THE SOLID STATE

IMPORTANT FORMULAE

1. Density of unit cell (d) = $\dfrac{\text{Mass of unit cell}}{\text{Volume of unit cell}} = \dfrac{z \times M}{a^3 \times N_A}$

2. **Table 1.1: Different Parameters of Cubic System**

Unit cell	No. of atoms per unit cell	Distance between nearest neighbour (d)	C.N.	Radius (r)
Simple cubic	1	a	6	$\dfrac{a}{2}$
Face-centred cubic	4	$\dfrac{a}{\sqrt{2}}$	12	$\dfrac{a}{2\sqrt{2}}$
Body-centred cubic	2	$\dfrac{\sqrt{3}}{2}a$	8	$\dfrac{\sqrt{3}}{4}a$

3. Packing efficiency = $\dfrac{\text{Volume occupied by atoms in unit cell } (v)}{\text{Total volume of the unit cell } (V)} \times 100$

Table 1.2: Packing efficiency of different crystals

S.No.	Crystal system	Packing efficiency
(*i*)	Simple cubic	52.4%
(*ii*)	Body-centred cubic	68%
(*iii*)	Face-centred cubic	74%
(*iv*)	Hexagonal close-packed	74%

4. Radius ratio = $\dfrac{\text{Radius of the cation}}{\text{Radius of the anion}} = \dfrac{r^+}{r^-}$

Table 1.3: Structural arrangement of different radius ratios of ionic solids

Radius ratio (r^+/r^-)	Possible coordination number	Structural arrangement	Examples
0.155 – 0.225	3	Trigonal planar	B_2O_3
0.225 – 0.414	4	Tetrahedral	ZnS, SiO_4^{4-}
0.414 – 0.732	6	Octahedral	NaCl
0.732 – 1.0	8	Body-centred cubic	CsCl

5. If R is the radius of the spheres in the close packed arrangement, then

(*i*) Radius of octahedral void, $r = 0.414\ R$

(*ii*) Radius of tetrahedral void, $r = 0.225\ R$

6. In a close packed arrangement:

(*i*) Number of octahedral voids = Number of atoms present in the close packed arrangement.

(*ii*) Number of tetrahedral voids = 2 × Number of atoms present in the close packed arrangement.

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. Which of the following conditions favours the existence of a substance in the solid state? [*NCERT Exemplar*]

(*a*) High temperature (*b*) Low temperature
(*c*) High thermal energy (*d*) Weak cohesive forces

2. Which of the following is not a characteristic of a crystalline solid? [*NCERT Exemplar*]

(*a*) Definite and characteristic heat of fusion.
(*b*) Isotropic nature.
(*c*) A regular periodically repeated pattern of arrangement of constituent particles in the entire crystal.
(*d*) A true solid

3. Which of the following is true about the value of refractive index of quartz glass? [*NCERT Exemplar*]

(*a*) Same in all directions (*b*) Different in different directions
(*c*) Cannot be measured (*d*) Always zero

4. Which of the following statement is not true about amorphous solids? [*NCERT Exemplar*]

(*a*) On heating they may become crystalline at certain temperature.
(*b*) They may become crystalline on keeping for long time.
(*c*) Amorphous solids can be moulded by heating.
(*d*) They are anisotropic in nature.

5. The sharp melting point of crystalline solids is due to __________. [*NCERT Exemplar*]

(*a*) a regular arrangement of constituent particles observed over a short distance in the crystal lattice.
(*b*) a regular arrangement of constituent particles observed over a long distance in the crystal lattice.
(*c*) same arrangement of constituent particles in different directions.
(*d*) different arrangement of constituent particles in different directions.

6. Which one of the following is a covalent crystal?

(*a*) Rock salt (*b*) Ice (*c*) Quartz (*d*) Dry ice

7. Which of the following solids is not an electrical conductor?

(*i*) Mg(*s*) **(*ii*) TiO(*s*)**
(*iii*) I_2(*s*) **(*iv*) H_2O(*s*)**

(*a*) (*i*) only (*b*) (*ii*) only (*c*) (*iii*) and (*iv*) (*d*) (*ii*), (*iii*) and (*iv*)

8. The number of atoms in a face centred cubic unit cell is

(*a*) 2 (*b*) 4 (*c*) 5 (*d*) 6

9. In a face centred cubic lattice, atom A occupies the corner positions and atom B occupies the face centre positions. If one atom of B is missing from one of the face centred points, the formula of the compound is:

(*a*) AB_2 (*b*) A_2B_3 (*c*) A_2B_5 (*d*) A_2B

10. The total number of tetrahedral voids in the face centred unit cell is __________.

(*a*) 6 (*b*) 8 (*c*) 10 (*d*) 12

11. If Z is the number of atoms in the unit cell that represents the closest packing sequence—ABC ABC, the number of tetrahedral voids in the unit cell is equal to

(*a*) Z (*b*) 2Z (*c*) $\frac{Z}{2}$ (*d*) $\frac{Z}{4}$

12. In which pair most efficient packing is present?

(*a*) *hcp* and *bcc* (*b*) *hcp* and *ccp*

(*c*) *bcc* and *ccp* (*d*) *bcc* and simple cubic cell

13. The fraction of the total volume occupied by the atoms present in a simple cube is

(*a*) $\pi/4$ (*b*) $\pi/6$ (*c*) $\pi/(3\sqrt{2})$ (*d*) $\pi/(4\sqrt{2})$

14. A metallic crystal has the *bcc* type staking pattern. What percentage of volume of this lattice is empty space?

(*a*) 68% (*b*) 32% (*c*) 26% (*d*) 74%

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

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

16. 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*) 250 pm (*b*) 200 pm (*c*) 300 pm (*d*) 335 pm

17. If a stands for the edge length of the cubic systems: simple cubic, body centred cubic and face centred cubic, then the ratio of the radius of the spheres in these systems will be respectively

(*a*) $\frac{1}{2}a:\frac{\sqrt{3}}{4}a:\frac{1}{2\sqrt{2}}a$ (*b*) $\frac{1}{2}a:\sqrt{3}\,a:\frac{1}{\sqrt{2}}a$ (*c*) $\frac{1}{2}a:\frac{\sqrt{3}}{2}a:\frac{\sqrt{2}}{2}a$ (*d*) $1a:3a:\sqrt{2a}$

