SAIVEERA ACADEMY - REVOLUTION FOR LEARNING
PEELAMEDU - 8098850809
12TH UNIT – 6 SOLID STATE INTENSIVE COACHING TEST

Marks : 90
Time : 1 hrs 45 min

I.Choose the best answers **10× 1 = 10**

1. Assertion : monoclinic sulphur is an example of monoclinic crystal system
Reason: for a monoclinic system, $a \neq b \neq c$ and $\alpha = \gamma = 90^0$ $\beta = 90^0$
a) Both assertion and reason are true and reason is the correct explanation of assertion.
b) Both assertion and reason are true but reason is not the correct explanation of assertion.
c) Assertion is true but reason is false.
d) Both assertion and reason are false.

2. In a solid atom M occupies ccp lattice and (2 /3) of tetrahedral voids are occupied by atom N. find the formula of solid formed by M and N.
a) MN b) M_3N_4 c) MN_3 d) M_3N_2

3. CsCl has bcc arrangement, its unit cell edge length is 400pm, its inter atomic distance is
a) $\sqrt{3} \times 200$pm b) 800pm c) $\sqrt{3} \times 400$ d) 400

4. The vacant space in fcc lattice unit cell is
a) 48% b) 23% c) 32% d) 26%

5. Frenkel defect in a crystal is observed when
a) unequal number of anions and anions are missing from the lattice
b) equal number of anions and anions are missing from the lattice
c) an ion leaves its normal site and occupies an interstitial site
d) no ion is missing from its lattice.

6. In a simple cubic cell, each point on a face centered is shared by
a) one unit cell b) two unit cells c) eight unit cells d) three unit cells

7. The co-ordination number of CsCl is
a) 3 b) 4 c) 6 d) 8

8.Find the odd one out Solid ice , glucose , urea , Solid CO_2

9. Percentage of Schottky defect in VO(Vanadium Mono oxide) crystal
a) 24% b) 14% c) 32% d) 26%

10. The Coordination number of each atom in Face centered cubic unit cell
a) 3 b) 4 c) 2 d) 8

II .Knowledge based questions **15× 1 = 15**

1.Refractive index of a solid is observed to have the same value along all directions.Find the nature of this solid
2.Solid A is very hard electrical insulator in solid as well as in molten state & melts at extremely high temperature .What type of solid is it ?
3.Ionic solids conduct electricity in molten state but not in solid state .Explain
4.Name the parameters that characterize a unit unit cell
5.Distinguish between i) Hexagonal and monoclinic unit cells
6.Explain how much portion of an atom is located at corner of a unit cell
7.What is two dimensional coordination number of a molecule in square closed layer
8.What type of stoichiometric defect is shown by i)ZnS ii) AgBr
9.Explain how vacancies are introduce in an ionic solid when a cation of higher valence is added as impurity in it

10.In ionic solids , which have anionic vacancies due to metal excess defect , develop color .Explain with the help of suitable example
11.Clasify each of the following solids as ionic , metallic , molecular , covalent , amorphous i)plastic ii) Ammonium phosphate iii) LiBr
12.A cubic solids is made of two elements P & Q .Atoms of P are at centre & atoms of Q are at corners of cube .What is the formula of the compound ?
13.Explain the relationship between atomic radius and edge length of fcc unit cell
14.Which type of ionic substances show schottky defect in solids ?
15.Why Schottky defect lowers the density of solid

III.Problems **5× 3 = 15**

1. Experiment shows that Nickel oxide has the formula $Ni_{0.98} O_{1.00}$. What fraction of Nickel exists as of Ni^{2+} and Ni^{3+} ions?
2. If NaCl is doped with 10^{-3} mol percentage of strontium chloride, what is the concentration of cation vacancy?
3. KF crystallizes in fcc structure like sodium chloride. Calculate the distance between K^+ and F^- in KF(Given: density of KF is 2.48 g cm^{-3}) and also the atomic radius
4.Aluminium crystallizes in a cubic closed packed structure .Radius of atom in the metal is 125 pm , find the edge length
5.Copper crystallizes with Body centered cubic unit cell .If the radius of copper atom is 127.8 pm .Calculate the density of copper metal (Atomic mas of Cu is 63.55u)

IV.Very short answers **5× 2 = 10**

1. 1.Define unit cell & Coordination number
2. Give any two characteristics of ionic crystals & solids
3. What are point defects? Calculate the number of atoms in a fcc unit cell.
4. .Why ionic crystals are hard and brittle?
5. What are two types of unit cells: primitive and non-primitive unit cells

V.Short answers **5× 3 = 15**

1. .Explain about impurity defect
2. Determine packing efficiency simple cubic unit cell
3. Write short note on metal excess and metal deficiency defect with an example
4. Explain Schottky defect
5. Explain Frenkel defect

VI.Long answers **5× 5 = 25**

1. Differentiate crystalline solids and amorphous solids
2. Distinguish between hexagonal close packing and cubic close packing
3. Distinguish tetrahedral and octahedral voids.
4.Determine packing efficiency Face centered cubic unit cell or cubic closed packing
5. Explain about classification of solids

If you believe in yourself
Anything is possible

UNIT – 6 SOLID STATE
One Marks (Book Back)

1. Graphite and diamond are
a) Covalent and molecular crystals b) ionic and covalent crystals
c) both covalent crystals d) both molecular crystals

2. An ionic compound A_xB_y crystallizes in fcc type crystal structure with B ions at the centre of each face and A ion occupying entre of the cube. the correct formula of A_xB_y is
a) AB **b) AB_3** c) A_3B d) A_8B_6

3. The ratio of close packed atoms to tetrahedral hole in cubic packing is
a) 1:1 **b) 1:2** c) 2:1 d) 1:4

4.Solid CO_2 is an example of
a) Covalent solid b) metallic solid
c) molecular solid d) ionic solid

5. Assertion : monoclinic sulphur is an example of monoclinic crystal system
Reason: for a monoclinic system, a≠b≠c and $\alpha = \gamma = 90^0$ $\beta \neq 90^0$
a) Both assertion and reason are true and reason is the correct explanation of assertion.
b) Both assertion and reason are true but reason is not the correct explanation of assertion.
c) Assertion is true but reason is false.
d) Both assertion and reason are false.

