Level - II

Chapter 1

The Solid State

Solutions

SECTION - A

Objective Type Questions

(General Characteristics of Solid State, Crystal Lattice or Space Lattice, Unit Cell, Calculation of number of atoms in a unit cell)

1. In crystalline solids, which of the following element of symmetry is not present?

   (1) Axis of symmetry (2) Angle of symmetry (3) Centre of symmetry (4) Plane of symmetry

Sol. Answer (2)

In crystalline solid angle of symmetry is not present.

2. Amorphous solids have

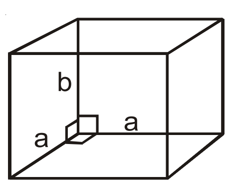
   (1) Orderly arrangement of atoms (2) Repeating unit of unit cell

   (3) Long range of melting point (4) Anisotropy

Sol. Answer (3)

Amorphous solids have → not ordered arrangement.
not repeating units
long range of melting point
→ Isotropy

3. The type of crystal system shown is



   (1) Cubic (2) Orthorhombic (3) Monoclinic (4) Tetragonal

Sol. Answer (4)

For tetragonal $a = b \neq c$

Two sides are equal and one side is unequal.

4. In a unit cell, atoms A, B, C and D are present at corners, face-centres, body-centre and edge-centre respectively in a cubic unit cell. The total number of atoms present per unit cell is

(1) 4 (2) 8 (3) 15 (4) 27

Sol. Answer (2)

A → at corners = 8

B → at face centres = 6

C → body centre = 1

D → edge centre = 12

Total atoms in a cube = 8 + 6 + 1 + 12 = 27

$A = 8\times\frac{1}{8}=1$

$B = 6\times\frac{1}{2}=3$

C = 1 × 1 = 1

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

Total = 8 atoms per unit cell

5. In a unit cell, atoms A, B, C and D are present at half of total corners, all face-centres, body-centre and one third of all edge-centres respectively. Then formula of unit cell is

(1) AB_3CD_3 (2) ABCD (3) $AB_6C_2D_4$ (4) $AB_6C_2D_2$

Sol. Answer (4)

Corner $A=\frac{1}{8}\times 4=\frac{1}{2}$

Face centre $B=\frac{1}{2}\times 6=3$

Total C = 1

Total D = $\frac{1}{4}\times 4=1$

formula $A_{\frac{1}{2}}B_3C_1D_1$

$AB_6C_2D_2$

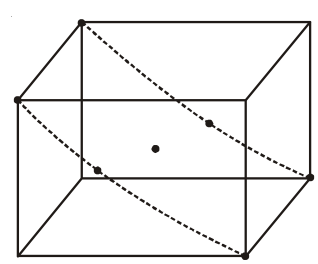
6. In a unit cell, atoms A, B, C and D are present at corners, face-centres, body-centre and edge-centres respectively. If atoms touching one of the plane passing through two diagonally opposite edges are removed, then formula of compound is

(1) $ABCD_2$ (2) ABD_2 (3) AB_2D_2 (4) AB_4D_5

Sol. Answer (4)

Given atoms of one diagonal planes are to be removed.

∴ 4 atoms from corner, 2 atom from face centre and 1 atom from body centre will be removed.



Total $A=4\times\frac{1}{8}=\frac{1}{2}$ [4 atoms removed from corner]

Total $B = \frac{1}{2} \times 4 = 2$ [2 atoms are removed from face centre]

Total C = 0 [1 atom removed from body centre]

Total $D = \frac{1}{4} \times 10 = \frac{5}{2}$ [2 atom removed from edge]

$A_{\frac{1}{2}}B_2C_0D_{\frac{5}{2}} \rightarrow A_1B_4D_5$

7. Number of atoms per unit cell, if atoms are present at the corner of unit cell and 2 atoms at each body diagonal

(1) 9 (2) 10 (3) 6 (4) 4

Sol. Answer (1)

Given = atoms are present at corners and 2 atoms at each body diagonal.

In normal total 4 – body diagonal are present in a simple cube.

So, Total no. of atoms on body diagonal = 4 × 2 = 8

for corners = $8 \times \frac{1}{8} = 1$

Body diagonal = 4 × 2 = 8

Total = 9

8. Glass is a

(1) Micro-crystalline solid (2) Super cooled liquid (3) Gel (4) Polymeric mixture

Sol. Answer (2)

Glass is a super cooled liquid or amorphous solid because on heating its arrangement of atoms become improper *i.e.*, become slightly liquid nature.

9. What is the relation between diamond and graphite?

(1) Polymorphous (2) Isomer (3) Isotope (4) Isomorphous

Sol. Answer (1)

Diamond and graphite are polymorphous because both have similar chemical composition but different arrangement of constituent particles i.e., carbon.

(Close Packed Structures, Calculation of Packing Efficiency, Close Packing in Ionic Compounds)

10. If radius of a metal atom (A) is 5 pm and radius of an electronegative atom (B) is 20 pm, then in the unit cell

(1) A in octahedral voids, B in FCC unit (2) A in FCC unit, B in tetrahedral void

(3) A in BCC unit, B in cubic void (4) A in tetrahedral void, B in FCC unit

Sol. Answer (4)

$\frac{r^+}{r^-} = \frac{5}{20} \Rightarrow \frac{1}{4} = 0.25$

This ratio comes in between 0.225 – 0.414 i.e., tetrahedral void. So, A in tetrahedral void due to cation (small size).

So, B in f.c.c.

11. In a unit cell containing X^{2+}, Y^{3+} and Z^{2-} where X^{2+} occupies 1/8th of tetrahedral voids, Y^{3+} occupies 1/2 of octahedral voids and Z^{2-} forms ccp structure. Then formula of compound is

(1) X_2Y_4Z (2) XY_2Z_4 (3) XY_3Z_4 (4) X_4YZ_2

Sol. Answer (2)

$$\underset{(Z^{-2})}{\text{ccp}} \rightarrow \text{number atoms per unit cell} = 4 \rightarrow \left[\underset{\text{(corners)}}{8\times\frac{1}{8}} + \underset{\text{(face centre)}}{6\times\frac{1}{2}}\right]$$

Total tetrahedral void = 8

Total octahedral void = 4

Given, $X^{+2} = \frac{1}{8}$ of T.V. $= \frac{1}{8}\times 8 = 1$

$Y^{+3} = \frac{1}{2}$ of O.V. $= \frac{1}{2}\times 4 = 2$

So, formula $Z_4^{-2}X_1^{+2}Y_2^{+3} \rightarrow XY_2Z_4$

12. In a ccp type structure, if half of the face-centred atoms are removed, then percentage void in unit cell is approximately

(1) 54% (2) 46.25% (3) 63% (4) 37%

Sol. Answer (1)

In ccp, $\rightarrow$ 74% space is occupied by 4 atoms (when all corner and face centre atoms are located)

Given Half of face centred atoms are removed.

