

## Chapter – 5: Solid State

### <H1>Additional Objective Questions

#### <H2>Single Correct Choice Type

1.(D) We know

$$\rho = \frac{Z \times M}{N_A \times a^3} \quad (1)$$

Substituting the values in Eq. (1), we get

$$\rho = \frac{4 \times 63.55}{6.023 \times 10^{23} \times (x \times 10^{-8})^3} = \frac{422}{x^3} \text{ g cm}^{-3}$$

2.(B) As X is present at the corners of the cube and also at the faces of the cube, so the contribution of X will be

$$8(\text{corners}) \times \frac{1}{8} \times (\text{contribution of each corner atom}) \\ + 6(\text{faces}) \times \frac{1}{2} (\text{contribution of each face}) = 4$$

As M is present at the body centre and at each diagonal,  
So, its contribution will be

$$4(\text{diagonals}) \times \frac{1}{4} (\text{contribution of each diagonal}) + 1(\text{body centre}) = 2$$

So, the unit cell formula becomes  $M_2X_4$  and the empirical formula will be  $MX_2$ .

3.(A) For triclinic unit cell, the edge lengths is  $a \neq b \neq c$ , and all axial angles are different from  $90^\circ$ .

4.(D) Since  $A_2B_3$  has a hcp lattice. If B form hcp lattice, then  $1/3^{\text{th}}$  of tetrahedral voids must be occupied by A to form  $A_2B_3$ .

5.(B) We know

$$\rho = \frac{Z \times M}{N_A \times a^3} \quad (1)$$

Substituting the values in Eq. (1), we get

$$9 \times 10^3 = \frac{4M}{(200\sqrt{2} \times 10^{-12})^3 \times N_A}$$

$$\Rightarrow M = \frac{9 \times 10^3 \times (200\sqrt{2} \times 10^{-12})^3 \times 6 \times 10^{23}}{4}$$

$$\Rightarrow M = 0.0305 \text{ kg mol}^{-1}$$

6.(C) Suppose number of  $B^-$  ions constituting the lattice = 100

Number of tetrahedral sites = 200

As 25% are occupied by  $A^+$  ions, their number = 50

Therefore, the ratio of  $A^+ : B^- = 50 : 100 = 1 : 2$ .

That is, the formula is  $AB_2$ .

7.(B) Edge length,  $a = 286$  pm

For bcc, radius of atom,  $r = \frac{\sqrt{3}}{4} a = \frac{\sqrt{3}}{4} \times 286 = \frac{1.732 \times 286}{4} = 123.8$  pm

8.(B) 1 mol of gold =  $197 \text{ g} \times 6.02 \times 10^{23}$

Therefore,  $1 \text{ g gold} = \frac{6.02 \times 10^{23}}{197} \text{ atoms}$

As fcc contains 4 atoms per unit cell, the number of unit cells in 1 g gold will be

$$\frac{6.02 \times 10^{23}}{197 \times 4} = 7.64 \times 10^{20}$$

9.(A) There will be eight atoms at corners of the cube and one atom at the body center.

Hence, Number of atoms per unit cell =  $\left(8 \times \frac{1}{8}\right) + 1 = 2$

$$\text{Number of atoms in 4.0 g of potassium} = \frac{4}{39} \times 6.023 \times 10^{23}$$

$$\text{Number of unit cells in 4.0 g of potassium} = \frac{4}{39} \times \frac{6.023 \times 10^{23}}{2} = 3.09 \times 10^{22}$$

10.(D) In a crystal, both ions are missing from normal sites in equal number, the density of the crystal is decrease and this defect known as Schottky defect.

11.(D) Concept based.

12.(D) The vacant spaces between the spheres in closed-packed structure is called void. The voids are of two types: tetrahedral voids and octahedral voids. Also radius of tetrahedral voids and octahedral voids are  $r_{\text{Void}} = 0.225 \times r_{\text{sphere}}$  and  $r_{\text{Void}} = 0.411 \times r_{\text{sphere}}$ , respectively. Thus, octahedral void is larger than tetrahedral void.

