Chapter
6 Solid State

I. Choose the correct answer.

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

Question 2.
An ionic compound $A_x B_y$ crystallizes in fee type crystal structure with B ions at the centre of each face and A ion occupying centre of the cube, the correct formula of A B is ....
(a) AB
(b) AB_3
(c) A_3B
(d) A_8B_6
Answer:
(b) AB_3

Hint: Number of A ions = $\left(\frac{N_c}{8}\right) = \left(\frac{8}{8}\right) = 1$

Number of B ions = $\left(\frac{N_f}{2}\right) = \left(\frac{6}{2}\right) = 3$

Simplest formula AB_3

Question 3.
The rano of close packed atoms to tetrahedral hole in cubic packing is ....
(a) 1:1
(b) 1:2
(c) 2:1
(d) 1:4
Answer:
(b) 1:2
Hint: If number of close packed atoms =N; then, The number of Tetrahedral holes formed = 2N, Number of Octahedral holes formed = N. Therefore N : 2N = 1 : 2

Question 4.

Solid CO_2 is an example of ……….
(a) Covalent solid
(b) metallic solid
(c) molecular solid
(d) ionic solid
Answer:
(c) molecular solid
Hint: Lattice points are occupied by CO_2 molecules

Question 5.
Assertion: monoclinic sulphur is an example of monoclinic crystal system.
Reason: for a monoclinic system, $a \neq b \neq c$ and $\alpha = \gamma = 90°$, $\beta \neq 90°$.
(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.
Answer:
(a) Both assertion and reason are true and reason is the correct explanation of assertion

Question 6.
In calcium fluoride, having the flurite 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
Answer:
(c) 8 and 4
Hint: CaF_2 has cubical close packed arrangement Ca^{2+} ions are in face centered cubic arrangement, each Ca^{2+} ions is surrounded by 8 F^- ions and each F^- ion is surrounded by 4 Ca^{2+} ions.Therefore coordination number of Ca^{2+} is 8 and of F^- is 4 pattern is (NA is the Avogadro number)

Question 7.
The number of unit cells in 8gm 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) $\left(\frac{6.023 \times 10^{23}}{8 \times 40}\right)$

Answer:

(b) 6.023×10^{22}

Hint: In bcc unit cell, 2 atoms = 1 unit cell

Number of atoms in 8g of element is, Number of moles = $\left(\frac{8g}{40g,mol^{-1}}\right)$ = 0.2 mol

1 mole contains 6.023×10^{23} atoms 0.2 mole contains $0.2 \times 6.023 \times 10^{23}$ atoms

$\left(\frac{1unitcell}{2atoms}\right) \times 0.2 \times 6.023 \times 10^{23} = 6.023 \times 10^{22}$ unit cells

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

Hint: In diamond carbon forming fee. Carbon occupies comers and face centres and also occupying half of the tetrahedral voids.

$\left(\frac{N_c}{8}\right) + \left(\frac{N_f}{2}\right)$ + 4C atoms in Td voids

$\left(\frac{8}{8}\right) + \left(\frac{6}{2}\right) + 4 = 8.$

Question 9.
In a solid atom M occupies ccp lattice and $(\frac{1}{3})$ 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
Answer:
(d) M_3N_2

Hint: If the total number of M atoms is n, then the number of tetrahedral voids = 2 n. Given that $\left(\frac{1}{3}\right)^{rd}$ of tetrahedral voids are occupied i.e., $\left(\frac{1}{3}\right) \times 2$ n are occupied by N atoms.

$\therefore$ M : N $\Rightarrow$ n : $\left(\frac{2}{3}\right)$

1 : $\left(\frac{1}{3}\right)$ 3 : 2 $\Rightarrow M_3N_2$

Question 10.
The Composition of a sample of wurizite 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%
Answer:
(b) 15.05%
Hint: Let the number of Fe^{2+} ions in the crystal be x. The number of Fe^{3+} ions in the crystal be y. Total number of Fe^{2+} and Fe^{3+} ions is x + y. Given that x + y = 0.93. The total charge= 0 x (2+) + (0.93 – x) (+ 3) – 2 = 0 ⇒ 2x + 2.97 – 3x – 2 = 0 x 0.79 Percentage of Fe^{3+} = $\left(\frac{(0.93-0.79)}{0.93}\right)100$ = 15.05%

Question 11.
The ionic radii of A^+ and B^- are 0.98×10^{-10} m and 1.81×10^{-10} m , the coordination number of each ion in AB is ……….
(a) 8
(b) 2
(c) 6
(d) 4
Answer:
(c) 6
Hint: $\frac{r_{c1}}{r_{A^-}} = \left(\frac{0.98\times10^{-10}}{1.81\times10^{-10}}\right)$ = 0.54. It is in the range of 0.414, 0.732,hence the coordination number of each ion is 6.

Question 12.
CsCl has bcc arrangement, its unit cell edge length is 400pm, its inter atomic distance is ……….
(a) 400pm
(b) 800pm
(c) $g\sqrt{3}$ x 100pm
(d) $\left(\frac{\sqrt{3}}{2}\right)$ x 400 pm

Answer:

(d) $\left(\frac{\sqrt{3}}{2}\right)$ x 400 pm

Hint:

$g\sqrt{3}a = r_{Cs^+} + 2r_{Cs^-} + r_{Cs^+}$

$\left(\frac{\sqrt{3}}{2}\right)a = (r_{Cs^+} + r_{Cs^-})$

$\left(\frac{\sqrt{3}}{2}\right)400$ = inter ionic distance

Question 13.
A solid compound XY has NaCl structure, if the radius of the cation is 100pm , the radius of the anion will be ………..