18. Which of the following crystals does not exhibit Frenkel defect?

(*a*) AgBr (*b*) AgCl (*c*) KBr (*d*) ZnS

19. The type of crystal defect is indicated in the diagram below

Na^+	Cl^-	Na^+	Cl^-	Na^+	Cl^-
Cl^-	◯	Cl^-	Na^+	◯	Na^+
Na^+	Cl^-	◯	Cl^-	Na^+	Cl^-
Cl^-	Na^+	Cl^-	Na^+	◯	Na^+

(*a*) Frenkel defect (*b*) Frenkel and Schottky defect

(*c*) Interstitial defect (*d*) Schottky defect

20. Which of the following is true about the charge acquired by *p*-type semiconductors?

(*a*) Positive (*b*) Neutral

(*c*) Negative (*d*) Depends on concentration of *p* impurity

21. Which among the following shows anisotropy?

(*a*) Wood (*b*) Sugar (*c*) Glass (*d*) Sodium chloride

22. In *hcp* arrangement, the coordination number of each atom is

(*a*) 4 (*b*) 6 (*c*) 8 (*d*) 12

23. The number of tetrahedral voids in a unit cell of *ccp* structure

(*a*) 4 (*b*) 6 (*c*) 8 (*d*) 10

24. The arrangement ABCABC... refers to

(*a*) Hexagonal close packing (*b*) Tetrahedral close packing

(*c*) Cubic close packing (*d*) Octahedral close packing

25. Which one of the following is an amorphous solid?

(*a*) Diamond (*b*) Graphite (*c*) Common salt (*d*) Glass

26. Which of the following is not the property of crystalline solids?

(*a*) Isotropy (*b*) Sharp melting point

(*c*) Strong intermolecular forces (*d*) A definite and regular geometry

27. In a *ccp* arrangement of spheres in three dimensions, the coordination number of each sphere is

(*a*) 3 (*b*) 6 (*c*) 9 (*d*) 12

28. The contribution of an atom at the edge centre of a unit cell is

(*a*) $\frac{1}{8}$ (*b*) $\frac{1}{4}$ (*c*) $\frac{1}{2}$ (*d*) 1

29. The closest packing sequence ABAB... represents

(*a*) primitive cubic packing (*b*) hexagonal packing

(*c*) *fcc* packing (*d*) *bcc* packing

30. The radius of an octahedral void relative to the radius of the spheres in a close packing is

(*a*) 1·414 (*b*) 0·225 (*c*) 0·414 (*d*) 1·225

31. For tetrahedral arrangement, the radius ratio r^+/r^- is

(*a*) 0.732 – 1.0 (*b*) 0.225 – 0.414 (*c*) 0.414 – 0.732 (*d*) 0.155 – 0.225

32. Which one of the following is a covalent solid?

(*a*) Fe (*b*) Diamond (*c*) Cu (*d*) NaCl

33. Which one of the following solids is very soft in nature?

(*a*) Ionic solid (*b*) Covalent solid (*c*) Metallic solid (*d*) Molecular solid

34. The existence of a substance in more than one solid modification is known as

(*a*) isomorphism (*b*) polymorphism (*c*) amorphism (*d*) none of these

35. Which of the following compounds is not isotropic in nature?

(*a*) Rubber (*b*) Glass (*c*) PVC (*d*) Diamond

36. Which type of semiconductor is developed by mixing As to Si?

(*a*) *n*-type (*b*) *p*-type (*c*) intrinsic (*d*) $n-p$ type

37. Which of the following substance will be capable of conducting current in the solid state?

(*a*) Diamond (*b*) Graphite (*c*) Carborundum (*d*) NaCl

38. The type of force that hold iodine molecules in its crystal are

(*a*) London force (*b*) dipole-dipole interaction

(*c*) Coulombic force (*d*) Covalent bond

39. Bravais lattices are of

(*a*) 7 types (*b*) 10 types (*c*) 17 types (*d*) 14 types

40. When NaCl crystal is doped with $MgCl_2$, the nature of defect produced is

(*a*) Interstitial (*b*) Schottky (*c*) Frenkel (*d*) Impurity

41. Which of the following is a pseudo solid?

(*a*) CaF_2 (*b*) Glass (*c*) NaCl (*d*) All of the above

42. The number of NaCl molecules in the unit cell of the crystal is

(*a*) 2 (*b*) 4 (*c*) 6 (*d*) 8

43. The presence of Frenkel defects in a crystal ________ its density.

(*a*) decreases. (*b*) increases.

(*c*) does not change. (*d*) either increase or decrease.

44. Number of particles in the unit cell of simple cube is

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

45. The total number of atoms per unit cell of a face centred Cubic crystal is

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

46. Lithium has a *bcc* structure. Its density is 530 kgm^{-3} and its atomic mass is 6.94 g mol^{-1}. The edge-length of a unit cell of ($N_A = 6.02 \times 10^{23}$ mol^{-1}) lithium metal is-

(*a*) 527 pm (*b*) 264 pm (*c*) 154 pm (*d*) 352 pm

47. 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

48. The correct statement regarding defects in crystalline solid 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 alkali metals.

(*d*) Schottky defects have no effect on the density of crystalline solids.

49. A given metal crystallises out with a cubic structure having edge length of 361 pm. If there are four metal atoms in one unit cell, then the radius of one atom is

(*a*) 80 pm (*b*) 108 pm (*c*) 40 pm (*d*) 128 pm

50. 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 (N_A Avagadro's constant = 6.02×10^{23} mol^{-1}) metal is

(*a*) 27 g mol^{-1} (*b*) 20 g mol^{-1} (*c*) 40 g mol^{-1} (*d*) 30 g mol^{-1}

51. 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

52. A metal crystallies with a face-centered 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

53. The number of octahedral voids per atom present in a cubic close-packed structure is

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

54. Lithium metal crytallises in a body-centered 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

55. Copper crystallises in a face-centered cubic lattice with a unit cell length of 334 pm. What is the radius of copper atom in pm?