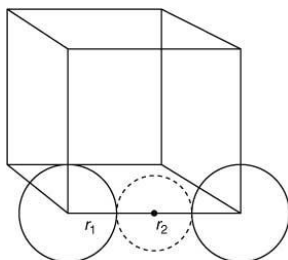
13.(C) Hexagonal close packing contains 6 atoms per unit cell and hence the number of octahedral voids per unit cell is 6. Hence, number of A atoms per unit cell = 6

and number of C atoms per unit cell =  $6 \times \frac{2}{3} = 4$ .

The formula of ionic compound is given as simplest formula and hence formula is  $C_2A_3$ .

14.(D) For body centred cubic cell

$$a = \frac{4r_1}{\sqrt{3}} \quad \text{or} \quad r_1 = \frac{\sqrt{3}a}{4} \quad (1)$$



Since, sphere fits properly at the centre of the edge of a BCC unit cell, therefore,

$$a = 2(r_1 + r_2) \quad (2)$$

From Eq. (1) and (2), we get

$$a = 2 \left( \frac{\sqrt{3}}{4} a + r_2 \right)$$

$$\frac{a}{2} = \frac{\sqrt{3}}{4} a + r_2$$

$$r_2 = \frac{a}{2} - \frac{\sqrt{3}}{4} a$$

$$= a \left[ \frac{1}{2} - \frac{\sqrt{3}}{4} \right]$$

$$r_2 = 0.067a$$

15.(B) For ccp unit cell, we have

No. of tetrahedral voids =  $2 \times$  No. of octahedral voids

Number of elements of B = 4

Number of elements of A =  $\frac{1}{2} \times 4 = 2$

Number of elements of O = 8

Therefore, the structural formula of bimetallic oxide is  $AB_2O_4$ .

16.(A) Molecular mass of  $CuCl = 99 \text{ g mol}^{-1}$  and  $z = 4$  for face-centered cubic cell, so

$$\text{Density} = \frac{n \times \text{Molecular weight}}{V \times \text{Avogadro's number}} = \frac{4 \times 99}{a^3 \times 6.023 \times 10^{23}}$$

or

$$3.4 = \frac{4 \times 99}{a^3 \times 6.023 \times 10^{23}}$$

Solving, we get  $a = 5.783 \times 10^{-8} \text{ cm} = 5.783 \text{ \AA}$ .

17.(B) Since the ratio of the coordination number P to that of Q is  $y : z$   
That is, P is surrounded by  $y$  atoms of Q while Q is surrounded by  $z$  atoms of P, that is, number of atoms of P is  $z$  and number of atoms of Q is  $y$ . So, the formula is  $P_z Q_y$ .

18.(A) Three spheres above, three below, and total six in that, makes it 12.

19.(C) Number of atoms = 6

Number of octahedral voids = Number of atoms = 6

Number of tetrahedral voids = 2. Number of atoms = 12

20.(A)  $\text{Ca}^{2+}$  ions are ccp and  $\text{F}^-$  ions are present in the tetrahedral voids. So, the number of  $\text{Ca}^{2+}$  ions is 4 and number of  $\text{F}^-$  ions is 8.

21.(D) Amorphous solids neither have ordered arrangement (i.e., no definite shape) nor have sharp melting point, but when heated, they become soft until they assume the properties usually related to liquid. Therefore, they are regarded as super cooled liquids.

22.(B) Anti-ferromagnetic substances possess complementary dipoles alignment, giving net dipole moment equal to zero.

23.(A) We know

$$d = \frac{\sqrt{3}}{2} a$$

$$d = \frac{\sqrt{3}}{2} \times 4.3 = 3.7238 \text{ \AA}$$

24.(C) It is Schottky defect.

25.(C) Contribution of X =  $1/5(2N)$

Contribution of Y =  $(1/2)(N)$

Contribution of O = N

X:Y:O

$$\frac{2}{5} : \frac{1}{2} : 1$$

Therefore, the formula of the oxide is  $X_4Y_5O_{10}$ .

26.(B) The complex  $[\text{Ni}(\text{CN})_4]^{2-}$  is square planar. So, it has limiting radius ratio as octahedral structure, that is,  $0.414 - 0.732$ .

27.(B) Diamond unit cell is fcc unit cell, therefore, the tetrahedral holes are occupied is 50%.

