

GRADED EXERCISE QUESTIONS**Chapter 1 – Solid State****Level-1 QUESTIONS****1 Why are solids rigid?**

Because the particles have fixed positions and can oscillate only about their mean position only.

2 Why do solids have a definite volume?

The particles of solid have fixed positions and can oscillate only about their mean positions only. That is, solids possess rigidity and hence have definite volume.

3 Why is glass considered a super cooled liquid?

Like liquids, amorphous solids have a tendency to flow, though very slowly.

4 Give the significance of a 'lattice point'.

It is the constituent particle (atom, ion or molecule) of a regular and repeating pattern of crystalline solid

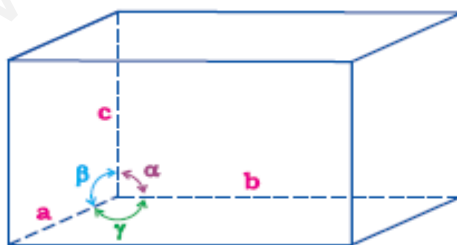
5 Name the parameters that characterise a unit cell.

A unit cell is characterised by:

- (i) its dimensions along the three edges, a , b and c . These edges may or may not be mutually perpendicular.
- (ii) angles between the edges, α (between b and c) β (between a and c) and γ (between a and b).

Thus, a unit cell is characterised by six parameters, a , b , c , α , β and γ .

These parameters of a typical unit cell are shown in the fig.

**6. Distinguish between Face-centred and end-centred unit cells and body-centred unit cells.**

A face centred unit cell has one constituent particle present at the centre of each face in addition to corner particles.

An end centred unit cell has one particle each at the centre of any two opposite faces in addition to corner particles.

A body centred unit cell has one particle at the centre of unit cell in addition to corner particles.

7 What type of stoichiometric defect is shown by: (i) ZnS (ii) AgBr

ZnS shows Frenkel defect due to large difference in ionic size.

AgBr shows both Frenkel defect and Schottky defect

8. Define the term 'amorphous'. Give a few examples of amorphous solids.

An amorphous solid consists of particles of irregular shape. The arrangement of constituent particles

(atoms, molecules or ions) in such a solid has only short range order. Glass, rubber and plastics are

typical examples of amorphous solids.

9 (i) What is meant by the term 'coordination number'?

(ii) What is the coordination number of atoms: (a) in a cubic close-packed structure?

(b) in a body-centred cubic structure?

(i) The number of immediate neighbouring atoms with which each atom is in contact with is known as co-ordination number.

(ii) a) in a cubic close-packed structure the coordination number is 12

b) in a body-centred cubic structure the coordination number is 8

10 How will you distinguish between the following pairs of terms?

(i) Crystal lattice and unit cell?

(ii) Tetrahedral void and octahedral void?

(i) a regular three dimensional arrangement of points in space is called a crystal lattice. Unit cell is the smallest portion of a crystal lattice which, when repeated in different directions, generates the entire lattice.

(ii)

Tetrahedral void

1.it is a void formed when 4 spheres (3 in one layer and 1 in next layer) are joined together.

2. Its co-ordination number is 4.

3.its radius is $0.225R$ where R is the radius of the close packed sphere

4. Tetrahedral void is much smaller than octahedral void

Octahedral void

1.it is a void formed when 6 spheres (3 in one layer and 3 in next layer) are joined together.

2. Its co-ordination number is 6.

3.its radius is $0.414R$ where R is the radius of the close packed sphere

4. Octahedral void is much bigger than tetrahedral void.

11. What is a semiconductor? Describe the two main types of semiconductors and contrast their conduction mechanism.

These are the solids with conductivities in the intermediate range of conductors and insulators (from 10^{-6} to $10^4 \text{ ohm}^{-1}\text{m}^{-1}$)

There are two types of semi conductors: p-type semiconductors and n-type semiconductors.

