1

Solid State

Multiple Choice Questions (MCQs)

Q. 1 Which of the following conditions favours the existence of a substance in the solid state?

(a) High temperature
(b) Low temperature
(c) High thermal energy
(d) Weak cohesive forces

Ans. *(b)* At low temperature existence of a substance in solid state is due to

(a) slow molecular motion and
(b) strong cohesive forces

These two forces hold the constituent particles together thus causes existence of substance in solid state.

Q. 2 Which of the following is not a characteristic of a crystalline solid?

(a) Definite and characteristic heat of fusion
(b) Isotropic nature
(c) A regular periodically repeated pattern of arrangement of constituent particles in the entire crystal
(d) A true solid

Ans. *(b)* Crystalline solid is anisotropic in nature as this solid shows different physical properties such as electrical resistance, refractive index in different directions.

Note *Isotropic and anisotropic properties are related to amorphous solid and crystalline solid which can be clearly understood as*

Property	Types of solid	Physical properties
Isotropy	*Amorphous solid*	*Same value*
Anisotropy	*Crystalline solid*	*Different values*

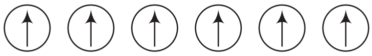
Q. 3 Which of the following is an amorphous solid?

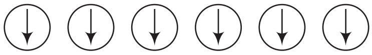
(a) Graphite (C)
(b) Quartz glass (SiO_2)
(c) Chrome alum
(d) Silicon carbide (SiC)

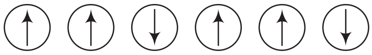
Ans. *(b)* Quartz glass (SiO_2) is an amorphous solid due to its short range order of constituent particles.

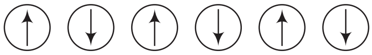
Note *Quartz is a crystalline solid while quartz glass is an amorphous solid.*

Q. 4 Which of the following arrangements shows schematic alignment of magnetic moments of antiferromagnetic substances?

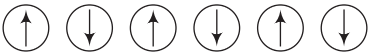
(a) 

(b) 

(c) 

(d) 

Ans. *(d)* The substances which have domain structure are oppositely oriented and cancel each other's magnetic field are known as antiferromagnetic substances.



Schematic arrangement of antiferromagnetic substance

Q. 5 Which of the following is true about the value of refractive index of quartz glass?

(a) Same in all directions
(b) Different in different directions
(c) Cannot be measured
(d) Always zero

Ans. *(a)* Since, quartz glass is an amorphous solid having short range order of constituents. Hence, value of refractive index is same in all directions, can be measured and not be equal to zero always.

Q. 6 Which of the following statement is not true about amorphous solids?

(a) On heating they may become crystalline at certain temperature
(b) They may become crystalline on keeping for long time
(c) Amorphous solids can be moulded by heating
(d) They are anisotropic in nature

Ans. *(d)* Amorphous solids are isotropic in nature because it has no long range order and any physical property will be same on all direction. On the other hand, anisotropic nature is a characteristic feature of crystalline solid.

Q. 7 The sharp melting point of crystalline solids is due to ....

(a) a regular arrangement of constituent particles observed over a short distance in the crystal lattice
(b) a regular arrangement of constituent particles observed over a long distance in the crystal lattice
(c) same arrangement of constituent particles in different directions
(d) different arrangement of constituent particles in different directions

Ans. *(b)* Crystalline solid has regular arrangement of constituent particles observed over a long distance in the crystal lattice. Due to this regular arrangement crystalline solid have sharp melting point.

Q. 8 Iodine molecules are held in the crystals lattice by ....

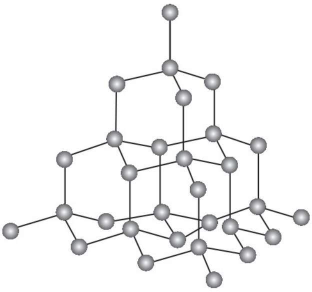
(a) London forces (b) dipole-dipole interactions
(c) covalent bonds (d) coulombic forces

Ans. (a) Iodine molecules are a class of non-polar molecular solid in which constituents molecules are held together by London or dispersion forces. These solids are soft and non-conductor of electricity.

Q. 9 Which of the following is a network solid?

(a) SO_2 (solid) (b) I_2
(c) Diamond (d) H_2O (ice)

Ans. (c) Diamond is a giant molecule in which constituent atoms are held together by covalent bond. Hence, this is a network solid.



Network structure of atom

Q. 10 Which of the following solids is not an electrical conductor?

1. Mg(s) 2. TiO (s) 3. I_2 (s) 4. H_2O (s)

(a) Only 1 (b) Only 2 (c) 3 and 4 (d) 2, 3 and 4

Ans. (c) Iodine is a non-polar molecular solid in which iodine molecules are held together by London force or dispersion force. This is soft and non-conductor of electricity.

Water is a hydrogen bonded molecular solid in which H and O are held together by polar covalent bond and each water molecule held together by hydrogen bonding. Due to non-ionic nature, they are not electrical conductor.

Q. 11 Which of the following is not the characteristic of ionic solids?

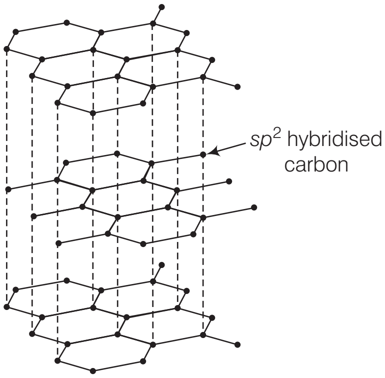
(a) Very low value of electrical conductivity in the molten state
(b) Brittle nature
(c) Very strong forces of interactions
(d) Anisotropic nature

Ans. (a) Ionic solids easily dissociated into its ions in molten state and show high electrical conductivity. So, statement (a) is incorrect while ionic solids are anisotropic and brittle linked with very strong force of interactions.

Q. 12 Graphite is a good conductor of electricity due to the presence of ....

(a) lone pair of electrons (b) free valence electrons
(c) cations (d) anions

Ans. *(b)* Graphite is a good conductor of electricity due to presence of free valence electrons. In graphite, each carbon is sp^2 hybridised having one free electron which makes graphite a good conductor of electricity.



Q. 13 Which of the following oxides behaves as conductor or insulator depending upon temperature?

(a) TiO (b) SiO_2 (c) TiO_3 (d) MgO

Ans. *(c)* Certain metal oxides like VO_2, VO, VO_3 and TiO_3 show metallic or insulating property depending upon temperature. As temperature varies metallic or insulating property varies. This is due to variation in energy gap between conduction band and valence band.

Q. 14 Which of the following oxides shows electrical properties like metals?

(a) SiO_2 (b) MgO (c) $SO_2(s)$ (d) CrO_2

Ans. *(d)* CrO_2, TiO and ReO_3 are some typical metal oxides which show electrical conductivity similar to metal. While SiO_2, MgO and SO_2 are oxides of metal, semimetal and non-metal which do not show electrical properties.

