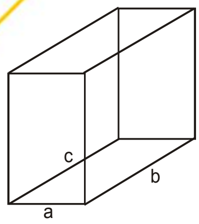
Cubic



; ***Tetragonal***

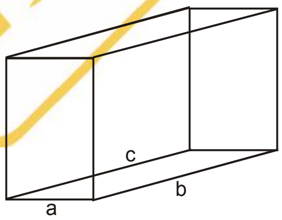


; ***Orthorhombic***



;

Monoclinic



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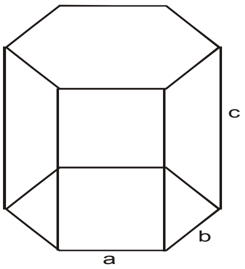
Hexagonal



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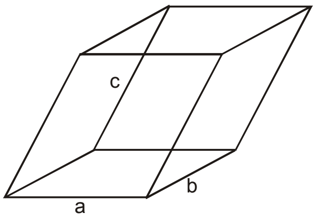
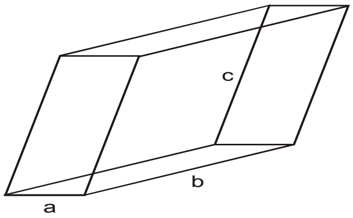
Rhombohedral



;

Triclinic

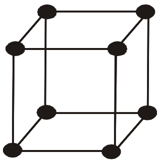


Seven Primitive Unit Cells

Crystal System	Axial distances	Axial angles	Examples	Type of Unit cells
Cubic	a = b = c	$\alpha = \beta = \gamma = 90°$	Cu, ZnS, KCl	S,BC,FC
Tetragonal	$a = b \neq c$	$\alpha = \beta = \gamma = 90°$	Sn(white tin), SnO_2,TiO_2	S,BC
Orthorhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90°$	Rhombic sulphur, $CaCO_3$	S,BC,FC,EC
Monoclinic	$a \neq b \neq c$	$\alpha = \gamma = 90°;\beta \neq 90°$	Monoclinic sulphur, $PbCrO_2$	S,BC
Hexagonal	$a = b \neq c$	$\alpha = \beta = 90°;\gamma = 120°$	Graphite, ZnO	S
Rhombohedral	a = b = c	$\alpha = \beta = \gamma \neq 90°$	$CaCO_3$(Calcite), HgS(Cinnabar)	S
Triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90°$	$K_2Cr_2O_7$, $CuSO_4.5H_2O$	S

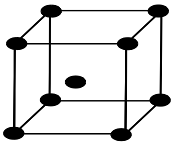
Ways of choosing unit cells in 3-dimensions:

1. ***Primitive /Simple***: lattice points only at the corners only.



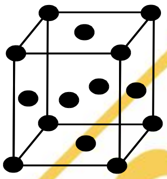
Found in **all** crystal systems.

2. ***Body centered:*** Lattice points at corners & at the body center.



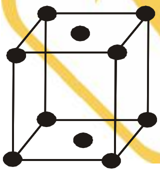
Found only in **Cubic,Tetragonal,Orthorhombic** and **Monoclinic** systems.

3. ***Face centered :*** Lattice points at corners & at each of the face centre.



Found only in **Cubic** and **Orthorhombic** systems.

4. ***End centered:*** Lattice point at corners & only at two oppsosite faces.



Found only in **Orthorhombic** system.

Total number of lattice arrangements in three dimensions = 14.These are called 14 BRAVAIS LATTICES

Contribution of different lattice points in one unit cell (CUBIC SYSTEM)

Corner atom: Since eight cubes meet at one corner, each atom at the corner gives 1/8th contribution to each cube.This means 1/8th of the electron density, 1/8th of the nuclear density(in case of atoms), 1/8th of the molecule are found completely inside one unit cell due to corner.

Face Center:Since each face is shared by two cubes, each atom/molecule is equally divided between them. Hence it contributes 1/2 to each cube

Body Centre:Whole of the atom/molecule is found inside and contributes 1 to each cube.

Edge Centre: Each edge is shared by four cubes, each atom/molecule at the cube contributes 1/4th to each cube.

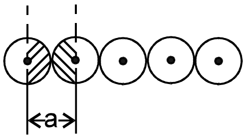
Structure of Solids

(a) Solids having only one type of particles : e.g. metallic, molecular, covalent network solids.

The particle of the solid will be represented by a sphere of radius r. We assume that there is only attraction force existing between those spheres.Hence in order to to get maximum stable arrangement of these particles the seperation between the particles should be minimum.

Arrangement in 1-D :

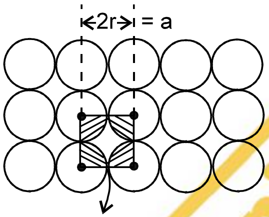
In one dimension it is possible to arrange the spheres in only one stable way.This is the position with minimum separation and minimum potential energy of the system(most stable)



1-D close packing stable arrangement

Arrangement in two dimension :

1. Square arrangement(poor arrangement) : If the one dimensional arrays are placed on top of one another, we get the square packing in twio dimensions.



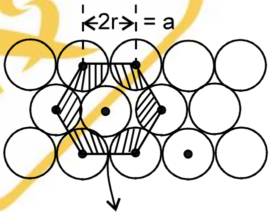
unit cell

One sphere will be in constant contact with 4 other spheres.

area of square = $a^2 = 4r^2$; area of atoms in the square = $\frac{1}{4} \times \pi r^2 \times 4 = \pi r^2$

Packing fraction, fraction of area occupied by spheres = $\frac{\pi r^2}{4r^2} = \frac{\pi}{4}$ = 0.78(78%)

2. Hexagonal arrangement(better arrangement) : If each one dimensional array is placed in the cavity of the just preceding array, we get the hexagonal packing in two dimensions.



unit cell

area of hexagon = $6 \times \frac{\sqrt{3}}{4} a^2 = 6 \times \frac{\sqrt{3}}{4} \times 4r^2$; area of atoms = $\pi r^2 + \frac{1}{3} \times 6\pi r^2 = 3\pi r^2$

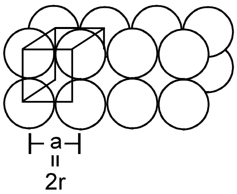
fraction of area occupied = $\frac{3\pi r^2}{6\sqrt{3}\, r^2} = \frac{\sqrt{3}\pi}{6} \simeq 0.91$ (91%)

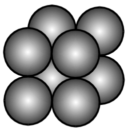
Arrangement in three Dimensions:

1. Simple cubical arrangement in three dimensions :

(will be made up of 2-D sheets arranged one over other)

The simple cubical packing is obtained by arranging the square pack sheets of two dimension one over the other such that spheres of the second sheet are exactly (vertically) above the spheres of first sheet.





