Chapter

15

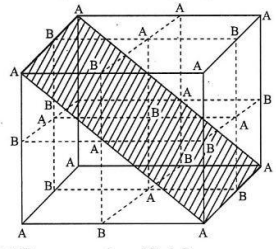
Solid State

Single Correct Option Type Questions

Q.1 In an atomic bcc, what fraction of edge is not covered by atoms ?

(A) 0.32 (B) 0.16 (C) 0.134 (D) 0.268

Q.2 A crystal is made of particles A and B. A form fcc packing and B occupies all the octahedral voids. If all the particles along the plane as shown in figure are removed, then, the formula of the crystal would be -



(A) AB (B) A_5B_7 (C) A_7B_5 (D) none of these

Q.3 Which is incorrect statement?

(A) Colourless crystal like NaCl appear to coloured due to F-centre

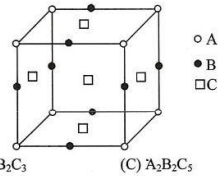
(B) In Frenkel defect, density of crystal remains constant

(C) In Pyroelectricity electric current produce when a crystal is subjected to mechanical stress

(D) Above curie temperature ferromagnetism disappear in Fe.

Q.4 Given : The unit cell structure of compound is shown below:

The formula of compound is:



(A) $A_8B_{12}C_5$ (B) AB_2C_3 (C) $A_2B_2C_5$ (D) ABC_5

Q.5 Ferrous oxide has a cubic structure and edge length of the unit cell is 5.0 Å. Assuming the density of ferrous oxide to be 3.84 g/cm^3, the no. of Fe^{2+} and O^{2-} ions present in each unit cell be : (use $N_A = 6 \times 10^{23}$):

(A) 4 Fe^{2+} and 4O^{2-} (B) 2Fe^{2+} and 2O^{2-} (C) 1 Fe^{2+} and 1O^{2-} (D) 3 Fe^{2+} and 4O^{2-}

Q.6 Select right expression for determining Packing fraction (P.F.) of NaCl unit cell (assume ideal), if ions along an edge diagonal are absent:

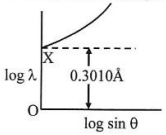
(A) $\text{P.F.} = \dfrac{\frac{4}{3}\pi(r_+^3 + r_-^3)}{16\sqrt{2}r_-^3}$

(B) $\text{P.F.} = \dfrac{\frac{4}{3}\pi\left(\frac{5}{3}r_+^3 + 4r_-^3\right)}{16\sqrt{2}r_-^3}$

(C) $\text{P.F.} = \dfrac{\frac{4}{3}\pi\left(\frac{5}{2}r_+^3 + r_-^3\right)}{16\sqrt{2}r_-^3}$

(D) $\text{P.F.} = \dfrac{\frac{4}{3}\pi\left(\frac{7}{2}r_+^3 + r_-^3\right)}{16\sqrt{2}r_-^3}$

Q.7 For a second order diffraction using X-ray Bragg's equation, for a crystal with separation between two layers as d Å, following graphical study was observed when varying θ at different λ.



What is the value of d?

(A) 0.3010 Å (B) 0.6020 Å (C) 2.0 Å (D) 4.0 Å

Q.8 LiCl has NaCl type structure with edge length 514 pm. Assuming that the Li^+ ion is small enough that the chloride ions are in contact, then radius of Cl^- ion is :

(A) 257 pm (B) 182 pm (C) 364 pm (D) 223 pm

Q.9 In a crystalline solid, atoms of X form fcc packing and the atoms of Y occupy all octahedral voids. If all the atoms along one body diagonal are removed then the simplest formula of the crystalline solid will be -

(A) XY (B) X_4Y_3 (C) X_5Y_4 (D) X_4Y_5

Q.10 Which of the following statement is correct?

(A) A metal that crystallizes in bcc structure has a co-ordination number of 12

(B) $MgAl_2O_4$ is known as spinel and Mg^{2+} ion occupies $\frac{1}{8}$th of tetrahedral void

(C) For bcc lattice, radius of metal atom = $\dfrac{\sqrt{3}a}{2}$

(D) None of the above

Q.11 Which of the following statement for crystal having Frenkel defect is not correct ?

(A) Frenkel defects are observed where the do difference in sizes of cations and anions is large.

(B) The density of crystals having Frenkel defect is less than that of a pure perfect crystal.

(C) Anionic crystal having Frenkel defect may also contains Schottky defect.