(a) n-type semiconductors:

Silicon and germanium belong to group 14 of the periodic table and have four valence electrons each. In their crystals each atom forms four covalent bonds with its neighbours. When doped with a group 15 element like P or As, which contains five valence electrons, they occupy some of the lattice sites in silicon or germanium crystal. Four out of five electrons are used in the formation of four covalent bonds and the fifth electron is extra and becomes delocalised. These delocalised electrons increase the conductivity of doped silicon (or germanium). Here the increase in conductivity is due to the negatively charged electron, hence silicon doped with electron-rich impurity is called n-type semiconductor.

(b) p-type semiconductors:

Silicon or germanium can also be doped with a group 13 element like B, Al or Ga which contains only three valence electrons. The place where the fourth valence electron is missing is called electron hole or electron vacancy. An electron from a neighbouring atom can come and fill the electron hole, leaving an electron hole at its original position. As a result, it would appear as if the electron hole has moved in the direction opposite to that of the electron that filled it. Under the influence of electric field, electrons would move towards the positively charged plate through electronic holes, but it would appear as if electron holes are positively charged and are moving towards negatively charged plate. This type of semi conductors is called p-type semiconductors.

12. In terms of band theory, what is the difference (i) between a conductor , an insulator and semiconductor?

(i) In case of conductors, the gap between the valence band and conduction band is too small or they overlap. Thus electrons can flow easily under an applied electric field and the conductor shows excellent conductivity.

(ii) If the gap between filled valence band and the next higher unoccupied band (conduction band) is large, electrons cannot jump to it and such a substance has very small conductivity and it behaves as an insulator.

(iii) In case of semiconductors, the gap between the valence band and conduction band is small. Therefore, some electrons may jump to conduction band and show some conductivity. Electrical conductivity of semiconductors increases with rise in temperature.

13. Explain the following terms with suitable examples:

(i) Schottky defect

It is basically a vacancy defect in ionic solids. In order to maintain electrical neutrality, the number of missing cations and anions are equal. Like simple vacancy defect, Schottky defect also decreases the density of the substance.

(ii) Frenkel defect

This defect is shown by ionic solids. The smaller ion (usually cation) is dislocated from its normal site to an interstitial site. It creates a *vacancy defect* at its original site and an interstitial defect at its new location. Frenkel defect is also called dislocation defect. It does not change the density of the solid.

(iii) Interstitial Defect:

When some constituent particles (atoms or molecules) occupy an interstitial site (void in between the constituent particles), the crystal is said to have interstitial defect. This defect increases the density of the substance.

(iv) F-centres.

The anionic sites occupied by unpaired electrons are called *F-centres*. They impart colour to the crystals and enhance electrical conductivity. These are created due to metal excess defect. The anion vacancies are occupied by free electrons furnished by the ionization of metal atom.

14. Explain the following with suitable examples:

(i) Ferromagnetism

It is a phenomenon in which substances show permanent magnetism even in the absence of external magnetic field. Such substances are called ferromagnetic substances and are attracted very strongly by a magnetic field. Besides strong attractions, these substances can be permanently magnetised. Substances like iron, cobalt, nickel, gadolinium and CrO_2 are examples.

(ii) Paramagnetism

Paramagnetism is a phenomenon in which the substances are weakly attracted by an external magnetic field. They lose their magnetism in the absence of magnetic field. Paramagnetism is due to presence of one or more unpaired electrons which are attracted by the magnetic field. O_2 , Cu^{2+} , Fe^{3+} , Cr^{3+} are some examples of such substances.

(iii) Ferrimagnetism

Ferrimagnetism is a phenomenon in which the magnetic moments of the domains in the substance are aligned in parallel and anti-parallel directions in unequal numbers. They are weakly attracted by magnetic field as compared to ferromagnetic substances. Fe_3O_4 (magnetite) and ferrites like MgFe_2O_4 and ZnFe_2O_4 are examples of such substances. These substances also lose ferrimagnetism on heating and become paramagnetic.