Simple cubic

(Note that $\begin{matrix} a = b = c \\ \alpha = \beta = r = 90^o \end{matrix}$, hence crystal thus formed will belong to the cubic crystal class, and as the lattice points are only at the corners, hence the unit cell will be simple, therefore what we get is the **simple cubic**)

(i) Relation between 'a' and 'r'

a = 2r (because atoms along the edge are touching each other)

(ii) effective no. of atoms per unit cell Z:

$$Z = \frac{1}{8} \times 8 = 1$$

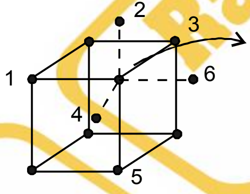
(iii) packing fraction :

$$\frac{\text{volume occupied by atoms / unit cell}}{\text{volume of unit cell}}$$

$$= \frac{\frac{4}{3}\pi r^3}{a^3} = \frac{4}{3(2r)^3}\pi r^3 = \frac{4\pi r^3}{3 \times 8\, r^3} = 0.52(\ 52\%\ )$$

(iv) Coordination Number, CN:

It is defined as the number of atoms touching any one particular atom = 6 for simple cubic



this sphere touches the numbered spheres as shown.

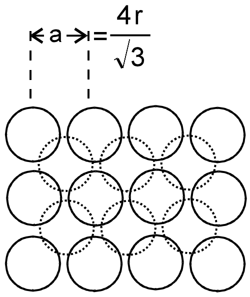
Type of neighbour	Distance	no.of neighbours	
nearest	a	6	(shared by 4 cubes)
(next)^1	$a\sqrt{2}$	12	(shared by 2 cubes)
(next)^2	$a\sqrt{3}$	8	(unshared)

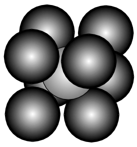
(v)Density of unit cell :

$$= \frac{\text{Mass of unit cell}}{\text{Volume}} = \frac{Z \times M}{N_A . a^3}$$

2. Body centred cubic :

The body centred cubic is a unique way of packing, as the 2D - arrays that can be imagined to constitute the space lattice are themselves formed in a unique way. The lattice points in the 2D array do not touch each other. The spheres start touching each other only upon moving from 2D to 3D, i.e when the 2D arrays are placed on top of each other in such a fashion that the spheres of the next plane are into the cavities of the first plane of spheres.The third plane of spheres is then exactly identical to the first plane of spheres.





(i) Relation between a and r: a ≠ 2r (as atoms along the edge are not touching each other) they touch along the body diagonal, hence $\sqrt{3}\,a = 4r$.

(ii) Effective no-of atoms (Z) = $1 + \frac{1}{8} \times 8 = 2$.

(iii) Packing fraction = $\frac{2\times\frac{4}{3}\pi r^3}{4\times4\times4r^3}\sqrt{3}\times\sqrt{3}\times\sqrt{3} = \frac{\pi\sqrt{3}}{8} \simeq 0.68$ (68%)

(iv) Coordination number CN: 8 (the sphere at the body centre will be touching the spheres at the eight corners)

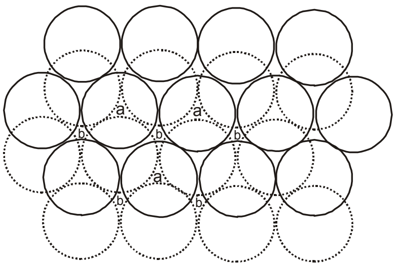
(v) Density = $\frac{ZM}{N_A\,a^3} = \frac{2M}{N_A\,a^3}$

BCC :

Type of neighbour	**Distance**	**no.of neighbours**	
nearest	$2r = a\frac{\sqrt{3}}{2}$	8	
$(next)^1$	$= a$	6	Same as cubical unit cell
$(next)^2$	$= a\sqrt{2}$	12	
$(next)^3$	$= a\sqrt{3}$	8	
$(next)^4$	$= a\frac{\sqrt{11}}{2}$	24	

Close Packing In Three Dimensions : This is the arrangements in which metallic crystals are generally found. To generate close packing we must start with best possible arrangements in two dimensions i.e., the hexagonal arranged sheets and spheres of IInd sheet must rest depressions/voids of 1st sheet hexagonal close packed

NOTE: All the voids of 1st sheet canot be occupied by spheres of 2nd sheet (because of same size of spheres) Only 50% of the viods can be occupied. Out of six voids around any sphere only three alternate voids can be occupied by 2nd sheet of spheres. This arrangements is shown below.

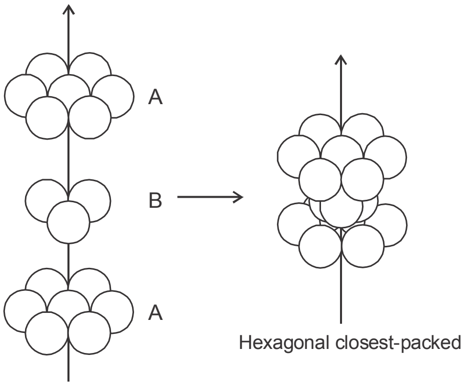


In second layer we have two kinds of voids.
(i) Voids of second layer below which there are spheres of first layer (all voids of type 'a').
(ii) Voids of second layer below which there are voids of first layer (all voids of type 'b').
for third layer we have two possibilities.

◆

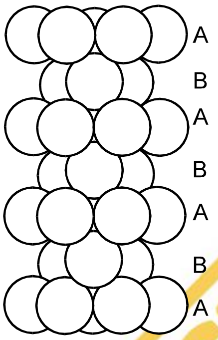
Hexagonal Close Packing (HCP)

If spheres of IIIrd layer are placed in voids of IInd layer which are lying exactly above the spheres of Ist layer i.e., voids of type **'a'** then Ist layer and IIIrd layer will become exactly identical and this generates ABABAB pattern or the hexagonal close packing **(HCP)**



Exploded view

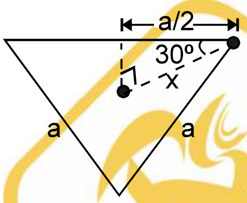
Hexagonal closest-packed

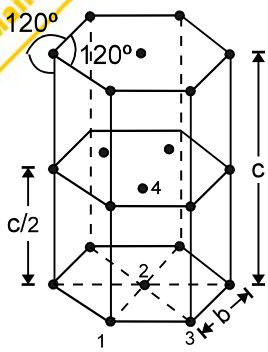


Unit cell : a = 2r = b; $\gamma = 120^\circ$

Calculations

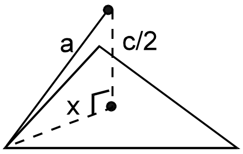
1. For 'c': For the estimation of 'c', consider the spheres marked 1,2,3,4 in the unit cell as shown.These four spheres form a regular tetrahedron. The length of the perpendicular from '4' to the equilateral triangle 1-2-3 will be equal to c/2.





$$\cos 30^\circ = \frac{a}{2x}$$

$$x = \frac{a}{2\cos 30} = \frac{a^2}{2\sqrt{3}} = \frac{a}{\sqrt{3}}$$



apply pythagoras theorem.
$x^2 + (c/2)^2 = a^2$

$$c = \sqrt{\frac{2}{3}}\ 4r$$

Volume of the hexagon = Area of base x Height.

$$= 6 \,.\, \frac{\sqrt{2}}{3}\, a^2 \times c = 4r^2 \times \frac{\sqrt{2}}{3}\, 4r \;=\; 24\,\sqrt{2}\,.\, r^3$$

2. Effective no. of atoms/unit cell, Z :

$$Z = 3 + 2 \times \frac{1}{2} + 12 \times \frac{1}{6} = 3 + 1 + 2 = 6 \;\; [z = 6]$$

The three atoms at the centre of the hexagonal structure is not completely inside the unit cell. A part of it lies in the unit cell, but a part of other atoms in the same plane whose centre is not in the unit cell is included inside the unit cell.
Hence eff. no. = 3.