(D) Usually alkali halides do not have Frenkel defect.

Q.12 The packing efficiency of the two dimensional square unit cell shown below is

(A) 39.27% (B) 68.02% (C) 74.05% (D) 78.54%

Q.13 A compound AB has rock salt structure where A is fcc packed and B is at edge centre and at centre of unit cell. The edge length is 115 pm. The distance between two nearest atoms of A is :

(A) 57.5 pm (B) 81.3 pm (C) 40.6 pm (D) 89 pm

Q.14 Which of the following statement is wrong ?

(A) The co-ordination number of each type of ion in CsCl crystal is 8.

(B) A metal that crystallizes in bcc structure has a coordination number of 12.

(C) A unit cell of an ionic crystal shares some of its ion with other unit cells.

(D) The length of the unit cell in NaCl is 552 pm ($r_{Na^+} = 95\,pm$, $r_{Cl^-} = 181\,pm$)

Q.15 A compound is composed of X, Y and Z. X & Y constitute CCP lattice and Z occupy half of the tetrahedral voids and X occupy corners of unit cell. If all the atoms from any axis of every unit cell, passing along body diagonal are missing then what is the formula of the compound ?

(A) XY_4Z_4 (B) XY_3Z_3 (C) XY_2Z_2 (D) XY_3Z_4

Q.16 A compound XY crystallize in BCC lattice with unit cell edge length of 480 pm. If the radius of Y^- is 225 pm. Then radius of X^+ is :

(A) 127.5 pm (B) 225 pm (C) 190.70 pm (D) None of these

Statement Based Questions

Q. 17 **Statement-1:** For fluorite structure, the F^- ions occupy tetrahedral void and Ca^{2+} ions in ccp.
Statement-2: The radius ratio of fluorite structure is 0.414.

(A) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1.

(C) Statement-1 is True, Statement-2 is False.

(D) Statement-1 is False, Statement-2 is True.

Q. 18 **Statement-1:** Antiferromagnetic substances become paramagnetic on heating to high temperature.
Statement-2: Heating result in spins of electrons becoming random.

(A) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1.

(C) Statement-1 is True, Statement-2 is False.

(D) Statement-1 is False, Statement-2 is True.

Q. 19 **Statement-1:** Electrical conductivity of semi-conductors increases with increasing temperature.
Statement-2: With increase in temperature, number of electrons from the valence bond can jump to the conduction band in semi-conductors.

(A) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1.

(C) Statement-1 is True, Statement-2 is False.

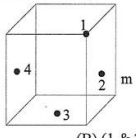
(D) Statement-1 is False, Statement-2 is True.

Multiple Correct Option Type Questions

Q.20 Select the correct statement (s) :
(A) Co-ordination no. of Cs^+ and Cl^- are 8, 8 in CsCl crystal
(B) If radius ratio (r_c / r_a) < 0.225 then shape of compound must be linear
(C) If radius ratio (r_c / r_a) is lie between 0.0414 to 0.732 then shape of ionic compound may be square planer (Ex. $PtCl_4^{2-}$)
(D) If radius ratio is less than 0.155 then shape of compound is linear

Q.21 Select the correct statement (s) -
(A) The ionic crystal of AgBr has Schottky defect
(B) The unit cell having crystal parameters, $\alpha = b \neq c$, $\alpha = \beta = 90°$, $\gamma = 120°$ is hexagonal
(C) In ionic compounds having Frenkel defect the ratio r^+ / r^- is high
(D) The co-ordination number of Na^+ ion in NaCl is 6

Q.22 In a F.C.C. unit cell, atoms are numbered as shown below. Identify the pair in which distance between the atoms is same. [Atoms, 2, 3, 4 are present face centre].



(A) (1 & 4) and (1 & 3) (B) (1 & 2) and (4 & 3)
(C) (1 & 2) and (1 & 4) (D) (1 & 2) and (2 & 3)

Q.23 The HCP and CCP structure for a given element would be expected to
(A) The same co-ordination number
(B) The same volume of unit cell
(C) The same packing fraction
(D) The same effective number of atoms per unit cell

Q.24 In which of following solids, cation occupy tetrahedral voids -
(A) NaCl (B) CsBr (C) ZnS (D) Na_2O