(iv) Antiferromagnetism

Antiferromagnetism is a phenomenon in which the magnetic moments of the domains in the substance are aligned in parallel and anti-parallel directions in equal numbers and cancel out each other's magnetic moment. MnO is an example

8. Density formula $d = \frac{ZM}{a^3 N_A}$

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

For hcp or ccp $a = 2\sqrt{2}r$

For simple cubic $a = 2r$

LEVEL-2 QUESTIONS

1.1 Classify the following as amorphous or crystalline solids: Polyurethane, benzoic acid, Teflon, potassium nitrate, cellophane, polyvinyl chloride, fibre glass, copper.

amorphous solids: Polyurethane, teflon, cellophane, polyvinyl chloride, fibre glass

crystalline solids: benzoic acid, potassium nitrate, copper.

1.2 Classify the following solids in different categories based on the nature of intermolecular forces

operating in them: Potassium sulphate, tin, benzene, urea, ammonia, water, zinc sulphide,

graphite, rubidium, argon, silicon carbide.

Potassium sulphate, zinc sulphide, -ionic

Tin, rubidium - metallic

Benzene, argon - molecular (non-polar)

Urea- molecular (polar)

Ammonia- molecular (hydrogen bonded)

Water- molecular (hydrogen bonded)

Graphite, silicon carbide. - covalent network

2.3. Solid A is a very hard electrical insulator in solid as well as in molten State and melts at

extremely high temperature. What type of solid is it?

Substance A is a covalent network solid.

2.4. Ionic solids conduct electricity in molten state but not in solid state. Explain.

In an ionic solid the ions are immobile due to strong electrostatic force of attraction

between the ions. In molten states the solids dissociate to produce mobile ions and hence can conduct electricity

1.5 Distinguish between (i) Hexagonal and monoclinic unit cells

(i) For Hexagonal $a=b \neq c$, $\alpha=\beta=90^\circ$, $\gamma=120^\circ$

For monoclinic $a \neq b \neq c$, $\alpha=\gamma=90^\circ$, $\beta \neq 90^\circ$

1.6 A compound is formed by two elements M and N. The element N forms ccp and atoms of M

occupy 1/3rd of tetrahedral voids. What is the formula of the compound?

Since the element N forms ccp, number of N atoms per unit cell = 4

The number of tetrahedral voids formed is equal to twice the number of atoms of element N and only

$\frac{2}{3}$ rd of these are occupied by the atoms of element M. that is $\frac{2}{3}$ rd of 4 = $\frac{2}{3} \times 4 = \frac{8}{3}$

Hence the ratio of the number of atoms of M and N is $\frac{8}{3} : 4 = 2:3$

Hence the formula of the compound is M_2N_3

1.7 What makes a glass different from a solid such as quartz? Under what conditions could quartz be converted into glass?

Quartz is a crystalline solid in which the arrangement of constituent particles (SiO_4) is ordered. It has long range order which means that there is a regular pattern of arrangement of particles which repeats itself periodically over the entire crystal. Glass is an amorphous solid in which the arrangement of constituent particles (SiO_4) has only short range order. In such an arrangement, a regular and periodically repeating pattern is absent. On melting quartz followed by rapid cooling, quartz can be converted to glass.

1.8 Classify each of the following solids as ionic, metallic, molecular, network (covalent) or amorphous.

(i) Tetra phosphorus decoxide (P_4O_{10}) –molecular

(ii) Ammonium phosphate ($(NH_4)_3PO_4$) – ionic

(iii) SiC - network (covalent)

(iv) I_2 –molecular

(v) P_4 –molecular

(vi) Plastic - amorphous

(vii) Graphite- network (covalent)

(viii) Brass- metallic

(ix) Rb -metallic

(x) LiBr– ionic

(xi) Si- network (covalent)

1.9 How can you determine the atomic mass of an unknown metal if you know its density and the

dimension of its unit cell? Explain.