(a) $\left(\frac{100}{0.414}\right)$

(b) $\left(\frac{0.732}{100}\right)$

(c) 100 x 0.414

(d) $\left(\frac{0.414}{100}\right)$

Answer:

(a) $\left(\frac{100}{0.414}\right)$

Hint: For an fcc structure

Question 14.
The vacant space in bcc lattice unit cell is ………..
(a) 48%
(b) 23%
(c) 32%
(d) 26%
Answer:
(c) 32%
Hint: Packing efficiency = 68%. Therefore empty space percentage = (100 – 68) = 32%

Question 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
Answer:

(b) 848.5pm

Hint: Let edge length = a $g\sqrt{2}$a = 4r

a = $\left(\frac{4\times300}{\sqrt{2}}\right)$

a = 600 x 1.414

a = 848.4 pm

Question 16.
The fraction of total volume occupied by the atoms in a simple cubic is ....

(a) $\left(\frac{\pi}{4\sqrt{2}}\right)$

(b) $\left(\frac{\pi}{6}\right)$

(c) $\left(\frac{\pi}{4}\right)$

(d) $\left(\frac{\pi}{3\sqrt{2}}\right)$

Answer:

(b) $\left(\frac{\pi}{6}\right)$

Hint:

$$\left|\frac{\frac{4}{3}\pi r^3}{a^3}\right| = \left|\frac{\frac{4}{3}\pi\left(\frac{a}{2}\right)^3}{a^3}\right| = \left(\frac{\pi}{6}\right)$$

Question 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
Answer:
(a) excitation of electrons in F centers

Question 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) $\left(\frac{1}{2}a:\frac{\sqrt{3}}{2}a:\frac{\sqrt{2}}{2}a\right)$

(b) $\left(\sqrt{1}a:\sqrt{3}a:\sqrt{2}a\right)$

(c) $\left(\frac{1}{2}a:\frac{\sqrt{3}}{4}a:\frac{1}{2\sqrt{2}}a\right)$

(d) $\left(\frac{1}{2}a:\sqrt{3}a:\frac{1}{\sqrt{2}}a\right)$

Answer:

(c) $\left(\frac{1}{2}a:\frac{\sqrt{3}}{4}a:\frac{1}{2\sqrt{2}}a\right)$

Hing:

$$sc \Rightarrow 2r = a \Rightarrow r = \frac{a}{2}$$

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

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

$$\left(\frac{a}{2}\right):\left(\frac{\sqrt{3}a}{4}\right):\left(\frac{a}{2\sqrt{2}}\right)$$

Question 19.

If a is the length of the side of the cube, the distance between the body centered atom and one comer atom in the cube will be ....

(a) $\left(\frac{2}{\sqrt{3}}\right)a$

(b) $\left(\frac{4}{\sqrt{3}}\right)a$

(c) $\left(\frac{\sqrt{3}}{4}\right)a$

(d) $\left(\frac{\sqrt{3}}{2}\right)a$

Answer:

(d) $\left(\frac{\sqrt{3}}{2}\right)a$

Hint: If a is the length of the side, then the length of the leading diagonal passing through the body centered atom is $g\sqrt{3}$a. Required distance = $\left(\frac{\sqrt{3}}{2}\right)a$

Question 20.
Potassium has a bcc structure with nearest neighbor distance 4.52 A. 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}
Answer:
(a) 915 kg m^{-3}
Hint:
$(\rho) = \frac{nM}{a^3 N_A}$ For bcc n = 2 M 39. Nearest distance 2r = 4.52

$$a = \frac{4r}{\sqrt{3}} = \frac{2 \times 4.52 \times 10^{-10}}{\sqrt{3}} = 5.21 \times 10^{-10}$$

$$\rho = \frac{2 \times 39}{\left(5.21 \times 10^{-10}\right)^3 \times \left(6.023 \times 10^{23}\right)}$$

ρ = 915 kg m^{-3} N_A

Question 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
(e) an ion leaves its normal site and occupies an interstitial site
(d) no ion is missing from its lattice.
Answer:
(b) equal number of anions and anions are missing from the lattice

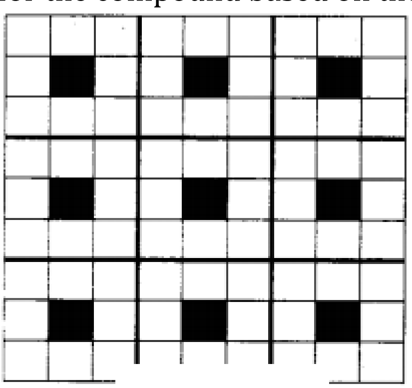
Question 22.
The cation leaves its normal position in the crystal and moves to some interstitial position, the defect in the crystal is known as ………..
(a) Schottky defect
(b) F center
(c) Frenkel defect
(d) non-stoichiometric defect
Answer:
(c) Frenkel defect

Question 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
Answer:
(d) Both assertion and reason are false

Question 24.
The crystal with a metal deficiency defect is ………..
(a) NaCI
(b) FeO
(c) ZnO
(a) KCI
Answer:
(b) FeO

Question 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
Answer:
(a) XY_8

II. Answer the following questions:

Question 1.
Define unit cell.
Answer:
A basic repeating structural unit of a crystalline solid is called a unit cell.

Question 2.
Give any three characteristics of ionic crystals.
Answer:

1. Ionic solids have high melting points.
2. These solids do not conduct electricity, because the ions are fixed in their lattice positions.
3. They do conduct electricity in molten state (or) when dissolved in water because the ions are free to move in the molten state or solution.

Question 3.
Differentiate crystalline solids and amorphous solids.
Answer:
Crystalline solids:

1. Long range orderly arrangement of constituents
2. Definite shape
3. Generally crystalline solids are anisotropic in nature
4. They are true solids
5. Definite Heat of fusion
6. They have sharp melting points.
7. Examples: NaCl, diamond etc.,

Amorphous solids:

1. Short range, random arrangement of constituents
2. Irregular shape
3. They are isotropic like liquids
4. They are considered as pseudo solids (or) super cooled liquids
5. Heat of fusion is not definite
6. Gradually soften over a range of temperature and so can be moulded.
7. Examples: Rubber, plastics, glass etc

Question 4.
Classify the following solids.

