CHAPTER

1

The Solid State

1.2 Amorphous and Crystalline Solids

1. The pure crystalline substance on being heated gradually first forms a turbid liquid at constant temperature and still at higher temperature turbidity completely disappears. The behaviour is a characteristic of substance forming
(a) allotropic crystals (b) liquid crystals
(c) isomeric crystals (d) isomorphous crystals.
(1993)

2. Glass is a
(a) liquid
(b) solid
(c) supercooled liquid
(d) transparent organic polymer. *(1991)*

3. Most crystals show good cleavage because their atoms, ions or molecules are
(a) weakly bonded together
(b) strongly bonded together
(c) spherically symmetrical
(d) arranged in planes. *(1991)*

4. The ability of a substance to assume two or more crystalline structures is called
(a) isomerism (b) polymorphism
(c) isomorphism (d) amorphism. *(1990)*

1.3 Classification of Crystalline Solids

5. Cation and anion combines in a crystal to form following type of compound
(a) ionic (b) metallic
(c) covalent (d) dipole-dipole. *(2000)*

6. For two ionic solids CaO and KI, identify the wrong statement among the following.
(a) CaO has high melting point.
(b) Lattice energy of CaO is much larger than that of KI.
(c) KI has high melting point.
(d) KI is soluble in benzene. *(1997)*

1.4 Crystal Lattice and Unit Cells

7. For orthorhombic system axial ratios are $a \neq b \neq c$ and the axial angles are
(a) $\alpha = \beta = \gamma \neq 90^\circ$ (b) $\alpha = \beta = \gamma = 90^\circ$
(c) $\alpha = \gamma = 90^\circ, \beta \neq 90^\circ$ (d) $\alpha \neq \beta \neq \gamma \neq 90^\circ$ *(1991)*

1.5 Number of Atoms in a Unit Cell

8. The number of carbon atoms per unit cell of diamond unit cell is
(a) 6 (b) 1
(c) 4 (d) 8 *(NEET 2013)*

9. In a face-centred cubic lattice, a unit cell is shared equally by how many unit cells?
(a) 2 (b) 4
(c) 6 (d) 8 *(2005)*

10. When Zn converts from melted state to its solid state, it has *hcp* structure, then find the number of nearest atoms.
(a) 6 (b) 8
(c) 12 (d) 4 *(2001)*

11. The *fcc* crystal contains how many atoms in each unit cell?
(a) 6 (b) 8
(c) 4 (d) 5 *(1996)*

12. The number of atoms contained in a *fcc* unit cell of a monatomic substance is
(a) 1 (b) 2
(c) 4 (d) 6 *(1993)*

1.6 Closed Packed Structures

13. A compound is formed by cation *C* and anion *A*. The anions form hexagonal close packed (*hcp*) lattice and the cations occupy 75% of octahedral voids. The formula of the compound is
(a) C_4A_3 (b) C_2A_3
(c) C_3A_2 (d) C_3A_4 *(NEET 2019)*

14. In calcium fluoride, having the fluorite structure, the coordination numbers for calcium ion (Ca^{2+}) and fluoride ion (F^-) are

(a) 4 and 2 (b) 6 and 6
(c) 8 and 4 (d) 4 and 8 *(NEET-II 2016)*

15. The ionic radii of A^+ and B^- ions are 0.98×10^{-10} m and 1.81×10^{-10} m. The coordination number of each ion in AB is

(a) 8 (b) 2
(c) 6 (d) 4 *(NEET-I 2016)*

16. The number of octahedral void(s) per atom present in a cubic close-packed structure is

(a) 1 (b) 3
(c) 2 (d) 4 *(2012)*

17. Structure of a mixed oxide is cubic close packed (*ccp*). The cubic unit cell of mixed oxide is composed of oxide ions. One fourth of the tetrahedral voids are occupied by divalent metal A and the octahedral voids are occupied by a monovalent metal B. The formula of the oxide is

(a) ABO_2 (b) A_2BO_2
(c) $A_2B_3O_4$ (d) AB_2O_2 *(Mains 2012)*

18. A solid compound XY has NaCl structure. If the radius of the cation is 100 pm, the radius of the anion (Y^-) will be

(a) 275.1 pm (b) 322.5 pm
(c) 241.5 pm (d) 165.7 pm *(Mains 2011)*

19. A compound formed by elements X and Y crystallises in a cubic structure in which the X atoms are at the corners of a cube and the Y atoms are at the face-centres. The formula of the compound is

(a) XY_3 (b) X_3Y
(c) XY (d) XY_2 *(2004)*

20. In cube of any crystal A-atom placed at every corners and B-atom placed at every centre of face. The formula of compound is

(a) AB (b) AB_3
(c) A_2B_2 (d) A_2B_3 *(2000)*

21. In crystals of which one of the following ionic compounds would you expect maximum distance between centres of cations and anions?