Let a be the edge length, z be the number of atoms per unit cell

Then density, $d = \frac{z \cdot M}{a^3 \cdot N_A}$ where M is the molecular mass

N_A the Avogadro number = 6.02×10^{23}

Molecular mass $M = \frac{d \cdot a^3 \cdot N_A}{Z}$

1.10. How will you distinguish between Hexagonal close-packing and cubic close-packing?

In hexagonal close packed (*hcp*) structure, the spheres of the third layer are exactly aligned with those of the first layer. Thus, the pattern of spheres is repeated in alternate layers. This pattern is often written as ABAB pattern. But in cubic close packed (*ccp*) or face-centred cubic (*fcc*) structure, the spheres of the third layer are not aligned with those of either the first or the second layer. Only when fourth layer is placed, its spheres are aligned with those of the first layer This pattern of layers is often written as ABC, ABC

1.11. Explain (i) The basis of similarities and differences between metallic and ionic crystals. (ii) Ionic solids are hard and brittle.

metallic crystals

ionic crystals

Similarities

Similarities

1. force of attraction is electrostatic
2. melting points is very high
3. the bond is non-directional

1. force of attraction is electrostatic
2. melting points is very high
3. the bond is non-directional

differences

differences

1. the force of attraction is between valence electron and the positively charged kernels.
2. valence electrons are mobile and hence are good conductors of heat and electricity even in the solid state.
3. the force of attraction is weaker than in ionic solids.

1. the force of attraction is between valence electron and the positively charged kernels.
2. valence electrons are mobile and hence are good conductors of heat and electricity even in the solid state.
3. the force of attraction is stronger than in metallic solids.

1.12. Calculate the efficiency of packing in case of a metal crystal for

(i) simple cubic

(ii) body-centred cubic

(iii) face-centred cubic (with the assumptions that atoms are touching each other).

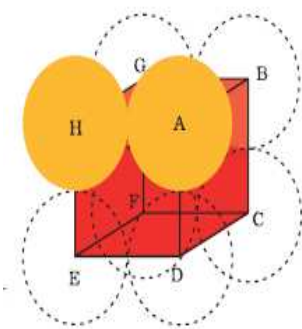
In a simple cubic lattice the atoms are located only on the corners of the cube. The particles touch each other along the edge (Fig. 1.22). Thus, the edge length or side of the cube 'a', and the radius of each particle, r are related as

$$a = 2r$$

$$\text{The volume of the cubic unit cell} = a^3 = (2r)^3 = 8r^3$$

Since a simple cubic unit cell contains only 1 atom

$$\text{The volume of the occupied space} = \frac{4}{3}\pi r^3$$



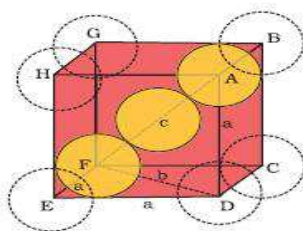
∴ Packing efficiency

$$= \frac{\text{Volume of one atom}}{\text{Volume of cubic unit cell}} \times 100\%$$

$$= \frac{\frac{4}{3}\pi r^3}{8r^3} \times 100 = \frac{\pi}{6} \times 100$$

$$= 52.36\% = 52.4\%$$

- (iii) In body centered cubic the atom at the centre will be in touch with the other two atoms diagonally arranged.



In $\triangle EFD$,

$$b^2 = a^2 + a^2 = 2a^2$$

$$b = \sqrt{2}a$$

Now in $\triangle AFD$

$$c^2 = a^2 + b^2 = a^2 + 2a^2 = 3a^2$$

$$c = \sqrt{3}a$$

The length of the body diagonal c is equal to $4r$, where r is the radius of the sphere (atom), as all the three spheres along the diagonal touch each other.

Therefore, $\sqrt{3}a = 4r$

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

Also we can write, $r = \frac{\sqrt{3}}{4} a$

In this type of structure, total number of atoms is 2 and their volume is $2 \times \left(\frac{4}{3}\right)\pi r^3$.