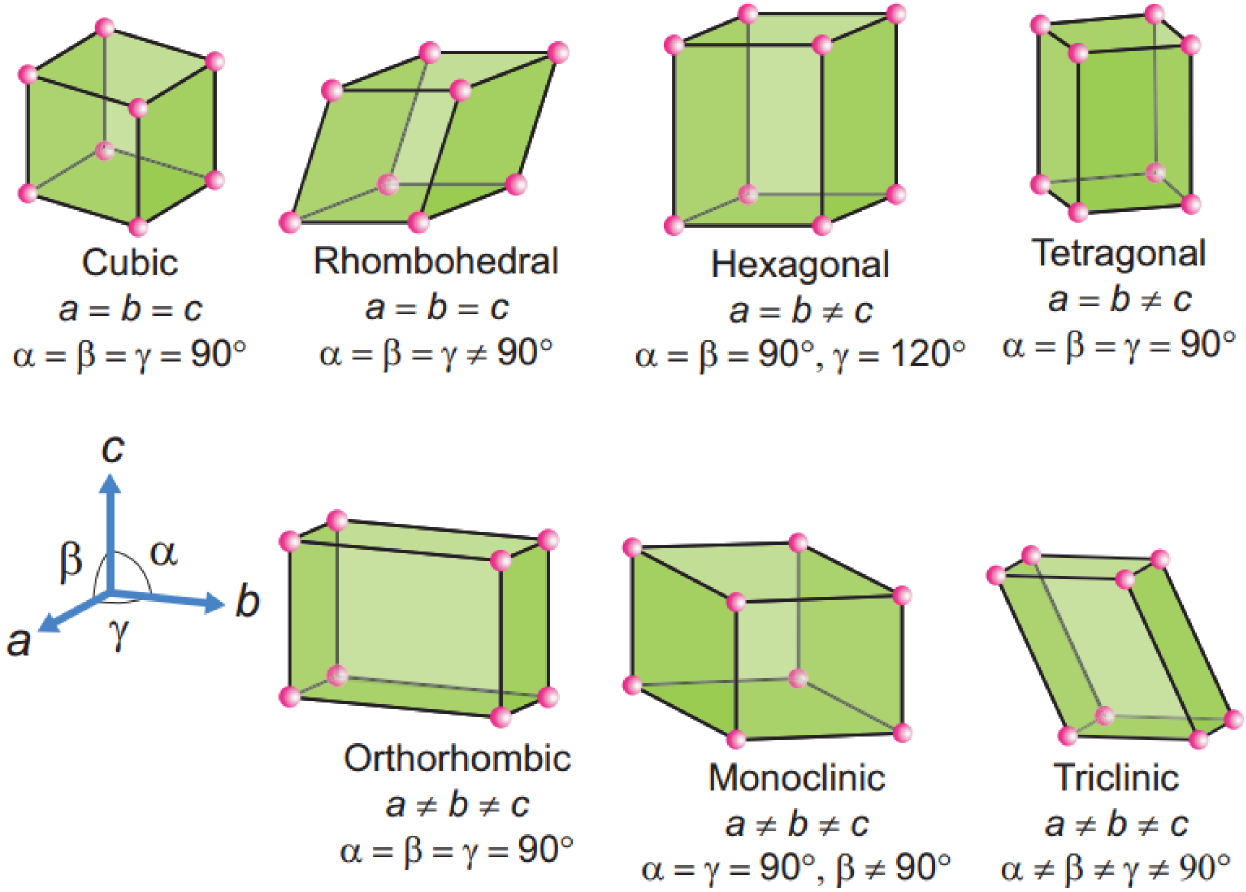
1. P_4
2. Brass
3. Diamond
4. NaCI
5. iodine

Answer:

1. P_4 – Molecular solid
2. Brass – Metallic solid

3. Diamond –
4. NaCl – Ionic solid
5. Iodine – Molecular solid

Question 5.
Explain briefly seven types of unit cell.
Answer:
Seven types of unit cell:



1. Cubic – NaCl
2. Tetragonal – TiO_2
3. Orthorhombic – $BaSO_4$
4. Hexagonal – ZnO
5. Monoclinic – $PbCrO_4$
6. Triclinic – H_3BO_3
7. Rhombohedral – Cinnabar Cubic

They differ in the arrangements of their crystallographic axes and angles. Corresponding to the above seven, Bravis defined 14 possible crystal system as shown in the figure.

Question 6.
Distinguish between hexagonal close packing and cubic close packing.

Answer:
Hexagonal close-packing

1. aba arrangement
2. In this case, the spheres of the third layer are exactly aligned with those of the first layer
3. In HCP, tetrahedral voids of the second layer may be covered by the spheres of the third layer

Cubic close packing:

1. abc arrangement
2. In this case, the spheres of the third layer are not aligned with those of the first layer or second layer. Only when fourth layer is placed, its spheres are aligned with the first layer
3. In cep third layer may be placed above the second layer in a manner such that its sphere cover the octahedral voids.

Question 7.
Distinguish tetrahedral and octahedral voids.
Answer:
Tetrahedral void

1. A single triangular void in a crystal is surrounded by four (4) spheres and is called a tetrahedral void
2. A sphere of second layer is above the void of the first layer, a tetrahedral void is formed
3. This constitutes four spheres, three in the lower and one in upper layer. When the centres of these four spheres are joined a tetrahedron is formed
4. The radius of the sphere which can be accommodated in an octahedral hole without disturbing the structure should not exceed 0.414 times that of the structure forming sphere