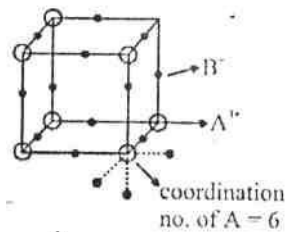
28.(A) Number of A atoms =  $8/8 = 1$

Number of B atoms =  $6/2 = 3$

Therefore, the formula is  $\text{AB}_3$

29.(C) In the given crystal formula,  $\text{AB}_3$

$$\frac{\text{Coordination number of cation}}{\text{Coordination number of anion}} = \frac{\text{Charge of cation}}{\text{Charge of anion}} = \frac{3}{1} = 3$$



Therefore, the coordination number of A is 6 as shown, so, that of B is 2.

30.(B) For orthorhombic crystal,  $a \neq b \neq c$ ,  $\alpha = \beta = \gamma = 90^\circ$ .

$$31.(D) \text{ Number of A atoms} = \left( \frac{1}{8} \times 8 + \frac{1}{2} \times 4 \right) = 3$$

$$\text{Number of B atoms} = \left( \frac{1}{4} \times 12 + 1 \right) = 4$$

Therefore, the formula is  $\text{A}_3\text{B}_4$ .

32.(C) Given,  $r_B = 2r_A$

From the packing efficiency of solid 2, we have

$$\text{Packing efficiency} = \left[ \frac{Z \times \left( \frac{4}{3} \pi r_A^3 \right) + Z \times \left( \frac{4}{3} \pi r_B^3 \right)}{a^3} \right] \quad (1)$$

From the given information, we have

$$2(r_A + r_B) = \sqrt{3}a$$

$$\Rightarrow 2(r_A + 2r_A) = \sqrt{3}a$$

$$\Rightarrow a = 2\sqrt{3}r_A$$

Substituting the values in Eq. (1), we get

$$\text{Packing efficiency} = \left[ \frac{1 \times \left( \frac{4}{3} \pi r_A^3 \right) + 1 \times \left( \frac{4}{3} \pi (2r_A)^3 \right)}{(2\sqrt{3}r_A)^3} \right]$$

$$\Rightarrow \text{Packing efficiency} = \left[ \frac{\left( \frac{4}{3} \pi r_A^3 \right) + 1 \times \left( \frac{4}{3} \pi \times 8r_A^3 \right)}{24\sqrt{3}r_A^3} \right]$$

$$\Rightarrow \text{Packing efficiency} = \frac{\pi}{6} \times \frac{\sqrt{3}}{1} \times 100 = 90\%$$

33.(C) The minimum distance between two tetrahedral voids in fcc lattice is  $\frac{a}{2}$ .

34.(A) We know

$$\rho = \frac{Z \times M}{N_A \times a^3} \quad (1)$$

Here,  $M = 108$ ,  $N_A = 6.023 \times 10^{23}$ ,  $a = 409 \text{ pm} = 4.09 \times 10^{-8} \text{ cm}$ ,  $\rho = 10.5 \text{ g cm}^{-2}$

Substituting the values in Eq. (1), we get

$$10.5 = \frac{Z \times 108}{6.023 \times 10^{23} \times (4.09 \times 10^{-8})^3}$$

$$\Rightarrow Z = \frac{10.5 \times 6.023 \times 10^{23} \times (4.09 \times 10^{-8})^3}{108} = 4.0$$

Therefore, the structure of the crystal lattice is fcc.

35.(C) Since tetrahedral holes are surrounded by 4 nearest neighbors. So, the coordination number (CN) of cation occupying tetrahedral hole is 4. Since octahedral hole is surrounded by six nearest neighbors. Therefore, CN of cation occupying octahedral is 6. In Schottky a pair of anion and cation leaves the lattice. Thus, the density of lattice decreases.

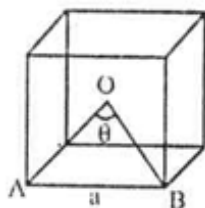
36.(B) The correct match is

- (a) → (r): Crystal defects are referred as Frenkel and Schottky defects.  
 (b) → (p): Hcp has AB AB AB type crystal units.  
 (c) → (t): CsCl has bcc crystal lattice.  
 (d) → (q): Diamond has covalent crystal.  
 (e) → (s): NaCl has fcc crystal lattice.