6. In calcium fluoride, having the flourite structure the coordination number of Ca^{2+} ion and F^- Ion are
a) 4 and 2 b) 6 and 6 **c) 8 and 4** d) 4 and 8

7.The number of unit cells in 8 gm of an element X (atomic mass 40) which crystallizes in bcc pattern is (N_A is the Avogadro number)
a) 6.023×10^{23} **b) 6.023×10^{22}** c) 60.23×10^{23} d) 6.023×10^{22} / 8×40

8. The number of carbon atoms per unit cell of diamond is
a) 8 b) 6 c) 1 d) 4

9.In a solid atom M occupies ccp lattice and (1 /3) of tetrahedral voids are occupied by atom N. find the formula of solid formed by M and N.
a) MN b) M_3N c) MN_3 **d) M_3N_2**

10.The composition of a sample of wurtzite is $Fe_{0.93}O_{1.00}$ what % of Iron present in the form of Fe^{3+} ?
a) 16.05% **b) 15.05%** c) 18.05% d) 17.05%

11. The ionic radii of A^+ and B^- are 0.98×10^{-10} m and 1.81×10^{-10} the coordination number of each ion in AB is
a) 8 b) 2 **c) 6** d) 4

12. CsCl has bcc arrangement, its unit cell edge length is 400pm, its inter atomic distance is
a) 400pm b) 800pm c) $\sqrt{3} \times 400$ **d) $\frac{\sqrt{3}}{2} \times 400$**

13.A solid compound XY has NaCl structure. if the radius of the cation is 100pm , the radius of the anion will be
a) $\frac{100}{0.414}$ b) $\frac{0.732}{100}$ c) 100×0.414 d) $\frac{0.414}{100}$

14. The vacant space in bcc lattice unit cell is
a) 48% b) 23% **c) 32%** d) 26%
15. The radius of an atom is 300pm, if it crystallizes in a face centered cubic lattice, the length of the edge of the unit cell is
a) 488.5pm b) 848.5pm **c) 884.5pm** d) 484.5pm
16. The fraction of total volume occupied by the atoms in a simple cubic is
a) $\frac{\pi}{4\sqrt{2}}$ **b)** $\frac{\pi}{6}$ c) $\frac{\pi}{4}$ d) $\frac{\pi}{3\sqrt{2}}$
17. The yellow colour in NaCl crystal is due to
a) excitation of electrons in F centers
b) reflection of light from Cl^- ion on the surface
c) refraction of light from Na^+ ion
d) all of the above
18. if 'a' stands for the edge length of the cubic system ; sc , bcc, and fcc. Then the ratio of radii of spheres in these systems will be respectively.
a) ½ a : $\frac{\sqrt{3}}{2}a$: $\frac{\sqrt{2}}{2}$ a b) $\sqrt{1}$ a : $\sqrt{3}$ a : $\sqrt{2}$ a
c) ½ a : $\frac{\sqrt{3}}{4}a$: $\frac{1}{2\sqrt{2}}$ **a** d) ½ a : $\sqrt{3}a$: $\frac{1}{\sqrt{2}}$ a
19. if 'a' is the length of the side of the cube, the distance between the body centered atom and one corner atom in the cube will be
a) $\frac{2}{\sqrt{3}}$ a b) $\frac{4}{\sqrt{3}}$ a c) $\frac{\sqrt{3}}{4}$ a **d)** $\frac{\sqrt{3}}{2}a$
20.Potassium has a bcc structure with nearest neighbour distance 4.52 A^0 . its atomic weight is 39. its density will be
a) 915 kg m^{-3} b) 2142 kg m^{-3} c) 452 kg m^{-3} d) 390 kg m^{-3}
21. Schottky defect in a crystal is observed when
a) unequal number of anions and anions are missing from the lattice
b) equal number of anions and anions are missing from the lattice
c) an ion leaves its normal site and occupies an interstitial site
d) no ion is missing from its lattice.
22. The cation leaves its normal position in the crystal and moves to some interstitial position, the defect in the crystal is known as
a) Schottky defect b) F center
c) Frenkel defect d) non-stoichiometric defect
23. Assertion: due to Frenkel defect, density of the crystalline solid decreases.
Reason: in Frenkel defect cation and anion leaves the crystal.
a) Both assertion and reason are true and reason is the correct explanation of assertion.
b) Both assertion and reason are true but reason is not the correct explanation of assertion.
c) Assertion is true but reason is false.
d) Both assertion and reason are false
24. The crystal with a metal deficiency defect is
a) NaCl **b) FeO** c) ZnO d) KCl

25. A two dimensional solid pattern formed by two different atoms X and Y is shown below. The black and white squares represent atoms X and Y respectively. the simplest formula for the compound based on the unit cell from the pattern is

a) XY_8 b) X_4Y_9 c) XY_2 d) XY_4

One MARKS (Book inside)

1.An example for metal deficiency defect is

a) NaCl b) AgCl **c) FeO** d) CsCl

2. An ion leaves its regular site and occupies a position in the space between the lattice sites. This defect is called as

a) Schottky defect **b) Frenkel defect** c) impurity defect d) vacancy defect

3. In a simple cubic cell, each point on a corner is shared by

a) one unit cell b) two unit cells **c) eight unit cells** d) four unit cells

4.In Bragg's equation 'n' represent

a) number of moles b) Avogadro number c) quantum number **d) order of reflection**

5.The Bragg's equation is

a) $\lambda = 2d \sin\theta$ b) $nd = 2 \lambda \sin\theta$ c) $2 \lambda = nd \sin\theta$ **d) $n \lambda= 2d \sin \theta$**