(a) CsI (b) CsF
(c) LiF (d) LiI *(1998)*

22. The second order Bragg diffraction of X-rays with $\lambda = 1.00$ Å from a set of parallel planes in a metal occurs at an angle 60°. The distance between the scattering planes in the crystal is

(a) 2.00 Å (b) 1.00 Å
(c) 0.575 Å (d) 1.15 Å *(1998)*

23. The intermetallic compound LiAg crystallizes in cubic lattice in which both lithium and silver have coordination number of eight. The crystal class is

(a) face-centred cube (b) simple cube
(c) body-centred cube (d) none of these. *(1997)*

24. In the fluorite structure, the coordination number of Ca^{2+} ion is

(a) 4 (b) 6
(c) 8 (d) 3 *(1993)*

1.7 Packing Efficiency

25. An element has a body centered cubic (*bcc*) structure with a cell edge of 288 pm. The atomic radius is

(a) $\frac{\sqrt{3}}{4} \times 288$ pm (b) $\frac{\sqrt{2}}{4} \times 288$ pm
(c) $\frac{4}{\sqrt{3}} \times 288$ pm (d) $\frac{4}{\sqrt{2}} \times 288$ pm

(NEET 2020)

26. The vacant space in *bcc* lattice unit cell is

(a) 48% (b) 23%
(c) 32% (d) 26% *(2015, 2008)*

27. If a is the length of the side of a cube, the distance between the body-centred atom and one corner atom in the cube will be

(a) $\frac{2}{\sqrt{3}}a$ (b) $a\frac{4}{\sqrt{3}}$
(c) $\frac{\sqrt{3}}{4}a$ (d) $\frac{\sqrt{3}}{2}a$ *(2014)*

28. A metal crystallises with a face-centred cubic lattice. The edge of the unit cell is 408 pm. The diameter of the metal atom is

(a) 288 pm (b) 408 pm
(c) 144 pm (d) 204 pm *(2012)*

29. AB crystallizes in a body-centred cubic lattice with edge length 'a' equal to 387 pm. The distance between two oppositely charged ions in the lattice is

(a) 335 pm (b) 250 pm
(c) 200 pm (d) 300 pm *(2010)*

30. Lithium metal crystallises in a body-centred cubic crystal. If the length of the side of the unit cell of lithium is 351 pm, the atomic radius of lithium will be

(a) 151.8 pm (b) 75.5 pm
(c) 300.5 pm (d) 240.8 pm *(2009)*

31. Copper crystallises in a face-centred cubic lattice with a unit cell length of 361 pm. What is the radius of copper atom in pm?

(a) 157 (b) 181
(c) 108 (d) 128 *(2009)*

32. Which of the following statements is not correct?
(a) The number of carbon atoms in a unit cell of diamond is 8.
(b) The number of Bravais lattices in which a crystal can be categorized is 14.
(c) The fraction of the total volume occupied by the atoms in a primitive cell is 0.48.
(d) Molecular solids are generally volatile. *(2008)*

33. If a stands for the edge length of the cubic systems: simple cubic, body-centred cubic and face-centred cubic, then the ratio of radii of the spheres in these systems will be respectively
(a) $\frac{1}{2}a : \frac{\sqrt{3}}{2}a : \frac{\sqrt{2}}{2}a$ (b) $1a : \sqrt{3}a : \sqrt{2}a$
(c) $\frac{1}{2}a : \frac{\sqrt{3}}{4}a : \frac{1}{2\sqrt{2}}a$ (d) $\frac{1}{2}a : \sqrt{3}a : \frac{1}{\sqrt{2}}a$
(2008)

34. The fraction of total volume occupied by the atoms present in a simple cube is
(a) $\frac{\mathbf{p}}{3\sqrt{2}}$ **(b)** $\frac{\mathbf{p}}{4\sqrt{2}}$ (c) $\frac{\mathbf{p}}{4}$ (d) $\frac{\mathbf{p}}{6}$ *(2007)*