39.(A) Number of atoms of 'A' in a unit cell =  $\frac{1}{8} \times 8 = 1$ ; number atoms of 'B' in a unit cell =

$$\frac{1}{2} \times 6 = 3 \text{ (face center)}$$

Formula of the compound =  $AB_3$



38.(B) Since, the number of atoms present in

Simple cube = 1

Body-centered cube = 2

Face-centered cube = 4

Therefore, the ratio of number of atoms present = 1: 2: 4

39.(D) In a simple cubic system, number of atoms  $a = 2r$ . Therefore,

$$\text{Packing fraction} = \frac{\text{Volume occupied by one atom}}{\text{Volume of unit cell}} = \frac{\frac{4}{3}\pi r^3}{a^3} = \frac{\frac{4}{3}\pi r^3}{(2r)^3} = \frac{\pi}{6}$$

40.(D) Since, the oxygen atom in ice is tetrahedrally surrounded by four other oxygen atoms form other ice molecules, therefore, the crystal of Ice belongs to tetragonal structures.

41.(D) Let  $AO = OB = \frac{\sqrt{3}}{2}a = l$ , therefore,

$$a^2 = 2l^2 - 2l^2 \cos \theta = 2l^2(1 - \cos \theta)$$

Therefore,

$$a^2 = \frac{3}{2}a^2(1 - \cos \theta)$$

Hence,

$$1 - \cos \theta = \frac{2}{3} \Rightarrow \cos \theta = \frac{1}{3} \Rightarrow \theta = 70^\circ 32'$$

42.(B) The volume of the unit cell =  $(2.88\text{\AA})^3 = 23.9 \times 10^{-24} \text{ cm}^3$

The volume of 100 g of the metal  $= \frac{m}{\rho} = \frac{100}{7.20} = 13.9 \text{ cm}^3$

Number of unit cells in this volume  $= \frac{13.9 \text{ cm}^3}{32.9 \times 10^{-24}} = 5.82 \times 10^{23}$

43.(C) The hexagonal close packing and the face-centered cubic system have the closest packing as their packing efficiency is 74 %.

44.(B) We know

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

For fcc-centered cubic cell  $Z = 4$ ,  $a = 3.5 \text{ \AA}$ , therefore

$$\rho_{\text{fcc}} = \frac{4 \times M}{N_A \times (3.5)^3} \quad (1)$$

For bcc lattice,  $Z = 2$ ,  $a = 3.0 \text{ \AA}$ , therefore

$$\rho_{\text{bcc}} = \frac{2 \times M}{N_A \times (3.0)^3} \quad (2)$$

Dividing Eq. (1) by Eq. (2), we get

$$\frac{\rho_{\text{fcc}}}{\rho_{\text{bcc}}} = \frac{4}{2} \times \frac{3^3}{(3.5)^3} = \frac{4 \times 3 \times 3 \times 3}{2 \times 3.5 \times 3.5 \times 3.5} = 1.259$$

Therefore, the ratio of density of fcc and bcc is 1.259

45.(A) For the lattice

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

where  $a = 620 \text{ pm}$ , as face diagonal atoms touches each other.

$$r = \frac{1}{2\sqrt{2}} \times a = \frac{1}{2\sqrt{2}} \times 620 \text{ pm} = 219.20 \text{ pm}$$

46.(A) Consider one tetrahedral void. If the side length of the tetrahedron is  $f$  and if  $d$  is the distance from the center to the corner, then

$$l^2 = 2d^2 - 2d^2 \cos \theta = 2d^2 \left(1 + \frac{1}{3}\right) = \frac{4}{3} \times 2d^2$$

Therefore,

$$l = \sqrt{\frac{8}{3}}$$

But if  $a$  is the side length of the unit cell

$$l = \frac{a}{\sqrt{2}} \text{ and } d = r_1 + r_2 \text{ where } r_1 \text{ is the radius of the corner}$$

atom and  $r_2$  the radius of the tetrahedral void. Therefore,

$$\sqrt{\frac{8}{3}}(r_1 + r_2) = \frac{a}{\sqrt{2}} \Rightarrow r_1 + r_2 = \frac{a}{\sqrt{2}} \times \frac{\sqrt{3}}{\sqrt{8}} = \frac{\sqrt{3}a}{4}$$