Q. 15 The lattice site in a pure crystal cannot be occupied by ....

(a) molecule (b) ion (c) electron (d) atom

Ans. *(c)* Each point in a lattice is known as lattice point which are either atom or molecule or ion which are joined together by a straight line to bring out geometry of lattice in pure crystal constituents are arranged in fixed stoichiometric ratio.

Hence, existence of free electrons are not possible, it is possible on in case of imperfection in solid.

Q. 16 Graphite cannot be classified as ....

(a) conducting solid (b) network solid

(c) covalent solid (d) ionic solid

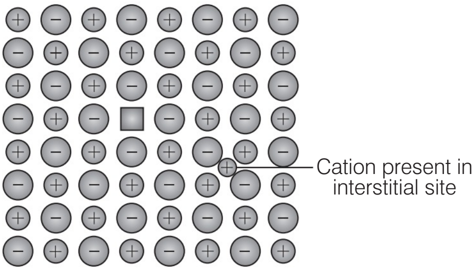
Ans. *(d)* Graphite can't be classified as ionic solid as graphite is not made up of ions. It is made up of carbon atoms covalently bonded to three carbon atoms so, it is a covalent solid.

Since, the formation of covalent bond occurs throughout the crystal therefore, it is a type of network solid. Due to presence of free electron graphite is also classified as conductor solid.

Q. 17 Cations are present in the interstitial sites in ....

(a) Frenkel defect
(b) Schottky defect
(c) vacancy defect
(d) metal deficiency defect

Ans. *(a)* When smaller ion (usually cation) is dislocated from its normal site in crystal and move to interstitial site is known as Frenkel defect as shown below



Frenkel defects

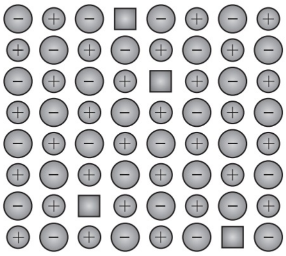
Q. 18 Schottky defect is observed in crystals when ....

(a) some cations move from their lattice site to interstitial sites
(b) equal number of cations and anions are missing from the lattice
(c) some lattice sites are occupied by electrons
(d) some impurity is present in the lattice

Ans. *(b)* Schottky defect is observed in crystal when equal number of cations and anions are missing from the lattice. Thus, density of solid decreases.

When some cations move from their lattice site to interstitial site is known as Frenkel defect. When some impurity is present on crystal is known as impurity defect.

When lattice site is occupied by electron, this type of defect is known as metal excess defect. Hence, except (b) all statements are incorrect regarding Schottky defect.

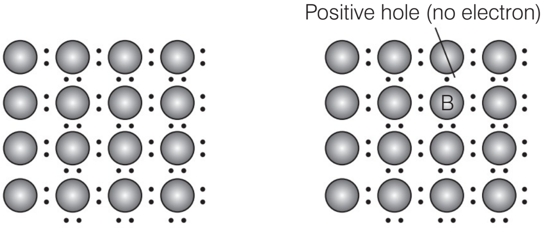


Schottky defect

Q. 19 Which of the following is true about the charge acquired by p - type semiconductors?

(a) Positive
(b) Neutral
(c) Negative
(d) Depends on concentration of *p* impurity

Ans. *(b)* When group 13 elements are doped in group 14 element, it creates a hole in a molecule but the molecule as a whole remain neutral. Thus, *p* -type semiconductor is neutral in nature.



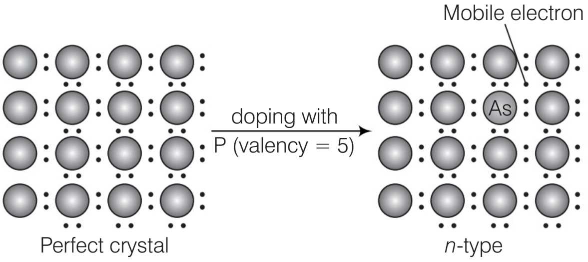
Perfect crystal   Perfect crystal

Q. 20 To get a n-type semiconductor from silicon, it should be doped with a substance with valency ....

(a) 2 (b) 1 (c) 3 (d) 5

Ans. *(d)* To get a *n*-type semiconductor from silicon, it should be doped with a substance with valence 5.

e.g., Si doped with P lead to formation of *n*-type semiconductor as shown below



Q. 21 The total number of tetrahedral voids in the face centred unit cell is ....

(a) 6 (b) 8 (c) 10 (d) 12

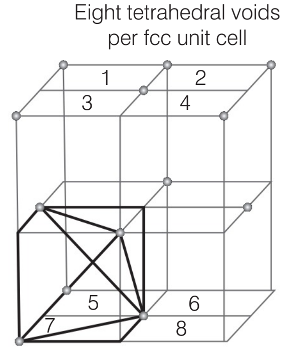
Thinking Process

If number of atoms in fcc unit cell = N

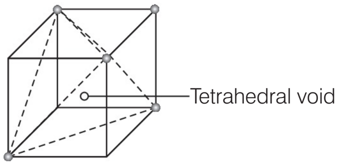
Number of tetrahedral voids = 2 N

Number of octahedral voids = N

Ans. *(b)* Fcc unit cell contains 8 tetrahedral voids at centre of each 8 smaller cube of an unit cell as shown below



Each cube represented by numeric 1, 2, 3, 4, 5, 6, 7, 8 contain one tetrahedral voids.



Each cube contain one tetrahedral void at its body centre as shown above

Number of atoms in fcc unit cell = 4

Number of octahedral voids = 4

Number of tetrahedral voids = 8

Q. 22 Which of the following point defects are shown by AgBr(s) crystals?

1. Schottky defect
2. Frenkel defect
3. Metal excess defect
4. Metal deficiency defect

(a) 1 and 2 (b) 3 and 4 (c) 1 and 3 (d) 2 and 4

Ans. *(a)* AgBr shows both Schottky as well as Frenkel defect. In AgBr, both Ag^+ and Br^- ions are absent from the lattice causing Schottky defect. However, Ag^+ ions are mobile so they have a tendency to move aside the lattice and trapped in interstitial site hence, cause Frenkel defect.

Q. 23 In which pair most efficient packing is present?

(a) hcp and bcc (b) hcp and ccp

(c) bcc and ccp (d) bcc and simple cubic cell

Ans. *(b)* Packing efficiency is the percentage of total filled space by particles and it can be calculated as packing efficiency

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

Since, packing efficiency for hcp or ccp is calculated to be 74% which is maximum among all type of crystals.

Q. 24 The percentage of empty space in a body centred cubic arrangement is ....

(a) 74 (b) 68 (c) 32 (d) 26

Ans. *(c)* Packing efficiency for bcc arrangement is 68% which represents total filled space in the unit cell. Hence, empty space in a body centred arrangement is 100 – 68 = 32 %.