Volume of the cube, a^3 will be equal to $\left(\frac{4}{\sqrt{3}}r\right)^3$ or $a^3 = \left(\frac{4}{\sqrt{3}}r\right)^3$.

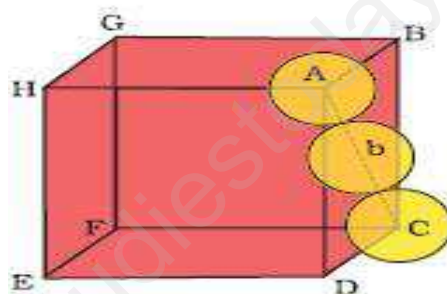
Therefore,

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

$$= \frac{2 \times \left(\frac{4}{3}\right)\pi r^3 \times 100}{\left[\left(\frac{4}{\sqrt{3}}r\right)^3\right]} \%$$

$$= \frac{(8/3)\pi r^3 \times 100}{64/(3\sqrt{3})r^3} \% = 68\%$$

(iii) In face-centered close packing (*hcp* and *ccp*) let the unit cell edge length be 'a' and face diagonal AC = b.



In ΔABC

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

$$= a^2 + a^2 = 2a^2 \text{ or}$$

$$b = \sqrt{2}a$$

If r is the radius of the sphere, we find

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

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

$$\text{(we can also write, } r = \frac{a}{2\sqrt{2}})$$

Each unit cell in *ccp* structure, has effectively 4 spheres.

Therefore,

$$\begin{aligned} \text{Packing efficiency} &= \frac{\text{Volume occupied by four spheres in the unit cell} \times 100}{\text{Total volume of the unit cell}} \% \\ &= \frac{4 \times (4/3) \pi r^3 \times 100}{(2\sqrt{2}r)^3} \% \\ &= \frac{(16/3) \pi r^3 \times 100}{16\sqrt{2}r^3} \% = 74\% \end{aligned}$$

1.13 Gold (atomic radius = 0.144 nm) crystallises in a face-centred unit cell. What is the length of a side of the cell?

For a face-centered unit cell. $a = 2\sqrt{2}r = 2 \times 1.414 \times 0.144 \text{ nm} = 0.407 \text{ nm}$

LEVEL-3 QUESTIONS

1.1 An element with molar mass $2.7 \times 10^{-2} \text{ kg mol}^{-1}$ forms a cubic unit cell with edge length 405 pm. If its density is $2.7 \times 10^3 \text{ kg}^{-3}$, what is the nature of the cubic unit cell?

Density, $d = z.M/a^3 \cdot N_A$

Therefore $Z = d a^3 \cdot N_A / M = 2.7 \times 10^3 \text{ kg}^{-3} \times (405 \times 10^{-12} \text{ m})^3 \times 6.02 \times 10^{23} / 2.7 \times 10^{-2} \text{ kg}^{-3} = 3.99 \approx 4$,

hence face-centered cubic or ccp structure

1.2 Explain how vacancies are introduced in an ionic solid when a cation of higher valence is added as an impurity in it.

An ionic solid is doped with another ionic solid containing a cation of higher valency. E.g. NaCl is doped with CdCl_2

1.3. Ionic solids, which have anionic vacancies due to metal excess defect, develop colour.

Explain

with the help of a suitable example.

Due to metal excess defect, anion vacancies are occupied by free electrons furnished by the ionization of metal atom. These sites are known as *F-centres*. When crystals of NaCl are heated in an atmosphere of sodium vapour, the sodium atoms are deposited on the surface of the crystal. The Cl^- ions diffuse to the surface of the crystal and combine with Na atoms to give NaCl. This happens by loss of electron by sodium atoms to form Na^+ ions. The released electrons diffuse into the crystal and occupy anionic sites. As a result the crystal now has an

excess of sodium. The anionic sites occupied by unpaired electrons are called *F-centres*. They impart yellow colour to the crystals of NaCl.

