

- Q1. Define primitive unit cells.
- Q2. "Stability of a crystal is related to the magnitude of its melting point". How?
- Q3. How do metallic and ionic substances differ in conducting electricity?
- Q4. Write a distinguish feature of metallic solids.
- Q5. What type of interactions holds the molecules together in a polar molecular solid?
- Q6. Write a feature which will distinguish a metallic solid from an ionic solid.
- Q7. Which one of the following is an example of molecular solid:
 CO_2 or SiO_2 ?
- Q8. Given an example each of a molecular solid and an ionic solid.
- Q9. Assign reason for the following: Some of the very old glass objects appear slightly milky instead of being transparent.
- Q10. Why is glass considered supercooled liquid?
- Q11. "Crystalline solids are anisotropic in nature". What does this statement mean?
- Q12. Some of the glass objects recovered from ancient monuments look milky instead of being transparent. Why?
- Q13. Why are crystalline solids anisotropic?
- Q14. What is the formula of a compound in which the element Y forms *ccp* lattice and atoms of X occupy $1/3^{\text{rd}}$ of tetrahedral voids?
- Q15. Find out the number of atoms per unit cell in a face-centred cubic structure having only single atom at its lattice points.
- Q16. How many effective sodium ions are located at the edge centre of a unit cell in a sodium chloride crystal?
- Q17. What is the total number of atoms per unit cell in a face centred cubic (*fcc*) structure?
- Q18. How many atoms are there in one unit cell of a body centred cubic crystal?
- Q19. Calculate the number of atoms in a face centred cubic unit cell.
- Q20. How many atoms constitute one unit cell of a face-centred cubic crystal?
- Q21. How many atoms per unit cell (*Z*) are present in *bcc* unit cell?
- Q22. Define crystal lattice.
- Q23. How will you distinguish between the following pair of terms: Crystal lattice and unit cell?

- Q24. Express the relationship between atomic radius (r) and the edge length (a) in the bcc unit cell.
- Q25. What is the coordination number of each type of ions in a rock-salt type crystal structure?
- Q26. An ionic compound AB_2 possesses CaF_2 type crystal structure. Write the coordination number of A^{2+} and B^- ions in crystals AB_2 .
- Q27. How will you distinguish between the following pair of terms: Tetrahedral and octahedral voids?
- Q28. What is the formula of a compound in which the element Y forms ccp lattice and atoms of X occupy $2/3^{rd}$ of octahedral voids?
- Q29. What type of stoichiometric defect is shown by KCl and why?
- Q30. Which stoichiometric defect does not change the density of the crystal?
- Q31. Define the following term: Schottky defect.
- Q32. Express the relationship between atomic radius (r) and the edge length (a) in the fcc unit cell.
- Q33. What type of semiconductor is obtained when silicon is doped with boron?
- Q34. What type of semiconductor is formed when silicon is doped with As ?
- Q35. Which point defect of its crystals decreases the density of a solid?
- Q36. Give an example of an ionic compound which shows Frenkel defect.
- Q37. Why is Frenkel defects not found in pure alkali metal halides?
- Q38. Which stoichiometric defect in crystals increases the density of a solid?
- Q39. What type of defect can arise when a solid is heated?
- Q40. What type of stoichiometric defect is shown by $AgBr$ and AgI ?
- Q41. Which stoichiometric defect increases the density of a solid?
- Q42. Which type of ionic substances show Schottky defect in solids?
- Q43. What change occurs when $AgCl$ is doped with $CdCl_2$?
- Q44. Account the following: Schottky defects lower the density of related solids.
- Q45. What type of point defect is produced when $AgCl$ doped with $CdCl_2$?
- Q46. What type of stoichiometric defect is shown by $AgCl$?
- Q47. What type of stoichiometric defect is shown by $NaCl$?
- Q48. Define the following term: Ferromagnetism.
- Q49. What type of magnetism is shown by a substance if magnetic moments of domains are arranged in same direction?
- Q50. Explain the following with suitable examples: Piezoelectric effect.