3. Packing fraction : $= \dfrac{\text{volume of the atoms}}{\text{volume of unit cell}} = \dfrac{6 \times \frac{4}{3}\pi r^3}{24\sqrt{2}\, r^2} = \dfrac{\pi}{3\sqrt{2}} = 0.74 = 74\%$

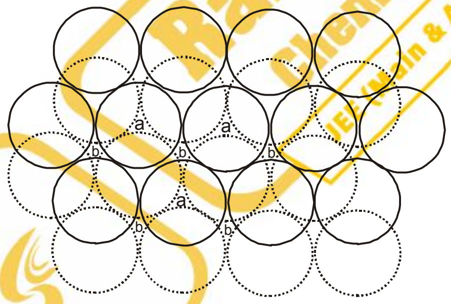
4. Coordination number CN= 12 (each spheres touches 6 spheres in its layer,3 above and 3 below)

5. Density $= \dfrac{\text{Mass}}{\text{Volume}} = \dfrac{ZM}{N_A\,(\text{volume})} = \dfrac{6M}{N_A\,(\text{volume})}$

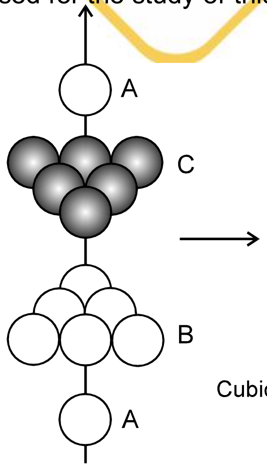
NOTE: In closest packings, whenever two consecutive layers are of different kind then packing efficiency will always be 74%

- **ABC-ABC Arrangement/Cubic Close Packing(ccp):**

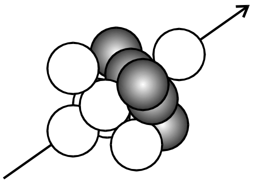
If the third layer spheres are placed in those voids of IInd layer under which there are voids of the first layer of spheres (voids of type 'b'), then the first and the third layer of spheres will not be identical.Such an arrangement will lead to an ABC-ABC type of arrangement.It is also known as the cubical close packing or also as the Face Centred Cubic structure(FCC).



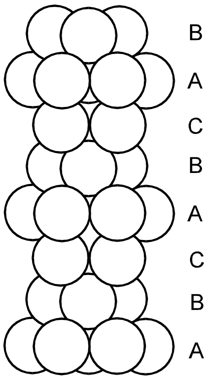
In the ABC – ABC Pattern the spheres of 4th layer are vertically above the spheres of Ist layer then these consecutive layers are different from each other, fourth layer will be idential to first layer so it will be called ABC – ABC repeat pattern.It is also called the ccp (cubical close packing) because a cubical type of unit cell is used for the study of this arrangement.

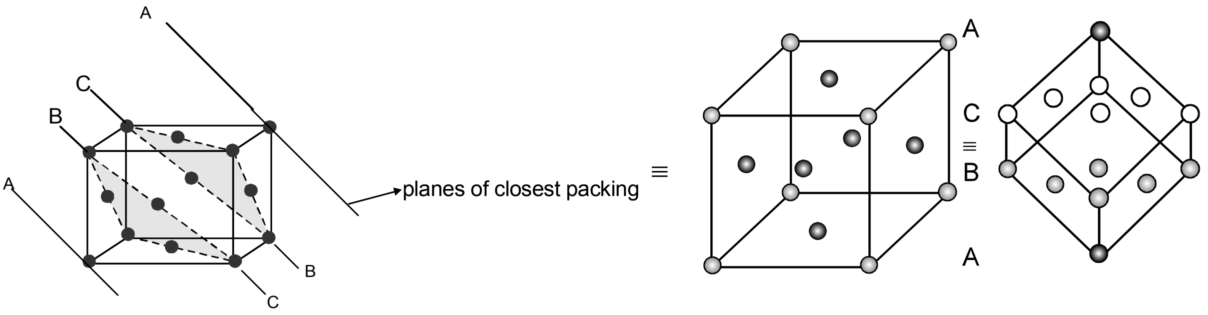


Exploded view



Cubical closest-packed structure





1. Relation between ‘a’ and ‘r’ :

$a \neq 2r$

$\sqrt{2}a = 4r$ (as the spheres touch along the face diagonal)

2. Effective no. of atoms per unit cell, Z :

$$Z = \frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 4$$

3. Packing fraction :

$$p.f. = \frac{4 \times \frac{4}{3}\pi r^3}{4 \times 4 \times 4\, r^3} \times \sqrt{2} \times 2 = \frac{\pi}{3\sqrt{2}} = .74(\ 74\%\ )$$

4. Coordination number, CN = 12 (each corner sphere touches three spheres per cube(each of them being shared by two of the eight cubes surrounding that sphere) **)**

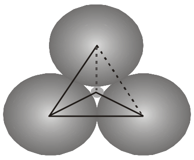
5. Density $= \dfrac{Z \times M}{N_A . a^3}$

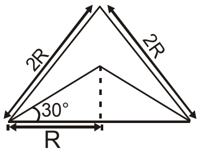
Type of neighbour	**Distance**	**no. of neighbours**
nearest	$\frac{a}{\sqrt{2}}$	$12 = \left(\frac{3 \times 8}{2}\right)$
$(next)^1$	a	$6 = \left(\frac{3 \times 8}{4}\right)$
$(next)^2$	$a\sqrt{\frac{3}{2}}$	24
$(next)^3$	$a\sqrt{2}$	12
$(next)^4$	$a\sqrt{\frac{5}{2}}$	24

Types of voids Found in Close packings :

(VOID IN TWO DIMENSIONS)

♦ **Triangular void (2-Dimensional 3-coordinate void)** The triangular voids are found in the planes of the close packed structures, whenever three speres are in contact in such a fashion.



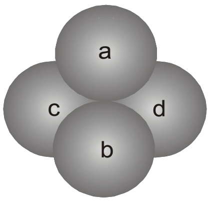


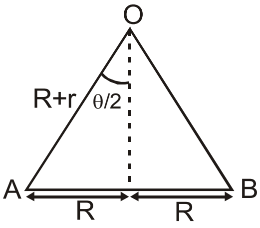
$$\cos 30^\circ = \frac{R}{R+r} \Rightarrow \frac{\sqrt{3}}{2} = \frac{R}{R+r} \Rightarrow \frac{2}{\sqrt{3}} = \frac{R+r}{R} \Rightarrow \mathbf{r = 0.155\ R}$$

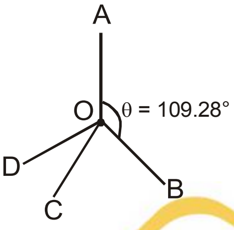
where, **R**= Radius of the sphere, **r** = maximum radius of a sphere that can be placed inside the void.

(VOIDS IN THREE DIMENSIONS)

- **Tetrahedral void (3-Dimensional 4-coordinate) :**
  The tetrahedral void is formed whenever a sphere is placed on top of the triangular arrangement.