Q.25 The co-ordination number of FCC structure for metals is 12, since -
(A) each atom touches 4 others in same layer, 3 in layer above and 3 in layer below
(B) each atom touches 4 others in same layer, 4 in layer above and 4 in layer below
(C) each atom touches 6 others in same layer, 3 in layer above and 3 in layer below
(D) each atom touches 3 others in same layer, 6 in layer above and 6 in layer below

Q.26 Select write statement(s)
(A) 8 Cs^+ ions occupy the second nearest neighbour locations of a Cs^+ ion
(B) Each sphere is surrounded by six voids in two dimensional hexagonal close packed layer
(C) If the radius of cations and anions are 0.3 Å and 0.4 Å then coordination number of cation in the crystal is 6
(D) In AgCl, the silver ion is displaced from its lattice position to an interstitial position such a defect is called a frenkel defect

Q.27 Which of the following statements are correct:
(A) The coordination number of each type of ion in CsCl is 8.
(B) A metal that crystallizes in **BCC** structure has a coordination number 12
(C) A unit cell of an ionic crystal shares some of its ions with other unit cells
(D) The length of the unit cell in NaCl is 552 pm. [r_{Na^+} = 95 pm ; r_{Cl^-} = 181 pm]

Passage Based Questions

Passage # 1 (Ques. 28 – 30)

Doping means introduction of small amount of impurities like phosphorus, arsenic or boron into the pure crystal. In pure silicon, there are four valencies used in bonding with other four adjacent silicon atoms. When a silicon crystal is doped with a group-15 element (with five valence electrons) such as P, As, or Bi, the structure of the crystal lattice remains unchanged. Out of the five valence electrons of group-15 doped element, four electrons are used in normal covalent bonding with silicon while fifth electron is delocalised and thus conducts electricity. Doping a silicon crystal with a group-13 element (with three valence electrons) such as B, Al, Ga or In products a semiconductor with three electrons in dopant. The place where fourth electron is missing is called an electron vacancy or hole. Such hole can move through the crystal like a positive charge giving rise of electricity.

Q.28 No. of valence electrons in silicon are -
(A) 3 (B) 4 (C) 5 (D) 6

Q.29 Silicon that has been doped with group-15 elements is called -
(A) p-type semiconductor (B) n-type semiconductor
(C) electron vacancy or hole (D) none of these

Q.30 Silicon that has been doped with group-13 elements is called -
(A) p-type semiconductor (B) n-type semiconductor
(C) electron vacancy or hole (D) none of these

Passage # 2 (Ques. 31 – 33)

Spinel is a mineral $MgAl_2O_4$ having general formula $MM^{\epsilon}{}_2O_4$, where divalent ions are occupied in tetrahedral voids and trivalent ions in octahedral voids and lattice is make up of oxide ion present in CCP arrangement. Only 1/8 of tetrahedral and 1/2 of octahedral void are occupied. (Assume ideal arrangement of particles)

Q.31 The packing fraction of $MgAl_2O_4$ unit cell is
(A) 0.768 (B) 0.786 (C) 0.74 (D) 0.68

Q.32 The % of Mg in $MgAl_2O_4$ is
(A) 16.9% (B) 38% (C) 12.5% (D) None of these

Q.33 If 50% octahedral voids occupied by Al^{+3} and 12.5% tetrahedral void occupied by Mg^{+2}, then formula of compound is
(A) $MgAl_2O_4$ (B) $Mg_4Al_3O_4$ (C) $Mg_2Al_2O_5$ (D) None of these

Column Matching Type Questions

Q.34

Column I	Column II (Types of bravais lattice)
(A) Rhombohedral	(P) Primitive only
(B) Orthorhombic	(Q) Primitive and body centred only
(C) Tetragonal	(R) Primitive and end centred only
(D) Hexagonal	(S) Primitive, body centred, end centred and face centred

Numeric Response Type Questions

Q.35 If edge fraction unoccupied in ideal anti-fluorite structure is x. Calculate the value of Z. Where $Z = \frac{x}{0.097}$

Q.36 Ionic acid Na^+A^- crystallise in rock salt type structure. 2.592 gm of ionic solid salt NaA dissolved in water to make 2 litre solution. The pH of this solution is 8. If distance between cation and anion is 300 pm. Calculate density of ionic solid (in gm/cm^3).
(Given: $pK_w = 13$, pK_a (HA) = 5, $N_A = 6 \times 10^{23}$)

Q.37 Calculate the value of $\frac{Z}{10}$. Where

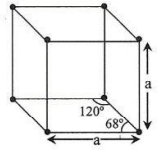
Z = Co-ordination number of 2D-square close packing
+
Co-ordination number of 2D-hcp
+
Co-ordination number of 3D-square close packing
+
Co-ordination number of 3D, ABCABC ..... packing
+
Co-ordination number of 3D, ABAB ..... packing

Q.38 Assume KBr, Li_2O, Zinc blende, Fe_2O_3, CaF_2, NaCl – all have perfect undistorted structures (exact fitting). How many above given compounds have void fraction greater than 0.3 ?