(*a*) 157 (*b*) 181 (*c*) 108 (*d*) 118

56. 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

57. If NaCl is doped with 10^{-4} mol% of $SrCl_2$, the concentration of cation vacancies will be

(*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}

58. The fraction of total volume occupied by atoms present in a simple cube is

(*a*) $\frac{\pi}{3\sqrt{2}}$ (*b*) $\frac{\pi}{4\sqrt{2}}$ (*c*) $\frac{\pi}{4}$ (*d*) $\frac{\pi}{6}$

59. The appearance of colour in solid alkali metal halides in generally due to

(*a*) Interstitial positions (*b*) F-centres

(*c*) Schottky defect (*d*) Frenkel defect

60. CsBr crystallises in a body centered 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*) 8.50 g/cm^3 (*b*) 42.5 g/cm^3 (*c*) 0.425 g/cm^3 (*d*) 8.25 g/cm^3

61. 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

62. 'C' represents the height of the HCP unit cell and 'a' represent edge length of the hexagonal surface of the HCP unit cell. The value of $\frac{C}{a}$ is

(*a*) $\sqrt{\frac{2}{3}}$ (*b*) $\sqrt{\frac{8}{3}}$ (*c*) $\sqrt{\frac{6}{3}}$ (*d*) $\sqrt{\frac{7}{3}}$

63. With respect to graphite and diamond, which of the following statement given below is correct?

(*a*) Graphite is harder than diamond.

(*b*) Graphic has higher electrical conductivity than diamond.

(*c*) Graphite has higher thermal conductivity than diamond.

(*d*) Graphite has lower C—C bond order than diamond.

64. The INCORRECT statement for cubic close packed (*ccp*) three-dimensional structure is

(*a*) The number of neighbours of an atom present in the topmost layer is 12.

(*b*) The efficiency of the atom packing is 74%.

(*c*) The number of octahedral and tetrahedral voids per atom are 1 and 2 respectively.

(*d*) The unit cell edge length is $2\sqrt{2}$ times the radius of the atom.

65. KCl crystallises in the same type of lattice as does NaCl. Given that r_{Na^+}/r_{Cl^-} = 0.55 and r_{K^+}/r_{Cl^-} = 0.74. The ratio of the side of the unit cell of KCl to that of NaCl is

(*a*) 1.123 (*b*) 0.414 (*c*) 0.891 (*d*) 1.414

66. Experimentally it was found that a metal oxide has formula $M_{0.98}O$. Metal M is present as M^{2+} and M^{3+} in its oxide. Fraction of the metal which exists as M^{3+} would be

(*a*) 5.08% (*b*) 7.01% (*c*) 4.08% (*d*) 6.05%

67. The crystal with metal deficiency defect is

(*a*) NaCl (*b*) FeO (*c*) KCl (*d*) ZnO

68. A metal has a *fcc* lattice. The edge length of the unit cell is 540 pm. The density of the metal is 2.72 gcm^{-3}. The molar mass of the metal is

(N_A, Avogadro's constant = 6.02×10^{23} mol^{-1})

(*a*) 40 g mol^{-1} (*b*) 30 g mol^{-1} (*c*) 64 g mol^{-1} (*d*) 20 g mol^{-1}

69. CsCl crystallises in body-centered cubic lattice. If 'a' is its edge length then which of the following expressions is correct?

(*a*) $r_{Cs^+} + r_{Cl^-} = \sqrt{3}a$ (*b*) $r_{Cs^+} + r_{Cl^-} = 3a$ (*c*) $r_{Cs^+} + r_{Cl^-} = \frac{3a}{2}$ (*d*) $r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$

70. Sodium metal crystallizes in a body-centered cubic lattice with a unit cell edge of 4.29 Å. The radius of sodium metal is approximately

(*a*) 5.72 Å (*b*) 0.93 Å (*c*) 1.86 Å (*d*) 3.22 Å

71. A metal crystallises in a face centered cubic structure. If the edge length of the unit cell is 'a', the closest approach between the two atoms in the metallic crystal will be

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

72. Body centered cubic lattice has a co-ordination number of

(*a*) 8 (*b*) 12 (*c*) 6 (*d*) 4

73. The number of atoms in 100 g of an *fcc* crystal with density *d* = 10 gcm^{-3} and cell edge as 200 pm is equal to

(*a*) 3×10^{25} (*b*) 5×10^{24} (*c*) 1×10^{25} (*d*) 2×10^{25}

74. Ionic solids with Schottky defects contain in their structure

(*a*) equal number of cation and anion vacancies.

(*b*) interstitial anions and anion vacancies.

(*c*) cation vacancies only.

(*d*) cation vacancies and interstitial cations.

75. Which of the following describes the hexagonal close packed arrangement of spheres in 2-dimension structure?

(*a*) ABCABA (*b*) ABCABC (*c*) ABABA (*d*) ABBABB

76. The correct order of the packing efficiency in different types of unit cells is

(*a*) *fcc*<*bcc*<simple cubic (*b*) *fcc*>*bcc*>simple cubic

(*c*) *fcc*<*bcc*>simple cubic (*d*) *bcc*<*fcc*>simple cubic

77. Among solids, the highest melting point is exhibited by

(*a*) covalent solids (*b*) ionic solids

(*c*) pseudo solids (*d*) molecular solids

78. In a face centered cubic lattice, atom A occupies the corner positions and atom B occupies the face centered positions. If one atom of B is missing from one of the face-centered points, the formula of the compound is

(*a*) A_2B (*b*) AB_2 (*c*) A_2B_3 (*d*) A_2B_5

79. The number of unit cells that are present in a cube shaped ideal crystal of NaCl of mass 1.00 g is

(*a*) 2.57×10^{21} (*b*) 5.14×10^{21} (*c*) 1.28×10^{21} (*d*) 1.71×10^{21}

80. An ionic compound has a unit cell consisting of A ions at the corners of a cube and B ion on the centre of the body of the cube. The empirical formula for this compound would be

(*a*) A_3B (*b*) AB_3 (*c*) A_2B (*d*) AB

81. Total volume of atoms present in a face-centered cubic unit cell of a metal is
(*r* is atomic radius)

(*a*) $\frac{20}{3}\pi r^3$ (*b*) $\frac{24}{3}\pi r^3$ (*c*) $\frac{12}{3}\pi r^3$ (*d*) $\frac{16}{3}\pi r^3$

82. The number of unit cells that are divided equally in a face-centred cubic lattice will be

(*a*) 2 (*b*) 4 (*c*) 6 (*d*) 8

83. A crystalline solid:

(*a*) changes abruptly from solid to liquid when heated.

(*b*) has no definite melting point.

(*c*) undergoes deformation of its geometry easily.

(*d*) has irregular 3-dimensional arrangements.