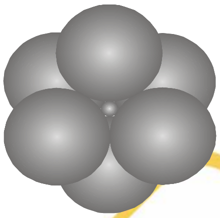


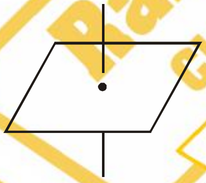


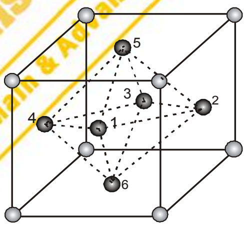


$$\sin\frac{\theta}{2} = \frac{R}{R+r} \Rightarrow \frac{R}{R+r} = \sin 54^\circ 44' \Rightarrow \qquad r = R\left\{\frac{1}{\sin\frac{\theta}{2}} - 1\right\} \Rightarrow \mathbf{r = 0.225\ R}$$

- **Octahedral void (3-Dimensional 6 coordinate void)** The octahedral void is formed whenever two spheres are placed, one on top and the other below a square arrangement of spheres.This can also be obtained by placing two THREE-BALL arrangements on the top of each other such that a hexagonal view is obtained.



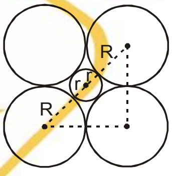




x = 2R;

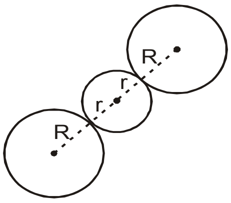
$2(R + r) = \sqrt{2}\,x = 2\sqrt{2}\,R$

$\Rightarrow$ **r =** $(\sqrt{2} - 1)$**R = 0.414 R**



- **Cubical void (3-Dimensional 8-coordinate void)**
  Along body diagonal : $\sqrt{3}a = 2\,(R + r)$

$2\sqrt{3}R = 2\,(R + r)$



$r = (\sqrt{3} - 1)\,R$

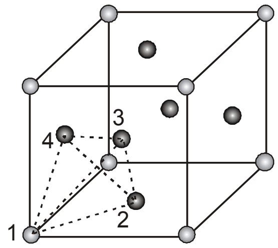
$r = (\sqrt{3} - 1)\,R \Rightarrow$ **r = 0.732 R**

The cubical void is generally not found in closed packed structures, but is generated as a result of distortions arising from the occupancy of voids by larger particles.

Location of Voids

FCC/CCP unit cell: **(with the help of model)**

(*A) Tetrahedral voids* **:** The FCC unit cell has **eight** tetrahedral voids per unit cell. Just below every corner of the unit cell, there is one Tetrahedral void. As there are eight corners, there are eight tetrahedral voids.



The spheres 1, 2, 3, 4 form a tetrahedral void.

(*B) Octahedral voids* **:**In an FCC unit cell, there are **four** octahedral voids. They are present at all the edge centres and at the body centre. The contribution of the edge centre is $\frac{1}{4}$

Hence, total number of octahedral voids = $\underset{\text{edge centres}}{\left(12\times\frac{1}{4}\right)} + \underset{\text{body centre}}{(1)} = 4$

HCP unit cell :(with the help of model)

(A) Tetrahedral voids:

Tetrahedral voids are found between any two spheres of alternate sheets that lie perpendicular to the plane of the sheets.

8 are completely inside and 12 are shared

Effective number of tetrahedral voids in hcp unit cell :

effectively $\rightarrow 8 + 12 \times \frac{1}{3} = 12$

(B) Octahedral Voids: Total 6 octahedral voids completely inside the unit cell.

VOIDS PER SPHERE IN CLOSED PACKING

1.Tetrahedral Voids

In HCP : Z = 6, tetrahedral voids = 12

In CCP/FCC :Z = 4, tetrahedral voids = 8

number of tetrahedral voids = 2 × Z

no. of tetrahedral voids in close packings = 2 × effective no. of spheres.

HENCE, there are two Tetrahedral Voids per sphere in closed packing arrangements.

(2) Octahedral Voidsl

In HCP: Z = 6, octahedral voids = 6

In CCP/FCC: Z = 4, octahedral voids = 4

no. of octahedral voids = Z

There is exactly one octahedral void per sphere in close packing.

Void in Simple cubic lattice

Cubical void (eight coordinate void)

along body diagonal, $2r\sqrt{3} = 2r + 2r_V$

$$r_V = r(\sqrt{3} - 1)$$

Triangular void in HCP: It is located in two dimsensional layers of HCP structure.

$$\frac{2r}{\sqrt{3}} = r + r_V \quad \Rightarrow \quad r_V = r\left(\frac{2}{\sqrt{3}} - 1\right) \quad \Rightarrow \quad r\left(\frac{3.464}{3} - 1\right)$$

$\boldsymbol{r_V \approx 0.155\ r.}$

Structure of ionic compounds

Structure of compounds containing two different types of atoms.

The bigger atom or ion will form the lattice & smaller atom / ion will occupy the voids. Generally, bigger ion is anion and smaller ion is cation. The type of void occupies by the cation is decided by radius ratio.

Radius ratio = $\left(\frac{r_+}{r_-}\right)$,this gives the idea about the type of void occupied.

Radius ratio	Type of void occupied	Coordination No.
$\frac{r_+}{r_-} < 0.155$	linear void	2
$0.155 \le \frac{r_+}{r_-} < 0.225$	triangular void	3
$0.225 \le \frac{r_+}{r_-} < 0.414$	tetrahedral void	4
$0.414 \le \frac{r_+}{r_-} < 0.732$	octahedral void	6
$0.732 \le \frac{r_+}{r_-} < 1$	cubical void	8

Structure of some representative ionic compounds

Ionic solids form rigid lattice structure. Large amount of energy is released when ions form lattice arrangement form their gaseous states. This is expressed in terms of the **Lattice energy**(kJ/mol). This much amount of energy is required to separate one mole of ionic-solid into its gaseous ions.

- **NaCl type(AB-type) of structure or rock salt structure or 6 : 6 C.N. compound**

Experimental: $\frac{r_{Na^+}}{r_{Cl^-}} = 0.51$

Cl^- ions:**fcc** lattice
effective no. of Cl^- ions in a unit cell = 4
Effective no. of Na+ ions in a unit cell must be 4 ($\because$ formula → Nacl)
Na^+ ions must occupy all the **octahedral** voids.
formula of one unit cell = Na_4Cl_4 = NaCl
Effective no. of formula units , **Z = 4**

mass of unit cell = $\frac{ZM}{N_A}$

M = 58.5 gm/mole
Edge length of unit cell :-
$a(fcc) = 2(r_{Na^+} + r_{Cl^-})$

density $\rho = \frac{ZM}{N_A . a_{fcc}^3}$

$C.N._{Na^+} = 6$
$C.N._{Cl^-} = 6$
NaCl = 6 (cation) : 6 (anion) CN compound

(2) ZnS type(AB-type) of unit cell or 4 : 4 CN compound

ZnS – **fcc** (zinc blende)
ZnS – **hcp** (wurtzite)

experimental: $\frac{r_{zn^{2+}}}{r_{s^{2-}}} \approx 0.3$

S^{2-} will form **fcc** lattice. effective no. of S^{2-} ions in one unit cell = 4.0
Zn^{2+} ions will occupy *alternate (non-adjacent*) **four** out of eight **Tetahedral** voids.
$\therefore$ effective no. of Zn^{2+} ions = 4
formula of unit cell = Zn_4S_4
Effective no. of formula units, **Z = 4**

$$\text{mass} = \frac{ZM}{N_A} \qquad M = 97\ \text{gm/mole}$$

$$r_{zn^{2+}} + r_{s^{2-}} = \frac{1}{2}\times\left(\sqrt{3}\,\frac{a_{fcc}}{2}\right) \qquad \Rightarrow \qquad a_{fcc} = \frac{4}{\sqrt{3}}\left(r_{Zn^{2+}} + r_{s^{2-}}\right)$$

density $\rho = \dfrac{ZM}{N_A a_{fcc}^3}$
C.N. of Zn^{2+} ions = 4
C.N. of s^{2-} ions = 4