- Q51. Assign reason for the following: Phosphorus doped silicon is a semiconductor.
- Q52. Impurity doped silicon is a semiconductor.
- Q53. What is meant by an 'intrinsic semiconductor'?
- Q54. What are *n*-type semiconductors?
- Q55. How may the conductivity of an intrinsic semiconductor be increased?
- Q56. What is meant by 'doping' in semiconductor?
- Q57. Account for the following: Conductivity of silicon increases on doping it with phosphorus.
- Q58. What type of substances would make better magnets, ferromagnetic or ferrimagnetic?
- Q59. What is meant by "antiferromagnetism"?
- Q60. Write the type of magnetism observed when the magnetic moments are aligned in parallel and anti-parallel directions in unequal numbers.
- Q61. Write the type of magnetism observed when the magnetic moments are oppositely aligned and cancel out each other.
- Q62. Explain the following with suitable example: Paramagnetism.
- Q63. Account for the following: Fe_3O_4 is ferrimagnetic at room temperature but becomes paramagnetic at 850 K.
- Q64. What are diamagnetic substances?
- Q65. What type of substances exhibits antiferromagnetism?
- Q66. What type of magnetism is shown in the following alignment of magnetic moments?
 $\uparrow\uparrow\uparrow\uparrow\uparrow$
- Q67. A compound forms *hcp* structure. What is the total number of voids in 0.5 mol of it? How many of these are tetrahedral voids?
- Q68. An alloy of gold and cadmium crystallises with a cubic structure in which gold atoms occupy the corners and cadmium atoms fit into the face centres. Assign formula for this alloy.
- Q69. An element crystallises in structure having *fcc* unit cell of an edge 200 pm. Calculate the density if 200 g of this element contains 24×10^{23} atoms.
- Q70. An element with density 2.8 g cm^{-3} forms a *fcc* unit cell with edge length of $4 \times 10^{-8} \text{ cm}$. Calculate the molar mass of the element. (Given: $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$)
- Q71. An element with density 11.2 g cm^{-3} forms a *fcc* lattice with edge length of $4 \times 10^{-8} \text{ cm}$. Calculate the atomic mass of the element. (Given: $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$)
- Q72. The edge of the face-centred cubic unit cell of aluminium is 404 pm. Calculate the radius of aluminium atom.
- Q73. Chromium metal crystallises in a body centred cubic lattice. The length of the unit cell edge is found to be 287 pm. Calculate the atomic radius of chromium.
- Q74. Calculate the packing efficiency of a metal for a simple cubic lattice.

Q90. Account for following:

- (a) Zinc oxide on heating becomes yellow.
- (b) Frenkel defect does not change the density of AgCl crystals.

Q91. Explain the following terms with suitable examples:

- (a) Schottky defect
- (b) Interstitial defect.

Q92. The radius of Na^+ ion is 95 pm and that of Cl^- ion is 181 pm. Predict whether the coordination number of Na^+ ion is 6 or 4.

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- S1.** A unit cell in which constituent particles (lattice points) are present only at the corner positions is called primitive or simple unit cell.
- S2.** The crystalline solids have sharp melting points. Melting point of a solid is related to the force of attraction between its molecules. Higher the melting point of a crystalline substance, greater is the force between the constituent particles and hence, greater is the stability.
- S3.** (a) Metallic solids are malleable and ductile whereas ionic solids are hard and brittle.
(b) In solid state, ionic solids are electrical insulators because ions are not free to move about, e.g., NaCl, Na₂SO₄, etc., while metals are good electrical conductors in solid state because of the presence of free electrons e.g., copper, nickel etc. (any one)
- S4.** Malleable, ductile, lustrous and conductor of heat and electricity.
- S5.** Strong dipole-dipole interactions.
- S6.** (a) Metallic solids are malleable and ductile whereas ionic solids are hard and brittle.
(b) In solid state, ionic solids are electrical insulators because ions are not free to move about, e.g., NaCl, Na₂SO₄, etc., while metals are good electrical conductors in solid state because of the presence of free electrons e.g., copper, nickel etc. (any one)
- S7.** Carbon dioxide (CO₂) is a molecular solid.
Quartz (SiO₂) is a covalent solid.
- S8.** Molecular solids: HCl, SO₂, H₂O (any one).
Ionic solids: KCl, CuSO₄, ZnS (any one).
- S9.** Some of the glass objects from ancient monuments look milky instead of being transparent because it undergoes heating during the day and cooling at night i.e., annealing over a number of years. As a result, it acquires some crystalline character. They become a bit opaque.
- S10.** Glass is considered as super cooled liquid because glass is an amorphous solid and has tendency to flow very slowly like liquids.
- S11.** Crystalline solids are anisotropic in nature because of different arrangements of particles in different directions. Some of their physical properties like electrical conductivity, refractive index, etc., shows different values in different directions in the same crystals.
- S12.** Some of the glass objects from ancient monuments look milky instead of being transparent because it undergoes heating during the day and cooling at night i.e., annealing over a number of years. As a result, it acquires some crystalline character. They become a bit opaque.
- S13.** Crystalline solids are anisotropic in nature because of different arrangements of particles in different directions. Some of their physical properties like electrical conductivity, refractive index, etc., shows different values in different directions in the same crystal.