1.4. What type of substances would make better permanent magnets, ferromagnetic or ferrimagnetic. Justify your answer.

Ferromagnetic substances make better permanent magnets. In solid state, the metal ions of ferromagnetic substances are grouped together into small regions called *domains*. Thus, each domain acts as a tiny magnet. In an unmagnetised piece of a ferromagnetic substance the domains are randomly oriented and their magnetic moments get cancelled. When the substance is placed in a magnetic field all the domains get oriented in the direction of the magnetic field and a strong magnetic effect is produced. This ordering of domains persist even when the magnetic field is removed and the ferromagnetic substance becomes a permanent magnet.

1.5 'Stability of a crystal is reflected in the magnitude of its melting points'. Comment. Collect melting points of solid water, ethyl alcohol, diethyl ether and methane from a data book. What can you say about the intermolecular forces between these molecules

Higher the melting point, greater will be the force of attraction between the particles and hence greater will be the stability.

substance	Melting point (K)
solid water	273
ethyl alcohol	155.7
diethyl ether	156.8
methane	90.5

Solid water has the highest melting point due to strong hydrogen bonding between the particles. Ethyl alcohol has lower melting point due to weaker hydrogen bonding than solid ice. Diethyl ether is a polar molecule with weaker dipole-dipole interaction than hydrogen bonding. Methane is a non-polar molecule with weakest London dispersion forces (van der Waal's forces)

1.6. Silver crystallises in fcc lattice. If edge length of the cell is 4.07×10^{-8} cm and density is 10.5 g cm^{-3} , calculate the atomic mass of silver.

Density, $d = z.M/a^3 \cdot N_A$

$$\begin{aligned} \text{Therefore atomic mass } M &= da^3 \cdot N_A / z = 10.5 \text{ g cm}^{-3} \times (4.07 \times 10^{-8} \text{ cm})^3 \times 6.02 \times 10^{23} \text{ mol}^{-1} / 4 \\ &= 107.09 \text{ g mol}^{-1} \end{aligned}$$

1.7 . Niobium crystallises in body-centered cubic structure. If density is 8.55 g cm^{-3} , calculate atomic

radius of niobium using its atomic mass 93 u.

For body-centered cubic structure, no. of atoms per unit cell $z = 2$

Density, $d = Z.M/a^3 \cdot N_A$

$$a = (Z.M/d \cdot N_A)^{1/3}$$

$$= (2 \times 93 \text{ g mol}^{-1} / 8.55 \text{ g cm}^{-3} \times 6.02 \times 10^{23} \text{ mol}^{-1})^{1/3} = 330.4 \text{ pm}$$

$$\begin{aligned} \text{For body-centred cubic structure } r &= \sqrt{3} a/4 \\ &= \sqrt{3} \times 330.4/4 \\ &= 143.1 \text{ pm} \end{aligned}$$

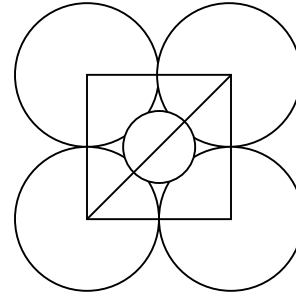
1.8. If the radius of the octahedral void is r and radius of the atoms in close packing is R , derive relation between r and R .

let the length of unit cell = a

Radius of octahedral void = r

Radius of sphere = R

In right angled ΔABC



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

$$\frac{AC}{AB} = \frac{\sqrt{2}a}{a} = \sqrt{2} \dots \dots \dots (1)$$

$$\text{Also } AB = 2R \quad AC = R + 2r + R = 2R + 2r$$

Sub in equation (1)

$$\frac{2R + 2r}{2R} = \sqrt{2}$$

$$1 + \frac{r}{R} = \sqrt{2} = 1.414$$

$$\frac{r}{R} = 1.44 - 1 = \underline{\underline{0.414}}$$

1.9. Copper crystallises into a fcc lattice with edge length 3.61×10^{-8} cm. Show that the calculated density is in agreement with its measured value of 8.92 g cm^{-3} atomic mass of Cu = 63.5 g mol^{-1}