3. CaF_2 (Flourite structure)(AB_2-type) or 8 : 4 coordination no. compound

$r_{ca^{2+}} > r_{F^-}$ Here Cation is bigger than Anion.

$$\text{experimental: } 0.225 > \frac{r_{F^-}}{r_{ca^{++}}} < 0.414$$

fcc lattice position are occupied by Ca^{2+} ion
Effective no. of ca^{2+} ions = 4
F^- ions occupy all the **Tetrahedral** voids
Effective no. of F^- ions = 8
formula = $Ca_4F_8 = CaF_2$
effective no. of formula units, **Z = 4**

$$a_{fcc} = \frac{4}{\sqrt{3}}\left(r_{Ca^{2+}} + r_{F^-}\right)$$

C.N. of Ca^{2+} = 8
C.N of F^- = 4

4. Na_2O (sodium oxide) (A_2B-type)or Anti - Fluorite structure or 4 : 8 coordination compound

O^{2-} – **fcc** lattice
Na^+ – all the **tetrahedral** voids

5. CsCl type of structure or 8 : 8 CN compound

$$\text{Experimental: } \frac{r_{Cs^+}}{r_{Cl^-}} \approx 0.93$$

Cl^- forms **Simple cubic** lattice
Effective Cl^- ions = 1
Cs^+ will occupy **cubic** void
Effective Cs^+ ion = 1
Formula = CsCl
Z = 1

$$\rho = \frac{ZM}{Na\, a_{sc}^3} \qquad\qquad a_{sc} = \frac{2}{\sqrt{3}}\left(r_+ + r_-\right)$$

C.N of Cs^+ = **8** C.N of Cl^- = **8**

Effect of pressure and temperature on coordination number of compound :

On increasing pressure → Coordination number tends to increase
On increasing temperature → Coordination number tends to decrease
e.g.

$$4:4 \xrightarrow{P\uparrow} 6:6$$

$$8:8 \xrightarrow{T\uparrow} 6:6$$

Crystal imperfections / defects

Imperfections can be because of :-

- Conditions under which crystals have been developed,
- Impurities,
- Temp (because of thermal conductivity some atoms/ions can get displaced)

These imperfections can be

(a) Point defects - defects will be only at certain lattice positions.

(b) Line defects - If atoms/ions are misplaced/missing/replaced by some other ions along a line.

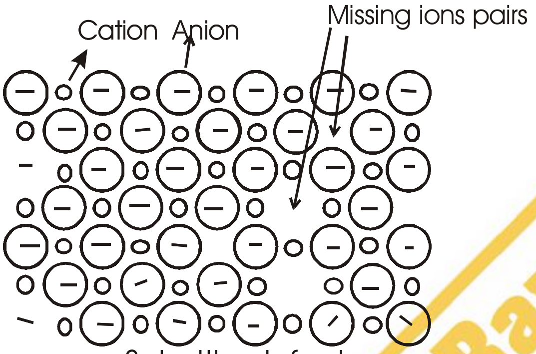
(c) plane (screw) defects - If atoms/ions are misplaced/missing/replaced by some other ions along a line in a plane.

Point Defects

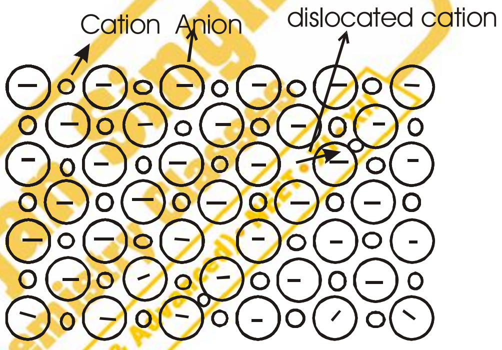
1. Stoichiometric -The formula of compound remains same even after presence of these defects.
2. Non-stoichiometric -The formula of compound will get modified because of the presece of these defects.

Stoichiometric defects

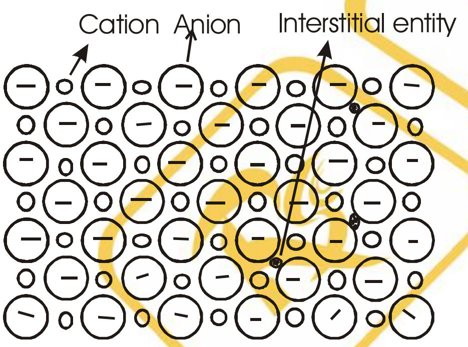
(a) Schottky (b) Frenkel (c) Interstitial



Schottky defect



Frenkel defect



Interstitial defect

Schottky : when atoms/point are totally missing from the lattice.

net density of crystal willl get decressed

$\rho_{exp} < \rho_{theoritical}$

% missing units = $\left(\frac{\rho_{th} - \rho_{exp}}{\rho_{th}}\right) \times 100\%$

FRENKEL : When atoms/ions displaced from normal lattice positions and are present in some interstitial voids.Density remains same

INTERSTITIAL :

When some small foreign atoms are trapped in interstitial voids of the lattice without any chemical reaction. Formula remains the same

$\rho_{exp} > \rho_{theortical}$

Non-stoichiometric defects :

(a) **metal excess** or **cation excess** defect :-

- If no. of missing anion is more than no. of missing cations.

- To maintain electrical neutrality some electron are trapped at anionic vacancies.

Because of these extra electron the electrical and optical (colour) properties of the compound get modified.

So these locations of electrons are also known as colour centres (F - centres) .

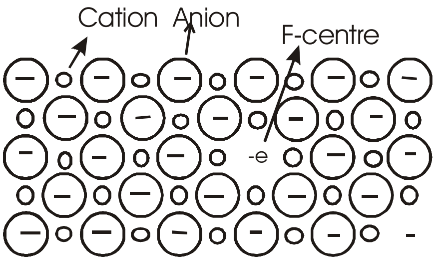
ZnO - white in colour at room temperature.

- on heating some O^{2-} ions get released in the form of O_2 and electrons are trapped at their locations. because of this it is yellow in colour.

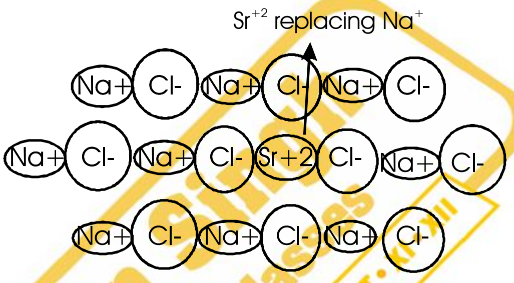
(b) **metal deficiency** (**cation deficiency**) defects

- no. of missing cations should be more than no. of missing anions.