S14. No. of Y atoms per unit cell = $\frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 4$

No. of tetrahedral voids = $2 \times 4 = 8$

\therefore No. of X atoms = $\frac{1}{3} \times 8 = \frac{8}{3}$

Formula of the compound = $X_{\frac{8}{3}}Y_4 = X_2Y_3$.

S15. In face centred cubic unit cell

(a) No. of atoms contributed from the corners of the unit cell

$$= 8 \text{ corner atoms} \times \frac{1}{8} \text{ atom per unit cell}$$

$$= 8 \times \frac{1}{8} = 1 \text{ atom}$$

(b) No. of atoms contributed from the faces

$$= 6 \text{ face centred atoms} \times \frac{1}{2} \text{ atoms per unit cell}$$

$$= 6 \times \frac{1}{2} = 3 \text{ atoms}$$

\therefore Total no. of atoms per unit cell = 4 atoms.

S16. Na units in edge = $12 \times \frac{1}{4} = 3$.

S17. In face centred cubic unit cell

(a) No. of atoms contributed from the corners of the unit cell

$$= 8 \text{ corner atoms} \times \frac{1}{2} \text{ atom per unit cell}$$

$$= 8 \times \frac{1}{8} = 1 \text{ atom}$$

(b) No. of atoms contributed from the faces

$$= 6 \text{ face centred atoms} \times \frac{1}{2} \text{ atoms per unit cell}$$

$$= 6 \times \frac{1}{2} = 3 \text{ atoms}$$

\therefore Total no. of atoms per unit cell = 4 atoms.

S18. In a body centred cubic unit cell.

(a) 8 corners $\frac{1}{8}$ per corner atom = $8 \times \frac{1}{8} = 1$ atom

(b) 1 body centre atom = $1 \times 1 = 1$ atom

\therefore Total number of atoms per unit cell = $1 + 1 = 2$ atoms.

S19. In face centred cubic unit cell

(a) No. of atoms contributed from the corners of the unit cell

$$= 8 \text{ corner atoms} \times \frac{1}{2} \text{ atom per unit cell}$$

$$= 8 \times \frac{1}{8} = 1 \text{ atom}$$

(b) No. of atoms contributed from the faces

$$= 6 \text{ face centred atoms} \times \frac{1}{2} \text{ atoms per unit cell}$$

$$= 6 \times \frac{1}{2} = 3 \text{ atoms}$$

\therefore Total no. of atoms per unit cell = 4 atoms.

S20. In face centred cubic unit cell

(a) No. of atoms contributed from the corners of the unit cell

$$= 8 \text{ corner atoms} \times \frac{1}{8} \text{ atom per unit cell}$$

$$= 8 \times \frac{1}{8} = 1 \text{ atom}$$

(b) No. of atoms contributed from the faces

$$= 6 \text{ face centred atoms} \times \frac{1}{2} \text{ atoms per unit cell}$$

$$= 6 \times \frac{1}{2} = 3 \text{ atoms}$$

\therefore Total no. of atoms per unit cell = 4 atoms.

S21. In a body centred cubic unit cell.

(a) 8 corners $\frac{1}{8}$ per corner atom = $8 \times \frac{1}{8} = 1$ atom

(b) 1 body centre atom = $1 \times 1 = 1$ atom

\therefore Total number of atoms per unit cell = $1 + 1 = 2$ atoms.

S22. Arrangement of lattice points in three dimensional space is called crystal lattice.

S23. Arrangement of lattice points in three dimensional space is called crystal lattice.

The smallest repeating unit which represents arrangement of lattice points in a crystal lattice is called unit cell.

S24. In *bcc* unit cell $r = \frac{\sqrt{3}}{4} a$.

S25. In a rock salt type crystal structure, coordination number is 6 : 6.

⇒ Coordination number of M^+ = 6

Coordination number of A^- = 6.

S26. Coordination number of A^{2+} = 8

Coordination number of B^- = 4.