35. The pyknometric density of sodium chloride crystal is 2.165×10^3 kg m^{-3} while its X-ray density is 2.178×10^3 kg m^{-3}. The fraction of unoccupied sites in sodium chloride crystal is
(a) 5.96 (b) 5.96×10^{-2}
(c) 5.96×10^{-1} (d) 5.96×10^{-3} *(2003)*

36. The edge length of face-centred unit cubic cells is 508 pm. If the radius of the cation is 110 pm, the radius of the anion is
(a) 144 pm (b) 398 pm
(c) 288 pm (d) 618 pm *(1998)*

1.8 Calculations Involving Unit Cell Dimensions

37. Iron exhibits *bcc* structure at room temperature. Above 900°C, it transforms to *fcc* structure. The ratio of density of iron at room temperature to that at 900°C (assuming molar mass and atomic radii of iron remains constant with temperature) is
(a) $\frac{\sqrt{3}}{\sqrt{2}}$ (b) $\frac{4}{3}\frac{\sqrt{3}}{\sqrt{2}}$ (c) $\frac{3}{4}\frac{\sqrt{3}}{\sqrt{2}}$ (d) $\frac{1}{2}$
(NEET 2018)

38. Lithium has a *bcc* structure. Its density is 530 kg m^{-3} and its atomic mass is 6.94 g mol^{-1}. Calculate the edge length of a unit cell of lithium metal. ($N_A = 6.02 \times 10^{23}$ mol^{-1})
(a) 527 pm (b) 264 pm
(c) 154 pm (d) 352 pm
(NEET-I 2016)

39. A metal has a *fcc* lattice. The edge length of the unit cell is 404 pm. The density of the metal is 2.72 g cm^{-3}. The molar mass of the metal is
(N_A Avogadro's constant = 6.02×10^{23} mol^{-1})
(a) 27 g mol^{-1} (b) 20 g mol^{-1}
(c) 40 g mol^{-1} (d) 30 g mol^{-1}
(NEET 2013)

40. CsBr crystallises in a body-centred cubic lattice. The unit cell length is 436.6 pm. Given that the atomic mass of Cs = 133 and that of Br = 80 amu and Avogadro number being 6.02×10^{23} mol^{-1}, the density of CsBr is
(a) 4.25 g/cm^3 (b) 42.5 g/cm^3
(c) 0.425 g/cm^3 (d) 8.25 g/cm^3 *(2006)*

41. An element (atomic mass = 100 g/mol) having *bcc* structure has unit cell edge 400 pm. The density of element is
(a) 7.289 g/cm^3 (b) 2.144 g/cm^3
(c) 10.376 g/cm^3 (d) 5.188 g/cm^3 *(1996)*

1.9 Imperfections in Solids

42. Formula of nickel oxide with metal deficiency defect in its crystal is $Ni_{0.98}O$. The crystal contains Ni^{2+} and Ni^{3+} ions. The fraction of nickel existing as Ni^{2+} ions in the crystal is
(a) 0.96 (b) 0.04
(c) 0.50 (d) 0.3
(Odisha NEET 2019)

43. The correct statement regarding defects in crystalline solids is
(a) Frenkel defects decrease the density of crystalline solids
(b) Frenkel defect is a dislocation defect
(c) Frenkel defect is found in halides of alkaline metals
(d) Schottky defects have no effect on the density of crystalline solids. *(2015)*

44. The appearance of colour in solid alkali metal halides is generally due to
(a) interstitial positions
(b) *F*-centres
(c) Schottky defect
(d) Frenkel defect. *(2006)*

45. Schottky defect in crystals is observed when
(a) density of the crystal is increased
(b) unequal number of cations and anions are missing from the lattice
(c) an ion leaves its normal site and occupies an interstitial site
(d) equal number of cations and anions are missing from the lattice. *(1998)*

46. Ionic solids, with Schottky defects, contain in their structure
(a) cation vacancies only
(b) cation vacancies and interstitial cations
(c) equal number of cation and anion vacancies
(d) anion vacancies and interstitial anions.
(1994)