So, total face centred atoms = 6 half removed it. becomes = 3

Now contribution for corners remain same *i.e.*, $8\times\frac{1}{8} = 1$

for face centred = $(3)\times\frac{1}{2} = \frac{3}{2}$

Total $= \frac{3}{2} + 1 = \frac{5}{2}$

For, 4 - atoms $\rightarrow$ 74% (space occupied) 1 - atom $\rightarrow \frac{74\%}{4}$

for $\frac{5}{2}$ atom $\rightarrow \frac{74\%}{4}\times\frac{5}{2} = 46.25\%$ *i.e.*, % void = 100 – occupied space = 100 – 46.25 = 54%

13. In a BCC unit cell, if half of the atoms per unit cell are removed, then percentage void is

(1) 68% (2) 32% (3) 34% (4) 66%

Sol. Answer (4)

In B.C.C. $\rightarrow$ 68% space is occupied by 2 atoms. If half of atoms per unit cell is removed then it becomes = 2 – 1 = 1.

So, 2 atom $\rightarrow$ 68%

1 atom $\rightarrow \frac{68}{2}$ = 34% (occupied space)

Now, % void = 100 – occupied space = 100 – 34 = 66%

(Calculation for Unit Cell Dimensions, Structure of Ionic Crystals)

14. A crystalline solid AB adopts sodium chloride type structure with edge length of the unit cell as 745 pm and formula mass of 74.5 a.m.u. The density of the crystalline compound is

(1) 2.16 g cm^{-3} (2) 0.99 g cm^{-3} (3) 1.88 g cm^{-3} (4) 1.197 g cm^{-3}

Sol. Answer (4)

$\rho(\text{density}) \Rightarrow \frac{Z \times M}{N_A \times a^3}$

$\rho \Rightarrow \frac{4 \times 74.5}{6.022 \times 10^{23} \times (745 \times 10^{-10})^3}$

$\Rightarrow 1.197\ g/cm^3$

for NaCl $\rightarrow$ f.c.c. (Z = 4)

M = 74.5 amu

a = 745 pm = 745 × 10^{-10} cm

15. If radius of an octahedral void is r and atomic radius of atoms assuming cubical close packing is R. Then the relation between r and R is

(1) r = 2R (2) r = 1.414 R

(3) r = 0.414 R (4) $r = \frac{R}{\sqrt{2}}$

Sol. Answer (3)

For octahedral void

r = 0.414 R

16. Which of the following statement is correct?

(1) On increasing temperature the coordination number of solid remains unchanged

(2) On increasing pressure the coordination number of solid increases

(3) On increasing temperature the coordination number of solid increases

(4) On increasing pressure the coordination number of solid decreases

Sol. Answer (2)

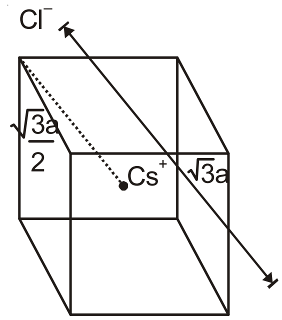
On increasing pressure the C.N. of solid increases because on increasing pressure atoms/particles come closer to each other i.e., C.N. increases [closeness increases] and [K.E. decreases] and on increasing temperature K.E. of particles increases by which particles go far away i.e., C.N. decreases [closeness decreases]

[C.N. $\Rightarrow$ closeness of atoms *i.e.*, coordination number]

17. In a CsCl structure, if edge length is x, then distance between one Cs atom and one Cl atom is

(1) $\frac{a\sqrt{3}}{2}$ (2) $\frac{a\sqrt{3}}{4}$ (3) $a\sqrt{2}$ (4) $\frac{a}{\sqrt{2}}$

Sol. Answer (1)



$\therefore$ [a = x]

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

18. The correct statement about, CCP structure is

(1) Packing fraction = 26%
(2) Coordination number = 6
(3) Unit cell is face centred cubic
(4) AB–AB type of packing

Sol. Answer (3)

ccp { packing fraction = 74%
C.N. = 12
Unit cell is fcc
ABCABC.........

19. In a NaCl structure, if positions of Na atoms and Cl atoms are interchanged, then in the new unit cell

(1) Na atom is present at body centre
(2) Cl atom is present at face centre
(3) Na atom is present in tetrahedral voids
(4) Cl atom is present in octahedral voids

Sol. Answer (4)

In NaCl structure

Na^+ present at edge centres [octahedral voids] and as well as body centre.

Cl^- present at corners and centre of each face.

Given if atom are interchanged then

Na^+ comes at corners and centre of each face.

Cl^- comes at edge centres (octahedral voids) and at body centre.

20. A metal can be crystallized in both BCC and FCC unit cells whose edge lengths are 2 pm and 4 pm respectively. Then ratio of densities of FCC and BCC unit cells is

(1) $\frac{1}{4}$
(2) 4
(3) $\frac{1}{16}$
(4) 16

Sol. Answer (1)

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

$$\frac{\rho_{F.C.C.}}{\rho_{B.C.C.}} = \frac{Z_{F.C.C.}}{Z_{B.C.C}} \times \frac{a^3_{B.C.C.}}{a^3_{F.C.C}}$$ [given, $a_{B.C.C} = 2$ pm; $a_{F.C.C.} = 4$ pm]

$$\Rightarrow \frac{4}{2} \times \frac{(2)^3}{(4)^3} = \frac{4 \times 8}{2 \times 64} \Rightarrow \frac{1}{4}$$

21. Number of unit cells in 10 g NaCl

(1) $\frac{1.5}{58.5}\times10^{24}$ (2) $\frac{2.5}{58.5}\times10^{23}$ (3) $\frac{5.6}{58.5}\times10^{20}$ (4) $\frac{5.6}{58.5}\times10^{21}$

Sol. Answer (1)

In NaCl, 4 atoms per unit cell

i.e., 4 atoms in one unit cell

$NaCl = 23 + 35.5 = 58.5$
$\text{mole} = \frac{10}{58.5}$

or 1 atom in $\frac{1}{4}$ unit cell

or N_A atoms = (1 mole) $\rightarrow \frac{1}{4}\times N_A$ unit cell

or $\frac{10}{58.5}$ mole $\rightarrow \frac{1}{4}\times N_A\times\frac{10}{58.5}$ unit cell = $\frac{1.5}{58.5}\times10^{24}$ unit cell

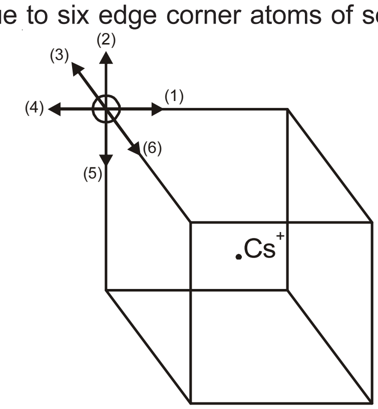
22. Second nearest neighbour in CsCl solid

(1) 8 (2) 6 (3) 16 (4) 10

Sol. Answer (2)

In CsCl $\rightarrow$ first nearest neighbours is (8) due to four atoms above at corners and four atoms below at corners.