6.The co-ordination number of ZnS is

a) 3 **b) 4** c) 6 d) 8

7. The co-ordination number of B_2O_3 is

a) 3 b) 4 c) 6 d) 8

8. The co-ordination number of NaCl is

a) 3 b) 4 **c) 6** d) 8

9. The co-ordination number of CsCl is

a) 3 b) 4 c) 6 **d) 8**

10.The crystal structure of CsCl is

a) simple cube b) face-centred cube **c) body-centred cube** d) edge-centred cube

11.A regular three dimensional arrangement of identical points in space is called

a) Unit cell b) Space lattice c) Primitive d) Crystallography

12. An example for Frenkel defect is

a) NaCl **b) AgBr** c) CsCl d) FeS

13.The solids which are good conductors of electricity and heat are

a) Ionic solids b) Molecular solids **c) Metallic solids** d) Covalent solids

14.The solid in which its constituents have an orderly arrangement extending over a long range

a) Ionic solid b) Molecular solids **c) Crystalline solids** d) Amorpous solids

15.The structural units of ionic crystal are **cations and anions**

16.Ionic solid act as **conductor** in molten state **insulator** in solid state

17.In covalent solids atoms held by **covalent bonds**

18.Covalent crystal are **poor thermal and electrical conductors**

19.Molecular solids **cannot conduct electricity**

20.Example for Non polar molecular solid ; **Napthalene , Anthracene**
21. Example for polar molecular solid ;**Solid CO_2 , Solid NH_3**
22. Example for Hydrogen bonded molecular solid ; **Solid ice , glucose , urea**
23. Example for Metallic solid ; **Cu , Fe , Zn , Ag , Au , Cu-Zn**
24.Two types of unit cells ; **Primitive & non primitive**
25.No of atoms in a **simple cubic** unit cell = **1**
26. No of atoms in a **body centered** cubic unit cell = **2**
27. No of atoms in a **Face centered** cubic unit cell = **4**
28.In AAA type each sphere is arranged in contact with **four** of its neighbours
29.In ABAB… type each sphere is arranged in contact with **six** of its neighbours
30.On comparing AAAA….. & ABAB…. Type **closest arrangement is ABAB…..**
31.Simple cubic arrangement obtained by **repeating AAAA type two dimensional arrangements** in three dimension
32.Packing efficiency **of Simple cubic , Body centered , Face centered cubic unit cell** (Cubic close packing) are **52.31 % , 68 % , 74 %**
33, Percentage of free space (vacant) **of Simple cubic , Body centered , Face centered cubic unit cell** (Cubic close packing) are **47..69 % , 32 % , 26 %**
34.Stoichiometric defect ; **Schottky , Frenkel**
35. Non Stoichiometric defect ; **Metal excess and deficiency effect**
36.Percentage of Schottky defect in VO(Vanadium Mono oxide) crystal : **14 %**
37.Example for Metal excess defect : **ZnO**
38.Example for impurity defect : **AgCl**
39.The Coordination number of each atom in **Simple Cubic , Face centered cubic , Body centered cubic are 6 , 2 , 8**

Answer the following questions (Book Back answers)

1.Define unit cell.

A basic repeating structural unit of a crystalline solid in a three dimensional pattern is called a unit cell

A unit cell is characterised by the three edge lengths or lattice constants a ,b and c and the angle between the edges α, β and γ

2. **Give any three characteristics of ionic crystals**

- Ionic solids have high melting points.
- In solids state it acts as insulators & they conduct electricity when dissolved in water.
- They are hard & brittle.

3. **Differentiate crystalline solids and amorphous solids**

Crystalline Solids	Amorphous solids
Long range orderly arrangement of constituents.	Short range, random arrangement of constituents.
Definite shape	Irregular shape
Anisotropic in nature	Isotropic in nature
They are true solids	They are considered as pseudo solids (or) super cooled liquids
Definite Heat of fusion	Heat of fusion is not definite
They have sharp melting points.	Gradually soften over a range of temperature and so can be moulded
Examples: NaCl , diamond,	Examples: plastics, glass