1.10 Electrical Properties

47. Which is the incorrect statement?
(a) Density decreases in case of crystals with Schottky defect.
(b) $NaCl_{(s)}$ is insulator, silicon is semiconductor, silver is conductor, quartz is piezoelectric crystal.
(c) Frenkel defect is favoured in those ionic compounds in which sizes of cation and anions are almost equal.
(d) $FeO_{0.98}$ has non-stoichiometric metal deficiency defect. *(NEET 2017)*

48. With which one of the following elements silicon should be doped so as to give *p*-type of semiconductor?
(a) Selenium (b) Boron
(c) Germanium (d) Arsenic *(2008)*

49. If NaCl is doped with 10^{-4} mol % of $SrCl_2$, the concentration of cation vacancies will be ($N_A = 6.02 \times 10^{23}$ mol^{-1})
(a) 6.02×10^{16} mol^{-1} (b) 6.02×10^{17} mol^{-1}
(c) 6.02×10^{14} mol^{-1} (d) 6.02×10^{15} mol^{-1}
(2007)

50. If we mix a pentavalent impurity in a crystal lattice of germanium, what type of semiconductor formation will occur?
(a) *n*-type semiconductor
(b) *p*-type semiconductor
(c) Both (a) and (b)
(d) None of these *(1996)*

51. On doping Ge metal with a little of In or Ga, one gets
(a) *p*-type semiconductor
(b) *n*-type semiconductor
(c) insulator
(d) rectifier. *(1993)*

ANSWER KEY

1.	(b)	**2.**	(c)	**3.**	(d)	**4.**	(b)	**5.**	(a)	**6.**	(d)	**7.**	(b)	**8.**	(d)	**9.**	(c)	**10.**	(c)
11.	(c)	**12.**	(c)	**13.**	(d)	**14.**	(c)	**15.**	(c)	**16.**	(a)	**17.**	(d)	**18.**	(c)	**19.**	(a)	**20.**	(b)
21.	(a)	**22.**	(d)	**23.**	(c)	**24.**	(c)	**25.**	(a)	**26.**	(c)	**27.**	(d)	**28.**	(a)	**29.**	(a)	**30.**	(a)
31.	(d)	**32.**	(c)	**33.**	(c)	**34.**	(d)	**35.**	(d)	**36.**	(a)	**37.**	(c)	**38.**	(d)	**39.**	(a)	**40.**	(a)
41.	(d)	**42.**	(a)	**43.**	(b)	**44.**	(b)	**45.**	(d)	**46.**	(c)	**47.**	(c, d)	**48.**	(b)	**49.**	(b)	**50.**	(a)
51.	(a)																		

Hints & Explanations

1. (b) : Liquid crystals on heating first become turbid and then on further heating turbidity completely disappears.

2. (c) : Glass is a supercooled liquid which forms a non-crystalline solid without a regular lattice.

3. (d) : Crystals show good cleavage because their constituent particles are arranged in planes.

4. (b) : The phenomenon of existence of a substance in two or more crystalline structures is called polymorphism.

5. (a) : The electrostatic force of attraction which exists between oppositely charged ions is called as ionic bond.

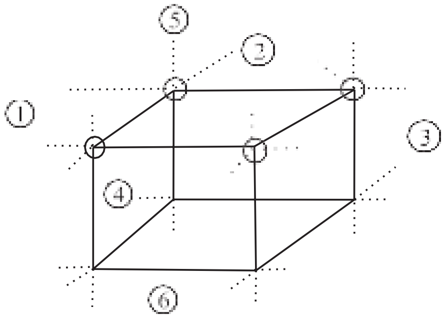
6. (d) : KI is an ionic compound while benzene is not.

7. (b) : For orthorhombic system, $\alpha = \beta = \gamma = 90°$

8. (d) : Diamond is like ZnS (Zinc blende).
Carbon forming *ccp* (*fcc*) and also occupying half of tetrahedral voids.
Total no. of carbon atoms per unit cell

$$= \underset{\text{(Corners)}}{8 \times \frac{1}{8}} + \underset{\text{(Face centred)}}{6 \times \frac{1}{2}} + \underset{\text{(Tetrahedral void)}}{4} = 8$$

9. (c) : Here given unit cell is shared equally by six faces in the *fcc* which is shared equally by six different unit cells.



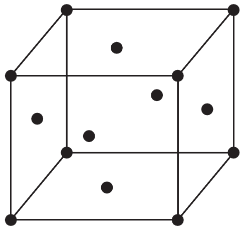
10. (c) : *hcp* is a closed packed arrangement in which the unit cell is hexagonal and coordination number is 12.