For face-centered cubic structure, no. of atoms per unit cell $z = 4$

Density, $d = z.M/a^3 .N_A$

$$= 4 \times 63.5 \text{ g mol}^{-1} / (3.61 \times 10^{-8} \text{ cm})^3 \times 6.02 \times 10^{23} \text{ mol}^{-1}$$

$$= 8.97 \text{ g cm}^{-3}, \text{ which is close to the measured value of } 8.92 \text{ g cm}^{-3}$$

1.10. Analysis shows that nickel oxide has the formula $\text{Ni}_{0.98}\text{O}_{1.00}$. What fractions of nickel exist as Ni^{2+} and Ni^{3+} ions?

Let the total no. of oxygen atoms be 100. Then the no. of nickel atoms as per the formula of nickel oxide is = 98

Let the no. of Ni^{2+} ions = x

Then no. of Ni^{3+} ions = $100 - x$

$$\begin{aligned}
 \text{Total Charge on Ni}^{2+} \text{ ions} &= 2x \text{ (since Ni}^{2+} \text{ is dipositive)} \\
 \text{Total Charge on Ni}^{3+} \text{ ions} &= 3(100 - x) \text{ (since Ni}^{3+} \text{ is tripositive)} \\
 \text{Total positive Charge} &= 2x + 3(100 - x) \\
 \text{Total negative Charge on 100 oxide ions} &= 2 \times 100 \text{ since oxygen is O}^{2-} \\
 \text{As the nickel oxide is neutral, Total positive Charge} &= \text{Total negative Charge} \\
 \text{i.e. } 2x + 3(98 - x) &= 200 \\
 \text{Hence } x &= 88 \\
 \text{Total no. of Ni}^{2+} \text{ ions} &= x = 88 \\
 \text{Then no. of Ni}^{3+} \text{ ions} &= 100 - x = 100 - 88 = 12 \\
 \% \text{ of Ni}^{2+} &= 88 \times 100 / 96 = 91.7\% \\
 \% \text{ of Ni}^{3+} &= 100 - 91.7 = 8.3\%
 \end{aligned}$$

1.11 Ferric oxide crystallises in a hexagonal close-packed array of oxide ions with two out of every three octahedral holes occupied by ferric ions. Derive the formula of the ferric oxide.

Oxide forms the hexagonal close packed structure.

$$\begin{aligned}
 \text{Total number of O}^{2-} \text{ in the unit cell} &= 12 \times 1/6 + 1 \times 3 + 2 \times 1/2 \\
 &= 2 + 3 + 1 = 6
 \end{aligned}$$

Therefore number of Octahedral voids = 6

Number of Octahedral voids occupied = $6 \times 2/3 = 4$

Number of $\text{Fe}^{3+} = 4$

Formulae of Ferric Oxide = $\text{Fe}_4\text{O}_6 = \text{Fe}_2\text{O}_3$

1.12 Aluminium crystallises in a cubic close-packed structure. Its metallic radius is 125

pm. (i) What is the length of the side of the unit cell? (ii) How many unit cells are there in 1.00 cm³ of aluminium?

For a ccp or face-centered unit cell. $a = 2\sqrt{2}r = 2 \times 1.414 \times 125 \text{ pm} = 354 \text{ pm}$

Volume one unit cell, $a^3 = (354 \times 10^{-10} \text{ cm})^3$

No. of unit cells in 1.00 cm³ of aluminium = $1/a^3 = 1/(354 \times 10^{-10} \text{ cm})^3$
 $= 2.25 \times 10^{22}$

1.13. If NaCl is doped with 10⁻³ mol % of SrCl₂, what is the concentration of cation vacancies?

$10^{-3} \text{ mol \% of SrCl}_2 = 10^{-3} \times 6.02 \times 10^{23} / 100$

(as 1 mol = 6.02×10^{23} , % = 1/100) = $6.02 \times 10^{18} \text{ mol}^{-1}$