But  $l = 2r_1 \Rightarrow r_1 = \frac{l}{2} = \frac{a}{2\sqrt{2}}$ , or

$$r_2 = \frac{\sqrt{3}a}{4} - \frac{\sqrt{2}a}{4} = \frac{a}{4}(\sqrt{3} - \sqrt{2})$$

For the octahedral void, if the radius of the void is  $r_3$ , then  $2(r_1 + r_3) = a$

$$r_1 + r_3 = \frac{a}{2} \Rightarrow r_3 = \frac{a}{2} - r_1$$

$$r_3 = \frac{a}{2} - \frac{a}{2\sqrt{2}} = \frac{2a}{4} - \frac{\sqrt{2}a}{4} = \frac{(2 - \sqrt{2})a}{4}$$

Therefore, ratio of the sizes of tetrahedral to octahedral voids is

$$\frac{r_2}{r_3} = \frac{\frac{a}{4}(\sqrt{3} - \sqrt{2})}{\frac{a}{4}(2 - \sqrt{2})} = \frac{1.732 - 1.414}{2 - 1.414} = \frac{0.318}{0.586} = 0.543$$

47.(B) Bragg's equation is

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

48.(C) In rock salt structure, atoms at the corner are also present at the face centers; hence

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

and the atoms at the body center are also present at edge centers. But from question, body centers are missing and hence

$$Z_P = 12 \times \frac{1}{4} = 3$$

Thus, formula of resulting solid is  $P_3Q_4$ .

## <H2>Multiple Correct Choice Type

1.(B, C) Frenkel defect occurs in compounds in which the anions are much larger in size than cations. It is a dislocation effect. The presence of Schottky defects lowers the density of the crystal, it hence affects the physical properties of the crystal. In the metal excess defects, the electrons trapped in anion vacancies are known as F-centres.

2.(A, D)  $MnO_2$  and  $SnO_2$  are rutile-like structure.

3.(A, B, C, D) All statements are correct.

4.(B, C) In fluorite structure, cations form the fcc lattice and anions occupy each of the tetrahedral voids. Therefore, 8 anion and 4 cations are touches by each cation.

5.(B, C) We know

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

Or 
$$Z = \frac{\rho \times N_A \times a^3}{M} \quad (1)$$

Substituting the values in Eq. (1), we get

$$Z = \frac{(654 \times 10^{-10})^3 \times 2.75 \times 6.023 \times 10^{23}}{119} \approx 4$$

Therefore, the unit cell has 4 ions in fcc unit cell.

6.(A, B, C) Concept based.

7.(B, D) Ni and Gd are ferromagnetic whereas silver and gold are not.

8.(A, B, D) Such coordinates are exhibited by compounds that have been lattice structures.

9.(A, C) Out of the statements, (A) is false because both are ferrites. (C) is false because number of tetrahedral voids is double the number of octahedral voids.

10.(A, B, C) From the radius ratio rule, we have

$$\frac{r_+}{r_-} = \frac{95}{181} = 0.525$$

which lies in the range 0.414–0.732. Hence, its coordination number is 6 and structure is octahedral.

$$\text{Length of the unit cell} = 2r_N = r(r_{\text{Na}^+} + r_{\text{Cl}^-}) = 2(95 + 181) = 552 \text{ pm}$$

11.(B, C) Frenkel defect is also called dislocation defect because smaller ions are dislocated from their lattice sites into the interstitial sites. Hence, option (B) is correct. Trapping of an electron leads to the formation of F-center. Hence, option (C) is correct.

12.(A, B, C) For hexagonal primitive unit cell,  $a = b \neq c$  and other have  $a \neq b \neq c$ .

13.(A, B, C) Concept based.

14.(A, C, D) CsCl is bcc because the coordination number = 8.

15.(A, B) As spinel has  $AB_2O_4$ , where A has oxidation state = +2 and B has oxidation state = +3.

16.(B, C) AgBr has both Frenkel and Schottky defects. The coordination number of  $Na^+$  is 6.

17.(B, C, D) Conductance through electrons is called *n*-type conduction.

18.(A, D) Option (A) is wrong as crystalline solids are anisotropic. Option (D) is wrong because they have thermodynamic defects.

19.(A, C) Coordination number = 12 in both the cases.

20.(B, D) Options (B) and (D) are true. (A) is false because in hcp, each atom has a coordination number of 12. (C) is wrong because solids have both types of voids.