84. In a simple cubic, body-centred cubic and face-centred cubic structure, the ratio of the number of atoms present is respectively

(*a*) 8 : 1 : 6 (*b*) 1 : 2 : 4 (*c*) 4 : 2 : 1 (*d*) 4 : 2 : 3

85. Na and Mg crystallize in crystals of *bcc* and *fcc* form respectively. The amount of Na and Mg atoms present in their respective crystal unit cells is

(*a*) 4 and 2 (*b*) 9 and 14 (*c*) 14 and 9 (*d*) 2 and 4

86. Ferrous oxide has a cubic structure and each unit cell edge is 5.0 Å. Assuming the oxide density is 4.0 g/cm^3, the amount of Fe^{2+} and O^{2-} ions in each unit cell will be

(*a*) four Fe^{2+} and four O^{2-} (*b*) two Fe^{2+} and four O^{2-}

(*c*) four Fe^{2+} and two O^{2-} (*d*) three Fe^{2+} and three O^{2-}

87. Each of the following solids shows the Frenkel defect except

(*a*) ZnS (*b*) AgBr (*c*) AgI (*d*) KCl

88. The total no. of voids in 0.5 mol of a compound forming hexagonal close-packed structure are

(*a*) 6.022×10^{23} (*b*) 3.011×10^{23} (*c*) 9.033×10^{23} (*d*) 4.516×10^{23}

89. 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_2A_3 (*b*) C_3A_2 (*c*) C_3A_4 (*d*) C_4A_3

90. A metal crystallises into two cubic faces namely face centered (*fcc*) and body centered (*bcc*), whose unit cell edge lengths are 3.5 Å and 3.0 Å respectively. The ratio of the densities of *fcc* and *bcc* will be

(*a*) 2.1 : 1 (*b*) 3.3 : 1 (*c*) 1.259 : 1 (*d*) 2.259 : 1

91. The total number of atoms present in *bcc* arrangement is

(*a*) 2 (*b*) 4 (*c*) 6 (*d*) 1

92. The number of octahedral voids in a unit cell of *ccp* structure is

(*a*) 2 (*b*) 3 (*c*) 4 (*d*) 6

93. The largest void is

(*a*) triangular (*b*) cubic (*c*) tetrahedral (*d*) octahedral

94. Close packing is maximum in the crystal lattice of

(*a*) *fcc* (*b*) *bcc* (*c*) simple cubic (*d*) none of these

95. The formula for determination of density of cubic unit cell is

(*a*) $\frac{a^3 N_0}{n \times M}$ (*b*) $\frac{n \times M}{N_0 \times a^3}$ (*c*) $\frac{n \times N_0}{a^3 \times M}$ (*d*) $\frac{a^3 \times M}{N_0 \times n}$

96. In a crystal composed of *n* spheres, the total number of tetrahedral voids are

(*a*) $n/2$ (*b*) n (*c*) $2n$ (*d*) $4n$

97. Which of the following is a molecular solid?

(*a*) Graphite (*b*) Dry ice (*c*) Sodium chloride (*d*) Fe

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

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

99. 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

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

Answers

1. (*b*)	**2.** (*b*)	**3.** (*a*)	**4.** (*d*)	**5.** (*b*)	**6.** (*c*)	**7.** (*c*)	**8.** (*b*)
9. (*c*)	**10.** (*b*)	**11.** (*b*)	**12.** (*b*)	**13.** (*b*)	**14.** (*b*)	**15.** (*c*)	**16.** (*d*)
17. (*a*)	**18.** (*c*)	**19.** (*d*)	**20.** (*b*)	**21.** (*d*)	**22.** (*d*)	**23.** (*c*)	**24.** (*c*)
25. (*d*)	**26.** (*a*)	**27.** (*d*)	**28.** (*b*)	**29.** (*b*)	**30.** (*c*)	**31.** (*b*)	**32.** (*b*)
33. (*d*)	**34.** (*b*)	**35.** (*d*)	**36.** (*a*)	**37.** (*b*)	**38.** (*a*)	**39.** (*d*)	**40.** (*d*)
41. (*b*)	**42.** (*b*)	**43.** (*c*)	**44.** (*a*)	**45.** (*d*)	**46.** (*d*)	**47.** (*c*)	**48.** (*b*)
49. (*d*)	**50.** (*a*)	**51.** (*d*)	**52.** (*a*)	**53.** (*a*)	**54.** (*a*)	**55.** (*d*)	**56.** (*b*)
57. (*b*)	**58.** (*d*)	**59.** (*b*)	**60.** (*a*)	**61.** (*a*)	**62.** (*b*)	**63.** (*b*)	**64.** (*a*)
65. (*a*)	**66.** (*c*)	**67.** (*b*)	**68.** (*c*)	**69.** (*d*)	**70.** (*c*)	**71.** (*b*)	**72.** (*a*)
73. (*b*)	**74.** (*a*)	**75.** (*c*)	**76.** (*b*)	**77.** (*b*)	**78.** (*d*)	**79.** (*a*)	**80.** (*d*)
81. (*d*)	**82.** (*c*)	**83.** (*a*)	**84.** (*b*)	**85.** (*d*)	**86.** (*a*)	**87.** (*d*)	**88.** (*c*)
89. (*c*)	**90.** (*c*)	**91.** (*a*)	**92.** (*c*)	**93.** (*b*)	**94.** (*a*)	**95.** (*b*)	**96.** (*c*)
97. (*b*)	**98.** (*c*)	**99.** (*d*)					

CASE-BASED QUESTIONS

1. Read the passage given below and answer the following questions:

Solid is that form of matter which possesses rigidity and hence a definite shape and a definite volume. If intermolecular forces are greater than thermal energy, substances exist as solid. Solids can be classified into two types: Crystalline solids and amorphous solids. Crystalline solids have regular arrangement of particles, definite geometric shapes, sharp melting points and definite heat of fusion. They are anisotropic and undergo clean cleavage. On the other hand, amorphous solids have no regular arrangement of particles, irregular shapes, melt over a range of temperature, no definite heat of fusion. They are isotropic and undergo irregular cleavage. Ionic solids, molecular solids, covalent solids and metallic solids are the types of crystalline solids.

The following questions are multiple choice questions. Choose the most appropriate answer:

(*i*) Solid A is very hard, electrical insulator in solid as well as molten state and melts at extremely high temperature. What type of solid is it?