Second nearest neighbours is 6 due to six edge corner atoms of second unit cell.



23. In a calcium fluoride structure, the co-ordination number of cation and anion is respectively.

(1) 6, 6 (2) 8, 4 (3) 4, 4 (4) 4, 8

Sol. Answer (2)

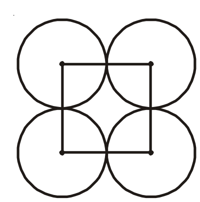
$CaF_2 \rightarrow AB_2$ type $\rightarrow$ C.N. = 8 : 4

because Ca^{+2} ions form ccp structure and F^- ions in all tetrahedral holes.

for ccp atoms = 4

Tetrahedral holes = 8

24. The packing efficiency of the 2D square unit cell shown below is



(1) 39.27 %

(2) 68.02%

(3) 74.05%

(4) 78.54%

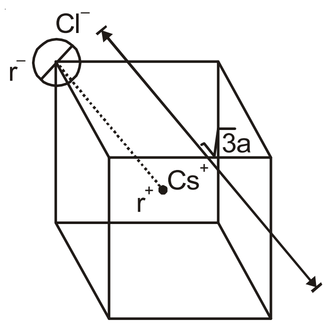
Sol. Answer (4)

% efficiency = $\frac{\pi r^2}{(2r)^2} \times 100$ = 78.54%

25. CsCl crystallises in a cubic cell that has a Cl^- at each corner and Cs^+ at the centre of the unit cell. If radius of Cs^+ is 1.69 Å and r_{Cl^-} =1.81 Å, what is the edge length of unit cell?

(1) 3.50 Å (2) 4.04 Å (3) 2.02 Å (4) 1.01 Å

Sol. Answer (2)



Distance between Cl^-(corner) and Cs^+ (centre) is half of body diagonal

$$\boxed{\frac{\sqrt{3}a}{2} = r^+ + r^-}$$

$$\frac{\sqrt{3} \times a}{2} = 1.69 + 1.81$$

∴ a = 4.04 Å

26. For tetrahedral co-ordination, the radius ratio (r_+/r_-) should be

(1) 0.414 – 0.732 (2) 0.732 – 1.0 (3) 0.156 – 0.225 (4) 0.225 – 0.414

Sol. Answer (4)

For tetrahedral void the radius ratio $\frac{r^+}{r^-} = 0.225 - 0.414$

27. The radius of the Na^+ is 95 pm and that of Cl^- ion is 181 pm. The co-ordination number of Na^+ will be

(1) 4 (2) 6 (3) 8 (4) Unpredictable

Sol. Answer (2)

$\frac{r^+}{r^-} = \frac{95}{181} = 0.52$ (this value is present in between normal range so, C.N. remain 6)

generaly the C.N. of NaCl is 6 when $\frac{r^+}{r^-} = 0.414 - 0.732$

28. A mineral having formula AB_2 crystallises in the cubic close packed lattice, with the A atoms occupying the lattice points. Hence coordination number of A and B atoms are

(1) 4, 8 (2) 4, 4 (3) 8, 8 (4) 8, 4

Sol. Answer (4)

$AB_2 \rightarrow CaF_2$ type of crystal which has C.N. = 8 : 4.

29. KF has NaCl type of structure. The edge length of its unit cell has been found to be 537.6 pm. The distance between K^+ F^- in KF is

(1) 26.88 pm (2) 268.8 pm (3) 2688 pm (4) Unpredictable

Sol. Answer (2)

For NaCl (fcc) and KF $(r^{+} + r^{-}) = \frac{a}{2} = \text{interionic distance.}$

$= \frac{537.6}{2} = 268.8 \text{ pm}$

30. Which of the following features is false regarding the structure of CsCl?

(1) It has bcc arrangements

(2) For each ion coordination number is 8

(3) For each ion coordination number is 6

(4) The radius ratio (r_+/r_-) is 0.93

Sol. Answer (3)

For CsCl,
- → It has B.C.C. arrangement
- C.N. = 8
- → $\frac{r^{+}}{r^{-}} = 0.93$

So, third option is incorrect because C.N. of CsCl is 8 not 6.

31. The mass of unit cell of Na_2O is

(1) Twice the formula mass of Na_2O

(2) Four times the formula mass of Na_2O

(3) Six times the formula mass of Na_2O

(4) Thrice the formula mass of Na_2O

Sol. Answer (2)

$Na_2O \rightarrow$ Has 4 atoms per unit cell

So, the mass of unit cell is = 4 × formula mass of Na_2O

32. In normal spinel structure there is a closed packed array of O^{2-} ions. The trivalent cations are present in

(1) 75% of octahedral voids

(2) 50% of octahedral voids

(3) 12.5% of tetrahedral voids

(4) 25% of octahedral voids

Sol. Answer (2)

In normal spinel structure

T.V
$1A^{+2} \rightarrow \text{occupy } \frac{1}{8} \text{ of T.V.}$ (12.5%) $\longleftarrow A^{+2}B_2^{+3}O_4^{-2} \longrightarrow \left.\begin{matrix} 8 \times \frac{1}{8} = 1 \\ \frac{1}{2} \times 6 = 3 \end{matrix}\right\} 4$

$\downarrow$

$2B^{+3}$ i.e., $\frac{1}{2}$ O.V. will be occupied (50%)

T.V. = tetrahedral void

O.V. = octahedral void

33. What is the coordination number of Rb^{+} in RbBr unit cell if ionic radii of Rb^{+} and Br^{-} ions being 148 and 195 respectively?

(1) 6

(2) 4

(3) 8

(4) 12

Sol. Answer (3)

$$\frac{r_{Rb^+}}{r_{Br^-}} = \frac{148}{195} = 0.75$$

This ratio (0.75) is more than 0.732 so, it is cubic structure which has C.N. = 8

34. A crystalline solid AB has NaCl type structure with radius of B^- ion is 250 pm. Which of the following cation can be made to slip into tetrahedral site of crystals of A^+B^- ?