21.(A, B, C) From the radius ratio rule, we have

For octahedral voids =  $\frac{r^+}{r^-} = 0.732$

$$r^+ = 0.732 \times 0.20 = 0.1464 \text{ nm}$$

For tetrahedral voids =  $\frac{r^+}{r^-} = 0.414$

$$r^+ = 0.414 \times 0.20 = 0.0828 \text{ nm}$$

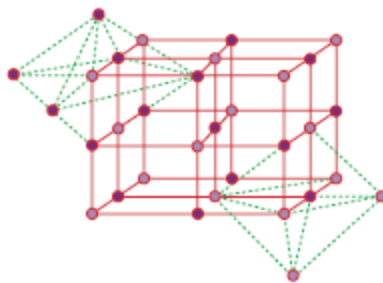
For triangular voids =  $\frac{r^+}{r^-} = 0.225$

$$r^+ = 0.225 \times 0.20 = 0.0450 \text{ nm}$$

22.(A, B, C, D) All statement are correct.

23.(A, B, C) Concept based.

24.(A, C) The rock salt structure can be depicted as follows:



The radius ratio is 0.732.

25.(A, C) *p*-Type semiconductors are produced when an electron-deficit impurity is added, that is, in (A) and (C) and not in (B) and (D).

26.(B, D) Concept based.

27.(A, C) KBr and CaO possess rock salt-type structure. CsBr has CsCl-type structure while BeS has zinc blende-type structure.

28.(A, B, C, D) Percentage of empty space =  $1 - \text{packing fraction}$

## <H2>Assertion-Reason Type

1.(B) The first statement is self-explanatory. The explanation for second statement is as follows: The ionic solids have different shearing stress in different directions because in one direction rows having alternate types of atoms are displaced, while in the other direction, the rows displaced consist of one type of atoms.

2.(A) Since,  $\text{Ag}^+$  is a small-sized ion, therefore it can be missed from its lattice, hence, Frenkel defect can be observed.

3.(A) Concept based.

4.(A) Assuming that the melting points are mainly affected by the intermolecular forces, the strength of the intermolecular forces between these molecules follow the order Water > ethyl alcohol > diethyl ether > methane.

Hence, the melting point decreases in the order: Water > ethyl alcohol > diethyl ether > methane.

5.(B) Concept based.

6.(A) This defect is caused when some of the ions leave their lattice sites to occupy an interstitial site.

7.(B) A tetrahedral void is formed when one sphere (or particle) is placed in the depression formed by three particles placed in a plane. The octahedral void is formed at the center of six spheres placed octahedrally.

8.(A) The number of octahedral voids are equal to the rank of the unit cell, that is, is equal to 4 in ccp.

9.(D) In primitive unit cell the atoms are present only at the corners, that is, a total of 8 atoms present in a unit cell.

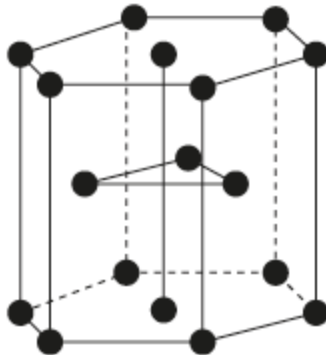
10.(B) Concept based.

11.(A) Concept based.

12.(A) Concept based.

## <H2>Comprehension Type

1.(B) The structure of unit hcp cell is



Therefore, the number of atoms in the unit cell is

$$12 \times \frac{1}{6} \text{ (corners)} + 2 \times \frac{1}{2} \text{ (face centres)} + 3 \text{ (in body)} = 6$$

2.(A) Volume of unit cell = base  $\times$  height.

$$\text{Base area of regular hexagon} = 6 \times (3)^{1/2} / 4 \times (2r)^2 = 6 \times (3)^{1/2} r^2.$$

$$\text{Volume of unit cell} = 6(3)^{1/2} r^2 \times 4 r(2/3)^{1/2} = 24 (2)^{1/2} r^3.$$

3.(D) The packing fraction of in hcp unit cell is 74%, therefore empty space is 26%.

4.(C) As none of the ions leave the crystal.

5.(A) Electrons are responsible for conductivity in this case.

6.(B) As germanium belongs to group 14.