11. (c) : The contribution of eight atoms of face-centred cubic unit cell = $8 \times \frac{1}{8}$ = 1 atom. There is one atom at each of six faces, which is shared by 2 unit cells each. The contribution of 6 face-centred atoms = $6 \times \frac{1}{2} = 3$.

Therefore $n = 1 + 3 = 4$

12. (c) : *fcc* crystal contains

$$= 8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4 \text{ atoms in a unit cell}$$



13. (d) : Number of atoms per unit cell in *hcp* = 6

Number of octahedral void in *hcp* = 6

Number of anions per unit cell = 6

Number of octahedral voids occupied by cations

$$= 6 \times \frac{75}{100} = \frac{9}{2}$$

∴ Formula of compound = $C_{9/2}A_6 = C_3A_4$

14. (c) : In fluorite structure, Ca^{2+} ions are in the face-centred cubic arrangement. Each Ca^{2+} is connected to 4 F^- ions below it and to another set of 4 F^- ions above it *i.e.* Ca^{2+} has a coordination number of 8 and each F^- ion has a coordination number 4.

15. (c) : Radius ratio, $\frac{r_+}{r_-} = \frac{0.98 \times 10^{-10}}{1.81 \times 10^{-10}} = 0.541$

It lies in the range of 0.414 to 0.732 hence, coordination number of each ion will be 6 as the compound will have NaCl type structure *i.e.*, octahedral arrangement.

16. (a) : Number of octahedral voids is same as number of atoms.

17. (d) : Number of atoms in *ccp* = 4 = O^{2-}

Number of tetrahedral voids = $2 \times N = 2 \times 4 = 8$

Number of A^{2+} ions = $8 \times \frac{1}{4} = 2$

Number of octahedral voids = Number of B^+ ions = $N = 4$

Ratio, $O^{2-} : A^{2+} : B^+ = 4 : 2 : 4 = 2 : 1 : 2$

Formula of oxide = AB_2O_2

18. (c) : For NaCl, $\frac{r_+}{r_-} = 0.414$

Given : radius of cation = 100 pm

$$\frac{100}{r_-} = 0.414 \Rightarrow \frac{100}{0.414} = r_- \Rightarrow r_- = 241.5 \text{ pm}$$

19. (a) : In a unit cell, *X* atoms at the corners $= \frac{1}{8} \times 8 = 1$

Y atoms at the face centres = $\frac{1}{2} \times 6 = 3$

Ratio of *X* and *Y* = 1 : 3. Hence formula is XY_3.

20. (b) : '*A*' atoms are at '8' corners of the cube. Thus, no. of '*A*' atoms per unit cell = $8 \times \frac{1}{8} = 1$

'*B*' atoms are at the face centre of six faces. Thus, no. of '*B*' atoms per unit cell = $6 \times \frac{1}{2} = 3$

The formula is AB_3.

21. (a) : As Cs^+ ion has larger size than Li^+ and I^- has larger size than F^-, so maximum distance between centres of cations and anions is in CsI.

22. (d) : According to Bragg's equation, $n\lambda = 2d \sin\theta$

As, $n = 2$, $\lambda = 1.00$Å, $\theta = 60°$, d = ?

$$2d\sin\theta = n\lambda$$

$$2d\sin 60° = 2 \times 1 \text{ Å}$$

$$2d \times \frac{\sqrt{3}}{2} = 2 \Rightarrow d = \frac{2}{\sqrt{3}} = 1.15 \text{ Å} \left(\because \sin 60° = \frac{\sqrt{3}}{2} \right)$$

23. (c) : A body-centred cubic unit cell consists of 8 atoms at the corners and one atom at the centre.

24. (c) : In fluorite (CaF_2) structure, C.N. of $Ca^{2+} = 8$, C.N. of $F^- = 4$.

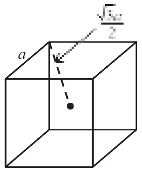
25. (a) : For *bcc* structure, $r = \frac{\sqrt{3}}{4}a$, where *a* is the unit cell edge length and *r* is the radius of the sphere (atom).

$$r = \frac{\sqrt{3}}{4} \times 288 \text{ pm}$$

26. (c) : Packing efficiency of *bcc* lattice = 68%

Hence, empty space = 32%.