S27. A void surrounded by four atoms whose centre when joined forms tetrahedron is tetrahedral void.

Number of tetrahedral voids = $2 \times$ Number of atoms.

A void surrounded by six atoms whose centre when joined forms an octahedron is called octahedral voids.

Number of octahedral voids = Number of atoms.

S28. No. of Y atoms per unit cell in *ccp* lattice = $\frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 4$

[∵ *ccp* is same as face-centred cubic packing. Thus, no. of atoms = 4]

No. of octahedral voids = No. of atoms present in *ccp* lattice

No. of octahedral voids occupied by atoms = $\frac{2}{3} \times 4 = \frac{8}{3}$

Therefore, formula of the compound = $X_{\frac{8}{3}} Y_4 = X_2 Y_3$.

S29. Schottky defect is shown by ionic solids in which the cation and anion are of almost similar sizes.

Examples: NaCl, KCl, CsCl, AgBr, etc.

S30. Frenkel defect does not change the density of the solid.

S31. Schottky defect: The defect in which cations and anions are missing in the stoichiometric ratio of compound is called Schottky defect. Schottky defect is actually vacancy defect in ionic solids. In this defect, electrical neutrality is maintained. In this defect, density of solid decreases. Schottky defect is shown by ionic solids in which the cation and anion are of almost similar sizes.

Examples: NaCl, KCl, CsCl, AgBr, etc.

S32. In *fcc* unit cell $r = \frac{a}{2\sqrt{2}}$.

S33. *p*-type semiconductor is obtained when silicon is doped with boron.

S34. *n*-type semiconductor is formed when silicon is doped with arsenic.

- S35.** Schottky defect.
- S36.** Frenkel defect is shown by ionic solids in which difference in size of cations and anions is large.
Examples: ZnS, AgI and AgBr.
- S37.** Frenkel defects is not found in alkali metal halides because the ions cannot get into the interstitial sites due to their larger size.
- S38.** Interstitial defect.
- S39.** On heating a solid vacancy defect is produced in the crystal. This is because on heating, some lattice sites become vacant.
- S40.** Frenkel defect is shown by ionic solids in which difference in size of cations and anions is large.
Examples: ZnS, AgI and AgBr.
- S41.** Interstitial defect.
- S42.** Schottky defect is shown by ionic solids in which the cation and anion are of almost similar sizes.
Examples: NaCl, KCl, CsCl, AgBr, etc.
- S43.** Addition of CdCl_2 to AgCl crystal causes impurity defect.
In this defect also one Cd^{2+} ion replaces two Ag^+ ions from the crystal. One site is occupied by one Cd^{2+} ion and other site remains vacant.
- S44.** Schottky defects occur when cations and anions are missing from their lattice site. Mass of unit cell decreases which decreases the density of the solid.
- S45.** Addition of CdCl_2 to AgCl crystal causes impurity defect.
In this defect also one Cd^{2+} ion replaces two Ag^+ ions from the crystal. One site is occupied by one Cd^{2+} ion and other site remains vacant.
- S46.** Frenkel defect.
- S47.** Schottky defect.
- S48. Ferromagnetism:** Materials which are strongly attracted by magnetic field are called ferromagnetic materials and the property thus exhibited is called ferromagnetism.
e.g., Fe, Co, Ni show ferromagnetism at room temperature.
- S49.** Ferromagnetism.
- S50. Piezoelectric effect:** When the electricity is produced by applying mechanical stress on some polar crystals, it is known as piezoelectric effect. Quartz shows this property.
- S51.** Phosphorus is pentavalent. When phosphorus is doped in silicon it increases the number of electrons which increases the conductivity of doped silicon and makes it semiconductor.
- S52.** The conductivity of intrinsic semiconductor like silicon is too low to be of practical use. This conductivity is increased by adding an appropriate amount of suitable impurity like Al or As which is electron deficient or electron rich. So, the electrical conductivity of silicon is increased.
- S53.** Pure substance which acts as semiconductor is called intrinsic semiconductor. *e.g.*, Si and Ge at high temperature.

S54. A semiconductor in which doped impurity has more valence electrons than the pure element is called *n*-type semiconductor. e.g., Ge or Si (Group-14) doped with P or As (Group-15).

S55. The conductivity of intrinsic semiconductor like silicon is too low to be of practical use. This conductivity is increased by adding an appropriate amount of suitable impurity like Al or As which is electron deficient or electron rich. So, the electrical conductivity of silicon is increased.