5. Radius of an tetrahedral void $\frac{r}{\mathrm{R}} = 0.225$

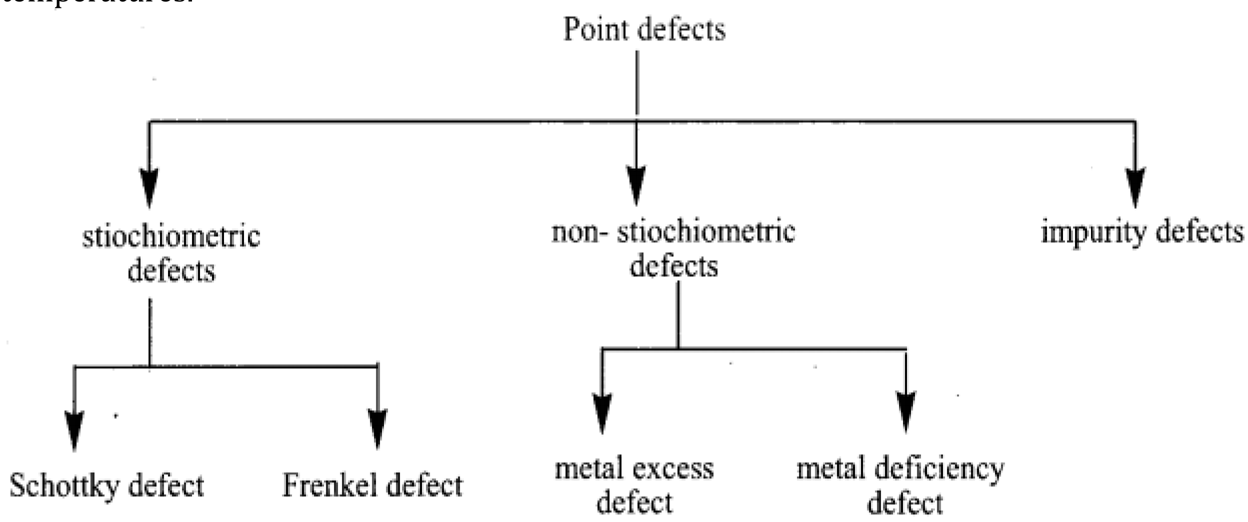
Octahedral void

1. A double triangular void like c is surrounded by six(6) spheres and is called an octahedral void
2. The voids in the first layer are partially covered by the spheres of layer now such a void is called an octahedral void
3. This constitutes six spheres, three in the lower layer and three in the upper layer. When the centers of these six spheres are joined an octahedron is formed
4. The sphere which can be placed in a tetrahedral hole without disturbing the close-packed structure should not have a radius larger than 0.225 times the

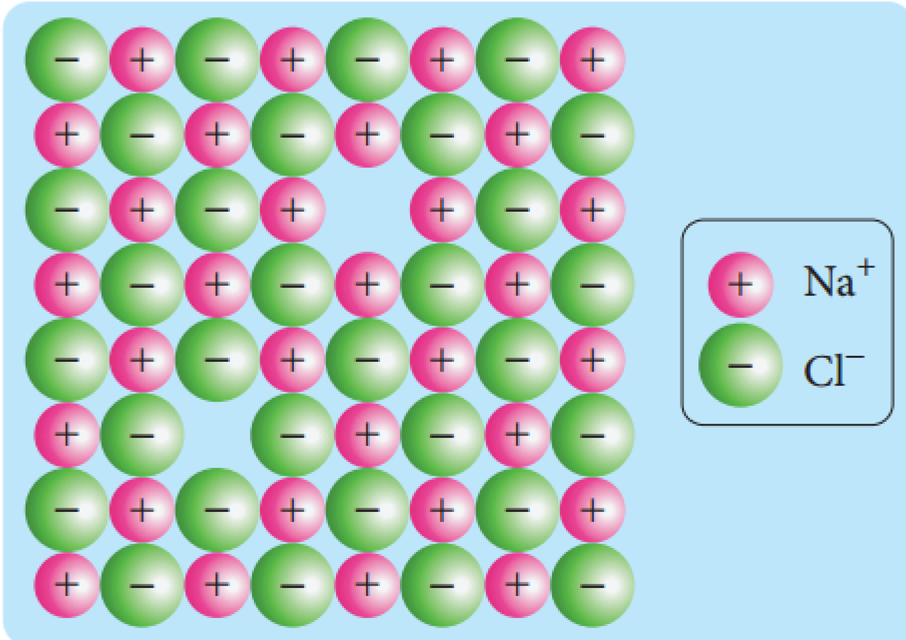
radius of the sphere-forming the structure

5. Radius of a octahedral void $\frac{r}{R} = 0.414$

Question 8.
What are point defects?
Answer:
If the deviation occurs due to missing atoms, displaced atoms or extra atoms the imperfection is named as a point defect. Such defects arise due to imperfect packing during the original crystallisation or they may arise from thermal vibrations of atoms at elevated temperatures.



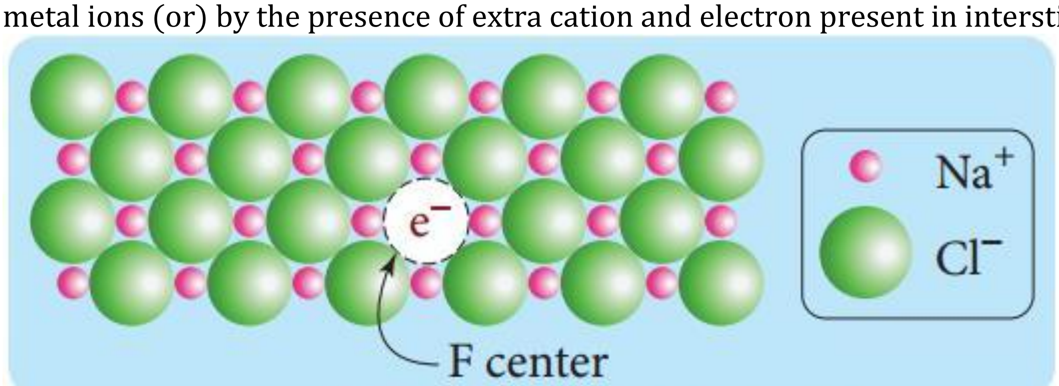
Question 9.
Explain Schottky defect.
Answer:
The schottky defect arises due to the missing of an equal number of cations and anions from the crystal lattice. This effect does not change the stoichiometry of the crystal. Ionic solids in which the cation and anion are of almost similar size show Schottky defect.
Example: NaCl.