27. (d) : The distance between the body-centred atom and one corner atom is $\frac{\sqrt{3}a}{2}$ *i.e.* half of the body diagonal.



28. (a) : For a face-centred cubic (*fcc*) structure,

$r = \frac{a}{2\sqrt{2}}$, a = 408 pm, $r = \frac{408}{2\sqrt{2}} = 144$ pm

Diameter = 2r = 2 × 144 = 288 pm

29. (a) : For a *bcc* lattice, $2(r_+ + r_-) = \sqrt{3}\,a$

where r_+ = radius of cation, r_- = radius of anion

a = edge length

$$\therefore (r_+ + r_-) = \frac{\sqrt{3}\times 387}{2} = 335.15 \text{ pm} \approx 335 \text{ pm}$$

30. (a) : Since Li crystallises in body-centred cubic crystal, atomic radius,

$$r = \frac{\sqrt{3}a}{4} \quad (a = \text{edge length})$$

$$\therefore r = \frac{\sqrt{3}}{4}\times 351 = 151.8 \text{ pm} \quad (\text{Given: } a = 351 \text{ pm})$$

31. (d) : Since Cu crystallises in a face-centred cubic lattice,

Atomic radius, $r = \frac{a}{2\sqrt{2}}$ (a = edge length = 361 pm)

$$\therefore r = \frac{361}{2\sqrt{2}} = 127.6 \approx 128 \text{ pm}$$

32. (c) : Packing fraction for a cubic unit cell is given by

$$f = \frac{Z\times\frac{4}{3}\pi r^3}{a^3}$$

where a = edge length, r = radius of cation and anion.

Efficiency of packing in simple cubic or primitive cell = π/6 = 0.52 *i.e.* 52% of unit cell is occupied by atoms and 48% is empty.

33. (c) : For simple cubic : $r = a/2$

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

For face-centred: $r = \frac{a}{2\sqrt{2}}$

where a = edge length, r = radius.

∴ Ratio of radii of the three will be $\frac{a}{2} : \frac{a}{4}\sqrt{3} : \frac{a}{2\sqrt{2}}$

34. (d)

35. (d) : Molar volume from pyknometric density

$$= \frac{M}{2.165\times10^3}\text{ m}^3$$

Molar volume from X-ray density $= \frac{M}{2.178\times10^3}\text{ m}^3$

Volume occupied $= \frac{M}{10^3}\left(\frac{1}{2.165} - \frac{1}{2.178}\right)\text{ m}^3$

Fraction unoccupied

$$= \left(\frac{0.013\,M\times10^{-3}}{2.165\times2.178}\right) \Bigg/ \left(\frac{M\times10^{-3}}{2.165}\right) = 5.96\times10^{-3}$$

36. (a) : In the face–centred cubic lattice, the edge length of the unit cell, $a = r + 2R + r$

where r = Radius of cation, R = Radius of anion

⇒ 508 = 2 × 110 + 2R ⇒ R = 144 pm

37. (c) : For *bcc* lattice : $Z = 2$, $a = \frac{4r}{\sqrt{3}}$

For *fcc* lattice : $Z = 4$, $a = 2\sqrt{2}\,r$

$$\therefore \frac{d_{\text{R.T.}}}{d_{900\,°\text{C}}} = \frac{\left(\frac{ZM}{N_A a^3}\right)_{bcc}}{\left(\frac{ZM}{N_A a^3}\right)_{fcc}}$$

Given, molar mass and atomic radii are constant.

$$= \frac{2}{4}\left(\frac{2\sqrt{2}r}{\frac{4r}{\sqrt{3}}}\right)^3 = \frac{3\sqrt{3}}{4\sqrt{2}}$$

38. (d) : For *bcc*, $Z = 2$, ρ = 530 kg m^{-3},

at. mass of Li = 6.94 g mol^{-1}, $N_A = 6.02\times10^{23}$ mol^{-1}

$$\rho = 530 \text{ kg m}^{-3} = \frac{530\times1000 \text{ g}}{1\times(100)^3\text{cm}^3} = 0.53 \text{ g cm}^{-3}$$

$$\rho = \frac{Z\times\text{At. mass}}{N_A\times a^3}$$

$$a^3 = \frac{Z\times\text{At. mass}}{N_A\times\rho} = \frac{2\times6.94}{6.02\times10^{23}\times0.53}$$