7.(C) Let iron present in +3 oxidation state be  $x$ ; then +2 state would be  $0.95x$ .

$$3x + 2x(0.95 - x) = 2 \Rightarrow x = 0.1$$

$$\% \text{ of Fe in +3 oxidation state} = 0.1/0.95 \times 100 = 10.5\%$$

8.(A) If all the electrons are paired, it is diamagnetic.

9.(B) For every  $\text{Cd}^{2+}$  ion introduced in NaCl crystal, two  $\text{Na}^+$  ions are removed to maintain electrical neutrality. One lattice site occupied by  $\text{Cd}^{2+}$  ion and the other remains vacant. Hence, a cationic vacancy is created in NaCl by doping with  $\text{CdCl}_2$ . Since by the addition of one  $\text{Cd}^{2+}$  ion, one cationic vacancy is created; therefore, by the addition of  $10^{-3}$  mol of  $\text{Cd}^{2+}$  ion,  $10^{-3}$  mol% of cationic vacancy will be created. Hence, 1 mol% of a substance contains  $6.023 \times 10^{23}$  atoms/molecules/ions/vacancies.

Therefore,  $10^{-4}$  mol% of cationic vacancy =  $6.023 \times 10^{23} \times 10^{-4} / 100 = 6.023 \times 10^{17}$

10.(B)  $24 \times 10^{23}$  atoms has mass 24 g.

So,  $6.023 \times 10^{23}$  atoms will have mass  $\frac{24 \times 6.023 \times 10^{23}}{24 \times 10^{23}} = M = 6.02$  g

The density is given by

$$\rho = \frac{Z \times M}{a^3 \times N_A} = \frac{4 \times 6.02}{100 \times 100 \times 100 \times 10^{-30} \times 6.02 \times 10^{23}} = 40 \text{ g cm}^{-3}$$

11.(C) The density is given by  $\rho = \frac{Z \times M}{a^3 \times N_A}$ . Therefore,

$$12.5 = \frac{2 \times M}{200 \times 200 \times 200 \times 10^{-30} - 30 \times 6.02 \times 10^{23}} \Rightarrow M = 30.1 \text{ g}$$

Now, 30.1 g contains  $6.023 \times 10^{23}$  atoms

So, 100 g will contain  $\frac{6.023 \times 10^{23} \times 100}{30.1} = 2 \times 10^{24}$  atoms

12.(B) The density is given by  $\rho = \frac{Z \times M}{a^3 \times N_A}$ . Therefore,

$$a^3 = \frac{2 \times 60}{4.2 \times 6.023 \times 10^{23}} = 4.74 \times 10^{-23} \text{ cm}^3$$

## <H2>Integer Answer Type

1.(6) Coordination number of Al is 6. It exists in ccp lattice with 6 coordinate layer structure.

2.(4) Number of octahedral voids is 4 as it is equal to the number of atoms in closed packed structure, that is, the rank of the unit cell.

4.(6) Radius ratio  $\frac{r^+}{r^-} = \frac{126}{216} = 0.58$ ; Thus, radius ratio suggests coordination number is six.

5.(8)  $\text{CaF}_2$  has fcc structure with 8:4 coordination and has four units of  $\text{CaF}_2$  per unit cell.

**6.(4)** In NaCl number of  $\text{Na}^+$  ion =  $12$  (at edge center)  $\times \frac{1}{4} + 1 = 4$   
 Number of Cl =  $8$  (corner)  $\times \frac{1}{8} + 6$  (at face)  $\times \frac{1}{2} = 4$   
 As, NaCl has rock salt arrangement.

**7.(6)** Number of atoms at corner =  $\frac{1}{6}$  (corners)  $\times 12 = 2$   
 Number of atoms at face center =  $\frac{1}{2}$  (face centers)  $\times 2 = 1$   
 Total atoms in body =  $2 + 1 + 3$  ( in the body) =  $6$

**8.(6)** Number of atoms of A in fcc packing  $8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4$

Number of atoms of B at octahedral voids =  $4$

Along one face, there are four A atoms and one B atom.