- oxidation no. of cation will get modified to maintain electrical mentrality.



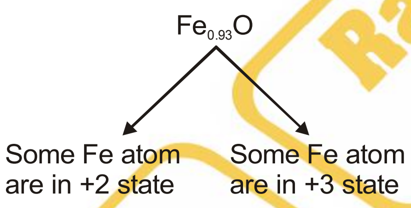
Metal excess



Cation Vacancy

Example: Ferrous oxide (FeO) is experimentally found to have the formula $Fe_{0.93}O$.Find the percentage of Fe ions in +3 state.

Sol:



Let there is x Fe atom in +3 state

$3x + 2(93 - x) = 200$

$x = 14$

$$\% \ Fe^{3+} = \frac{14}{93} \times 100\% = \frac{1400}{93} \%$$

$\approx 15.54\%$

TOPIC WISE MCQS

Types of Crystal

01. Which one is called pseudo solid -
(A) CaF_2 (B) Glass
(C) NaCl (D) All

02. Graphite is an example of -
(A) Ionic solid
(B) Covalent solid
(C) Vander waal's crystal
(D) Metallic crystal

03. Amorphous solids -
(A) Possess sharp melting points
(B) Undergo clean cleavage when cut with knife
(C) Do not undergo clean cleavage when cut with knife
(D) Possess orderly arrangement over long distances

04. Wax is an example of -
(A) Ionic crystal (B) Covalent crystal
(C) Molecular crystal (D) Metallic crystal

05. Crystals which are good conductor of electricity and heat are known as -
(A) Ionic crystals
(B) Covalence crystals
(C) Metallic crystals
(D) Molecular crystals

06. Iodine crystals are -
(A) Metallic solid (B) Ionic solid
(C) Molecular solid (D) Covalent solid

07. Which among the following will show anisotropy-
(A) Glass (B) Barium chloride
(C) Wood (D) Paper

08. Which is covalent solid-
(A) Fe_2O_3 (B) Diamond
(C) Graphite (D) All

Packing in Crystals & Voids

09. The arrangement ABC ABC .... is referred to as-
(A) Octahedral close packing
(B) Hexagonal close packing
(C) Tetrahedral close packing
(D) Cubic close packing

10. The most malleable metals (Cu, Ag, Au) have close - packing of the type-
(A) Hexagonal close - packing
(B) Cubic close - packing
(C) Body - centred cubic packing
(D) Malleability is not related to type of packing

11. The maximum percentage of available volume that can be filled in a face centred cubic system by an atom is-
(A) 74% (B) 68%
(C) 34% (D) 26%

12. The rank (effective atoms per unit cell) of a cubic unit cell is 4. The type of cell as-
(A) Body centred (B) Face centred
(C) Primitive (D) None of these

13. An element occurring in the BCC structure has 12.08×10^{23} unit cells. The total number of atoms of the element in these cell will be-
(A) 24.16×10^{23} (B) 36.18×10^{23}
(C) 6.04×10^{23} (D) 12.08×10^{23}

14. The space occupied by B.C.C. arrangement is approx-
(A) 50% (B) 68% (C) 74% (D) 56%

15. In a close pack array of N spheres, the number of tetrahedral holes are-
(A) 4N (B) N/2 (C) 2N (D) N

16. Transition metals, when they form interstitial compounds, the non-metals (H, B, C, N) are accomodated in-
(A) Voids or holes in cubic - packed structure
(B) Tetrahedral voids
(C) Octahedral voids
(D) All of these

Mathematical analysis of Crystal

17. Ferrimagnetism is in -
(A) ↑↑↑↑↑ (B) ↑↓↑↓
(C) ↑↑↑↓↓ (D) none of these

18. If a is the length of unit cell, then which one is correct relationship-
(A) For simple cubic lattice, Radius of metal atom = $\frac{a}{2}$
(B) For bcc lattice, Radius of metal atom = $\frac{\sqrt{3}\,a}{4}$
(C) For fcc lattice,Radius of metal atom = $\frac{a}{2\sqrt{2}}$
(D) All

19. The number of atoms present in a simple cubic unit cell are-
(A) 4 (B) 3 (C) 2 (D) 1

20. The number of atoms/molecules contained in one face centred cubic unit cell of a monoatomic substance is-
(A) 4 (B) 6
(C) 8 (D) 12

21. In a body centred cubic arrangement, the number of atoms per unit cell is-

(A) 8 (B) 2 (C) 1 (D) 4

22. The fraction of total volume occupied by the atoms in a simple cube is -

(A) $\frac{\pi}{4}$ (B) $\sqrt{2}\frac{\pi}{8}$ (C) $\sqrt{2}\frac{\pi}{6}$ (D) $\frac{\pi}{6}$

C. No., Symmetry in Crystal

23. 6 : 6 of NaCl coordination changes to 8 : 8 coordination on -

(A) applying high P
(B) increase in temperature
(C) both (A) and (B)
(D) no effect on coordination

24. The second order Bragg diffraction of X-rays with λ = 1.0 Å from a set of parallel planes in a metal occurs at an angle 60°. The distance between the scattering planes in the crystals is -

(A) 1.155 Å (B) 1.00 Å
(C) 2.00 Å (D) 1.7 Å

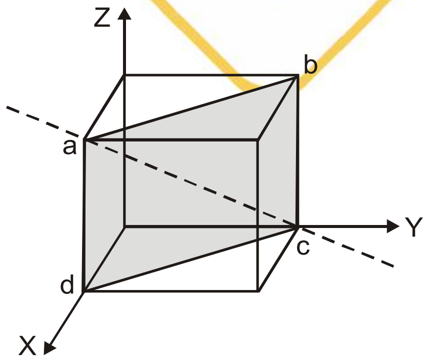
25. The elements of symmetry in a crystal are-

(A) Plane of symmetry
(B) Axis of symmetry
(C) Centre of symmetry
(D) All

26. A crystal may have one or more planes and one or more axes of symmetry but it possesses -

(A) Two centres of symmetry
(B) One centre of symmetry
(C) No centre of symmetry
(D) None of these

27. The shaded plane *abcd* is referred to as -



(A) rectangular plane of symmetry
(B) diagonal plane of symmetry
(C) unit plane
(D) none of these

Ionic Crystals

28. The C.N. of a M^{2+} in MX_2 is 8. Hence, C.N. of X^- is -

(A) 8 (B) 6
(C) 4 (D) 2

29. The melting point of RbBr is 682ºC, while that of NaF is 988ºC. The principal reason that melting point of NaF is much higher than that of RbBr is that-

(A) The two crystals are not isomorphous
(B) The molar mass of NaF is smaller than that of RbBr
(C) The internuclear distance, $r_c + r_a$ is greater for RbBr than for NaF
(D) The bond in RbBr has more covalent character than the bond in NaF

30. A binary solid ($A^+ B^-$) has a rock salt structure. If the edge length is 400 pm and radius of cation is 75 pm the radius of anion is -