(*a*) Ionic (*b*) Molecular (*c*) Covalent (*d*) Metallic

(*ii*) Which of the following is a crystalline solid?

(*a*) Glass (*b*) Sodium chloride (*c*) Rubber (*d*) Plastic

OR

The sharp melting point of crystalline solids is due to __________.

(*a*) a regular arrangement of constituent particles observed over a short distance in the crystal lattice.

(*b*) a regular arrangement of constituent particles observed over a long distance in the crystal lattice.

(*c*) same arrangement of constituent particles in different directions.

(*d*) different arrangement of constituent particles in different directions.

(*iii*) Which of the following is not a characteristic of a crystalline solid?

(*a*) Definite and characteristic heat of fusion.

(*b*) Isotropic nature.

(*c*) A regular periodically repeated pattern of arrangement of constituent particles in the entire crystal.

(*d*) A true solid

(*iv*) Which of the following is true about the value of refractive index of quartz glass?

(*a*) Same in all directions (*b*) Different in different directions

(*c*) Cannot be measured (*d*) Always zero

Answers

(*i*) (*c*) (*ii*) (*b*) **OR** —(*b*) (*iii*) (*b*) (*iv*) (*a*)

2. Read the passage given below and answer the following questions:

Any departure from a perfectly ordered arrangement of constituent particles is called defect or imperfection. In solids, when the ratio between cations and anions remains the same after defect, it is termed as stoichiometric defects. Schottky and Frenkel defects are categorised into stoichiometric defects. In Schottky defect equal number of cations and anions are missing while in Frenkel defect cations are missing from lattice sites and occupy interstitial sites. In non-stoichiometric defects, the ratio of cations and anions changes as a result of the defect. Metal excess and metal deficiency defects are non-stoichiometric defects.

In these questions (Q. No (i) to (iv)), a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(*i*) **Assertion (A) :** Stoichiometry defects are the point defects that disturb the stoichiometry of the solid.

Reason (R) : Stoichiometric defects are also known as thermodynamic defects.

(*ii*) **Assertion (A) :** Schottky and Frenkel defects are stoichiometric defects.

Reason (R) : The ratio between cations and anions remains the same in Schottky and Frenkel defects.

(*iii*) **Assertion (A) :** Frenkel defect is not found in pure alkali metal halides.

Reason (R) : In Frenkel defect, cations are missing from lattice sites.

OR

Assertion (A) : Zinc oxide turns yellow on heating.

Reason (R) : Zinc oxide shows metal deficiency defect.

(*iv*) **Assertion (A) :** NaCl shows metal excess defect due to anionic vacancies.

Reason (R) : Sodium loses electron to from Na^+ ions and the released electrons occupy anionic sites.

Answers

(*i*) (*d*) (*ii*) (*a*) (*iii*) (*b*) **OR** (*c*) (*iv*) (*a*)

3. Read the passage given below and answer the following questions:

A unit cell is the smallest repeating portion of a crystal lattice. The cubic crystal system is composed of these different types of unit cells: Simple cubic, body-centred and face-centred.

In simple cubic unit cell, atoms are only at its corners. So, the total number of atoms in one unit cell is $8 \times \frac{1}{8} = 1$ atom.

In body-centred unit cell, unit cell has an atom at each of its corners and also one atom at its body centre. Thus, total number of atom per unit cell:

(8 corners $\times \frac{1}{8}$ per corner atom) unit cell + 1 body centre atom = 1 + 1 = 2 atoms

In face-centred unit cell, unit cell contains atoms at all the corners and at the centre of all the faces of the cube. Thus, total number of atoms per unit cell:

(8 corners $\times \frac{1}{8}$ per corner atom) + (6 face centred atoms $\times \frac{1}{2}$ per unit cell) = 1 + 3 = 4 atoms.

In these questions (Q. No (i) to (iv)), a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(*i*) **Assertion (A) :** The total number of atoms present in a simple cubic unit cell is one.

Reason (R) : Simple cubic unit cell has atoms at its corners, each of which is shared between eight adjacent unit cells.

(ii) **Assertion (A) :** In face-centred unit cell, atoms are at the centre of all faces.

Reason (R) : Total number of atoms per unit cell is 4.

(iii) **Assertion (A) :** A crystal lattice is made up of unit cells.

Reason (R) : Each point in a crystal lattice represents an ion.

OR

Assertion (A) : The total number of atoms in body-centred unit cell is 2.

Reason (R) : In body centred unit cell, an atom is at each of its corners and one atom at its body centre.

(iv) **Assertion (A) :** *Bcc* arrangement is less closely packed than *ccp* arrangement.

Reason (R) : In *ccp* arrangement, the two atoms at the corners of the unit cell are touching each other whereas in *bcc* arrangement, they are not touching each other

Answers

(i) (a) (ii) (d) (iii) (c) **OR** (a) (iv) (c)

ASSERTION-REASON QUESTIONS

In the following questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

1. **Assertion (A) :** Graphite is a good conductor of electricity however diamond belongs to the category of insulators.

   Reason (R) : Graphite is soft in nature on the other hand diamond is very hard and brittle.

2. **Assertion (A) :** The total number of atoms present in a simple cubic unit cell is one.

   Reason (R) : Simple cubic unit cell has atoms at its corners, each of which is shared between eight adjacent unit cells.

3. **Assertion (A) :** The coordination number of square close packing in two dimensions is 6.

   Reason (R) : In square close packing, each sphere is in contact with four of its neighbours.

4. **Assertion (A) :** Total number of octahedral voids present in unit cell of cubic close packing including the one that is present at the body centre, is four.

   Reason (R) : Besides the body centre there is one octahedral void present at the centre of each of the six faces of the unit cell and each of which is shared between two adjacent unit cells.

5. **Assertion (A) :** The packing efficiency is maximum for the *fcc* structure.

   Reason (R) : The coordination number is 12 in *fcc* structures.

6. **Assertion (A) :** Semiconductors are solids with conductivities in the intermediate range from $10^{-6} - 10^{4}$ ohm^{-1} m^{-1}.

   Reason (R) : Intermediate conductivity in semiconductor is due to partially filled valence band.

7. **Assertion (A) :** Schottky defect is generally shown by the compounds which have high coordination number.