S56. Addition of an appropriate amount of suitable impurity in a crystalline solid is called doping. Doping is done to increase the conductivity of intrinsic semiconductors.

S57. Silicon when doped with phosphorus, which contains five valence electrons, they occupy some of the lattice sites in silicon crystal. Four out of five electrons are used in the formation of four covalent bonds with the four neighboring silicon atoms. The fifth electron is extra and becomes delocalised. These delocalised electrons increases the conductivity of doped silicon.

S58. Ferromagnetic substances because these substances become a permanent magnet.

S59. Antiferromagnetism: Paramagnetic substances which show very poor magnetic effect are antiferromagnetic and this property is called Antiferromagnetism.

Examples: MnO, Fe₂O, Cr₂O₃.

S60. Ferrimagnetism.

S61. Antiferromagnetism.

S62. Paramagnetism: Materials which are weakly attracted by magnetic fields are called paramagnetic materials and this property is called paramagnetism.

Paramagnetic substances contain unpaired electrons.

Examples: TiO, CuO, O₂ and VO₂, etc.

S63. On heating at 850 K, the magnetic domains undergo realignment and become paramagnetic.

S64. Substances which are weakly repelled by magnetic field are called diamagnetic and this property is called diamagnetism. Diamagnetism is shown by those substances in which all electrons are paired.

Examples: NaCl, H₂O, C₆H₆, Zn²⁺.

S65. Antiferromagnetism: Paramagnetic substances which show very poor magnetic effect are antiferromagnetic and this property is called Antiferromagnetism.

Examples: MnO, Fe₂O, Cr₂O₃.

S66. Ferromagnetism.

S67. Number of atoms in 0.5 mol *hcp* lattice = $0.5 \times 6.022 \times 10^{23} = 3.011 \times 10^{23}$

∴ Number of octahedral voids = Number of atoms = 3.011×10^{23}

Number of tetrahedral voids = $2 \times$ Number of atoms

= $2 \times 3.011 \times 10^{23} = 6.022 \times 10^{23}$

$$\begin{aligned}\text{Total number of voids} &= \text{Number of octahedral voids} + \text{Number of tetrahedral voids} \\ &= 3.011 \times 10^{23} + 6.022 \times 10^{23} \\ &= 9.033 \times 10^{23} \text{ voids.}\end{aligned}$$

S68. When the particles are present not only at the corners but also at the centre of each face of the unit cell. It is called face-centred unit cell.

Number of atoms in a unit cell of the face-centred-cubic (fcc) \Rightarrow 8 atoms on the corners (gold) and 6 atoms of cadmium on the face (one of each face).

$$\text{Contribution by atoms (gold) on the corners} = \frac{1}{8} \times 8 = 1$$

$$\text{Contribution by atom (cadmium) on the faces} = \frac{1}{2} \times 6 = 3$$

Formula of this alloy = AuCd₃.

S69. Given,

$$\text{Edge length} = 200 \text{ pm}$$

$$\begin{aligned}\text{Volume of the unit cell} &= (200 \times 10^{-10} \text{ cm})^3 \\ &= 8 \times 10^{-24} \text{ cm}^3\end{aligned}$$

In a fcc unit cell there are four atoms per unit cell.

$$\therefore \text{Mass of unit cell} = \frac{200 \times 4}{24 \times 10^{23}} = 33.3 \times 10^{-23} \text{ g}$$

$$\begin{aligned}\text{Density} &= \frac{\text{Mass of unit cell}}{\text{Volume of unit cell}} \\ &= \frac{33.3 \times 10^{-23} \text{ g}}{8 \times 10^{-24} \text{ cm}^3} = 41.6 \text{ g cm}^{-3}.\end{aligned}$$

S70. Given, Density of solid,

$$d = 2.8 \text{ g cm}^{-3}$$

For fcc unit cell,

$$Z = 4$$

Edge length,

$$a = 4 \times 10^{-8} \text{ cm}$$

Molar mass,

$$M = ?$$

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

Using formula,

$$d = \frac{Z \times M}{N_A \times a^3}$$

or

$$M = \frac{d \times N_A \times a^3}{Z}$$

Substituting these values, we get

$$M = \frac{2.8 \text{ g cm}^{-3} \times 6.022 \times 10^{23} \text{ mol}^{-1} \times (4 \times 10^{-8} \text{ cm})^3}{4}$$

or

$$M = \frac{2.8 \times 6.022 \times 6.4}{4} = 26.98 \text{ g mol}^{-1}.$$

S71. Given : $d = 11.2 \text{ g cm}^{-3}$, $Z = 4$, $a = 4 \times 10^{-8} \text{ cm}$, $M = ?$, $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$.