(A) 100 pm (B) 125 pm
(C) 250 pm (D) 325 pm

31. Each unit cell of NaCl consists of 4 chloride ions and -

(A) 13 Na atoms (B) 4 Na ions
(C) 6 Na atoms (D) 8 Na atoms

32. In the unit cell of NaCl lattice there are –

(A) $3Na^+$ ions (B) $6Na^+$ ions
(C) $6Cl^-$ ions (D) 4 NaCl units

33. TiCl has structure similar to CsCl, the co-ordination number of Ti^+ is-

(A) 4 (B) 6
(C) 10 (D) 8

Radius Ratio

34. For tetrahedral co-ordination the radius ratio (r^+/r^-) should be -

(A) 0.414 - 0.732 (B) > 0.732
(C) 0.156 - 0.225 (D) 0.225 - 0.414

35. The ratio of cations to anion in a closed pack tetrahedral is-

(A) 0.414 (B) 0.225 (C) 0.02 (D) None

36. The radius of the Na^+ is 95 pm and that of Cl^- ion is 181 pm. Predict the co-ordination number of Na^+

(A) 4 (B) 6
(C) 8 (D) Unpredictable

37. The ionic radii of Rb^+ and I^- are 1.46 and 2.16 Å. The most probable type of structure exhibited by it is-

(A) CsCl type (B) NaCl type
(C) ZnS type (D) CaF_2 type

Electrical & Magnetic Crystals

38. One among the following is an example of ferroelectric compound-

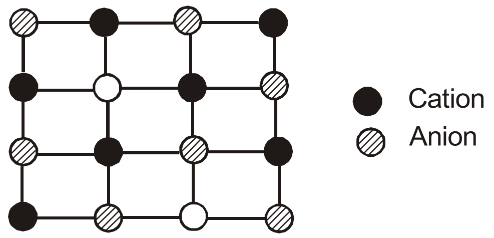
(A) Quartz (B) Lead chromate
(C) Barium titanate (D) Tourmaline

39. Certain crystals produce electric signals on application of pressure. This phenomenon is called-

(A) Pyro electricity (B) Ferroelectricity
(C) Piezoelectricity (D) Ferrielectricity

Defects in Crystal

40. Structure shown here represents -



(A) Schottky defect
(B) Frenkel defect
(C) metal excess defect
(D) none of these

41. Which of the following defect, if present, lowers the density of the crystal-

(A) Frenkel
(B) Schottky
(C) Edge dislocation
(D) Constitution of F-centres.

42. The yellow colour of ZnO and conducting nature produced in heating is due to-

(A) Metal excess defects due to interstitial cation
(B) Extra positive ions present in an interstitial site
(C) Trapped electrons
(D) All

43. In antiflourite structure, the negative ions-

(A) Occupy tetrahedral voids
(B) Occupy octahedral voids
(C) Are arranged in ccp
(D) Are arrange in hcp

44. A silicon solar battery makes use of-

(A) n-Type semiconductor
(B) p-Type semiconductor
(C) Combination of Si doped with As and B
(D) p-n junction

MISCELLANEOUS QUESTIONS

01. How many number of atoms are there in a cube based unit cell having one atom on each corner and two atoms on each body diagonal of cube -

(A) 8 (B) 6 (C) 4 (D) 9

02. An alloy of copper, silver and gold is found to have copper constituting the C.C.P. lattice. If silver atoms occupy the edge centres and gold is present at body centre, the alloy has a formula-

(A) Cu_4Ag_2Au (B) Cu_4Ag_4Au
(C) Cu_4Ag_3Au (D) CuAgAu

03. The number of atoms/molecules contained in one face centred cubic unit cell of a mono atomic substance is-

(A) 1 (B) 2 (C) 4 (D) 6

04. In a face centred cubic arrangement of A & B atoms whose A atoms are at the corner of the unit cell & B atoms at the face centres. One of the A atom is missing from one corner in unit cell. The simplest formula of compound is-

(A) A_7B_3 (B) AB_3
(C) A_7B_{24} (D) $A_{7/8}\,B_3$

05. Which is/are amorphous solids-

(A) Rubber (B) Plastics
(C) Glass (D) All

06. A solid has a B.C.C. structure. If the distance of closest approach between the two atoms is 1.73 Å. The edge length of the cell is-

(A) 200 pm (B) $\frac{\sqrt{3}}{\sqrt{2}}$ pm
(C) 142.2 pm (D) $\sqrt{2}$ pm

07. In a close packed array of N spheres, the number of tetrahedral holes are-

(A) $\frac{N}{2}$ (B) 4N
(C) 2N (D) N

08. In a face centred cubic cell, an atom at the face centre is shared by-

(A) 4 unit cells (B) 2 unit cells
(C) 1 unit cell (D) 6 unit cells

09. A solid XY has NaCl structure. If radius of X^+ is 100 pm. What is the radius of Y^- ion-

(A) 120 pm
(B) 136.6 to 241.6 pm
(C) 280 pm
(D) Unpredictable

10. How many atoms are there in a unit cell of Mg which forms hexagonal crystals, there being a face-centred atom in each end of the unit cell and 3 completely enclosed atoms within the unit cell-

(A) 4 (B) 6
(C) 12 (D) 8

11. A solid is made of two elements X and Z. The atoms Z are in C.C.P. arrangement while atoms X occupy all the tetrahedral sites. What is the formula of the compound-

(A) XZ (B) XZ_2
(C) X_2Z (D) Unpredictable

12. Close packing is maximum in the crystal-

(A) Simple cubic (B) Face centred
(C) Body centred (D) None of these

13. The vacant space in B.C.C. unit cell is-

(A) 32% (B) 10% (C) 23% (D) 46%

14. The density of KCl is 1.9893 g cm^{-3} and the length of a side unit cell is 6.29082 Å as determined by X-Rays diffraction. The value of avogadro's number calculated from these data is-

(A) 6.017×10^{23} (B) 6.023×10^{23}
(C) 6.03×10^{23} (D) $6.017 \times 10^{19]}$

15. The unit cell cube length for LiCl (just like NaCl structure) is 5.14 Å. Assuming anion-anion contact, the ionic radius for chloride ion is-

(A) 1.815 Å (B) 2.8 Å
(C) 3.8 Å (D) 4.815 Å

16. At room temperature, sodium crystallizes in a body centred cubic lattice with a = 4.24 Å. The theoretical density of sodium (At. wt. of Na = 23) is-

(A) 1.002 g cm^{-3} (B) 2.002 g cm^{-3}
(C) 3.002 g cm^{-3} (D) None of these

17. In a body centred cubic cell an atom at the body of centre is shared by-

(A) 1 unit cell (B) 4 unit cells
(C) 3 unit cells (D) 2 unit cells

18. In a face centred cubic lattice the number of nearest neighbour for a given lattice point are-

(A) 6 (B) 8
(C) 12 (D) 14

19. In a solid, oxide ions are arranged in CCP. Cations A occupy one-sixth of the tetrahedral voids and cations B occupy one-third of the octahedral voids. The formula of the compound is -

(A) ABO_3 (B) AB_2O_3
(C) A_2BO_3 (D) $A_2B_2O_3$

20. A solid AB has rock salt structure. If the edge length is 520 pm and radius of A^+ is 80 pm, the radius of anion B^- would be -