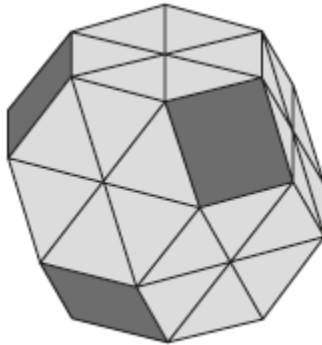
Number of effective atoms of A after removal =  $4 - 4 \times \frac{1}{8} = \frac{7}{2}$

Number of effective atoms of B after removal =  $4 - 1 = 3$

**9.(4)** The density is given by  $\rho = \frac{Z \times M}{a^3 \times N_A}$ . Therefore,

$$4 = \frac{Z \times 72}{500 \times 500 \times 500 \times 10^{-30} \times 6.023 \times 10^{23}} \Rightarrow Z = 4$$

**10.(6)** A truncated octahedron; **8** regular hexagonal faces. The remaining **6** faces are square.



## <H2>Matrix-Match Type

1.(A)→(p), (s); (B)→(p), (q); (C)→(q); (D)→(q), (r)

The correct matching between the crystal/unit cell systems and the parameters can be obtained based on the properties listed as follows:

Crystals Class	Axial Distances	Angles
Cubic	$a = b = c$	$\alpha = \beta = \gamma = 90^\circ$
Tetragonal	$a = b \neq c$	$\alpha = \beta = \gamma = 90^\circ$
orthorhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90^\circ$



Hexagonal	$a = b \neq c$	$\alpha = \beta = 90^\circ$ $\gamma = 120^\circ$
Trigonal and rhombohedral	$a = b = c$	$\alpha = \beta = \gamma \neq 90^\circ$
Monoclinic	$a \neq b \neq c$	$\alpha = \beta = 90^\circ$ $\gamma \neq 90^\circ$
Triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90^\circ$

2. A  $\rightarrow$  (q); B  $\rightarrow$  (s); C  $\rightarrow$  (p); D  $\rightarrow$  (r)

**Normal spinel structure:** (AB<sub>2</sub>O<sub>4</sub>)

Number of A<sup>+2</sup> in tetrahedral void = 1

Number of A<sup>+3</sup> in octahedral void = 2

Thus,  $\frac{1}{8}$  th of the tetrahedral and  $\frac{1}{2}$  of the octahedral void are occupied.

**Inverse spinel structure:**

Number of A<sup>+2</sup> in octahedral void = 1

Number of A<sup>+3</sup> in tetrahedral void = 1

Number of A<sup>+3</sup> in octahedral void = 1

Thus  $\frac{1}{2}$  of the octahedral and  $\frac{1}{8}$  of the tetrahedral void are occupied.

**Diamond:** Alternate tetrahedral voids are occupied.

**Na<sub>2</sub>O:** All tetrahedral voids are occupied.

3. A  $\rightarrow$  (r); B  $\rightarrow$  (q); C  $\rightarrow$  (p); D  $\rightarrow$  (s)

For simple cubic: rank = 1 and  $r = a/2$ .

For bcc: rank = 2 and  $r = (3a)^{1/2}/4$

For fcc: rank = 4 and  $r = a/2(2)^{1/2}$

For hcp: rank = 6 and  $r = a/2$

4. A  $\rightarrow$  (q); B  $\rightarrow$  (p, q); C  $\rightarrow$  (p, q, s); D  $\rightarrow$  (r, s)

In Schottky defect, equal number of cations and anions are missing from their lattice points.

Frenkel defect arises when an ion goes missing from its lattice site and occupies an interstitial site.

Here excess cations occupy interstitial sites.

Metal excess defect is a type of non-stoichiometric defect as the ratio of cation to anion differs from that in normal chemical formula. Metal excess defect is caused due to anion vacancies and is similar to Schottky defect, here also conduction is due to free electrons.

Metal deficient defect, is also a type of non-stoichiometric defect that occurs when a cation goes missing from a lattice site and a similar cation with greater charge occupies adjacent site. Here the conduction is due to positive holes, so it acts as a *p*-type semiconductor.

5. A  $\rightarrow$  (p,q,r,s); B  $\rightarrow$  (p,r,s); C  $\rightarrow$  (p,s); D  $\rightarrow$  (p,r,s)

A  $\rightarrow$  (p,q,r,s) Zinc blende (spalerrite) has ccp arrangement.

B → (p,r,s) Wurtzite has hcp arrangement.

C → (p,s) NaCl has fcc arrangement.

D → (p,r,s) Diamond has fcc arrangement.