(1) P^+ (radius = 180 pm)

(2) Q^+ = (radius = 56 pm)

(3) R^+ = (radius = 200 pm)

(4) S^+ = (radius = 150 pm)

Sol. Answer (2)

For NaCl type $\frac{r^+}{r^-} = 0.414 - 0.732$

$$\frac{r^+}{250} = 0.414$$

$r^+ = 0.414 \times 250$

$r^+ = 103.5$

This is radius of void so, the cation which has equal to this radius or smaller to this radius can easily fit into it that is option (2) Q^+ = 56 pm which is smaller than radius of void thats why it can fit into it.

35. Number of formula units in unit cell of MgO (rock salt), ZnS (zinc blende) and Pt (fcc) respectively

(1) 4, 3, 2

(2) 4, 3, 4

(3) 4, 4, 4

(4) 4, 3, 1

Sol. Answer (3)

MgO = 4

ZnS = 4

Pt (f.c.c.) = 4

(Imperfections or Defects in Solids, Applications of p-type and n-type Semiconductors)

36. On rising temperature and decreasing pressure in CsCl solid

(1) C.N. of metal ion increases from 6 to 8

(2) Number of formula unit per unit cell (Z) changes from one to four

(3) Density of unit cell is increased

(4) $\frac{r_+}{r_-}$ (radius ratio) is increased

Sol. Answer (2)

$$\underset{C.N. = 8:8}{CsCl} \xrightarrow{T\uparrow,\ P\downarrow} \underset{C.N. = 6:6}{NaCl}$$

(Z = 1) no. of atom due to simple cubic   (Z = 4) due to F.C.C.

On increasing temperature and decreasing pressure closeness of atoms in CsCl crystal decreases because

K.E. increases. So, that $\left\{\begin{matrix}\frac{r_+}{r_-}\text{(radius ratio)} \rightarrow \text{decreases} \\ \text{density of unit cell decreases}\end{matrix}\right\}$ due to closeness $\downarrow$

37. Some of the molecular solids upon heating produces small amount of electricity, hence solid is

(1) Piezoelectric (2) Pyroelectric (3) Ferrielectric (4) Ferroelectric

Sol. Answer (2)

Pyroelectric are the molecular solids which produces small amount of electricity upon heating.

38. NaCl becomes paramagnetic at high temperature due to

(1) Formation of F-centre (2) Molten state

(3) Change in oxidation state (4) Conversion of Na^+ to Na

Sol. Answer (1)

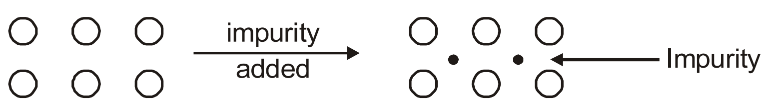
NaCl becomes paramagnetic at high temperature in the presence of Na - vapour due to migration of Cl^- ion to the surface from lattice by which vacancy is produced known as F-centre in which e^- is trapped from outer Na vapour i.e., some free electrons comes in lattice that's why it becomes paramagnetic.

39. In which of the following defect density increases?

(1) Schottky defect (2) Frenkel defect (3) F-centre (4) Impurity defect

Sol. Answer (4)

In impurity defect density increases because some impurities will come from outside which increases mass. So, density increases.



Normal crystal mass increases = density increases

40. A crystal may have one or more planes of symmetry as well as one or more than one axis of symmetry but it has

(1) Two centres of symmetry (2) Only one centre of symmetry

(3) No centre of symmetry (4) Three centres of symmetry

Sol. Answer (2)

A crystal may have more than plane of symmetry and axis of symmetry but centre of symmetry is only one.

41. Which of the following is **incorrect** statement about the Bragg's equation $n\lambda = 2d \sin\theta$?

(1) n, represents order of reflection (2) λ, represents wavelength of UV-rays used

(3) θ, represents angle of incidence (4) d, represents distance between two parallel planes

Sol. Answer (2)

λ represents wavelength of X-rays used.

42. The ratio of number of rectangular plane and diagonal plane in a cubic unit cell

(1) 1 : 2 (2) 3 : 1 (3) 2 : 3 (4) 3 : 4

Sol. Answer (1)

Total number of rectangular plane = 3.

Number of diagonal plane = 6.

ratio = 3 : 6 = 1 : 2

SECTION - B

Previous Years Questions

1. 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

[NEET-2018]

(1) $\frac{\sqrt{3}}{\sqrt{2}}$ (2) $\frac{4\sqrt{3}}{3\sqrt{2}}$ (3) $\frac{1}{2}$ (4) $\frac{3\sqrt{3}}{4\sqrt{2}}$

Sol. Answer (4)

For BCC lattice : Z = 2, $a = \frac{4r}{\sqrt{3}}$

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

$$\therefore \frac{d_{25°C}}{d_{900°C}} = \frac{\left(\frac{ZM}{N_A\ a^3}\right)_{BCC}}{\left(\frac{ZM}{N_A\ a^3}\right)_{FCC}}$$

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

2. Which is the incorrect statement? **[NEET-2017]**

(1) $FeO_{0.98}$ has non stoichiometric metal deficiency defect

(2) Density decreases in case of crystals with Schottky's defect

(3) NaCl(s) is insulator, silicon is semiconductor, silver is conductor, quartz is piezo electric crystal

(4) Frenkel defect is favoured in those ionic compounds in which sizes of cation and anions are almost equal

Sol. Answer (1 & 4)

Frenkel defect occurs in those ionic compounds in which size of cation and anion is largely different.

Non-stoichiometric ferrous oxide is $Fe_{0.93-0.96}O_{1.00}$ and it is due to metal deficiency defect.

3. In calcium fluoride, having the fluorite structure, the coordination numbers for calcium ion (Ca^{2+}) and fluoride ion (F^-) are **[NEET-Phase-2-2016]**

(1) 4 and 2 (2) 6 and 6 (3) 8 and 4 (4) 4 and 8

Sol. Answer (3)

In CaF_2, $Ca^{2(+)}$ has fcc arrangement and $F^{(-)}$ ions are present in all tetrahedral voids.

∴ Co-ordination numbers for $Ca^{2(+)}$ and $F^{(-)}$ ions are 8 and 4.

4. 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 ($N_A = 6.02 \times 10^{23}\ mol^{-1}$) **[NEET-2016]**

(1) 264 pm (2) 154 pm (3) 352 pm (4) 527 pm

Sol. Answer (3)

$$0.53\ g/cm^3\ \frac{2\times 6.94\ (g/mol)}{a^3\times 6.02\times 10^{23}\ mol^{-1}}$$

On solving, a = 352 pm

5. 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 **[NEET-2016]**

(1) 2 (2) 6 (3) 4 (4) 8

Sol. Answer (2)

$$\frac{r_{(+)}}{r_{(-)}} = \frac{0.98 \times 10^{-10}}{1.81 \times 10^{-10}} = 0.54$$

i.e., Ionic solid has octahedral geometry, thus co-ordination number of each ion in AB is 6.