   Reason (R) : In Schottky defect, equal number of cations and anions are missing from the lattice sites

8. **Assertion (A)** : Frenkel defect does not change the density of the solid.
Reason (R) : In Frenkel defect smaller ion usually cation is dislocated from its normal site to an interstitial site

9. **Assertion (A)** : In crystalline solids electrical resistance show different values when measured along different directions in the same crystal.
Reason (R) : Crystalline solids are isotropic in nature

10. **Assertion (A)** : Total number of octahedral voids present in unit cell of cubic close packing including the one that is present at the body centre, is four.
Reason (R) : Besides the body centre there is one octahedral void present at the centre of each of the six faces of the unit cell and each of which is shared between two adjacent unit cells.

Answers

1. (*b*) **2.** (*a*) **3.** (*d*) **4.** (*c*) **5.** (*b*) **6.** (*c*) **7.** (*b*) **8.** (*a*)
9. (*c*) **10.** (*c*)

HINTS/SOLUTIONS OF SELECTED MCQS

1. (*b*) At low temperature, substance exists in solid state due to low thermal energy and hence decreased molecular motion, which in turn leads to strong intermolecular cohesive forces, *i.e.*, which hold the constituent particles together.

7. (*c*) Iodine is a non-polar molecular solid iodine molecules are held together by London force or dispersion force, this is soft and non - conductor for electricity.

Water is a hydrogen bonded molecular solid in which H and O are held together by hydrogen bonding to non-ionic nature, so, it is not an electrical conductor.

9. (*c*) In a face centered cubic lattice, atom (A) occupies the corner positions. There are 8 corner positions and each position contributes one eighth to the unit cell. Hence, total number of (A) atoms per unit cell = $8 \times 1/8 = 1$.

Atom (B) occupied the face centre positions. There are six face centre positions. One atom of (B) is missing from one of the face centered points. Thus, there are 5 face centre positions that are occupied with (B). Each such position contributes one half to the unit cell. Hence, total number of (B) atoms per unit cell= $5 \times 1/2 = 2.5$

The formula of the compound is $AB_{2.5}$ or A_2B_5

15. (*c*) For NaCl $\frac{r^+}{r^-} = 0.414$

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

16. (*d*) Distance between two oppositely charge ions for BCC

$$(r^+ + r^-) = \frac{a\sqrt{3}}{2} = \frac{387 \times \sqrt{3}}{2}$$
$$= 335.15 \text{ pm}$$

21. (*d*) **Anisotropy** is the property of substances to exhibit variations in electrical and optical properties along different planes of the same crystal. It is seen in crystals, liquid crystals and, less commonly, in liquids. Crystalline solids such as NaCl, $BaCl_2$, etc, will show anisotropy.

22. (*d*) The **hexagonal** closed packed (*hcp*) has a **coordination number** of 12 and contains 6 atoms per unit cell.

23. (*c*) In *ccp*, number of atoms present per unit cell =4

Since in cubic closed packing, the number of tetrahedral voids is equal to twice the number of atoms present per unit cell, hence

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

25. (*d*) Glass is an amorphous solid due to its short range order and irregular arrangement of constituent particles.

26. (*a*) Crystalline solids are anisotropic in nature means some of their physical properties like electrical conductivity,refractive index etc. are different in different directions in the same crystal.

27. (*d*) A *ccp* arrangement consists of three repeating layers (ABCABC…) of hexagonally arranged spheres. Spheres in a *ccp* structure have a coordination number of 12 because they contact six spheres in their layer, three atoms in the layer above and three spheres in the layer below.

28. (*b*) An atom that lies on the edge of a unit cell is shared by four adjacent unit cells, so the contribution of each edge atom is $\frac{1}{4}$.

29. (*b*) The closest-packing sequence ABAB... represents hexagonal packing. In every second row, the particles occupy the depressions between the particles of first row. In the third row, the particles are vertically aligned with those in the first row giving ABABAB... arrangement.

30. (*c*) The radius of the sphere that would fit well into an octahedral void in a close-packing is given by $r = 0.414R$; where r = radius of octahedral void and R = radius of sphere.

31. (*b*) For tetrahedral arrangement, co-ordination number is 4 and radius ratio (r^+/r^-) is 0.225 – 0.414.

32. (*b*) Covalent solids form crystals which can be viewed as a single giant molecule made up of an almost endless number of covalent bonds.

Out of the given solids, diamond is an example of covalent solid while Fe and Cu is a metallic solid, and NaCl is an ionic solid.

33. (*d*) A molecular solid is composed of molecules held together by dispersion or london forces. Its properties are dictated by the weak nature of these intermolecular forces. Molecular solids are soft, have low melting temperatures, and are electrical insulators.

34. (*b*) The existence of a substance in more than one solid modifications is known as polymorphism. It is the ability of a solid material to exist in more than one form or crystal structure.

35. (*d*) Diamond being a crystalline solid is anisotropic in nature. In amorphous solids, there is not long-range order exist between them and therefore the given properties such as electrical conductivity, thermal conductivity, refractive index are identical in all directions and they are isotropic in nature.

36. (*a*) Doping of impurity of higher valent to lower group elements results in formation of *n*-type of semiconductor. On mixing arsenic with silicon, *n*-type of semiconductor is obtained.

37. (*b*) In **graphite**, each carbon is bonded with other 3 other carbons and one valence electron is free. Due to this valence electron, **graphite** conducts electricity in the solid state.

38. (*a*) Iodine molecules are a class of non-polar molecular solid in which constituents molecules are held together by London or dispersion forces. These solids are soft and are insulators.

39. (*d*) Bravais Lattice refers to the 14 different ways of arrangement of points in a regular 3-dimensional space.

40. (*d*) When NaCl is doped with $MgCl_2$, two Na^+ are replaced by one Mg^{2+} ion to maintain electrical neutrality. Thus, the cationic vacancies thus produced are equal in number to that of Mg^{2+} ions. Thus, this type of defect is called impurity defect.

41. (*b*) Glass is an amorphous solid. Like liquids, it has a tendency to flow, though very slowly and due to which, it is considered as pseudo-solid.