Schottky Defect

Presence of large number of schottky defects in a crystal, lowers its density. For example, the theoretical density of vanadium monoxide (VO) calculated using the edge length of the unit cell is 6.5 g cm^{-3} but the actual experimental density is 5.6 gcm^3. It indicates that there is approximately 14% Schottky defect in VO crystal. Presence of Schottky defect in the crystal provides a simple way by which atoms or ions can move within the crystal lattice.

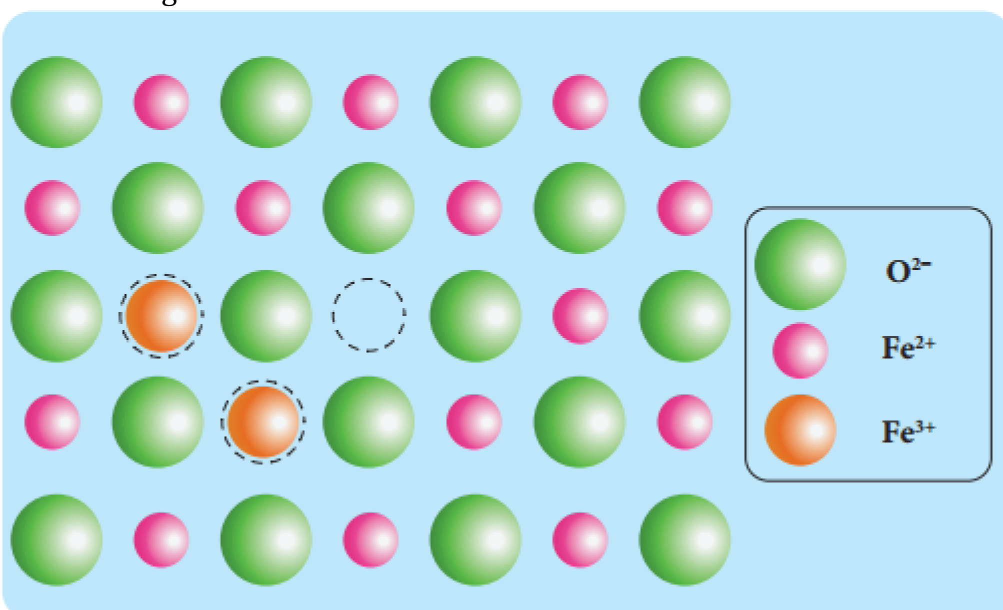
Question 10.
Write short note on metal excess and metal deficiency defect with an example. Metal excess defect.
Answer:
Metal excess defect arises due to the presence of more number of metal ions as compared to anions.Alkali metal halides NaCl, KCl show this type of defect.The electrical neutrality of 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.



Metal Excess Defect

For example, when NaCl crystals are heated in the presence of sodium vapour, Na^+ ions are

formed and are deposited on the surface of the crystal. Chloride ions (Cl^-) diffuse to the surface from the lattice point and combines with Na^+ ion.
The electron lost by the sodium vapour diffuse into the crystal lattice and occupies the vacancy created by the Cl^- ions. Such anionic vacancies which are occupied by unpaired electrons are called F centers. Hence, the formula of NaCl which contains excess Na^+ ions can be written as $Na_{1+x}Cl$.
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. For example, in FeO crystal, some of the Fe^{2+} ions are missing from the crystal lattice.
To maintain electrical neutrality, twice the number of other Fe^{2+} ions in the crystal is oxidized to Fe^{3+} ions. In such cases, the overall number of Fe^{2+} and Fe^{3+} ions is less than the O^{2-} ions. It was experimentally found that the general formula of ferrous oxide is Fe_xO, where x ranges from 0.93 to 0.98.

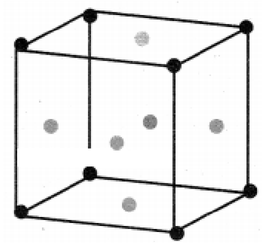


Metal Deficiency Defect

Question 11.
Calculate the number of atoms in a fee unit cell.
Answer:
Number of atoms in a fee unit cell,

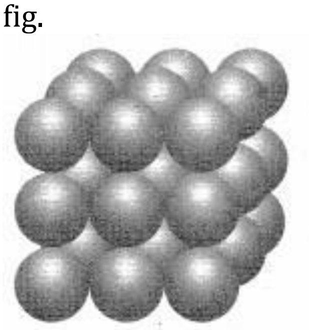
$$= \frac{N_c}{8} + \frac{N_f}{2}$$

$$= \frac{8}{8} + \frac{6}{2} = 1 + 3 = 4$$



Question 12.
Explain AAAA and ABABA and ABCABC type of three-dimensional packing with the help of a neat diagram.
Answer:
1. AAAA type of three-dimensional packing
This type of three-dimensional packing arrangements can be obtained by repeating the AAAA type two dimensional arrangements in three dimensions, i.e., spheres in one layer sitting directly on the top of those in the previous layer so that all layers are identical.

All spheres of different layers of crystal are perfectly aligned horizontally and also vertically so that any unit cell of such arrangement has a simple cubic structure as shown in fig.