6. The vacant space in bcc lattice unit cell is **[Re-AIPMT-2015]**

(1) 23% (2) 32% (3) 26% (4) 48%

Sol. Answer (2)

Packing fraction in bcc lattice is 68%.

$\therefore$ The vacant space in bcc lattice = 32%

7. The correct statement regarding defects in crystalline solids is **[Re-AIPMT-2015]**

(1) Frenkel defect is a dislocation defect

(2) Frenkel defect is found in halides of alkaline metals

(3) Schottky defects have no effect on the density of crystalline solids

(4) Frenkel defects decrease the density of crystalline solids

Sol. Answer (1)

Fact.

8. A given metal crystallizes out with a cubic structure having edge length of 361 pm. If there are four metal atoms in one unit cell, what is the radius of one atom? **[AIPMT-2015]**

(1) 108 pm (2) 40 pm (3) 127 pm (4) 80 pm

Sol. Answer (3)

For fcc arrangement, $r = \frac{\sqrt{2} \times a}{4} = \frac{\sqrt{2} \times 361}{4} \approx 127\,\text{pm}$

9. If a is the length of the side of a cube, the distance between the body centered atom and one corner atom in the cube will be **[AIPMT-2014]**

(1) $\frac{2}{\sqrt{3}}a$ (2) $\frac{4}{\sqrt{3}}a$ (3) $\frac{\sqrt{3}}{4}a$ (4) $\frac{\sqrt{3}}{2}a$

Sol. Answer (4)

$\sqrt{3}a = 4r$ (BCC)

$$\boxed{2r = \frac{\sqrt{3}a}{2}}$$

10. A metal has an 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 is Avogadro's constant = 6.02×10^{23} mol^{-1}) **[NEET-2013]**

(1) 30 g mol^{-1} (2) 27 g mol^{-1} (3) 20 g mol^{-1} (4) 40 g mol^{-1}

Sol. Answer (2)

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

$a = 404 \times 10^{-12} \times 100$ cm

$= 404 \times 10^{-10}$ cm

$Z = 4 \rightarrow$ for f.c.c.

$= \frac{2.72 \times 6 \times 10^{23} \times (404 \times 10^{-10})^3}{4}$

$= 26.9 \simeq 27$ g/mol

11. The number of carbon atoms per unit cell of diamond unit cell is **[NEET-2013]**

(1) 8 (2) 6 (3) 1 (4) 4

Sol. Answer (1)

Number of carbon atoms per unit cell of diamond unit cell is 8. It has ZnS (zinc blende) like structure in which Zn^{+2} located at half of tetrahedral voids (= 4) and $S^{2(-)}$ has fcc arrangement (= 4).

Carbon atom per unit cell is $\underset{\text{(corners)}}{8 \times \frac{1}{8}} + \underset{\text{(face centre)}}{6 \times \frac{1}{2}} = 4$

12. A metal crystallizes with a face-centered cubic lattice. The edge of the unit cell is 408 pm. The diameter of the metal atom is **[AIPMT (Prelims)-2012]**

(1) 144 pm (2) 204 pm (3) 288 pm (4) 408 pm

Sol. Answer (3)

For F.C.C. $r = \frac{a}{2\sqrt{2}} = \frac{408}{2\sqrt{2}}$ pm

diameter $= 2r = \frac{2 \times 408}{2\sqrt{2}} = 288.5$ pm

13. The number of octahedral void(s) per atom present in a cubic close-packed structure is **[AIPMT (Prelims)-2012]**

(1) 2 (2) 4 (3) 1 (4) 3

Sol. Answer (3)

Number of O.V. equal to number of atoms

4 atoms in unit cell $\rightarrow$ 4 O.V.

So, for 1 atom $\rightarrow$ 1 O.V.

14. 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 **[AIPMT (Mains)-2012]**

(1) ABO_2 (2) A_2BO_2 (3) $A_2B_3O_4$ (4) AB_2O_2

Sol. Answer (4)

Given oxide ions = ccp = 4 $\rightarrow \left(\underset{\text{corner}}{8 \times \frac{1}{8}} + \underset{\text{face centres}}{6 \times \frac{1}{2}} \right)$

$\frac{1}{4}$th of T.V. by $A^{+2} \Rightarrow \frac{1}{4} \times 8$ (Total T.V. = 8)

$\Rightarrow 2$

O.V. by $B^{+} \Rightarrow 4 \times 1 \Rightarrow 4$ (Total O.V. = 4)

$A_2^{+2}\ B_4^{+}\ O_4^{-2} \rightarrow$

$2 : 4 : 4 \rightarrow 1 : 2 : 2$

AB_2O_2

15. A solid compound XY has NaCl structure. If the radius of the cation is 100 pm, the radius of the anion (Y^-) will be **[AIPMT (Mains)-2011]**

(1) 241.5 pm (2) 165.7 pm (3) 275.1 pm (4) 322.5 pm

Sol. Answer (1)

XY has NaCl structure $\frac{r^+}{r^-} = 0.414 - 0.732$

$\Rightarrow \frac{100}{r^-} = 0.414 \Rightarrow r^- = \frac{100}{0.414} = 241.5$ pm

16. AB crystallizes in a body centred cubic lattice with edge length 'a' equal to 387 pm. The distance between two oppositively charged ions in the lattice is **[AIPMT (Prelims)-2010]**

(1) 335 pm (2) 250 pm (3) 200 pm (4) 300 pm

Sol. Answer (1)

B.C.C., d = 2r

$(r^+ + r^-) = \frac{\sqrt{3}a}{2} = \frac{\sqrt{3}\times 387}{2} = 335$ pm

17. Among the following which one has the highest cation to anion size ratio? **[AIPMT (Mains)-2010]**

(1) CsI (2) CsF (3) LiF (4) NaF

Sol. Answer (2)

$\frac{r^+}{r^-} = \frac{Cs^+}{F^-}$

Size of Cs^+ is maximum and size F^- is minimum so ratio is highest.