$$M = \frac{d \times a^3 \times N_A}{Z}$$
$$= \frac{11.2 \times (4 \times 10^{-8})^3 \times 6.022 \times 10^{23}}{4} = 108 \text{ g mol}^{-1}.$$

S72. Edge of the face-centred cubic unit cell, $a = 404 \text{ pm}$

$$\therefore \text{Radius, } r = \frac{a}{2\sqrt{2}} = \frac{404}{2\sqrt{2}} = \frac{202}{\sqrt{2}}$$
$$= \frac{202}{\sqrt{2}} \times \frac{\sqrt{2}}{\sqrt{2}} = \frac{202\sqrt{2}}{2} = 101\sqrt{2}$$
$$= 101 \times 1.414 = 142.814 \text{ pm}.$$

S73. Atomic radius for *bcc* lattice, $r = \frac{\sqrt{3}a}{4}$

or $r = \frac{1.732 \times 287 \text{ pm}}{4} = 124.27 \text{ pm}.$

S74.

Given, Packing efficiency = $\frac{Z \times \text{Volume of one atom}}{\text{Volume of cubic unit cell}} \times 100 = \frac{Z \times \frac{4}{3} \pi r^3}{a^3} \times 100$

For a simple cubic lattice, $a = 2r$ and $Z = 1$

$$\therefore \text{Packing efficiency} = \frac{1 \times \frac{4}{3} \pi r^3}{(2r)^3} \times 100 = \frac{\pi}{6} \times 100 = 52.4\%.$$

S75. For *fcc* (or *ccp*),

$$a = 2\sqrt{2}r = 2 \times 1.414 \times 125 \text{ pm} = 354 \text{ pm}$$

S76. For *fcc*,

$$Z = 4$$

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

$$a = 2 \times 1.414 \times 128 \text{ pm} = 362 \text{ pm}$$

$$a = 362 \times 10^{-10} \text{ cm}$$

$$d = \frac{Z \times M}{a^3 \times N_A}$$

$$= \frac{4 \times 63.5 \text{ g/mol}}{(362 \times 10^{-10} \text{ cm})^3 \times (6.02 \times 10^{23} \text{ mol}^{-1})} = 8.9 \text{ g cm}^{-3}.$$

S77. We can determine the atomic mass of an unknown metal by using the formula of density of its unit cell.

$$d \text{ (density)} = \frac{Z \text{ (No. of atoms per unit cell)} \times M \text{ (Atomic mass)}}{a^3 \text{ (Cell edge)} \times N_A \text{ (Avogadro's number)}}$$

By knowing density d , dimension of unit cell we can calculate M , the atomic mass of metal as for a given unit cell, Z is fixed and N_A is a universal constant.

S78. For fcc structure $Z = 4$, $d = 7.2 \text{ g/cm}^3$.

Let a be the edge length in pm

We know that density,
$$d = \frac{Z \times M}{a^3 \times 10^{-30}}$$

Mass per atom,
$$M = \frac{208}{4.2832 \times 10^{24}}$$

$$a^3 = \frac{Z \times M}{d \times 10^{-30}}$$

$$= \frac{4 \times 208}{7.2 \times 4.2832 \times 10^{24} \times 10^{-30}}$$

$$= 26.97 \times 10^6 \text{ pm} \Rightarrow a = (27 \times 10^6)^{1/3} = 300 \text{ pm.}$$

S79. Atomic mass, $M = 108 \text{ u}$, $d = 10.5 \text{ g/cm}^3$, $a = 409 \text{ pm}$

We know,
$$d = \frac{Z \times M}{a^3 \times 10^{-30} \times N_A} \quad [\because a \text{ is in pm}]$$

$$Z = \frac{d \times a^3 \times 10^{-30} \times N_A}{M}$$

$$Z = \frac{10.5 \times (409)^3 \times 10^{-30} \times 6.022 \times 10^{23}}{108} = 4$$

S80. (a) Schottky defect.

(b) Density of the crystal decreases.

(c) This is shown by ionic substances in which the cation and anion are of almost similar sizes.