Note *Here, empty space in bcc arrangement is asked therefore empty space in any crystal packing can be calculated as empty space in unit cell* =100 – *packing efficiency*

Q. 25 Which of the following statement is not true about the hexagonal close packing?

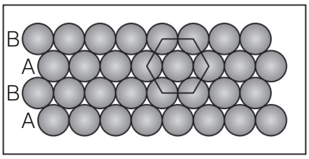
(a) The coordination number is 12

(b) It has 74% packing efficiency

(c) Tetrahedral voids of the second layer are covered by the spheres of the third layer

(d) In this arrangement spheres of the fourth layer are exactly aligned with those of the first layer

Ans. *(d)* Hexagonal close packing can be arranging by two layers *A* and *B* one over another which can be diagramatically represented as



Here, we can see easily that 1st layer and 4th layer are not exactly aligned.

Thus, statement (d) is not correct while other statements (a), (b) and (c) are true.

Q. 26 In which of the following structures coordination number for cations and anions in the packed structure will be same?

(a) Cl^- ions form fcc lattice and Na^+ ions occupy all octahedral voids of the unit cell

(b) Ca^{2+} ions form fcc lattice and F^- ions occupy all the eight tetrahedral voids of the unit cell

(c) O^{2-} ions form fcc lattice and Na^+ ions occupy all the eight tetrahedral voids of the unit cell

(d) S^{2-} ions form fcc lattice and Zn^{2+} ions go into alternate tetrahedral voids of the unit cell

Ans. *(a)* NaCl crystal have rock salt structure having fcc lattice in which Cl^- ions are present at fcc lattice points and face centre and Na^+ occupies all the octahedral void of given unit cell.

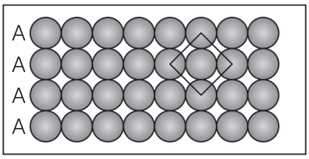
Where, coordination number of $Na^+ = 6$

coordination number of $Cl^- = 6$

Q. 27 What is the coordination number in a square close packed structure in two dimensions?

(a) 2 (b) 3 (c) 4 (d) 6

Ans. *(c)* Coordination number in a square closed packed structure in two dimensions is equal to 4 as shown below



Cubic closed structure

Q. 28 Which kind of defects are introduced by doping?

(a) Dislocation defect (b) Schottky defect

(c) Frenkel defect (d) Electronic defect

Ans. *(d)* When electron rich or electron deficient impurity is added to a perfect crystal it introduces electronic defect in them.

Q. 29 Silicon doped with electron rich impurity forms ....

(a) *p* -type semiconductor (b) *n*-type semiconductor

(c) intrinsic semiconductor (d) insulator

Ans. *(b)* Silicon doped with electron rich impurity such as phosphorus forms a *n*-type semiconductor. This is due to presence of mobile electron.

Q. 30 Which of the following statements is not true?

(a) Paramagnetic substances are weakly attracted by magnetic field

(b) Ferromagnetic substances cannot be magnetised permanently

(c) The domains in antiferromagnetic substances are oppositely oriented with respect to each other

(d) Pairing of electrons cancels their magnetic moment in the diamagnetic substances

Ans. *(b)* Ferromagnetic substances can be magnetised by applying magnetic field to it and magnetic property persist within it even after removal of magnetic field.

Hence, choice (b) is the correct answer while other three choices are correct.

Q. 31 Which of the following is not true about the ionic solids?

(a) Bigger ions form the close packed structure

(b) Smaller ions occupy either the tetrahedral or the octahedral voids depending upon their size

(c) Occupation of all the voids is not necessary

(d) The fraction of octahedral or tetrahedral voids occupied depends upon the radii of the ions occupying the voids

Ans. *(d)* The fraction of octahedral or tetrahedral voids occupied depends upon the radii of the ions present at the lattice points. As we know the radii of octahedral or tetrahedral void is related to radii of atoms (*r*) as

$$\text{Radius of octahedral void } (R_0) = 0.414\, r$$
$$\text{Radius of tetrahedral void } (R_t) = 0.225\, r$$

Where, r = radius of bigger atom involved.

Q. 32 A ferromagnetic substance becomes a permanent magnet when it is placed in a magnetic field because ....

(a) all the domains get oriented in the direction of magnetic field

(b) all the domains get oriented in the direction opposite to the direction of magnetic field

(c) domains get oriented randomly

(d) domains are not affected by magnetic field

Ans. *(a)* When a ferromagnetic substance is placed in a magnetic field it becomes a permanent magnet because all the domains get oriented in the direction of magnetic field even after removal of applied magnetic field.

Q. 33 The correct order of the packing efficiency in different types of unit cells is ....

(a) fcc $<$ bcc $<$ simple cubic

(b) fcc $>$ bcc $>$ simple cubic

(c) fcc $<$ bcc $>$ simple cubic

(d) bcc $<$ fcc $>$ simple cubic

Ans. *(b)* *Packing efficiency in different types of unit cells can be tabulated as*

Unit cell	Packing efficiency
fcc	74%
bcc	68%
Simple cubic	52%

Hence, correct order is fcc (74%) > bcc (68%) > simple cubic (52%).

Q. 34 Which of the following defects is also known as dislocation defect?

(a) Frenkel defect

(b) Schottky defect

(c) Non-stoichiometric defect

(d) Simple interstitial defect

Ans. *(a)* Frenkel defect is also known as dislocation defect because in Frenkel defect atoms present in crystal lattice is dislocated to interstitial site.

Q. 35 In the cubic close packing, the unit cell has ....

(a) 4 tetrahedral voids each of which is shared by four adjacent unit cells
(b) 4 tetrahedral voids within the unit cell
(c) 8 tetrahedral voids each of which is shared by four adjacent unit cells
(d) 8 tetrahedral voids within the unit cells

Ans. *(d)* In the cubic close packing the unit cell has 8 tetrahedral voids within it and are located at each eight smaller cube of an unit cell.

Q. 36 The edge lengths of the unit cells in terms of the radius of spheres constituting fcc, bcc and simple cubic unit cells are respectively ....