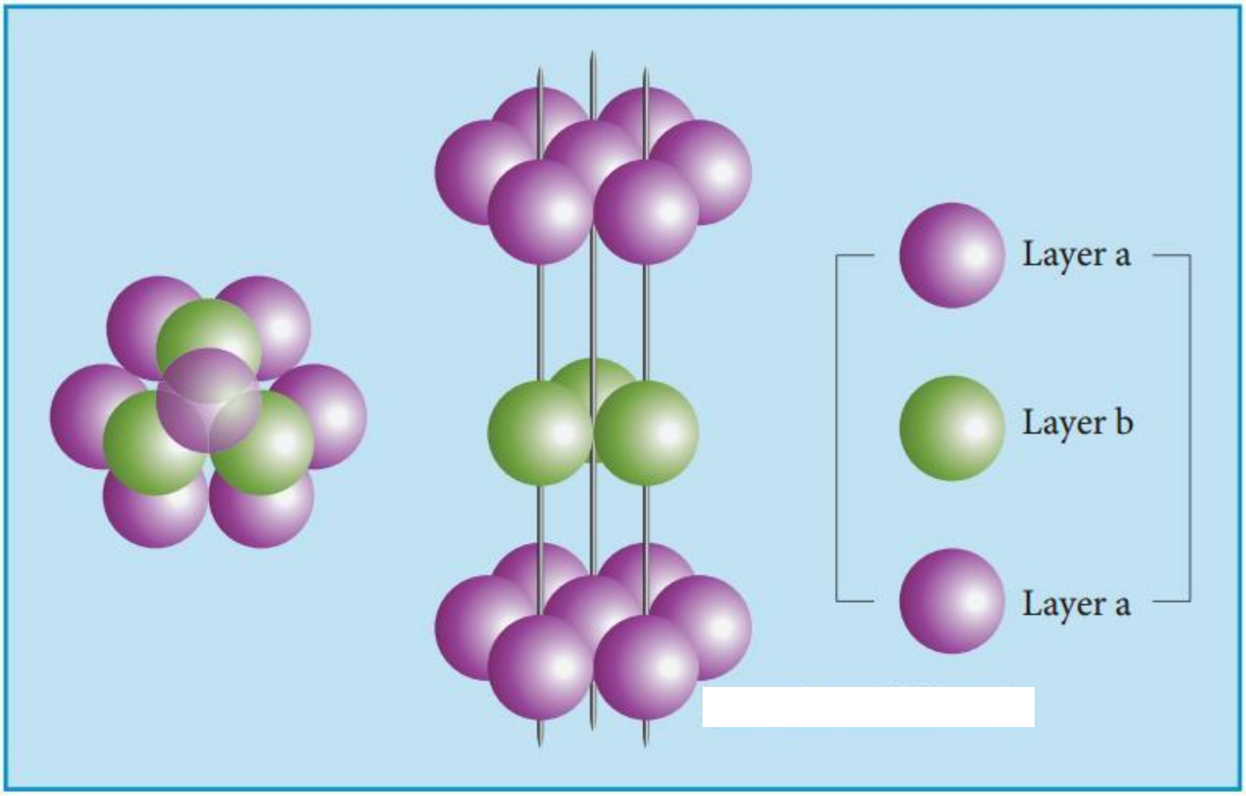


Simple Cubic (SC)

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.

2. ABABA type of three-dimensional packing:
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 as shown in figure.

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.

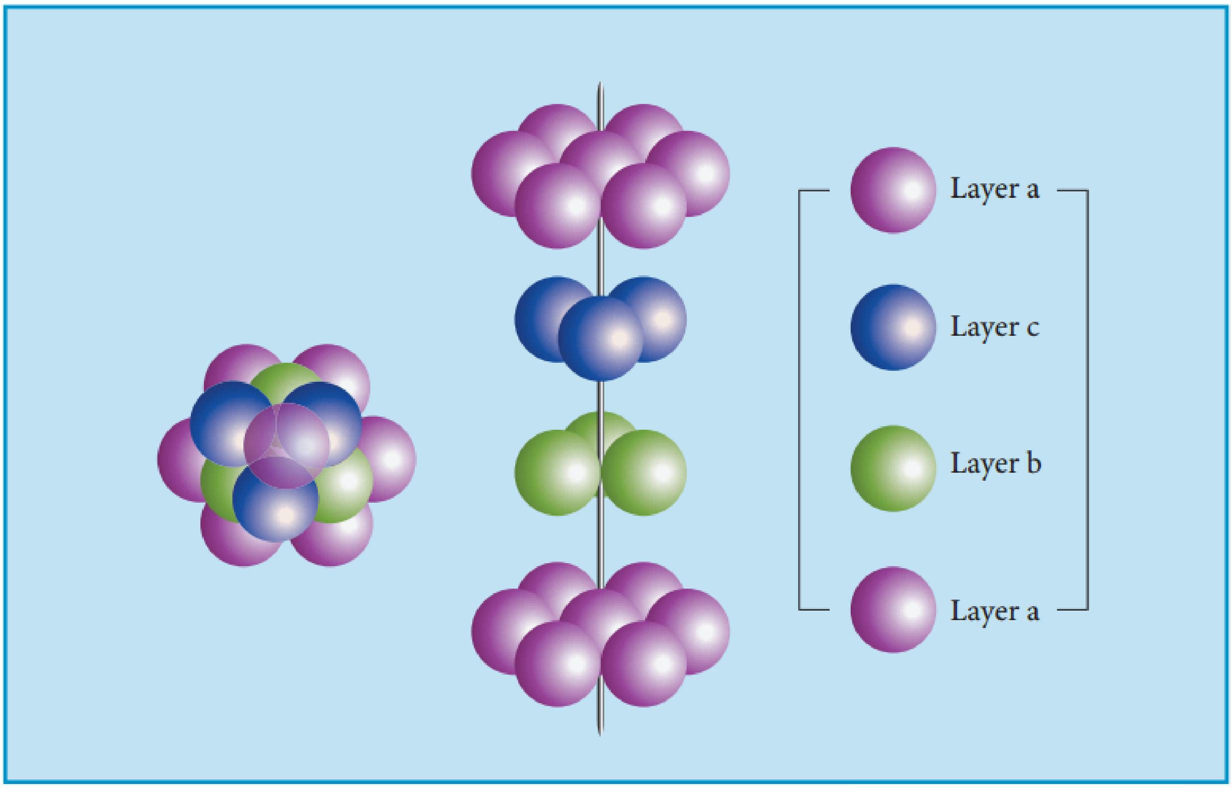


3. ABCABC type of three-dimensional packing:
In this arrangement (FCC) second layer spheres are arranged at the dips of first layer. Third layer spheres are arranged in a manner such that it cover the octahedral void. Then no longer third layer is similar to first or second layer.