$= 43.5\times10^{-24}$ cm^3

⇒ $a = 352\times10^{-10}$ cm = 352 pm

39. (a) : $d = \frac{ZM}{N_A a^3}$ (Z = 4 for *fcc*)

$$M = \frac{d\times N_A\times a^3}{Z} = \frac{2.72\times6.023\times10^{23}\times\left(404\times10^{-10}\right)^3}{4}$$

M = 27 g mol^{-1}

40. (a) : Density of CsBr $= \frac{Z\times M}{a^3\times N_A}$

$$= \frac{1\times213}{(436.6\times10^{-10})^3\times6.023\times10^{23}} = 4.25 \text{ g/cm}^3$$

(It has one formula unit in the unit cell, so Z = 1.)

41. (d) : Cell edge = 400 pm; number of atoms in *bcc* (Z) = 2 and atomic mass = 100 g/mol.

Since atomic mass is 100 g/mol, therefore mass of each atom (m) $= \frac{100}{6.023\times10^{23}} = 16.6\times10^{-23}$ g

We know that volume of unit cell = $(400\ \text{pm})^3$
$= (64 \times 10^6)\text{pm}^3 = 64 \times 10^{-24}\ \text{cm}^3$ and
mass of unit cell $= Z \times m = 2 \times (16.6 \times 10^{-23})$
$= 33.2 \times 10^{-23}$ g

Therefore density $= \dfrac{\text{Mass of unit cell}}{\text{Volume of unit cell}}$

$$= \frac{33.2 \times 10^{-23}}{64 \times 10^{-24}} = 5.188\ \text{g/cm}^3$$

42. (a) : Let the fraction of metal which exists as Ni^{2+} ion be x. Then the fraction of metal as $Ni^{3+} = 0.98 - x$
$\therefore\ 2x + 3(0.98 - x) = 2$
$\Rightarrow 2x + 2.94 - 3x = 2 \Rightarrow x = 0.94$

43. (b) : Frenkel defect is a dislocation defect as smaller ions (usually cations) are dislocated from normal sites to interstitial sites. Frenkel defect is shown by compounds having large difference in the size of cations and anions hence, alkali metal halides do not show Frenkel defect. Also, Schottky defect decreases the density of crystal while Frenkel defect has no effect on the density of crystal.

44. (b) : *F*-centres are the sites where anions are missing and instead electrons are present. They are responsible for colours.

45. (d) : In Schottky defect, equal no. of cations and anions are missing from the lattice. So, the crystal remains neutral. Such defect is more common in highly ionic compounds of similar cationic and anionic size, *i.e.* NaCl.

46. (c) : When an atom is missing from its normal lattice site, a lattice vacancy is created. Such a defect, which involves equal number of cation and anion vacancies in the crystal lattice is called a Schottky defect.

47. (c, d) : Frenkel defect is favoured in those ionic compounds in which there is large difference in the size of cations and anions.

Non-stoichiometric defects due to metal deficiency is shown by Fe_xO where $x = 0.93$ to 0.96.

48. (b) : If silicon is doped with any of the elements of group 13 (B, Al, Ga, In, Tl) of the periodic table, *p*-type of semiconductor will be obtained.

49. (b) : As each Sr^{2+} ion introduces one cation vacancy, therefore, concentration of cation vacancies = mole % of $SrCl_2$ added.

$\therefore$ Concentration of cation vacancies $= 10^{-4}$ mole%

$$= \frac{10^{-4}}{100} \times 6.023 \times 10^{23} = 6.023 \times 10^{17}$$

50. (a) : When an impurity atom with 5 valence electrons (as arsenic) is introduced in a germanium crystal, it replaces one of the germanium atoms. Four of the five valence electrons of the impurity atom form covalent bonds with each valence electron of four germanium atoms and fifth valence electron becomes free to move in the crystal structure. This free electron acts as a charge carrier. Such as an impure germanium crystal is called *n*-type semiconductor because in it charge carriers are negative (free electrons).

51. (a) : *p*-type of semiconductors are produced
(a) due to metal deficiency defects (b) by adding impurity containing less electrons (*i.e.* atoms of group 13). Ge belongs to Group 14 and In or Ga to Group 13. Hence on doping *p*-type semiconductor is obtained. This doping of Ge with In increase the electrical conductivity of the Ge crystal.

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