(a) $2\sqrt{2}r, \frac{4r}{\sqrt{3}}, 2r$
(b) $\frac{4r}{\sqrt{3}}, 2\sqrt{2}r, 2r$
(c) $2r, 2\sqrt{2}r, \frac{4r}{\sqrt{3}}$
(d) $2r, \frac{4r}{\sqrt{3}}, 2\sqrt{2}r$

Ans. *(a)* *Edge length for different types of unit cells can be tabulated as*

Types of unit cell	Edge length
fcc	$2\sqrt{2}r$
bcc	$\frac{4}{\sqrt{3}}r$
scc	$2r$

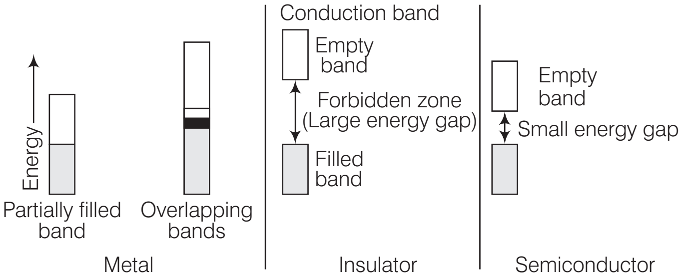
Q. 37 Which of the following represents correct order of conductivity in solids?

(a) $\kappa_{\text{metals}} >> \kappa_{\text{insulators}} < \kappa_{\text{semiconductors}}$
(b) $\kappa_{\text{metals}} << \kappa_{\text{insulators}} < \kappa_{\text{semiconductors}}$
(c) $\kappa_{\text{metals}} \cdot, \kappa_{\text{semiconductors}} > \kappa_{\text{insulators}} = \text{zero}$
(d) $\kappa_{\text{metals}} < \kappa_{\text{semiconductors}} > \kappa_{\text{insulators}} \neq \text{zero}$

Thinking Process

Look at the option and choose the correct answer using the concept that metal have maximum value of κ and insulator has minimum value.

Ans. *(a)* Conductivity of metal, insulator and semiconductors can be represented in the term of κ (Kappa) which depends upon energy gap between valence band and conduction band.



Value of κ (in Ω^{-1} m^{-1}) $10^4 - 10^7$ $10^{-20} - 10^{-10}$ 10^{-6} to 10^4

Hence, correct order is

$$\kappa_{\text{metals}} >> \kappa_{\text{insulators}} < \kappa_{\text{semiconductors}}$$

Multiple Choice Questions (More Than One Options)

Q. 38 Which of the following is not true about the voids formed in 3 dimensional hexagonal close packed structure?

(a) A tetrahedral void is formed when a sphere of the second layer is present above triangular void in the first layer

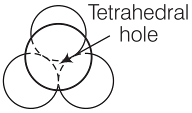
(b) All the triangular voids are not covered by the spheres of the second layer

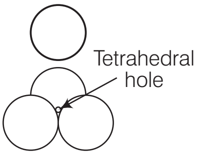
(c) Tetrahedral voids are formed when the triangular voids in the second layer lie above the triangular voids in the first layer and the triangular shapes of these voids do not overlap

(d) Octahedral voids are formed when the triangular voids in the second layer exactly overlap with similar voids in the first layer

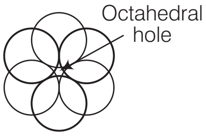
Ans. *(c, d)*

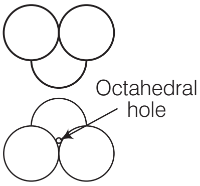
Tetrahedral voids are formed when the triangular void in the second layer lie exactly above the triangular voids in the first layer and the triangular shape of these voids oppositely overlap.





Octahedral voids are formed when triangular void of second layer is not exactly overlap with similar void in first layer.





Q. 39 The value of magnetic moment is zero in the case of antiferromagnetic substances because the domains ....

(a) get oriented in the direction of the applied magnetic field

(b) get oriented opposite to the direction of the applied magnetic field

(c) are oppositely oriented with respect to each other without the application of magnetic field

(d) cancel out each other's magnetic moment

Ans. *(c, d)*

In the case of antiferromagnetic substances, the magnetic moment becomes zero because the domains are oppositely oriented with respect to each other without the application of magnetic field which cancel out each other.

Q. 40 Which of the following statements are not true?

(a) Vacancy defect results in a decrease in the density of the substance

(b) Interstitial defects results in an increase in the density of the substance

(c) Impurity defect has no effect on the density of the substance

(d) Frenkel defect results in an increase in the density of the substance

Ans. ***(c, d)***

Statements (c) and (d) can be correctly written as (c)Impurity defect changes the density of substance as impurity has different density than the ion present on perfect crystal. *e.g.*, When $SrCl_2$ is added to the NaCl crystal it causes impurity defect.

(d) Frenkel defect results neither decrease nor increase in density of substance.

Q. 41 Which of the following statements are true about metals?

(a) Valence band overlaps with conduction band
(b) The gap between valence band and conduction band is negligible
(c) The gap between valence band and conduction band cannot be determined
(d) Valence band may remain partially filled

Ans. ***(a, b, d)***

Option (a), (b) and (d) are true, option (c) can be correctly stated as the gap between valence band and conduction band can be determined. The gap between valence band and conduction band decide the conductivity of material.

Q. 42 Under the influence of electric field, which of the following statement is true about the movement of electrons and holes in a p-type semiconductor?

(a) Electron will move towards the positively charged plate through electron holes
(b) Holes will appear to be moving towards the negatively charged plate
(c) Both electrons and holes appear to move towards the positively charged plate
(d) Movement of electrons is not related to the movement of holes

Ans. ***(a, b)***

In *p*-type semiconductor, the conductivity is due to existence of hole. When electric field is applied to *p* -type semiconductor hole starts moving towards negatively charged plate and electron towards positively charged plate.

Q. 43 Which of the following statements are true about semiconductors?

(a) Silicon doped with electron rich impurity is a *p* -type semiconductor
(b) Silicon doped with an electron rich impurity is an *n*-type semiconductor
(c) Delocalised electrons increase the conductivity of doped silicon
(d) An electron vacancy increases the conductivity of *n*-type semiconductor

Ans. ***(b, c)***

Silicon doped with an electron rich impurity is an *n*-type semiconductor. Conductivity of *n*-type semiconductor is due to presence of free electron delocalisation of electrons increases the conductivity of doped silicon due to increase in mobility of electron.

Q. 44 An excess of potassium ions makes KCl crystals appear violet or lilac in colour since ....

(a) some of the anionic sites are occupied by an unpaired electron
(b) some of the anionic sites are occupied by a pair of electrons
(c) there are vacancies at some anionic sites
(d) F-centres are created which impart colour to the crystals

Ans. ***(a, d)***

When KCl crystals are heated it leads the diposition of potassium ion on surface of KCl. The Cl^- ions diffuse to the surface of crystal and loss electron by potassium atom to form K^+ ion released electron occupies anionic site which is known as F-centre and impart colour to the crystal.

Q. 45 The number of tetrahedral voids per unit cell in NaCl crystal is ....

(a) 4

(b) 8

(c) twice the number of octahedral voids

(d) four times the number of octahedral voids

Ans. ***(b, c)***

NaCl has a rock salt type structure having fcc arrangement.

Total number of atoms per unit cell = 4

∴ Number of tetrahedral voids = 2 × 4 = 8

Number of octahedral voids = 4

Hence, (b) and (c) are correct choices.