42. (*b*) There are a total of four formula units of NaCl per unit cell, *i.e.*, $4Na^+$ and $4Cl^-$ ions.

$$Na^+ \text{ ions} = \underset{\text{(edges)}}{12 \times \frac{1}{4}} + \underset{\text{(body centre)}}{1} = 4$$

$$Cl^- \text{ ions} = \underset{\text{(corners)}}{8 \times \frac{1}{8}} + \underset{\text{(face centre)}}{\frac{1}{2} \times 6} = 4$$

43. (*c*) Frenkel defect is produced because of missing ions from their normal crystal sites. It is produced when some ions are displaced from their normal sites and occupy interstitial sites. So, it does not affect the density of the crystal.

44. (*a*) The simple cubic has a coordination number of 6 and contains 1 atom per unit cell. This can be calculated as $\underset{\text{(Corner atoms)}}{8 \times \frac{1}{8}} = 1$

45. (*d*) The face-centered cubic (*fcc*) has a coordination number of 12 and contains 4 atoms per unit cell. This can be calculated as $\underset{\text{(Corner)}}{8 \times \frac{1}{8}} + \underset{\text{(face atoms)}}{6 \times \frac{1}{2}} = 4$

46. (*d*) For *bcc*, Z = 2, ρ = 530 kgm^{-3}

Atomic mass of Li = 6.94 g mol^{-1}, N_A = 6.022 × 10^{23} mol^{-1}

$$\rho = 530 \text{ kgm}^{-3} = \frac{530 \times 1000 \text{ g}}{1 \times (100)^3 \text{ cm}} = 0.53 \text{ g cm}^{-3}$$

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

$$\Rightarrow \quad 0.53 = \frac{2 \times 6.94}{6.022 \times 10^{23} \times a^3}$$

$$a^3 = \frac{2 \times 6.94}{6.022 \times 10^{23} \times 0.53} = 43.5 \times 10^{-24} \text{ cm}^3$$

$$a = 352 \times 10^{-10} \text{ cm} = 352 \text{ pm}$$

47. (*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.

48. (*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. In case of alkali metal halides, the size alkali metal ions is large and therefore it cannot be fit into the interstitial site and hence do not show frenkel defect. Also, Schottky defect decreases the density of crystal while Frenkel defect has no effect on the density of crystal.

49. (*d*) Z = 4, *i.e.*, structure is *fcc*

Hence, $$r = \frac{a}{2\sqrt{2}} = \frac{361}{2\sqrt{2}} = 127.65 \text{ pm} \approx 128 \text{ pm}$$

50. (*a*) Z = 4: for *fcc* structure

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

$$M = \frac{d \times N_A \times a^3}{Z} = \frac{2.72 \times 6.02 \times 10^{23} \times (404 \times 10^{-10})^3}{4}$$

$\Rightarrow$ $26.99 \approx 27 \text{ g mol}^{-1}$.

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

Number of tetrahedral voids = 2 × 4 = 8

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

Number of octahedral voids = Number of B^+ ion = 4

So, Ratio, O^{2-} : A^{2+} : B^+

4 : 2 : 4

2 : 1 : 2

Hence, formula of oxide = AB_2O_2

52. (*a*) For a face-centered cubic (*fcc*) structure,

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

Diameter = 2*r* = 2 × 144 = 288 pm

53. (*a*) Number of octahedral voids is same as number of atoms present in a unit cell.

The number of atoms in each unit cell of *ccp* = 4. Therefore, the total number of octahedral voids per atom present in *ccp* = $\frac{4}{4} = 1$

54. (*a*) Since Li crystallises in *bcc* crystal atomic radius, $r = \frac{\sqrt{3}a}{4}$ (*a* = edge length)

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

55. (*d*) Since copper crystallises in a face-centered cubic lattice, atomic radius, $r = \frac{a}{2\sqrt{2}}$

Given (edge length = *a* = 334 pm)

$\therefore$ $$r = \frac{334}{2\sqrt{2}} = 118.10 = 118 \text{ pm}$$

56. (*b*) If silicon or germanium is doped with any of the element of group III (B, Al, Ga, In, Th) of the periodic table, *p*-type of semiconductor will be obtained.

57. (*b*) As each Sr^{2+} ion introduces one cation vacancy, therefore, concentration of cation vacancies

= mol% of $SrCl_2$ added.

Thus, Concentration of cation vacancies = 10^{-4} mol%

$$= \frac{10^{-4}}{100} \times 6.022 \times 10^{23}$$
$$= 6.022 \times 10^{17}$$

58. (*d*) The maximum properties of the available volume which may be filled by hard sphere in simple cubic arrangement is given as $\frac{\pi}{6}$ or 0.52.

59. (*b*) F-centres are anionic sites occupied by unpaired electrons. They are responsible for colours.

60. (*a*) $\rho = \dfrac{Z \times M}{a^3 \times N_A} = \dfrac{2 \times 213}{(436.6 \times 10^{-10})^3 \times 6.022 \times 10^{23}} = 8.50 \text{ g/cm}^3$

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

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

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

62. (*b*) In HCP unit cell

$$C = 4r\sqrt{\frac{2}{3}},\ a = 2r$$

$$\therefore \quad \frac{C}{a} = 2\sqrt{\frac{2}{3}} = \sqrt{\frac{8}{3}}$$

63. (*b*) (*i*) Diamond is the hardest known substance and graphite is soft.

(*ii*) In graphite, each carbon atom is joined to three other C atoms leaving one free valence electron which results in electrical conductance. In diamond, all four valencies of carbon are satisfied due to which diamond is an insulator. Thus, graphite has higher electrical conductivity than diamond.

(*iii*) Diamond has higher thermal conductivity than graphite due to the transfer of thermal vibrations from atom to atom. Diamond has a compact and precisely aligned crystal which helps in the fast movement of heat.

(*iv*) Graphite has a higher C–C bond order than diamond as graphite contains C=C double bond whereas diamond contains C–C single bond only.

64. (*a*) The atom in the middle layers will have 12 nearest neighbours. But the atom in topmost layer has 9 nearest neighbours (6 atoms in the same layer + 3 atoms in the bottom layer).

65. (*a*) Given; $\dfrac{r_{Na^+}}{r_{Cl^-}} = 0.55$ and $\dfrac{r_{K^+}}{r_{Cl^-}} = 0.74$

$$\frac{r_{Na^+}}{r_{Cl^-}} + 1 = 1.55 \text{ and } \frac{r_{K^+}}{r_{Cl^-}} + 1 = 1.74$$

i.e., $\dfrac{r_{Na^+} + r_{Cl^-}}{r_{Cl^-}} = 1.55$ ...(*i*)

and $\dfrac{r_{K^+} + r_{Cl^-}}{r_{Cl^-}} = 1.74$ ...(*ii*)

Dividing (*ii*)/(*i*), $\dfrac{r_{K^+} + r_{Cl^-}}{r_{Na^+} + r_{Cl^-}} = \dfrac{1.74}{1.55} = 1.123$

66. (*c*) The formula $M_{0.98}O$ shows that if there were 100 O-atoms present as O^{2-} ions, then there will be 98 metal atoms present as M^{2+} and M^{3+}.