4. Classify the following solids a. P_4 b. Brass c. diamond d. NaCl e. Iodine

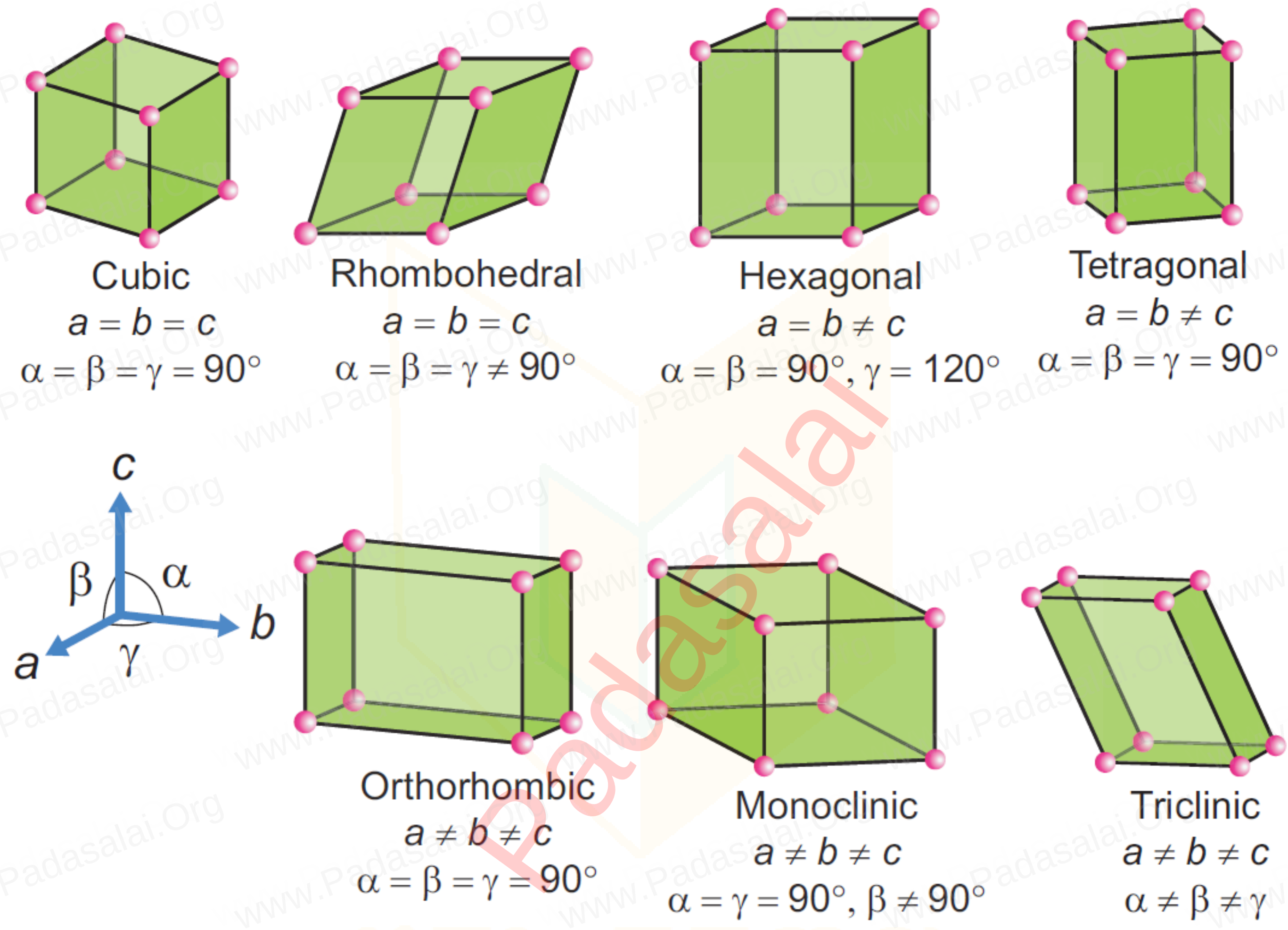
a. P_4 - Molecular solid b. Brass – Metallic solid

c. diamond – Covalent solid d. NaCl – Ionic solid e. Iodine – Molecular solid

5. Explain briefly seven types of unit cell.

There are seven primitive crystal systems; cubic, tetragonal, orthorhombic, hexagonal, monoclinic, triclinic and rhombohedral. They differ in the arrangement of their crystallographic axes and angles

NaCl **HgS** **Zinc Oxide** **TiO_2**



BaSO4 **Monoclinic sulphur** **$CuSO_4 . 5H_2O$**

6.Distinguish between hexagonal close packing and cubic close packing

Hexagonal Close packing	**Cubic Close packing**
'ABA' arrangement is known as the hexagonal close packed (hcp) arrangement.	**'ABC' arrangement** is known as the hexagonal cubic close packing. (ccp) arrangement.
The spheres of the third layer is exactly aligned as first layer	The spheres of the third layer is not aligned with those of either the first or second layer.
The hexagonal close packing is based on hexagonal unit cells with sides of equal length	The cubic close packing is based on the face centered cubic unit cell.
Tetrahedral voids of the second layer are covered by the sphere of the third layer	octahedral voids of the second layer are covered by the sphere of the third layer
The unit cell of hexagonal close packing **has 6 spheres**.	The unit cell of cubic close packing has **4 spheres**
This type is found in metals like **Mg,Zn,**	This type is found in metals like **Cu, Ag**,

7. Distinguish tetrahedral and octahedral voids.

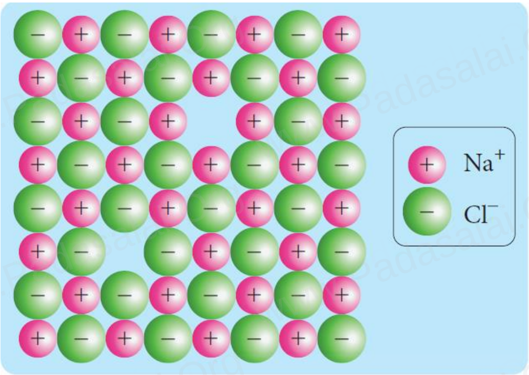
Tetrahedral Void	Octahedral Void
When **a sphere of second layer (b) is above the void (x) of the first layer (a),** tetrahedral void is formed.	**When the voids (y) in the first layer (a) are partially covered by the spheres of layer (b),** octahedral void (a)
If the number of close packed spheres be 'n' then, the number of tetrahedral voids generated is equal to **2n.**	If the number of close packed spheres be 'n' then, the number of octahedral voids generated is equal to **n**
This constitutes four spheres , three on the lower (a) and one in the upper layer (b).	This constitutes six spheres the lower layer (a) and three in the upper layer (b)
When the centers of these four spheresare joined, a tetrahedron is formed	When the centers of these six spheres are joined, an octahedron is formed.
The coordination number is **4.**	The coordination number is **6**.

8. What are point defects?

Point defects are the irregularities or deviations from ideal arrangement around a point or an atom in a crystal

Types : Stoichiometric , Non stoichiometric , Impurity defect

9. Explain Schottky defect



Schottky Defect

Schottky defect arises due to **the missing of equal number of cations and anions** from the crystal lattice.

This effect **does not change the stoichiometry** of the crystal.

Ionic solids in which the **cation and anion are of almost of similar size** show schottky defect.

Example: NaCl.

Presence of large number of schottky defects in a crystal, **lowers its density.**

Example: vanadium monoxide (VO)

Theoretical density is **6.5 g cm-3,** but the actual

Experimental density is **5.6 g cm-3**.

Approximately **14% Schottky defect** in VO crystal.

10. Write short note on metal excess and metal deficiency defect with an example

Metal excess defect

Metal excess defect arises due to the **presence of more number of metal ions** as compared to anions.

Alkali metal halides **NaCl, KCl** show this type of defect.