Third layer gives a different arrangement. Fourth layer spheres are similar to first layer. If the first, second and third layer are represented as A,B,C then this type of packing gives the arrangement of layers as ABCABC… (i.e.,), the first three layers do not resemble first, second and third layers respectively and the sequence is repeated.

with the addition of more layers. In this arrangement, atoms occupy 74% of the available space and thus has 26% vacant space. The coordination number is 12. Voids – The empty spaces between the three-dimensional layers are known as voids. There are two types of common voids possible. They are tetrahedral and octahedral voids.

Tetrahedral void – A void formed by three spheres of a layer in contact with each other and also with a sphere on the top or bottom layer is a hole between four spheres. The spheres are arranged at the vertices of a regular tetrahedron such a hole or void is called tetrahedral void.



abc arrangement – ccp structure

Octahedral void:
A hole or void formed by three spheres of a hexagonal layer and another three spheres of the adjacent layer is a hole between six spheres. The spheres are arranged at the vertices of a regular octahedron. Such a hole or void is abc arrangement – ccp structure called octahedral void.

Question 13.
Why ionic crystals are hard and brittle?
Answer:

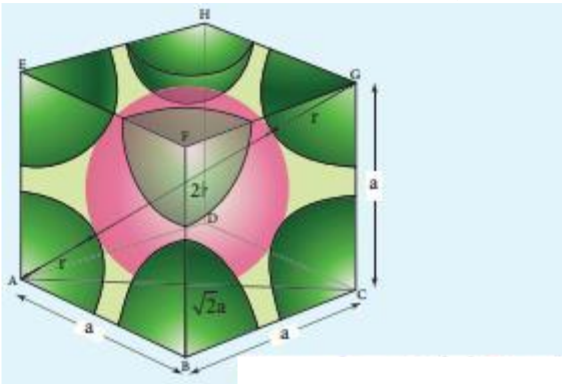
The ionic compounds are very hard and brittle. In ionic compounds the ions are rigidly held in a lattice because the positive and negative ions are strongly attracted to each other and difficult to separate. But the brittleness of a compound is now easy to shift the position of atoms or ions in a lattice.

If we apply a pressure on the ionic compounds the layers shifts slightly. The same charged ions in the lattice comes closer. A repulsive forces arises between ' same charged ions, due to this repulsion the lattice structure breaks down chemical bonding.

Question 14.
Calculate the percentage efficiency of packing in the case of a body-centered cubic crystal.
Packing efficiency.

Answer:

In body-centered cubic arrangement the spheres are touching along the leading diagonal of the cube as shown in the In ΔABC,



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

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

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

In ΔACG,

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

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

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

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

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

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

∴ Volume of the sphere with radius 'r'

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

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

$= \frac{\sqrt{3}}{6}\pi a^3$

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

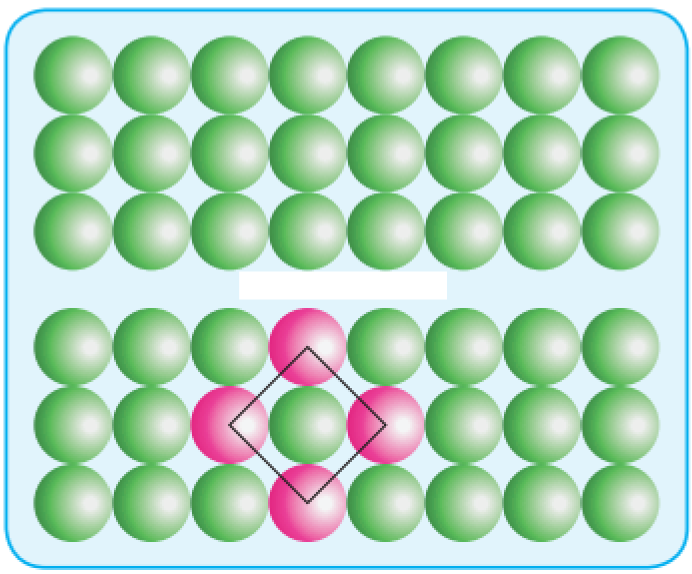
$$= 2 \times \frac{\sqrt{3}\pi a^3}{16} = \frac{\sqrt{3}\pi a^3}{8}$$

$$\text{Packing fraction} = \frac{\text{Total volume occupied by spheres in a unit cell}}{\text{Volume of the unit cell}} \times 100$$

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

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

Question 15.
What is the two dimensional coordination number of a molecule in square close packed layer?
Answer:
Square close packing – When the spheres of the second row are placed exactly above those of the first row. This way the spheres are aligned horizontally as well as vertically. The arrangement is AAA type. Coordination number is 4.



Question 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 ?
Answer:
Let the number of Ni^{2+}. Then the number of Ni^{3+} ion will be = (0.96 – x). Total number of cation, = 2 x + 3 (0.96 – x)
= 2x + 2.88 – 3x
= (– x) + 2.88

Number of anions O2- (– 2) x 1 = -2. Number of cations = Number of anions
– x + 2.88 2
– x = – 2.88 + 2
x =0.88
%of Ni as Ni2 =$\frac{0.08}{0.96}$×100 = 91.66%
Number of Ni^{3+} ion will be = 0.96 – x
= 0.96 – 0.88 = 0.08
% of Ni as Ni^{3+} = $\frac{0.08}{0.96}$×100 = 8.3 %

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

1. Coordination number – The number of nearest neighbours that surrounding a particle in a crystal is called the coordination number of that particle.
2. Coordination number of atoms in a bcc structure is 8

Question 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 ¡n 208g of the element.
Answer:
An elemeñt has bec structure with a cell edge of 288 pm. The density of the element is 7.2 gcm^{-3}. For the Bec structure, n = 2