Q. 46 Amorphous solids can also be called ....

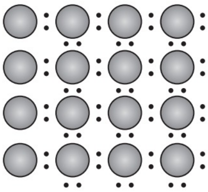
(a) pseudo solids (b) true solids

(c) super cooled liquids (d) super cooled solids

Ans. ***(a, c)***

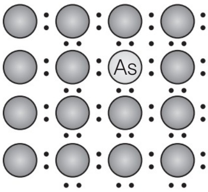
Amorphous solid has short range order which has a tendency to flow very slowly. Hence, it is also known as pseudo solids or super cooled liquids. Glass panes fixed to windows or doors of old buildings are invariably observed to be thicker at bottom than at the top. These are examples of amorphous solids.

Q. 47 A perfect crystal of silicon (fig) is doped with some elements as given in the options. Which of these options shows n -type semiconductors?

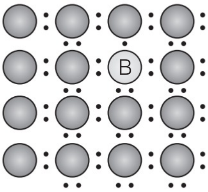


Pure crystal

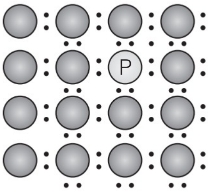
(a)



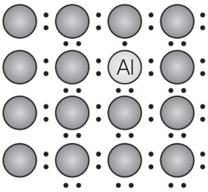
(b)



(c)



(d)



Ans. ***(a, c)***

***n*-type semiconductor** When group 15 elements are doped into a perfect crystal it leads to formation of *n*-type semiconductor.

Here, in (a) as (group 15, period 3) is doped to perfect Si-crystal and in (c) as (group 15, period 2) is doped to perfect Si-crystal.

Q. 48 Which of the following statements are correct?

(a) Ferrimagnetic substances lose ferrimagnetism on heating and become paramagnetic

(b) Ferrimagnetic substances do not lose ferrimagnetism on heating and remain ferrimagnetic

(c) Antiferromagnetic substances have domain structures similar to ferromagnetic substances and their magnetic moments are not cancelled by each other

(d) In ferromagnetic substances, all the domains get oriented in the direction of magnetic field and remain as such even after removing magnetic field

Ans. *(a, d)*

Ferrimagnetic substances lose ferrimagnetism on heating and become paramagnetic. In ferrimagnetic substance domains are alligned in parallel and antiparallel direction in unequal numbers.

In ferromagnetic substances, all the domains get oriented in the direction of magnetic field and remain as such even after removing magnetic field.

Hence, (a) and (d) are correct choices.

Q. 49 Which of the following features are not shown by quartz glass?

(a) This is a crystalline solid

(b) Refractive index is same in all the directions

(c) This has definite heat of fusion

(d) This is also called super cooled liquid

Ans. *(a, c)*

Quartz glass is an amorphous solid so it has not definite heat of fusion. This is due to short range order of molecule while quartz glass is also known as super cooled liquid and isotropic in nature.

Q. 50 Which of the following cannot be regarded as molecular solid?

(a) SiC (silicon carbide)
(b) AIN
(c) Diamond
(d) I_2

Ans. *(a, b, c)*

SiC, AIN and diamond are examples of network solid as they have three dimensional structure while, I_2 is a molecular solid, because such solid particles are held together by dipole-dipole interactions.

Q. 51 In which of the following arrangements octahedral voids are formed?

(a) hcp
(b) bcc
(c) simple cubic
(d) fcc

Ans. *(a, d)*

In hcp and fcc arrangement octahedral voids are formed. In fcc the octahedral voids are observed at edge and centre of cube while in bcc and simple cubic, no any octahedral voids are observed.

Q. 52 Frenkel defect is also known as ....

(a) stoichiometric defect
(b) dislocation defect
(c) impurity defect
(d) non-stoichiometric defect

Ans. *(a, b)*

Frenkel defect arises when the smaller ion (usually cation) is dislocated from its original site to interstitial site, this is also known as dislocation defect. Since, stoichiometry of substance persist so, it is categorised as stoichiometric defect.

Q. 53 Which of the following defects decrease the density?

(a) Interstitial defect
(b) Vacancy defect
(c) Frenkel defect
(d) Schottky defect

Ans. *(b, d)*

Vacancy and Schottky defects which lead to decrease the density both are the types of a stoichiometric defect. In case of Frenkel defect and interstitial defect, there is no change in density of substance.

Short Answer Type Questions

Q. 54 Why are liquids and gases categorised as fluids?

Ans. Liquids and gases have the tendency to flow, *i.e.*, their molecules can move freely from one place to another. Therefore, they are known as fluids. *e.g.*, glass panes fixed to windows or doors of old buildings are sometimes found to be thicker at bottom. This is due to ability of glass to flow.

Q. 55 Why are solids incompressible?

Ans. The distance between the constituent particles is very less in solids. On bringing them still closer repulsion will start between electron clouds of these particles. Hence, they cannot be brought further close together and are incompressible.

Q. 56 Inspite of long range order in the arrangement of particles why are the crystals usually not perfect?

Ans. Crystals have long range repeated pattern of arrangement of constituent particles but in the process of crystallisation some deviations from the ideal arrangement (*i.e.*, defects) may be introduced, therefore, crystals are usually not perfect.

Q. 57 Why does table salt, NaCl sometimes appear yellow in colour?

Ans. Yellow colour in NaCl is due to metal excess defect due to which unpaired electrons occupy anionic sites, known as F-centres. These electrons absorb energy from the visible region for the excitation which makes crystal appear yellow.

Q. 58 Why is FeO(s) not formed in stoichiometric composition?

Ans. In the crystals of FeO, some of the Fe^{2+} cations are replaced by Fe^{3+} ions. Three Fe^{2+} ions are replaced by two Fe^{3+} ions to make up the loss of positive charge. Eventually there would be less amount of metal as compared to stoichiometric composition.

Q. 59 Why does white ZnO (s) becomes yellow upon heating?

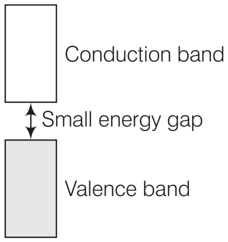
Ans. *On heating* ZnO *loses oxygen as follows*

$$ZnO \xrightarrow{\text{Heat}} Zn^{2+} + \frac{1}{2}O_2 + 2e^-$$

Zn^{2+} ions and electrons move to interstitial sites and F-centres are formed which impart yellow colour to ZnO(*s*).

Q. 60 Why does the electrical conductivity of semiconductors increase with rise in temperature?

Ans. The gap between conduction band and valence band is small in semiconductors. Therefore, electrons from the valence band can jump to the conduction band on increasing temperature. Thus, they become more conducting as the temperature increases.