Q.39 How many square faces are there in truncated octahedron?

Q.40 The figure given below show the location of atoms in three crystallographic planes in FCC lattice. Draw the unit cell for the corresponding structure and identify these planes in your diagram

Q.41 Ice crystallizes in a hexagonal lattice. At the low temperature at which the structure was determined, the lattice constants were a = 4.53 Å, and b = 7.60 Å (see figure). How many molecules are contained in a given unit cell ? [density of ice = 0.92 gm/cm^3]



Q.42 A compound formed by elements X & Y, Crystallizes in a cubic structure, where X is at the corners of the cube and Y is at six face centers. What is the formula of the compound ? If side length is 5Å, estimate the density of the solid assuming atomic weight of X and Y are 60 and 90 respectively.

Q.43 The mineral hawleyite, one form of CdS crystallizes in one of the cubic lattices, with edge length 5.87Å. The density of hawleyite is 4.63 g cm^{-3}.
(i) In which cubic lattice does hawleyite crystallize ?
(ii) Find the Schottky defect in g cm^{-3}

Q.44 Diamond structure can be considered as ZnS (Zinc blende) structure in which each Zn^{2+} in alternate tetrahedral void and S^{2-} in cubic closed pack arrangement is replaced by one carbon atom. If C – C covalent bond length in diamond is 1.5Å, what is the edge length of diamond unit cell (z = 8)

Q.45 In zinc blende structure, if Zn^{+2} is introduced in all vacant tetrahedral void. Calculate the co-ordination number of S^{-2} in new structure.

Q.46 Calculate distance (in Å) between A^{+2} and B^- having Fluorite structure. Given edge length of unit cell is 4.62 Å.

Q.47 Compound AB_2 have antifluorite structure. Calculate sum of minimum distance and maximum distance between cation (in Å). Given edge length of unit cell = 2.93 Å

Q.48 A molecule X_2Y (molecular weight = 166.4) occupies orthorhombic lattice with a = 5Å, b = 8Å and c = 4Å. If density of X_2Y is 5.2 gm cm^{-3}. Calculate number of molecules present in one unit cell ($N_A = 6 \times 10^{23}$).

Q.49 In Inverse spinel structure (Fe_3O_4 type) O^{-2} form FCC lattice, Fe^{2+} ions occupy 1/8 of the tetrahedral voids and trivalent cation occupies 1/8 of the tetrahedral voids and 1/4 of the octahedral voids. Calculate the value of Z.
Where $Z = \frac{\text{Packing fraction}}{0.384}$. Given: $r_{Fe^{+2}} = 0.225\ r_{O^{-2}}$; $r_{Fe^{+3}} = 0.414\ r_{O^{-2}}$

ANSWER KEY

Single Correct Option type Questions

1. (C) **2.** (A) **3.** (C) **4.** (B) **5.** (B) **6.** (B) **7.** (C)
8. (B) **9.** (C) **10.** (B) **11.** (B) **12.** (D) **13.** (B) **14.** (B)
15. (A) **16.** (C)

Statement Based Questions

17. (C) **18.** (A) **19.** (A)

Multiple Correct Option type Questions

20. (A,C,D) **21.** (A,B,C) **22.** (A,B,D) **23.** (A,C) **24.** (C,D) **25.** (B,C) **26.** (B,D)
27. (A,C,D)

Passage Based Questions

28. (B) **29.** (B) **30.** (A) **31.** (A) **32.** (A) **33.** (A)

Column Matching Type Questions

34. [A → P; B → S; C → Q; D → P]

Numerical Response Type Questions

35. (3) **36.** (4) **37.** (4) **38.** (0) **39.** (6)
40. (i) Face plane, (ii) Face diagonal plane, (iii) diagonal plane **41.** 4 molecules of H_2O
42. XY_3, 4.38 g/cm^3 **43.** (i) 3.90, (ii) 0.120 g/cc **44.** 3.46 Å **45.** 8 **46.** 2
47. 4 **48.**3 **49.** 2