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

$$7.2 \text{ g cm}^{-3} = \frac{2M}{\left(288\times10^{-10}\text{cm}\right)^3 \times \left(6.023\times10^{23}\text{mol}^{-1}\right)}$$

$$7.2 \text{ g cm}^{-3} = \frac{2M}{\left(2.38\times10^{-23}\text{cm}^3\right)\times\left(6.023\times10^{23}\text{mol}^{-1}\right)}$$

$$7.2 \text{ g cm}^{-3} = \frac{2M}{14.33\text{cm}^3\text{mol}^{-1}}$$

$$7.2\text{g} = 0.140 \text{ M mol}$$

$$M = \frac{7.2\text{g}}{0.140 \text{ mol}} = 51.42 \text{ g mol}^{-1}$$

By mole concept, 51.42 g of the element contains 6.023 x 10^{23} atom 208 g of the element will contain

$= \frac{6.023 \times 10^{23} \times 208}{51.42}$ atoms

$= 24.17 \times 10^{23}$ atoms (or) 2.417×10^{24} atoms

Question 19.
Aluminium crystallizes in a cubic close packed structure. Its metallic radius is 125pm. Calculate the edge length of unit cell.
Answer:
Given, Radius (r) = 125 pm
Edge length of unit cell (a) = ?
Since aluminium crystallizes in Face centered cubic

$r = \frac{a\sqrt{2}}{4}$ (or) $r = \frac{a}{2\sqrt{2}}$

$a = r \times 2 \times g\sqrt{2}$

$= 125 \times 2 \times 1.414$

$a = 353.5$ pm

Question 20.
If NaCI is doped with 10^2 mol percentage of strontium chloride, what is the concentration of cation vacancy?
Answer:
We know that two Na^+ ions are replaced by each of the Sr^{2+} ions while $SrCl^2$, is doped with NaCI. But in this case, only one lattice point is occupied by each of the Sr^{2+} ions and produce one cation vacancy.
Here 10^{-2} mole of $SrCI_2$, is doped with 100 moIes of NaCI. Thus, cation vacancies produced by NaCi = 10^{-2} mol. Since, 100 moles of NaCl produces cation vacancies after doping = 10^{-2} mol. Therefore, I mole of NaCl will produce cation vacancies after doping

$= \frac{10^{-2}}{100} = 10^{-4}$mol

:. Total cationic vacancies,

$= 10^{-4} \times$ Avogadro's number

$= 10 \times 6.023 \times 10^{23}$

$= 6.023 \times 10^{19}$ vacancies

Question 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})
Answer:

Density of KF 2.48 g cm^{-3}

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

$$n = 4 \text{(for Fcc)}$$

$$\rho = \frac{4 \times 58}{a^3 \times 6.023 \times 10^{23}}$$

$$2.48 = \frac{4 \times 58}{a^3 \times 6.023 \times 10^{23}}$$

$$a^3 = \frac{4 \times 58}{2.48 \times 6.023 \times 10^{23}}$$

$$a^3 = \frac{232}{14.93 \times 10^{23}}$$

$$a^3 = 15.54 \times 10^{-23}$$

$$a = 537.5 \text{ pm}$$

$$d = \frac{a}{\sqrt{2}} \quad \text{(For fcc)}$$

$$d = \frac{537.5}{1.414}$$

$$d = 380.12 \text{ pm}$$

Question 22.
An atom crystallizes ¡n fcc crystal lattice and has a density of 10 gcm3 with unit cell edge length of 100pm. calculate the number of atoms present in 1 g of crystal.
Answer:
Given, Density = 10 g cm^{-3}
mass = 1 g
Edge length of unit cell = 100 pm

$$\text{Volume} = \frac{\text{mass}}{\text{density}} = \frac{1\text{g}}{10\text{g cm}^{-3}}$$

= 0.1 cm^3
Volume of unit cell = a^3
= (100 x 10^{-10}cm)^3
= 1 x 10^{-24} cm^3
Number of unit cell in 1 g of crystal,

$$= \frac{\text{Total volume}}{\text{Volume of unit cell}}$$

$$= \frac{0.1 cm^3}{1 \times 10^{-24} cm^3}$$

The given unit cell is of FCC type. Therefore. it contains 4 atoms.
0.1×10^{24} unit cells will contain $4 \times 0.1 \times 10^{24} = 4 \times 10^{23}$atoms

Question 23.
Atoms X and Y form bcc crystalline structure. Atom X is present at the corners of the cube and Y is at the centre of the cube. What is the formula of the compound?
Answer:
Atoms X and Y form bcc crystalline structure. Atom X is present at the corners of the cube Atom Y is present at the centre of the cube.

No of atoms of X in the unit cell = $\frac{N_c}{8} = \frac{8}{8} = 1$

No of atoms of Y in the unit cell = $\frac{N_b}{1} = \frac{1}{1} = 1$

Ratio of atoms X : Y = 1 : 1

Hence formula of the compound = XY.

Question 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.
Answer:

Edge length of the unit cell (a) = 4.3×10^{-8}cm

Radius of sodium atom (r) = ?

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

$= \frac{\sqrt{3}}{4} a \, (4.3 \times 10^{-8} cm)$

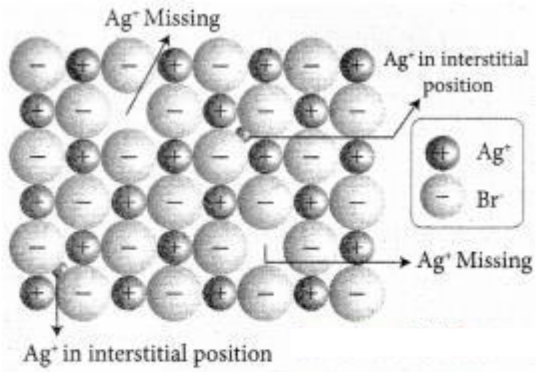
$\frac{1.732 \times 4.3 \times 10^{-8}}{4}$

$= \frac{1.732}{4} \times 10^{-8} cm$

= 1.86×10^{-8} cm = l.86Å

Question 25.
Write a note on Frenkel defect.
Answer:
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. For example AgBr, in this casc, small Ag ion leaves its normal site and occupies an interstitial position as shown in the figure.



Frenkel Defect