Q. 61 Explain why does conductivity of germanium crystals increase on doping with galium?

Ans. On doping germanium with galium some of the positions of lattice of germanium are occupied be galium. Galium atom has only three valence electrons. Therefore, fourth valency of nearby germanium atom is not satisfied and the place remains vacant.

This place is deficient of electrons and is therefore called electron hole or electron vacancy. Electron from neighbouring atom comes and fills the hole, thereby creating a hole in its original position.

Under the influence of electric field electrons move towards positively charged plates through these and conduct electricity. The holes appear to move towards negatively charged plates.

Q. 62 In a compound, nitrogen atoms (N) make cubic close packed lattic and metal atoms (M) occupy one-third of the tetrahedral voids present. Determine the formula of the compound formed by M and N?

Ans. Let the number of N atoms in ccp is x

$$\therefore \quad \text{Number of tetrahedral voids} = 2x$$

$$\therefore \quad \text{Number of } M \text{ atoms} = \frac{1}{3} \times 2x$$

$$\frac{\text{Number of N atoms}}{\text{Number of } M \text{ atoms}} = \frac{3x}{2x} = \frac{3}{2}$$

So, the formula of the compound is M_2N_3.

Q. 63 Under which situations can an amorphous substance change to crystalline form?

Ans. On heating, amorphous substances change to crystalline form at some temperature some objects from ancient civilisation are found to be milky in appearance. This is due to crystallisation.

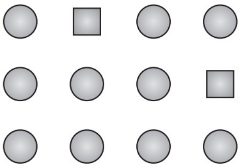
Matching The Columns

Q. 64 Match the defects given in Column I with the statements in given Column II.

	Column I		Column II
A.	Simple vacancy defect	1.	Shown by non-ionic solids and increases density of the solid
B.	Simple interstitial defect	2.	Shown by ionic solids and decreases density of the solid
C.	Frenkel defect	3.	Shown by non-ionic solids and density of the solid decreases
D.	Schottky defect	4.	Shown by ionic solids and density of the solid remains the same

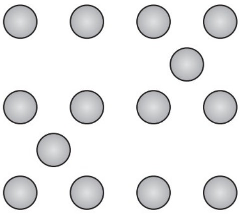
Ans. **A.** → (3) **B.** → (1) **C.** → (4) **D.** → (2)

A. When some of lattice sites are vacant in any non-ionic solid, the crystal is said to have vacancy defect and due to decrease in number of particles present in crystal lattice the density of crystal decreases.



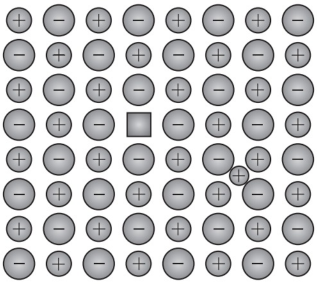
Vacancy defects

B. Simple interstitial defect are shown by non-ionic solids in which constituent particles is displaced from its normal site to an interstitial site. Hence, density of solid increases.



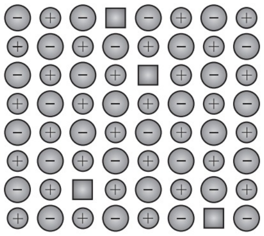
Interstitial defects

C. Frenkel defect is shown by ionic solids in which smaller ions get dislocated from its normal site to its interstitial site which lead to decrease its density.



Frenkel defects

D. Schottky defect is shown by ionic solids in which equal number of cation and anion get missed from ionic solids and thus, density of solid decreases.


Schottky defects

Q. 65 Match the type of unit cell given in Column I with the features given in Column II.

	Column I		Column II
A.	Primitive cubic unit cell	1.	Each of the three perpendicular edges compulsorily have the different edge length *i.e.*, $a \neq b \neq c$
B.	Body centred cubic unit cell	2.	Number of atoms per unit cell is one
C.	Face centred cubic unit cell	3.	Each of the three perpendicular edges compulsorily have the same edge length *i.e.*, $a = b = c$
D.	End centred orthorhombic unit cell	4.	In addition to the contribution from the corner atoms the number of atoms present in a unit cell is one
		5.	In addition to the contribution from the corner atoms the number of atoms present in a unit cell is three

Ans. **A.** → (2, 3) **B.** → (3, 4) **C.** → (3, 5) **D.** → (1, 4)

A. For primitive unit cell, $a = b = c$

Total number of atoms per unit cell $= 1/8 \times 8 = 1$

Here, 1/8 is due to contribution of each atom present at corner.

B. For body centred cubic unit cell, $a = b = c$

This lattice contain atoms at corner as well as body centre. Contribution due to atoms at corner $= 1/8 \times 8 = 1$ contribution due to atoms at body centre = 8

C. For face centred unit cell, $a = b = c$

Total constituent ions per unit cell present at corners $= \frac{1}{8} \times 8 = 1$

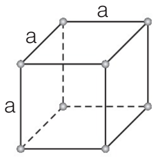
Total constituent ions per unit cell present at face centre $= \frac{1}{2} \times 6 = 3$

D. For end centered orthorhombic unit cell, $a \neq b \neq c$

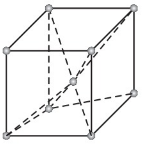
Total contribution of atoms present at corner $= \frac{1}{8} \times 8 = 1$

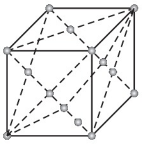
Total contribution of atoms present at end centre $= \frac{1}{2} \times 2 = 1$

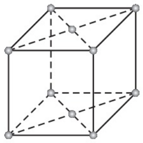
Hence, other than corner it contain total one atom per unit cell.



Primitive
(or simple)


Body centred


Face centred


End centred

Q. 66 Match the types of defect given in Column I with the statement given in Column II.

Column I	Column II
A. Impurity defect	1. NaCl with anionic sites called F-centres
B. Metal excess defect	2. FeO with Fe^{3+}
C. Metal deficiency defect	3. NaCl with Sr^{2+} and some cationic sites vacant

Ans. A. → (3) **B.** → (1) **C.** → (2)

A. Impurity defect arises due to replacement of one common ion present in any crystal by another uncommon ion.

B. Metal excess defect is due to missing of cation from ideal ionic solid which lead to create a F-centre generally occupied by unpaired electrons. *e.g.*, NaCl with anionic site.

C. Metal deficiency defect In FeO, Fe^{3+} exists along with Fe^{2+} which lead to decrease in metal ion(s) so this is a type of metal deficiency defect.