(A) 440 pm (B) 220 pm
(C) 360 pm (D) 180 pm

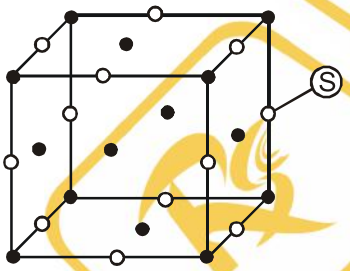
21. A binary solid (A^+ B^-) has a zinc blende structure with B^- ions constituting the lattice and A^+ ions occupying 25% tetrahedral holes. The formula of solid is-

(A) AB (B) A_2B
(C) AB_2 (D) AB_4

22. A certain metal crystallises in a simple cubic structure. At a certain temperature, it arranges to give a body centred structure. In this transition, the density of the metal-

(A) Decreases
(B) Increases
(C) Remain unchanged
(D) Changes without a definite pattern

23. For the structure given below the site marked as S is a-



(A) Tetrahedral void (B) Cubic void
(C) Octahedral void (D) None of these

24. ZnS is-

(A) Ionic crystal
(B) Covalent crystal
(C) Metallic crystal
(D) Vander Waals' crystal

25. LiF is a/an-

(A) Ionic crystal (B) Metallic crystal
(C) Covalent crystal (D) Molecular crystal

26. A solid having no definite shape is called-

(A) Amorphous solid (B) Crystalline solid
(C) Anisotropic solid (D) None of these

27. The mass of a unit cell of CsCl corresponds to-

(A) $8Cs^+$ and $1Cl^-$ (B) $1Cs^+$ and $6Cl^-$
(C) $1Cs^+$ and $1Cl^-$ (D) $4Cs^+$ and $4Cl^-$

28. Close packing is maximum in the crystal lattice of-

(A) Simple cubic (B) Face centred
(C) Body centred (D) None of these

29. The structure of MgO is similar to NaCl. The co-ordination number of Mg is-

(A) 2 (B) 6
(C) 4 (D) 8

30. Each unit cell of NaCl consists of 14 chlorine atoms and-

(A) 13 Na atoms (B) 14 Na atoms
(C) 6 Na atoms (D) 8 Na atoms

31. Schottky defect is noticed in-

(A) NaCl (B) KCl
(C) CsCl (D) All

32. The structure of sodium chloride crystal is-

(A) Body centred cubic lattice
(B) Face centred cubic lattice
(C) Octahedral
(D) Square planar

33. A crystal of Fe_3O_4 is-

(A) Paramagnetic (B) Diamagnetic
(C) Ferrimagnetic (D) None of these

34. A cubic crystal possesses in all ..... elements of symmetry-

(A) 9 (B) 13
(C) 1 (D) 23

35. The structure of sodium crystal is-

(A) Body centred cubic lattice
(B) Face centred cubic lattice
(C) Octahedral
(D) Square planar

36. Extremely pure samples of Ge and Si are non-conductors, but their conductivity increases suddenly on introducing .... in their crystal lattice-

(A) As (B) B
(C) Both (A) and (B) (D) None of these

37. The co-ordination number of a body centred atom is-

(A) 4 (B) 6 (C) 8 (D) 12

38. Which is ferromagnetic-

(A) Ni (B) Co
(C) CrO_2 (D) All

39. Which of the following is ferroelectric compound

(A) $BaTiO_3$ (B) $K_4[Fe(CN)_6]$
(C) Pb_2O_3 (D) All.

40 An example of body cubic is -
(A) Sodium (B) Magnesium
(C) Zinc (D) Copper.

41. Sodium crysrallizes in cubic lattice with cell edge a=4.29Å. What is the radius of Na atom -
(A) 1.86 Å (B) 6.81 Å
(C) 8.61 Å (D) 2.94 Å

42. A binary solid $x^+ y^-$ crystallizes in rock structure. If the edge lenght is 400pm and radius of cation 75pm, the radius of anion will be -
(A) 325 pm (B) 250 pm
(C) 125 pm (D) 325 pm

43. A mineral having the formula AB_2 crystallize in cubic close packed lattice with the A atoms occupying the lattice points. The coordination number of atoms of A, atoms of B and the fraction of the tetrahedral sites occupied by B are respectively -
(A) 2, 6, 75% (B) 8, 4, 100%
(C) 3, 1,25% (D) 6, 6, 50%

44. In Corundum, oxide ions are arranged in hcp arrangement and aluminium ion occupy two third of the octahedral holes. Its formula is -
(A) Al_2O_3 (B) Al_2O_4
(C) Al_3O_4 (D) AlO_2.

45. NH_4Cl crystallizes in bcc lattice with edge length of unit cell equal to 387 pm. If radius of Cl^- is 181 pm, the radius of NH_4^+ will be -
(A) 174 pm (B) 154 pm
(C) 116 pm (D) 206 pm

46. 8 : 8 coordination number of CsCl change into 6 : 6 on -
(A) Applying high P
(B) Increasing temperature
(C) Both A and B
(D) Can't be changed

47. Point defect which lowers the density of materials -
(A) schottky (B) Frenkel
(C) Both (D) None of these

48. At low temperature O_2 freezes to form crystalline solid. Which term best describer the solid -
(A) Ionic crystal (B) Covalent crystal
(C) Metallic crystal (D) Molecular crystal

49. Arrangement of Cl^- in CsCl is -
(A) HCP (B) Simple cubic
(C) FCC (D) BCC

50. The decreasing order of the size of void is -
(A) Cubic > Octahedral > Tetrahedral > Trigonal
(B) Trigonal > Tetrahedral > Octahedral > Cubic
(C) Trigonal > Octahedral > Tetrahedral > Cubic
(D) Cubic > Tetrahedral > Octahedral > Trigonal

◆ ◆ ◆ ◆ ◆ ◆

ANSWER KEY

TOPIC WISE MCQS

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	B	B	C	C	C	C	B	D	D	B	A	B	A	B	C
Q.No.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	D	C	D	D	A	B	D	A	A	D	B	B	C	C	B
Q.No.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	
Ans.	B	D	D	D	B	B	B	C	C	A	B	D	C	C	

MISCELLANEOUS QUESTIONS

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	D	C	C	C	D	A	C	B	B	B	C	B	A	A	A
Ques.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	A	A	C	A	D	C	B	C	A	A	A	C	B	B	A
Ques.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	D	B	C	D	A	C	C	D	A	A	A	C	B	A	B
Ques.	46	47	48	49	50										
Ans.	B	A	D	B	A										

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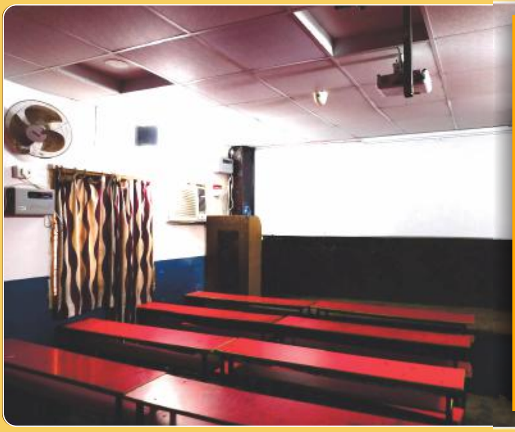

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