18. 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 the lithium will nearly be **[AIPMT (Prelims)-2009]**

(1) 152 pm (2) 75 pm (3) 300 pm (4) 240 pm

Sol. Answer (1)

a = 351 pm

B.C.C. , $r = \frac{\sqrt{3}a}{4} = \frac{\sqrt{3}\times 351}{4} = 151.9$ pm

19. 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 ? **[AIPMT (Prelims)-2009]**

(1) 157 (2) 181 (3) 108 (4) 128

Sol. Answer (4)

F.C.C. $r = \frac{a}{2\sqrt{2}}$

$r = \frac{361}{2\times 1.414} = 127.65 \simeq 128$

20. 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 **[AIPMT (Prelims)-2008]**

(1) $1a : \sqrt{3}a : \sqrt{2}a$ (2) $\frac{1}{2}a : \frac{\sqrt{3}}{4}a : \frac{1}{2\sqrt{2}}a$ (3) $\frac{1}{2}a : \sqrt{3}a : \frac{1}{\sqrt{2}}a$ (4) $\frac{1}{2}a : \frac{\sqrt{3}}{2}a : \frac{\sqrt{2}}{2}a$

Sol. Answer (2)

S.C.C $\rightarrow r = \frac{a}{2}$

B.C.C. $\rightarrow r = \frac{\sqrt{3}a}{4}$

F.C.C. $\rightarrow$ $r = \dfrac{a}{2\sqrt{2}}$

$\dfrac{a}{2} : \dfrac{\sqrt{3}a}{4} : \dfrac{a}{2\sqrt{2}}$

21. Percentage of free space in a body centred cubic unit cell is **[AIPMT (Prelims)-2008]**

(1) 28% (2) 30% (3) 32% (4) 34%

Sol. Answer (3)

Occupied space in B.C.C. = 68%

free space = 100 – 68 $\Rightarrow$ 32%

22. With which one of the following elements silicon should be doped so as to give p-type of semiconductor ?

[AIPMT (Prelims)-2008]

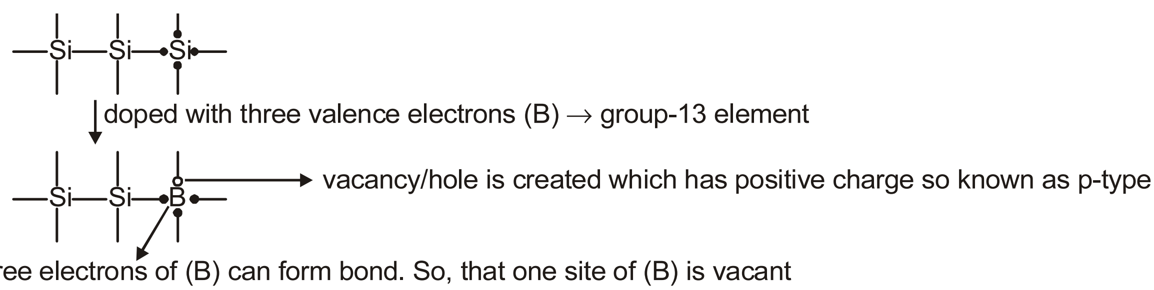
(1) Boron (2) Germanium

(3) Arsenic (4) Selenium

Sol. Answer (1)

Si = 4 valence electrons

(group-14 element)



23. Which of the following statements is not correct ? **[AIPMT (Prelims)-2008]**

(1) The number of Bravais lattices in which a crystal can be categorized is 14

(2) The fraction of the total volume occupied by the atoms in a primitive cell is 0.52

(3) Molecular solids are generally volatile

(4) The number of carbon atoms in a unit cell of diamond is 4

Sol. Answer (4)

Option (4) is incorrect because number of atoms in an unit cell of diamond is 8 not 4.

24. The fraction of total volume occupied by the atoms present in a simple cube is **[AIPMT (Prelims)-2007]**

(1) $\dfrac{\pi}{4}$ (2) $\dfrac{\pi}{6}$ (3) $\dfrac{\pi}{3\sqrt{2}}$ (4) $\dfrac{\pi}{4\sqrt{2}}$

Sol. Answer (2)

$$\text{Packing fraction} = \frac{\text{volume of total lattice points}}{\text{total volume of unit cell}}$$

$$\therefore \quad a = 2r \text{ (for S.C.C.)} = \frac{1\times\frac{4}{3}\pi r^3}{a^3} = \frac{\frac{4}{3}\pi r^3}{(2r)^3} = \frac{\pi}{6}$$

25. If NaCl is doped with 10^{-4} mol % $SrCl_2$, the concentration of cation vacancies will be ($N_A = 6.02\times10^{23}$ mol^{-1})

[AIPMT (Prelims)-2007]

(1) 6.02×10^{14} mol^{-1}
(2) 6.02×10^{15} mol^{-1}
(3) 6.02×10^{16} mol^{-1}
(4) 6.02×10^{17} mol^{-1}

Sol. Answer (4)

One mole $SrCl_2$ causes one mole cation vacancy.

So, 10^{-4}% mole $SrCl_2$ will cause $\frac{10^{-4}}{100}$ mole cation vacancy.

$\therefore$ Number of cation vacancy $= \frac{10^{-4}}{100}\times N_A = 6.02\times10^{23-6} = 6.02\times10^{17}\ mol^{-1}$

26. 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 Avagadro number being 6.02×10^{23} mol^{-1}, the density of CsBr is

[AIPMT (Prelims)-2006]

(1) 42.5 g/cm^3
(2) 0.425 g/cm^3
(3) 8.25 g/cm^3
(4) 4.25 g/cm^3

Sol. Answer (4)

a = 436.6 pm

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

Cs = 133, Br = 80 amu

$\rho = \frac{213\times1}{6\times10^{23}\times(436.6\times10^{-10})^3}$

Total mass = 133 + 80 = 213

Z = 1 for CsBr (S.C.C.)

$\rho = \frac{213}{8.32\times6} = 4.26\ g/cm^3$

27. The appearance of colour in solid alkali metal halides is generally due to **[AIPMT (Prelims)-2006]**

(1) F-centres
(2) Schottky defect
(3) Frenkel defect
(4) Interstitial positions

Sol. Answer (1)

Due to F-centres

28. In a face-centered cubic lattice, a unit cell is shared equally by how many unit cells? **[AIPMT (Prelims)-2005]**

(1) 8
(2) 4
(3) 2
(4) 6

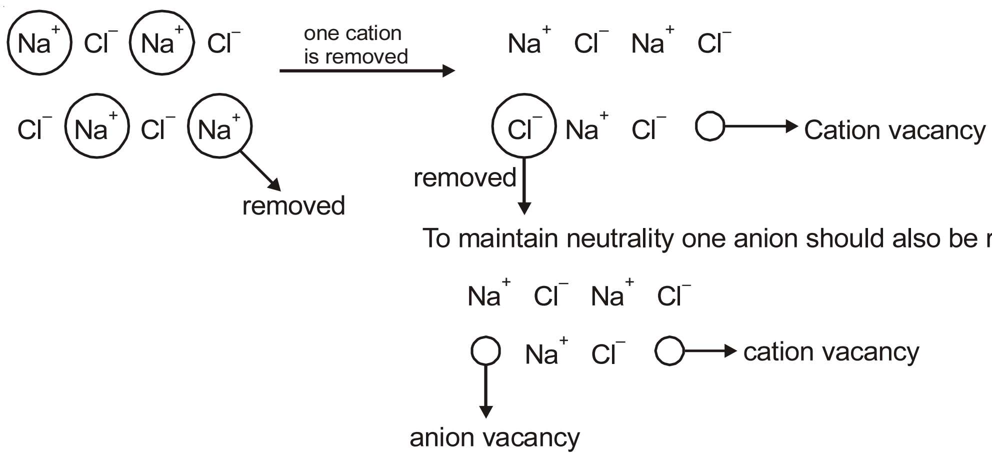
Sol. Answer (4)

29. Ionic solids, with Schottky defects, contain in their structure

(1) Cation vacancies only
(2) Cation vacancies and interstitial cations
(3) Equal number of cation and anion vacancies
(4) Anion vacancies and interstitial anions

Sol. Answer (3)

In Schottky defect equal number of cation and anion vacancies are present.