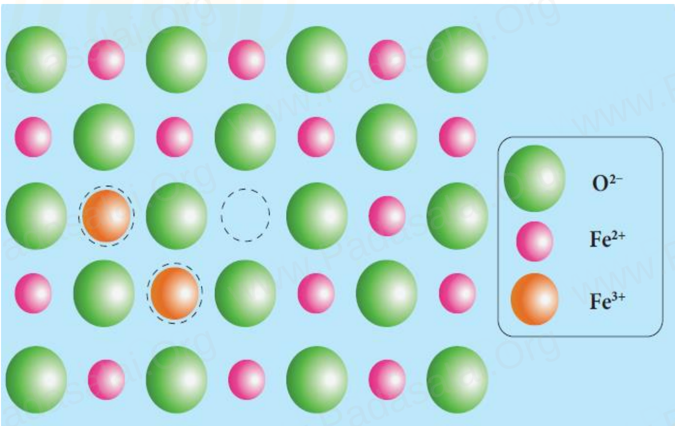
The electrical neutrality of the crystal can be maintained by the presence of anionic vacancies equal to the excess metal ions (or) by the presence of extra cation and electron present in interstitial position.

Example ; ZnO is colourless at room temperature. When it is heated, it becomes yellow in colour. On heating, it loses oxygen and thereby forming free Zn2+ ions. The excess Zn2+ ions move to interstitial sites and the electrons also occupy the interstitial positions.

Metal deficiency defect

Metal deficiency defect arises due to the presence of less number of cations than the anions.

This defect is observed in a crystal in which, the cations have variable oxidation states.



Example : In FeO crystal, some of the Fe^{2+} ions are missing from the crystal lattice. To maintain the electrical neutrality, twice the number of other Fe^{2+} ions in the crystal is oxidized to Fe^{3+} ions. In such cases, overall number of Fe^{2+} and Fe^{3+} ions is less than the O^{2-} ions.

11.Calculate the number of atoms in a fcc unit cell.

In a face centered cubic unit cell, identical atoms lie at each corner as well as in the centre of each face.

Those atoms in the corners touch those in the faces but not each other.

The coordination number is 2. The atoms in the face centre is being shared by two unit cells, each atom in the face centers makes ½ contribution to the unit cell.

N_c = 8 (Number of atoms in corners) N_f = 6 (Number of atoms in face)

Number of unit cell in fcc = $N_C/8 + N_f/2$

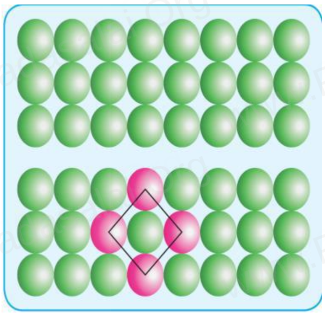
= 8/8 + 6/2

= 1 + 3

= 4

12.Explain AAAA and ABABA and ABCABC type of three dimensional packing with the help of neat diagram.

(i) AAAA type:



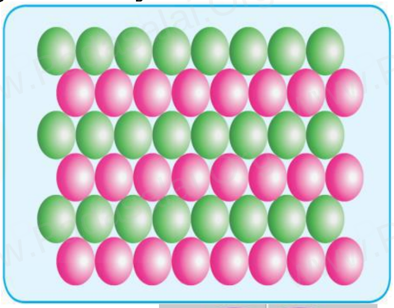
Linear arrangement of spheres in one direction is repeated in two dimension i.e., more number of rows can be generated identical to the one dimensional arrangement such that all spheres of different rows align vertically as well as horizontally.

If we denote the first row as A type arrangement, then the above mentioned packing is called AAA type, because all rows are identical as the first one.

In this arrangement each sphere is in contact with **four** of its neighbours.

(ii) **ABAB.. Type:**

In this type, the second row spheres are arranged in such a way that they fit in the depression of the first row .

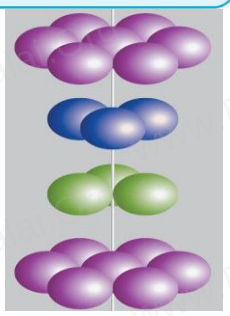


The second row is denoted as B type.

The third row is arranged similar to the first row A, and the fourth one is arranged similar to second one. i.e., the pattern is repeated as ABAB….

In this arrangement each sphere is in contact with **6** of its neighbouring spheres

(iii) ABCABC type arrangement – ccp structure



The third layer may be placed over the second layer in such a way that all the spheres of the third layer fit in octahedral voids.

This arrangement of the third layer is different from other two layers (a) and (b), and hence, the third layer is designated (c). If the stacking of layers is continued in abcabcabc… pattern, then the arrangement is called cubic close packed (ccp) structure

13.Why ionic crystals are hard and brittle?

Only strong forces can change the relative position of its constituent ions , so they are hard

In ionic compounds the ions are rigidly held in a lattice because the positive and negative ions are strongly attracted to each other and difficult to separate.

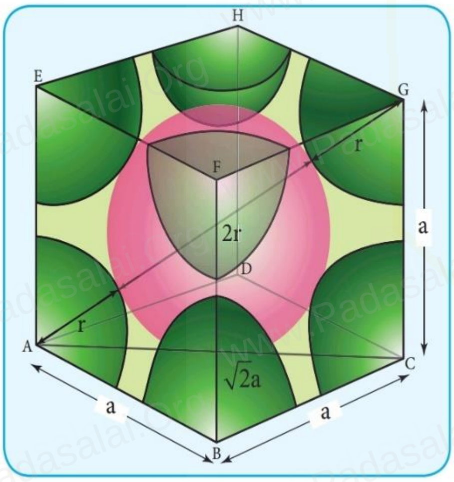
But the brittleness of a compound is how easy it is to shift the position of atoms or ions in a lattice

14.Calculate the percentage efficiency of packing in case of body centered cubic crystal

In this arrangement, the spheres in the first layer (A type) are slightly separated and the second layer is formed by arranging the spheres in the depressions between the spheres in layer A .