Q. 67 Match the items given in Column I with the items given in Column II.

Column I	Column II
A. Mg in solid state	1. *p* –type semiconductor
B. $MgCl_2$ in molten state	2. *n* –type semiconductor
C. Silicon with phosphorus	3. Electrolytic conductors
D. Germanium with boron	4. Electronic conductors

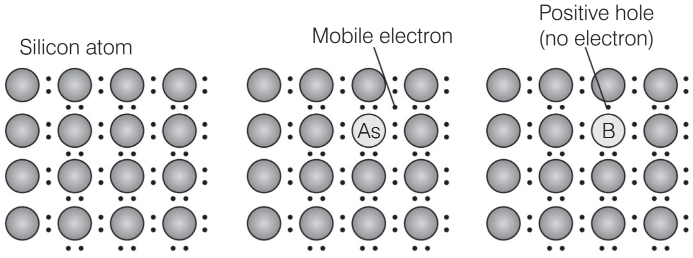
Ans. A. → (4) **B.** → (3) **C.** → (2) **D.** → (1)

A. Mg in solid state show electronic conductivity due to presence of free electrons hence, they are known as electronic conductors.

B. $MgCl_2$ in molten state show electrolytic conductivity due to presence of electrolytes in molten state.

C. Silicon doped with phosphorus contain one extra electron due to which it shows conductivity under the influence of electric field and known as *p-type* semiconductor.

D. Germanium doped with boron contain one hole due to which it shows conductivity under the influence of electric field and known as *n*-type semiconductor.



Perfect crystal (a)

n-type semiconductor (b)

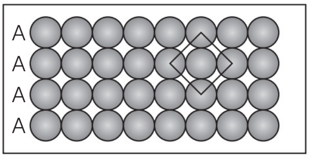
p-type semiconductor (c)

Q. 68 Match the type of packing given in Column I with the items given in Column II.

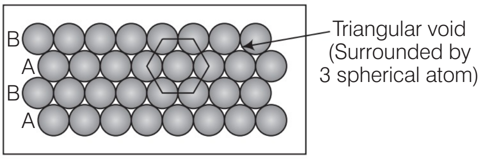
	Column I		Column II
A.	Square close packing in two dimensions	1.	Triangular voids
B.	Hexagonal close packing in two dimensions	2.	Pattern of spheres is repeated in every fourth layer
C.	Hexagonal close packing in three dimensions	3.	Coordination number = 4
D.	Cubic close packing in three dimensions	4.	Pattern of sphere is repeated in alternate layers

Ans. **A.** → (3) **B.** → (1) **C.** → (4) **D.** → (2)

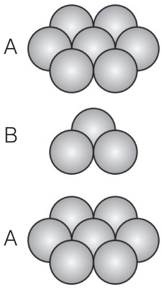
A. Square close packing in two dimensions each sphere have coordination number 4, as shown below



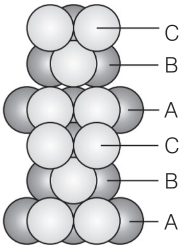
B. Hexagonal close packing in two dimensions each sphere have coordination number 6 as shown below and creates a triangular void



C. Hexagonal close packing in 3 dimensions is a repeated pattern of sphere in alternate layers also known as *ABAB* pattern



D. Cubic close packing in a 3 dimensions is a repeating pattern of sphere in every fourth layer



Assertion and Reason

In the following questions a statement of Assertion (A) *followed by a statement of Reason* (R) *is given. Choose the correct answer out of the following choices.*

(a) Assertion and Reason both are correct statements and Reason is correct explanation for Assertion.

(b) Assertion and Reason both are correct statements but Reason is not correct explanation for Assertion.

(c) Assertion is correct statement but Reason is wrong statement.

(d) Assertion is wrong statement but Reason is correct statement.

Q. 69 **Assertion** (A) The total number of atoms present in a simple cubic unit cell is one.

Reason (R) Simple cubic unit cell has atoms at its corners, each of which is shared between eight adjacent unit cells.

Ans. ***(a)*** In simple cubic unit cell each atom is present at corners having contribution 1/8.

Hence, total number of atoms present per unit cell in scc is $\frac{1}{8} \times 8 = 1$.

Q. 70 **Assertion** (A) Graphite is a good conductor of electricity however diamond belongs to the category of insulators.

Reason (R) Graphite is soft in nature on the other hand diamond is very hard and brittle.

Ans. ***(b)*** Assertion and Reason both are correct but Reason is not correct explanation of Assertion.

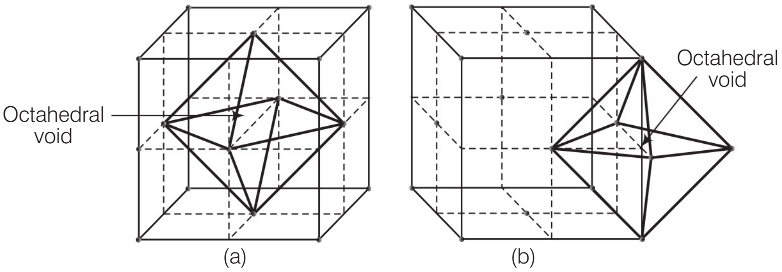
Correct explanation is that graphite have layered structure with free electrons due to which it is a good conductor of electricity. On the other hand, diamond have tetrahedral arrangement with no unpaired electron. Therefore, diamond is hard and brittle but insulator.

Q. 71 **Assertion** (A) Total number of octahedral voids present in unit cell of cubic close packing including the one that is present at the body centre, is four.

Reason (R) Besides the body centre there is one octahedral void present at the centre of each of the six faces of the unit cell and each of which is shared between two adjacent unit cells.

Ans. ***(c)*** Assertion is correct statement but Reason is incorrect statement.

Assertion is true as in ccp atom present at face centre and corner of each unit cell which creates octahedral void at each body centre and all twelve edges of a unit cell as shown below



Correct reason is that beside the body centre there is one octahedral void at centre of each of 12 edges which is surrounded by six atoms.

Out of six atoms four belongs to same unit cell (2 at corner and 2 at face centre) and 2 atoms belongs to adjacent unit cell.

Q. 72 Assertion (A) The packing efficiency is maximum for the fcc structure.

Reason (R) The coordination number is 12 in fcc structures.

Ans. *(b)* Assertion and Reason both are correct statements but reason is not the correct explanation of Assertion.

Correct reason is that, packing efficiency is maximum for fcc structure because it consists of total four atoms per unit cell. Packing efficiency is maximum in fcc structure which is equal to 74%.

Q. 73 Assertion (A) Semiconductors are solids with conductivities in the intermediate range from $10^{-6} - 10^{4}\ \text{ohm}^{-1}\text{m}^{-1}$.

Reason (R) Intermediate conductivity in semiconductor is due to partially filled valence band.

Ans. *(c)* Assertion is correct statement but reason is incorrect statement.

Semiconductors are solids with conductivities in the intermediate range varie from $10^{-6} - 10^{4}\ \Omega^{-1}\ \text{m}^{-1}$. Intermediate conductivity is due to small energy gap between valence band and conduction band.