30. The number of atoms in 100 g of an FCC crystal with density d = 10 g/cm^3 and cell edge equal to 100 pm, is equal to

(1) 2×10^{25} (2) 1×10^{25} (3) 4×10^{25} (4) 3×10^{25}

Sol. Answer (3)

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

Z = 4 for f.c.c,. $a = 100 \times 10^{-12} \times 10^2$

$= 100 \times 10^{-10}$ cm,

w = 100 g.

$$\text{Molar mass} = \frac{\rho \times N_A \times a^3}{Z} = \frac{10 \times 6 \times 10^{23} \times (100 \times 10^{-10})^3}{4} = 1.5 \text{ g}$$

$$\text{Number of atoms} = \text{moles} \times N_A = \frac{w}{M} \times N_A = \frac{100}{1.5} \times 6 \times 10^{23} = 4 \times 10^{25}$$

31. An element (atomic mass = 100 gm/mol) having BCC structure has unit cell edge 400 pm. The density of element is

(1) 7.289 gm/cm^3 (2) 2.144 gm/cm^3

(3) 10.376 gm/cm^3 (4) 5.188 gm/cm^3

Sol. Answer (4)

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

$$\rho = \frac{2 \times 100}{6 \times 10^{23} \times (4 \times 10^{-8})^3}$$

$$= \frac{2 \times 100}{6 \times 10^{23} \times 64 \times 10^{-24}}$$

$$= \frac{1}{3 \times 64} \times 10^2 \times 10$$

$= 0.0052 \times 10^3 = 5.2$ g/cm^3

$z = 2 \rightarrow$ (B.C.C.)

$a = 400 \times 10^{-12}$ m

$= 400 \times 10^{-12} \times 100$ cm

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

32. If we mix a pentavalent impurity in a crystal lattice of germanium, what type of semiconductor formation will occur?

(1) n-type semiconductor

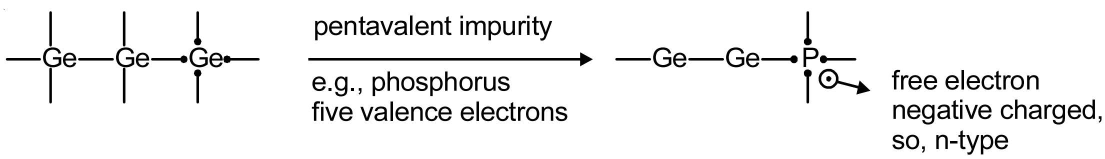
(2) p-type semiconductor

(3) Both (1) & (2)

(4) None of these

Sol. Answer (1)

Ge $\rightarrow$ 14^{th} group element $\rightarrow$ 4 valence electrons.

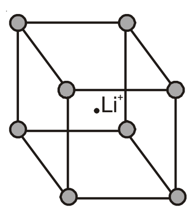


33. The intermetallic compound LiAg crystallizes in cubic lattice in which both lithium and silver have coordination number of eight. The crystal class is

(1) Face-centred cube (2) Simple cube (3) Body-centred cube (4) None of these

Sol. Answer (2)

Both Li and Ag have simple cubic arrangements.



34. Schottky defect in crystals is observed when

(1) Density of the crystal is increased

(2) Unequal number of cations and anions are missing from the lattice

(3) An ion leaves its normal site and occupies an interstitial site

(4) Equal number of cations and anions are missing from the lattice

Sol. Answer (4)

Equal number of cations and equal number of anions missing from lattice.

35. The edge length of rock salt type unit cell is 508 pm. If the radius of the cation is 110 pm, the radius of the anion assuming NaCl type structure is

(1) 144 pm (2) 398 pm

(3) 288 pm (4) 618 pm

Sol. Answer (1)

$(r^+ + r^-) = \frac{a}{2}$ = interionic distance for f.c.c.

$110 + r^- = \frac{508}{2}$

$r^- = 254 - 110 = 144$ pm

36. The second order Bragg diffraction of X-rays with λ = 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

(1) 2.00 Å
(2) 1.00 Å
(3) 0.575 Å
(4) 1.15 Å

Sol. Answer (4)

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

$2 \times 1 = 2 \times d\sin 60°$

$n = 2 \rightarrow$ second order
$\theta = 60°,\ \lambda = 1$ Å (given)

$\therefore \quad \sin 60° = \frac{\sqrt{3}}{2}$

$\therefore$ d = 1.15 Å

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

(1) CsI
(2) CsF
(3) LiF
(4) LiI

Sol. Answer (1)

$Cs^+ \rightarrow$ largest cation and I^- largest anion among their group. So, distance between them is also very high.

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

(1) AB
(2) AB_3
(3) A_2B_2
(4) A_2B_3

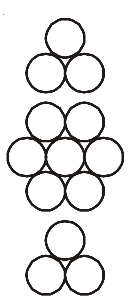
Sol. Answer (2)

$$\left.\begin{array}{l} A \rightarrow \text{corners} = 8 \times \underset{\text{(Contribution)}}{\frac{1}{8}} = 1 \\ B \rightarrow 6 \times \frac{1}{2}(\text{face}) \Rightarrow 3 \end{array}\right\} AB_3$$

39. Coordination number in ABAB... type arrangement is

(1) 6
(2) 8
(3) 12
(4) 4

Sol. Answer (3)



C.N. = 12

40 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 kgm^{-3}. The fraction of unoccupied sites in sodium chloride crystal is

(1) 5.96
(2) 5.96×10^{-2}
(3) 5.96×10^{-1}
(4) 5.96×10^{-3}

Sol. Answer (4)

Unoccupied sites = X-ray density – pyknometric density

$= 2.178 \times 10^3 - 2.165 \times 10^3$

$= 0.013 \times 10^3$

$$\% \text{ of unoccupied sites} = \frac{0.013\times10^3}{\text{X-ray density}} = \frac{0.013\times10^3}{2.178\times10^3}$$