The third layer is a repeat of the first. This pattern ABABAB is repeated throughout the crystal.

In this arrangement, each sphere has a coordination number of 8, four neighbors in the layer above and four in the layer below.



In ΔABC

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

$$AC = \sqrt{AB^2 + BC^2}$$

$$AC = \sqrt{a^2 + a^2} = \sqrt{2a^2} = \sqrt{2}\, a$$

In ΔACG

$$AG^2 = AC^2 + CG^2$$

$$AG = \sqrt{AC^2 + CG^2}$$

$$AG = \sqrt{\left(\sqrt{2}a\right)^2 + a^2}$$

$$AG = \sqrt{2a^2 + a^2} = \sqrt{3a^2}$$

$$AG = \sqrt{3}\, a$$

i.e., $\sqrt{3}a = 4r$

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

∴ Volume of the sphere with radius 'r'

$$= \frac{4}{3}\pi r^3$$

$$= \frac{4}{3}\pi\left(\frac{\sqrt{3}}{4}a\right)^3$$

$$= \frac{\sqrt{3}}{16}\pi a^3 \quad ...(1)$$

Number of spheres belong to a unit cell in bcc arrangement is equal to two and hence the total volume of all spheres

$$= 2 \times \left(\frac{\sqrt{3}\,\pi\, a^3}{16}\right) = \frac{\sqrt{3}\,\pi\, a^3}{8}$$

Dividing (2) by (3)

$$\text{Packing fraction} = \frac{\left(\frac{\sqrt{3}\,\pi\, a^3}{8}\right)}{(a^3)} \times 100$$

$$= \frac{\sqrt{3}\,\pi}{8} \times 100$$

$$= \sqrt{3}\,\pi \times 12.5$$

$$= 1.732 \times 3.14 \times 12.5$$

$$= 68\ \%$$

i.e., 68 % of the available volume is occupied. The available space is used more efficiently than in simple cubic packing.

15.What is the two dimensional coordination number of a molecule in square close packed layer?

The two dimensional coordination number of a molecule in square close packed layer is **4**

16. Experiment shows that Nickel oxide has the formula $Ni_{0.96}O_{1.00}$. What fraction of Nickel exists as of Ni^{2+} and Ni^{3+} ions?

Given **$Ni_{0.96}O_{1.00}$**

Ratio of Ni : O = 96:100

So, if there are 100 atoms of oxygen then 98 atoms of Ni

Let number of atoms of Ni^{2+} = x

Then number of atoms of Ni^{3+} = 96–x

Charge on Ni = charge on O

oxygen has charge –2

3(96 – x) + 2x - 2 (100) = 0

288 –3x +2x - 200 = 0

x = 88

Fraction of Ni^{2+} = (atom of Ni^{2+} / total number of atoms of Ni)

= (88/96)

= 0.916

= 91.6%

Fraction of Ni^{3+} = (atom of Ni^{3+} / total number of atoms of Ni)

= (8/96)

= 0.083

= 8.33%

17. What is meant by the term "coordination number"? What is the coordination number of atoms in a bcc structure?

The number of spheres (atoms, molecules or ions) directly surrounding a single sphere in a crystal, is called **coordination number**. The coordination number of atoms in a bcc structure is **8.**

18. An element has bcc structure with a cell edge of 288 pm. the density of the element is 7.2 gcm^{-3}.

How many atoms are present in 208g of the element?

a = 288 pm ρ = 7.2 **gcm^{-3}** **To find how many atoms are present in 208g of the element**

Volume of the unit cell $=a^3 = (288\ pm)^3$

$= (288\times10^{-10}\ cm)^3$

$= 2.39\times10^{-23}\ cm^3$

Volume of 208 g of the element

$$= \frac{mass}{density} = \frac{208g}{7.2\,g\,cm^{-3}} = 28.88\,cm^3$$

Number of unit cells in this volume

$$= \frac{28.88cm^3}{2.39\times10^{-23}cm^3\,/unit\ cell} = 12.08\times10^{23}\ \text{unit cells}$$

Since **each bcc cubic unit cell contains 2 atoms**, therefore,
the **total number of atoms in 208 g = 2 (atoms/unit cell) × 12.08 × 102^3 unit cells = 24.16×10^{23} atoms**

19. Aluminium crystallizes in a cubic close packed structure. Its metallic radius is 125pm. Calculatethe edge length of unit cell.

let 'a' is the edge of the cube and 'r' is the radius of atom.
Given that r = 125 pm
a = 2√2 r
Sub the **value of 'r'** we get,
a = 2 x 1.414 x125 pm
= 354 pm (approximately

20.If NaCl is doped with 10^{-2} mol percentage of strontium chloride, what is the concentration of cation vacancy?

Given ; Concentration of $SrCl_2$ = 10^{-2} mole%
Concentration is in percentage so that take total 100 mole of solution
Number of moles of NaCl = 100 – moles of $SrCl_2$
Moles of $SrCl_2$ is very negligible as compare to total moles.
Number of moles of NaCl = 100
1 mole of NaCl is dopped with $SrCl_2$ = 10^{-2}/100 moles
= 10^{-4} mole of $SrCl_2$
cation vacancies per mole of NaCl =10^{-4}mole
1 mole = 6.022 x1023 particles
So, cation vacancies per mole of NaCl = 10^{-4}x 6.022 x10^{23}
= 6.022 x10^{19}
So that, the concentration of cation vacancies created by $SrCl_2$ is **6.022 × 10^{19}** per mole of NaCl.

21.KF crystallizes in fcc structure like sodium chloride. Calculate the distance between K^+ and F^- in
KF. (Given: density of KF is 2.48 g cm^{-3})

ρ = 2.48 g cm^{-3}

$$\rho = \frac{nM}{a^3 N_A}$$

Since it is face centered number of unit cell **= 4**

Molar mass of KF = 58.8 g mol^{-1} N_A = 6.023 × 10^{23}

$$a^3 = \frac{nM}{\rho N_A}$$

$$= \frac{4 \times 58.8}{2.48 \times 6.023 \times 10^{23}}$$

a^3 = 1.57 × 10^{-22} cm^3

V = (Edge length)^3 = a^3

Edge length = $\sqrt{V}$ = $\sqrt{1.57 \times 10^{-22}}$

= 538 pm

22.An atom crystallizes in fcc crystal lattice and has a density of 10 gcm^{-3} with unit cell edge length of

100pm. calculate the number of atoms present in 1 g of crystal.