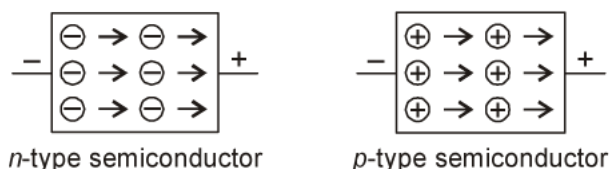
S81. (a) Metal excess defect is responsible for pink colour of LiCl. It is also known as anion vacancy defect.

(b) NaCl crystal shows Schottky defect.

S82. The solids which have conductivities between 10^{-6} to 10^4 ohm m^{-1} are called semiconductors. e.g., Germanium and silicon. The two main types of semiconductors are as follows:

(a) ***n*-type semiconductor:** When a silicon crystal is doped with atoms of group-15 elements, such as P, As Sb or Bi then only four of the five valence electrons of each impurity atom participate in forming covalent bonds and fifth electron is almost free to conduct electricity. Group-14 elements doped with a group-15 elements are called *n*-type semiconductors.

(b) ***p*-type semiconductor:** When a silicon crystal is doped with atoms of group-13 elements, such as B, Al Ga or In. Each impurity atoms form only three covalent bonds with the host atom. The place where the fourth electron is missing is caused a hole which move through the crystal like a positive charge and hence increases its conductivity. Group-14 elements doped with group-13 elements are called *p*-type semiconductors.



S83. (a) Ferromagnetism: Substances which are very strongly attracted by the magnetic field are called ferromagnetic and this property is called ferromagnetism.

Examples: Iron, cobalt, nickel, gadolinium and CrO_2 .

These substances can be permanently magnetised *i.e.*, they retain magnetic property even in absence of applied magnetic field.

In ferromagnetic substance all the domains (tiny magnet formed by grouping of metal ions in small region) are oriented in the direction of the applied magnetic field and produce a strong magnetic effect. This ordered orientation of domain persists even when the magnetic field is removed.

(b) Paramagnetism: Materials which are weakly attracted by magnetic fields are called paramagnetic materials and this property is called paramagnetism.

Paramagnetic substances contain unpaired electrons.

Examples: Tio , Cuo , O_2 and VO_2 , etc.

S84. Ferromagnetism: Substances which are very strongly attracted by the magnetic field are called ferromagnetic and this property is called ferromagnetism.

Examples: Iron, cobalt, nickel, gadolinium and CrO_2 .

These substances can be permanently magnetised *i.e.*, they retain magnetic property even in absence of applied magnetic field.

In ferromagnetic substance all the domains (tiny magnet formed by grouping of metal ions in small region) are oriented in the direction of the applied magnetic field and produce a strong magnetic effect. This ordered orientation of domain persists even when the magnetic field is removed.

Paramagnetism: Materials which are weakly attracted by magnetic fields are called paramagnetic materials and this property is called paramagnetism.

Paramagnetic substances contain unpaired electrons.

Examples: Tio , Cuo , O_2 and VO_2 , etc.

S85. (a) Ferromagnetism: Substances which are very strongly attracted by the magnetic field are called ferromagnetic and this property is called ferromagnetism.

Examples: Iron, cobalt, nickel, gadolinium and CrO_2 .

These substances can be permanently magnetised *i.e.*, they retain magnetic property even in absence of applied magnetic field.

In ferromagnetic substance all the domains (tiny magnet formed by grouping of metal ions in small region) are oriented in the direction of the applied magnetic field and produce a strong magnetic effect. This ordered orientation of domain persists even when the magnetic field is removed.

- (b) **Antiferromagnetism:** Paramagnetic substances which show very poor magnetic effect are antiferromagnetic and this property is called Antiferromagnetism.

Examples: MnO, Fe₂O, Cr₂O₃.

- S86. Ferromagnetism:** Substances which are very strongly attracted by the magnetic field are called ferromagnetic and this property is called ferromagnetism.

Examples: Iron, cobalt, nickel, gadolinium and CrO₂.

These substances can be permanently magnetised *i.e.*, they retain magnetic property even in absence of applied magnetic field.

In ferromagnetic substance all the domains (tiny magnet formed by grouping of metal ions in small region) are oriented in the direction of the applied magnetic field and produce a strong magnetic effect. This ordered orientation of domain persists even when the magnetic field is removed.