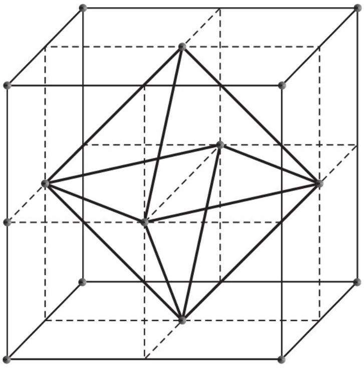
(*Also, refer to Q.* 60)

Long Answer Type Questions

Q. 74 With the help of a labelled diagram show that there are four octahedral voids per unit cell in a cubic close packed structure.

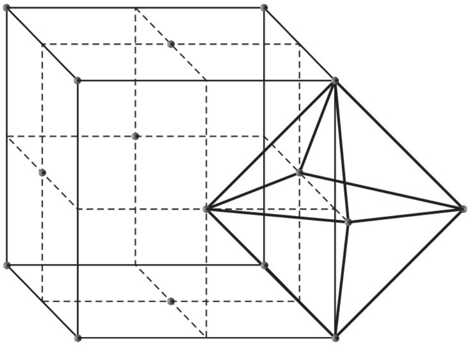
Ans. Cubic close packed structure contains one atom at each of eight corners of a unit cell and one atom at each of six faces which can be represented below

As we know any atom surrounded by six atoms (hard sphere) creates an octahedral void. In case of fcc body centre is surrounded by six identical atoms present at face centre hence, there is a octahedral void at body centre of each unit cell.



Location of octahedral voids per unit cell of ccp or fcc lattice at the body centre of the cube

Beside the body centre there is one octahedral void at centre of each of 12 edge as shown below



Octahedral void at centre of each edge

Since, each void is shared by 4 unit cell. Therefore, contribution of octahedral void to each edge of a unit cell is $\frac{1}{4}$.

Number of octahedral void at centre of 12 edge = $\frac{1}{4} \times 12 = 3$

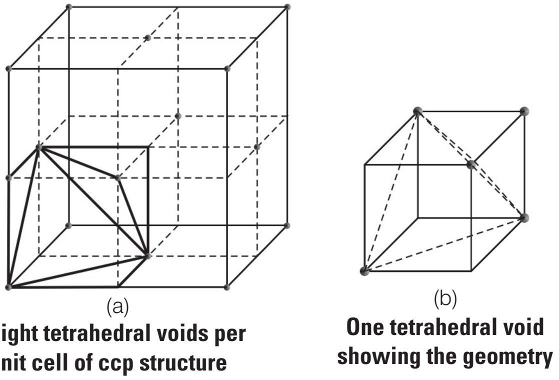
Number of octahedral void at body centre = 1

Therefore, total number of octahedral void at each ccp lattice = 3 + 1= 4

Q. 75 Show that in a cubic close packed structure, eight tetrahedral voids are present per unit cell.

Ans. Cubic close packed structure contains one atom at each corner of an unit cell and at face centre of each unit cell. Each unit cell consists of 8 small cubes.

Each small cube contains 4 *atoms at its alternate corner when these atoms are joined to each other lead to creation of a tetrahedral void as shown below*


(a)
Eight tetrahedral voids per unit cell of ccp structure

(b)
One tetrahedral void showing the geometry

Since, there are total 8 smaller cubes present at one unit cell and each smaller cube has one tetrahedral void hence, total number of tetrahedral void present in each unit cell is equal to eight.

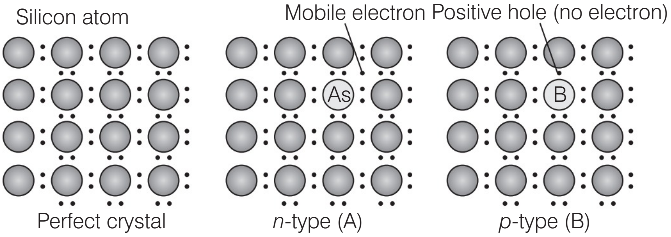
As we know ccp structure has 4 atoms per unit cell. Thus, total number of tetrahedral void in one ccp unit cell is equal to 8.

Q. 76 How does the doping increase the conductivity of semiconductors?

Ans. Conductivity of a semiconductor is too low for practical use. The conductivity of a semiconductor can be increased by adding a suitable amount of impurity to perfect crystal. This process is known as doping. It can be done by adding either of two types of impurity to the crystal.

(A) By adding **electron rich impurities** *i.e.*, group 15 elements to the silicon and germanium of group 14 elements. Out of 4 valence electrons of group 14 elements and 5 valence electrons of group 15 elements, four electrons of each element led to formation of four covalent bonds while the one extra electron of group 15 elements become delocalised.

Thus, increases conductivity of semiconductor. This type of semiconductor is known as *n*-type semiconductor.



Creation of*n*-type and *p*-type semiconductors by doping groups 13 and 15 elements

(B) By adding **electron deficient impurity** *i.e.*, group 14 to the perfect crystal of group 14 elements when group 13 element is doped to group 14 element it lead to create a hole in the ideal crystal which is known as electron hole or electron vacancy.

An electron from the neighbouring atom come and fill the electron hole in doing so an electron from the neighbour leaves an electron hole to its original position. Thus, it increases conductivity of semiconductor. This type of semiconductor is known as *p*-type semiconductor.

Q. 77 **A sample of ferrous oxide has actual formula $Fe_{0.93}O_{1.00}$. In this sample, what fraction of metal ions are Fe^{2+} ions? What type of non-stoichiometric defect is present in this sample?**

Thinking Process

Consider the number of Fe^{2+} and Fe^{3+} ions as x and y then write their sum equal to 0.93. Write another equation in terms of x and y by taking the sum of their total charge equal to 2 [charge on oxygen]. Now using the substitution method. Calculate the value of x and y then calculate fraction of Fe^{2+} ion present in this sample.

Ans. Let the formula of the sample be $(Fe^{2+})_x\ (Fe^{3+})_y\ O$

On looking at the given formula of the compound

$$x + y = 0.93 \qquad \text{...(i)}$$

Total positive charge on ferrous and ferric ions should balance the two units of negative charge on oxygen

Therefore,
$$2x + 3y = 2 \qquad \text{...(ii)}$$

$$\Rightarrow \quad x + \frac{3}{2}y = 1 \qquad \text{...(iii)}$$

On subtracting equation (i) from equation (iii) we have

$$\frac{3}{2}y - y = 1 - 0.93$$

$$\Rightarrow \quad \frac{1}{2}y = 0.07$$

$$\Rightarrow \quad y = 0.14$$

On putting the value of y in equation (i), we get

$$x + 0.14 = 0.93$$

$$\Rightarrow \quad x = 0.93 - 0.14$$

$$\Rightarrow \quad x = 0.79$$

Fraction of Fe^{2+} ions present in the sample $= \frac{0.79}{0.93} = 0.849$

Metal deficiency defect is present in the sample because iron is less in amount than that required for stoichiometric composition.