ρ = 10 gcm^{-3} a = 100 pm Mass = 1 g

No of atoms in Fcc unit cell = 4

Volume of unit cell a^3 = (100 x 10 $^{-10}$ cm)^3 = 10^{-24} gcm^{-3}

Number of atoms in 1g of crystal = $\frac{Z \times M}{\rho a^3}$ = $\frac{4 \times 1}{10^{-23}}$ = 4 × 10^{23}

23. Atoms X and Y form bcc crystalline structure. Atom X is present at the corners of the cube and Y

is at the center of the cube. What is the formula of the compound?

The atom at the corner makes a contribution of 1/8 to the unit cell (X)

The atom at the center makes a contribution of 1 to the unit cell (Y)

Thus, number of atoms X per unit cell = Number of atoms × Contribution per unit cell

= 8 (at the corners) × 1/8 atoms per unit cell

= 1

Thus, number of atoms X per unit cell = Number of atoms × contribution per unit cell

= 1 (at the body centre) × 1

= 1

Thus, the formula of the given compound is XY.

24. Sodium metal crystallizes in bcc structure with the edge length of the unit cell 4.3 ×10^{-8} cm.

calculate the radius of sodium atom.

a = 4.3 ×10^{-8} *cm*.

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

= $\frac{\sqrt{3}}{4}$ × 4.3 ×10^{-8} *cm.*

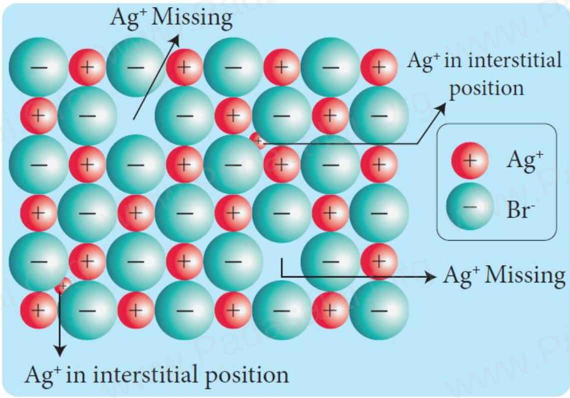
= **1. 786 x 10^{-8} cm**

25. Write a note on Frenkel defect.

Frenkel defect arises due to the dislocation of ions from its crystal lattice.

The ion which is missing from the lattice point occupies an interstitial position. This defect is shown by ionic solids in which cation and anion differ in size.

Unlike Schottky defect, this defect does not affect the density of the crystal.



Frenkel Defect

Book inside

1.What are General characteristics of solids

(i) Solids have definite volume and shape.
(ii) Solids are rigid and incompressible
(iii) Solids have strong cohesive forces.
(iv) Solids have short inter atomic, ionic or molecular distances.
(v) Their constituents (atoms , ions or molecules) have fixed positions and can only oscillate about their mean positions

2.What are two types of solids based on the arrangement of their constituents.

(i) Crystalline solids
(ii) Amorphous solids.

3.Define isotropy and anisotropy

Isotropy means uniformity in all directions. In solid state isotropy means having identical values of physical properties such as refractive index, electrical conductance etc., in all directions,

Anisotropy is the property which depends on the direction of measurement

4.Explain about classification of solids

Ionic Solids

The structural units of an ionic crystal are cations and anions. They are bound together by strong electrostatic attractive forces. To maximize the attractive force, cations are surrounded by as many anions as possible and vice versa. Ionic crystals possess definite crystal structure

Example ; NaCl

Covalent solids:

In covalent solids, the constituents (atoms) are bound together in a three dimensional network entirely by covalent bonds. Such covalent network crystals are very hard, and have high melting point. They are usually poor thermal and electrical conductors.

Examples: Diamond, silicon carbide etc

Molecular solids:

In molecular solids, the constituents are neutral molecules. They are held together by weak van der Waals forces. Generally molecular solids are soft and they do not conduct electricity. These molecular solids are further classified into three types.

(i) Non-polar molecular solids:
In non polar molecular solids constituent molecules are held together by weak dispersion forces or London forces
Examples: naphthalene, anthracene etc.,

(ii) Polar molecular solids
T h e constituents are molecules formed by polar covalent bonds. They are held together by relatively strong dipole-dipole interactions. They have higher melting points than the non-polar molecular solids.
Examples are solid CO2 , solid NH3 etc.

(iii) Hydrogen bonded molecular solids
The constituents are held together by hydrogen bonds. They are generally soft solids under room temperature. **Examples: solid ice (H2O), glucose, urea etc.,**

iv)Metallic solids:
In metallic solids, the lattice points are occupied by positive metal ions and a cloud of electrons pervades the space. They are hard, and have high melting point. Metallic solids possess excellent electrical and thermal conductivity. They possess bright lustre. Examples: Metals and metal alloys belong to this type of solids,
E xample ; Cu,Fe,Zn, Ag ,Au, Cu- Zn etc.

5.Define Crystal lattice
The regular arrangement of these species throughout the crystal is called a crystal lattice.

6.What are two types of unit cells: primitive and non-primitive unit cells
A unit cell that contains only one lattice point is called a primitive unit cell, which is made up from the lattice points at each of the corners.
In non-primitive unit cells, there are additional lattice points, either on a face of the unit cell or with in the unit cell.