Antiferromagnetism: Substances which are weakly attracted by the magnetic field as compared to ferromagnetic substances are called ferrimagnetic and this property is called ferrimagnetism.

Examples: Fe₃O₄, (Magnetite), Ferrites – MgFe₂O₄, ZnFe₂O₄.

Ferrimagnetism is observed when the magnetic domains are aligned in parallel and antiparallel directions in unequal numbers. Hence, net magnetic moment is never zero.

These substances lose ferrimagnetism and become paramagnetic on heating.

(a) 

(b) 

Schematic alignment of magnetic moments in (a) ferromagnetic (b) ferrimagnetic.

- S87.** The number of cation vacancies created in the lattice of NaCl is equal to the number of divalent Sr²⁺ ions added.

Concentration of Sr²⁺ = 10⁻³ mol%

$$= \frac{10^{-3}}{100} = 10^{-5} \text{ mol}$$

$$1 \text{ mole of Sr}^{2+} = 6.023 \times 10^{23} \text{ Sr}^{2+} \text{ ions}$$

$$10^{-5} \text{ mole of Sr}^{2+} = 6.023 \times 10^{23} \times 10^{-5}$$

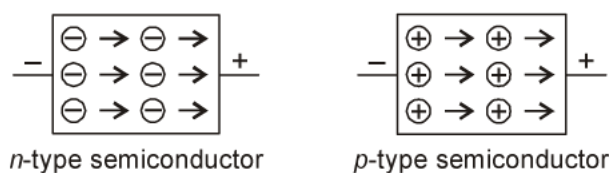
$$= 6.023 \times 10^{18} \text{ Sr}^{2+} \text{ ions.}$$

Hence, the concentration of cation vacancies is 6.023 × 10¹⁸.

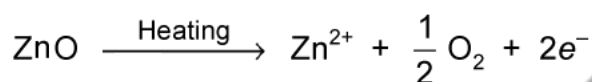
- S88.** The solids which have conductivities between 10⁻⁶ to 10⁴ ohm m⁻¹ are called semiconductors. *e.g.*, Germanium and silicon. The two main types of semiconductors are as follows:

- (a) ***n*-type semiconductor:** When a silicon crystal is doped with atoms of group-15 elements, such as P, As Sb or Bi then only four of the five valence electrons of each impurity atom participate in forming covalent bonds and fifth electron is almost free to conduct electricity. Group-14 elements doped with a group-15 elements are called *n*-type semiconductors.

- (b) **p-type semiconductor:** When a silicon crystal is doped with atoms of group-13 elements, such as B, Al, Ga or In. Each impurity atom forms only three covalent bonds with the host atom. The place where the fourth electron is missing is called a hole which moves through the crystal like a positive charge and hence increases its conductivity. Group-14 elements doped with group-13 elements are called p-type semiconductors.



- S89.** (a) Frenkel defects are not found in alkali metal halides because the ions cannot get into the interstitial sites due to their larger size.
- (b) Schottky defects occur when cations and anions are missing from their lattice sites. Mass of unit cell decreases which decreases the density of the solid.
- S90.** (a) Zinc oxide is white in colour at room temperature. On heating, it loses oxygen and turns yellow.



Now, there is excess of zinc in the crystal and excess Zn^{2+} ions move to interstitial sites and the electrons to neighbouring interstitial sites.

- (b) Due to Frenkel defect, no ions are missing from the crystal as a whole. Thus, there is no change in density.
- S91.** (a) **Schottky defect:** The defect in which cations and anions are missing in the stoichiometric ratio of compound is called Schottky defect. Schottky defect is actually a vacancy defect in ionic solids. In this defect, electrical neutrality is maintained. In this defect, density of solid decreases. Schottky defect is shown by ionic solids in which the cation and anion are of almost similar sizes.

Examples: NaCl, KCl, CsCl, AgBr, etc.

- (b) **Interstitial defect:** The defect in which some constituent particles occupy the interstitial site in the crystal is called interstitial defect. This defect increases the density of solid e.g., non-ionic solids.

- S92.** Here, Radius of Na^+ = 95 pm
Radius of Cl^- = 181 pm

Radius ratio,
$$\frac{r_+}{r_-} = \frac{r(\text{Na}^+)}{r(\text{Cl}^-)} = \frac{95}{181} = 0.524$$

The radius ratio lies between 0.414 – 0.732.

Hence, Na^+ ions prefer to occupy octahedral holes having coordination number 6.