$= 5.96 \times 10^{-3}$

41. A compound formed by elements X and Y crystallizes 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

(1) XY_3

(2) X_3Y

(3) XY

(4) XY_2

Sol. Answer (1)

$$\left.\begin{array}{l} X \rightarrow \text{ corners } = \underset{\text{(Contribution)}}{8 \times \frac{1}{8}} = 1 \\ Y \rightarrow \text{face centre} = 6\times\frac{1}{2}(\text{Contribution}) = 3 \end{array}\right\} XY_3$$

42. In a face-centered cubic lattice, a unit cell is shared equally by how many unit cells?

(1) 2

(2) 4

(3) 6

(4) 8

Sol. Answer (3)

FACT

SECTION - C

Assertion-Reason Type Questions

1. A : In NaCl structure, the interionic distance is a/2. (a = Unit cell edge length)

R : NaCl forms face centered cubic unit cell.

Sol. Answer (2)

In NaCl

$$r^+ + r^- = \frac{a}{2} \rightarrow \text{True}$$

F.C.C. $\rightarrow$ true

But (R) is not explanation of Assertion.

2. A : The co-ordination number of Ca F_2 is 8 : 4.

R : Ca^{2+} ions occupy ccp lattice while F^- ions occupy 50% octahedral voids and 50% tetrahedral voids.

Sol. Answer (3)

(i) C.N. of CaF_2 is 8 : 4 $\rightarrow$ true

(ii) Ca^{2+} occupy ccp lattice while F^- ions occupy all tetrahedral holes not 50% O.V. and 50% T.V. i.e., reason is wrong.

3. A : The number of spheres are equal to the number of octahedral void as well as tetrahedral void.

R : Octahedral void and tetrahedral void has equal size.

Sol. Answer (4)

(i) Number of spheres = number of O.V.

Number of T.V. = 2 × number of sphere

(ii) Octahedral and tetrahedral voids does not have equal size.

So, (A) & (R) are wrong

4. A : In Schottky defect, density of crystal decreases.

R : Equal number of cations and anions are missing in Schottky defect.

Sol. Answer (1)

In Schottky defect density decreases because equal number of cations and equal number of anions are missing i.e., A & R $\rightarrow$ true and correct explanation.

5. A : If a tetrad axis is passed through the unit cell of NaCl and all ions are removed which are touching to tetrad axis then the formula of NaCl becomes Na_3Cl_4.

R : Only one Na^+ is removed not the Cl^-.

Sol. Answer (4)

If tetrad axis are passed through the unit cell of NaCl two Cl^- ions and one Na^+ will be removed. Formula unit will be

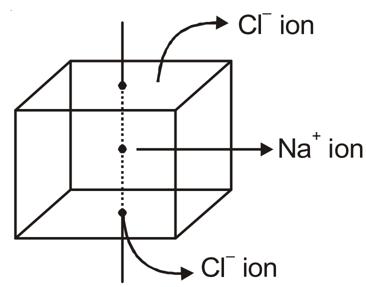
$Cl^- = 8\times\frac{1}{8}+\frac{1}{2}\times 4 = 3$

$Na^+ = \frac{1}{4}\times 12 = 3$

i.e., Na_3Cl_3

NaCl

Both statements are wrong.



6. A : A particle at the corner of CCP unit cell has $\frac{1}{8}$th of its contribution to the unit cell.

R : In any space lattice, the corner of the unit cell is always shared by the eight unit cell.

Sol. Answer (3)

Assertion is true but reason is wrong because unit cell is always shared by eight unit cell only for cubic crystal not for all space lattice.

7. A : Glass belongs to the category of covalent network solid.

R : Unit cell of glass is hexagonal.

Sol. Answer (4)

Glass belongs to amorphous solid not have an unit cell, so both A & R are wrong.

8. A : NaCl shows Schottky defect at room temperature.

R : NaCl shows 'F centre' at high temperature.

Sol. Answer (2)

Both are true but not correct explanation.

9. A : Fe_3O_4 is ferrimagnetic at room temperature but becomes paramagnetic at 850 K.

R : The magnetic moment in Fe_3O_4 are aligned equally in parallel and antiparallel directions which on heating randomise.

Sol. Answer (3)

A is true but R is wrong because in ferrimagnetic magnetic moment are aligned inequally.

10. A : In molecular solids the lattice points are occupied by the atoms or molecules.

R : Molecular solids are generally sublime.

Sol. Answer (2)

Both are true but not correct explanation.

11. A : Silicon is insulator at 0 K but semiconductor at room temperature.

R : Conductivity of silicon at room temperature is due to electronic defect.

Sol. Answer (1)

Silicon is semiconductor $\rightarrow$ true.

at room temperature due to electronic defect (doping).

12. A : Amorphous solids are isotropic.

R : Amorphous solids are not rigid.

Sol. Answer (2)

Not explanation.

13. A : In NaCl coordination number of Cl^- ion is 6 but in CsCl coordination number of Cl^- ion is 8.

R : Ionic radii changes with type of lattice.

Sol. Answer (3)

In NaCl C.N. = 6, CsCl = 8

and ionic radii is not change with type of lattice.

14. A : All crystals of same substance possess the same elements of symmetry.

R : The size of crystal of same substance may vary depending upon the conditions of crystallisation.

Sol. Answer (2)

Both are true but not correct explanation.

15. A : AgBr shows both Schottky and Frenkel defect.

R : AgBr is a crystalline solid.

Sol. Answer (2)

AgBr shows both Schottky and Frenkel defects it is a crystalline solid.

16. A : Number of carbon atoms per unit cell in diamond is 8.

R : The structure of diamond is similar to ZnS.

Sol. Answer (1)

Diamond shows C.N. = 8 it has ZnS type structure.

17. A : The coordination number of ionic compound depends upon radius ratio.

R : Higher the coordination number higher will be stability.

Sol. Answer (2)

C.N. of ionic compounds depends upon radius ratio, more the radius ratio, more will be C.N. and higher will be stability.

18. A : Number of rectangular plane in a cubic crystal is 3.

R : Rectangular planes passes through corner to corner of unit cell.

Sol. Answer (3)

Total rectangular planes are 3 and rectangular plane passes through opposite face.

19. A : ccp is more efficient than hcp.

R : Packing fraction is different in both cases.

Sol. Answer (4)

CCP and HCP both have same packing efficiency.

20. A : Coordination number of both Na^+ and Cl^- in NaCl is 6.

R : Second coordination number of Cl^- in the NaCl unit is 12.

Sol. Answer (2)

A & R both are correct but not correct explanation.

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