7.Calculate the Number of atoms in a simple and body centered cubic unit cell
Simple cubic unit cell
In the simple cubic unit cell, each corner is occupied by an identical atoms or ions or molecules. And they touch along the edges of the cube, do not touch diagonally. The coordination number of each atom is 6.
Each atom in the corner of the cubic unit cell is shared by 8 neighboring unit cells
N_c – Number of atoms in corners = 8
Number of atoms in a simple cubic unit cell = $N_c/8$
= 8/8
= 1

Body centered cubic unit cell. (BCC)

In a body centered cubic unit cell, each corner is occupied by an identical particle and in addition to that one atom occupies the body centre.

Those atoms which occupy the corners do not touch each other, however they all touch the one that occupies the body centre. Hence, each atom is surrounded by eight nearest neighbours and coordination number is 8. An atom present at the body centre belongs to only to a particular unit cell i.e unshared by other unit cell.

N_c – Number of atoms in corners = 8 N_b = 1

Number of atoms in a body centered cubic unit cell = $N_c/8$ + N_b / 1

= 8/8 + 1/1

= 1+1 = 2

8.What is Stoichiometric defects in ionic solid:

This defect is also called intrinsic (or) thermodynamic defect. In stoichiometric ionic crystals, a vacancy of one ion must always be associated with either by the absence of another oppositely charged ion (or) the presence of same charged ion in the interstitial position so as to maintain the electrical neutrality

9.Explain about impurity defect

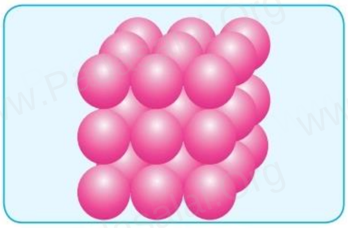
A general method of introducing defects in ionic solids is by adding impurity ions. If the impurity ions are in different valance state from that of host, vacancies are created in the crystal lattice of the host. For example, addition of $CdCl_2$ to silver chloride yields solid solutions where the divalent cation Cd^{2+} occupies the position of Ag+. This will disturb the electrical neutrality of the crystal. In order to maintain the same, proportional number of Ag^+ ions leaves the lattice. This produces a cation vacancy in the lattice, such kind of crystal defects are called impurity defects.

10.Determine packing efficiency simple cubic unit cell

In simple cubic packing, each sphere is in contact with 6 neighbouring spheres - Four in its own layer, one above and one below and hence the coordination number of the sphere in simple cubic arrangement is 6.

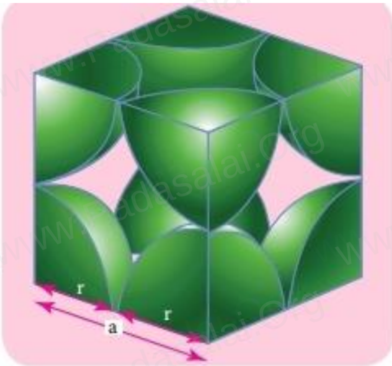
Packing efficiency:

There is some free space between the spheres of a single layer and the spheres of successive layers. The percentage of total volume occupied by these constituent spheres gives the packing efficiency of an arrangement .



Simple Cubic (SC)

simple cubic arrangement,



$$\begin{Bmatrix}\text{Packing fraction}\\ \text{(or) efficiency}\end{Bmatrix} = \frac{\begin{Bmatrix}\text{Total volume occupied by}\\ \text{spheres in a unit cell}\end{Bmatrix}}{\text{Volume of the unit cell}} \times 100$$

Let us consider a cube with an edge length 'a' as shown in fig.

Volume of the cube with edge length a is = a × a × a = a^3

Let 'r' is the radius of the sphere. From the figure, a=2r $\Rightarrow r = \frac{a}{2}$

∴ Volume of the sphere with radius 'r'

$$= \frac{4}{3}\pi r^{3v}$$

$$= \frac{4}{3}\pi \left(\frac{a}{2}\right)^3$$

$$= \frac{4}{3}\pi \left(\frac{a^3}{8}\right)$$

$$= \frac{\pi a^3}{6} \quad \ldots (1)$$

In a simple cubic arrangement, number of spheres belongs to a unit cell is equal to one

$$\therefore \text{Total volume occupied by the spheres in sc unit cell} = 1 \times \left(\frac{\pi a^3}{6}\right) \quad \ldots (2)$$

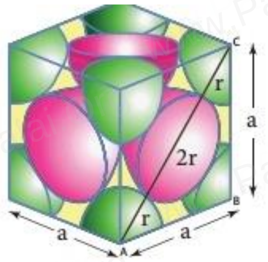
Dividing (2) by (3)

$$\text{Packing fraction} = \frac{\left(\frac{\pi a^3}{6}\right)}{(a^3)} \times 100 = \frac{100\,\pi}{6}$$

$$= 52.31\%$$

11.Determine packing efficiency Face centered cubic unit cell or cubic closed packing

The cubic close packing is based on the face centered cubic unit cell. Let us calculate the packing efficiency in fcc unit cell.



From the figure

$AC = 4r$

$4r = a\sqrt{2}$

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

In ΔABC

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

$AC = \sqrt{AB^2 + BC^2}$

$AC = \sqrt{a^2 + a^2} = \sqrt{2a^2} = \sqrt{2}\,a$

Volume of the sphere with radius r is $= \frac{4}{3}\pi\left(\frac{\sqrt{2}a}{4}\right)^3$

$= \frac{4}{3}\pi\left(\frac{2\sqrt{2}a^3}{64}\right)$

$= \frac{\sqrt{2}\,\pi a^3}{24}$

Total number of spheres belongs to a single fcc unit cell is 4

∴ the volume of all spheres in a fcc unit cell $= 4 \times \left(\frac{\sqrt{2}\,\pi a^3}{24}\right)$

$= \left(\frac{\sqrt{2}\,\pi a^3}{6}\right)$

packing efficiency $= \frac{\left(\frac{\sqrt{2}\,\pi\, a^3}{6}\right)}{(a^3)} \times 100$

$= \frac{\sqrt{2}\,\pi}{6} \times 100$

$= \frac{1.414 \times 3.14 \times 100}{6}$

$= 74\%$