Let $M^{3+} = x$, then $M^{2+} = 98 - x$.

As the compound as a whole is neutral, therefore

Total charge on M^{3+} and M^{2+} will be equal to total charge on 100 O^{2-} ions.

$$x(+3) + (98 - x)(+2) = 100 \times 2$$

or $\quad 3x + 196 - 2x = 200$

or $\quad x = 4$

$\therefore \quad \% \text{ of } M^{3+} = \dfrac{4}{98} \times 100 = 4.08\%$

67. (*b*) The defect that arises due to the missing of a cation from its lattice site and presence of the cation with higher charge in the adjacent site is called metal deficiency defect. Hence, the metals showing variable valency. For example, in FeO, as some Fe may be present as Fe^{3+} and for charge neutrality $3Fe^{2+} = 2Fe^{3+}$. Hence, FeO should have metal deficiency defect.

68. (*c*) Density,
$$\rho = \frac{Z \times M}{a^3 \times N_A}$$
$$\therefore \quad 2.72 = \frac{4 \times M}{(540 \times 10^{-10})^3 \times (6.02 \times 10^{23})}$$
$$\text{or} \quad M = \frac{2.72 \times (540)^3 \times 6.02 \times 10^{23} \times 10^{-30}}{4}$$
$$= 64 \text{ g mol}^{-1}$$

69. (*d*) In body-centered cubic (*bcc*), oppositely charged ions touch each other along the body diagonal.
$$\therefore \quad \text{Body diagonal} = 2r_{Cs^+} + 2r_{Cl^-}$$
$$\text{But body diagonal} = \sqrt{3}\,a$$
$$\therefore \quad 2(r_{Cs^+} + r_{Cl^-}) = \sqrt{3}\,a$$
$$\text{or} \quad r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$$

70. (*c*) For *bcc*,
$$r = \frac{\sqrt{3}}{4}a$$
$$= \frac{1.732}{4} \times 4.29 \text{ Å}$$
$$= 1.86 \text{ Å}$$

71. (*b*) For the *fcc* structure, nearest neighbour distance $(d) - \frac{a}{\sqrt{2}}$

73. (*b*)
$$d = \frac{Z \times M}{a^3 \times N_A} \quad \text{or} \quad M = \frac{d \times a^3 \times N_A}{Z}$$
for *fcc*, $Z = 4$

Now, we know that
$$n = \frac{m}{M} = \frac{N}{N_0}$$
So,
$$\frac{100}{M} = \frac{N}{6.022 \times 10^{23}}$$
$$N = \frac{100 \times 6.022 \times 10^{23} \times Z}{d \times a^3 \times N_A}$$
$$\Rightarrow \frac{100 \times 6.022 \times 10^{23} \times 4}{10 \times (200 \times 10^{-10})^3 \times 6.022 \times 10^{23}}$$
$$\Rightarrow \frac{40}{(200 \times 10^{-10})^3} \quad \text{or} \quad \frac{40}{8 \times 10^{-24}}$$
$$\Rightarrow 5 \times 10^{24} \text{ atoms}$$

74. (*a*) Schottky defect arises when equal number of cations and anions are missing from the lattice so that electrical neutrality is maintained.

75. (*c*) ABABA describes a hexagonal closed packed arrangement of spheres. In this type of arrangement, the coordination number is 6 and successive rows are arranged in such a way that the crests of the spheres of one row are placed into depression formed between adjacent spheres of the next row.

77. (*b*) Ionic solids have highest melting point due to strong electrostatic forces of attraction.

78. (*d*) $A \Rightarrow 8 \times \frac{1}{8} = 1$

$B \Rightarrow 5 \times \frac{1}{2} = \frac{5}{2}$ (Since one atom is missing from one of the face centred point.)

Therefore, formula = $A_1B_{5/2}$ or A_2B_5

79. (*a*) $n = \frac{m}{M} = \frac{1}{58.5}$ moles

$n = \frac{N}{N_0}$ *or* $N = n \times N_0$

$= \frac{1}{58.5} \times 6.022 \times 10^{23}$ molecules

We know that, there are 4 molecules of NaCl present in a unit cell.

$\therefore$ Number of the unit cell $= \frac{6.022 \times 10^{23}}{58.5 \times 4}$

$= 2.57 \times 10^{21}$ unit cells.

80. (*d*) As unit cell consists of A ions at the eight corners. Thus, number of A ions $= \frac{1}{8} \times 8 = 1$

Unit cell consists of B ions at the centre of the body. Thus, number of B ion = 1

So, the formula will be AB.

81. (*d*) For *fcc*, number of atoms = 4

Volume of single atom $= \frac{4}{3}\pi r^3$

Total volume of atoms $= 4 \times \frac{4}{3}\pi r^3$

$= \frac{16}{3}\pi r^3$

82. (*c*) As the F.C.C unit cells consists of 6 faces. Therefore, unit cells is equally shared by 6 different unit cells.

83. (*a*) In crystalline solid there is a regular arrangement of the constituent particles. As the temperature increases the chance that a lattice site may be unoccupied by an ion increases. As the number of defects increases with temperature solid changes abruptly into liquid.

84. (*b*) For simple cubic cell $= 8 \times \frac{1}{8} = 1$

For *bcc* $= 8 \times \frac{1}{8} + 1 = 2$

For *fcc* $= 8 \times \frac{1}{8} + \frac{1}{2} \times 6$

$= 4$

So, the ratio will be 1 : 2 : 4

85. (*d*) For *bcc* $= 8 \times \frac{1}{8} + 1 = 2$

For *fcc* $= 8 \times \frac{1}{8} + \frac{1}{2} \times 6$

$= 4$

Therefore, the number of Na and Mg atoms present in their respective crystals is 2 and 4.

86. (*a*) $a = 5$ Å or 5×10^{-8} cm

Volume of unit cell $= a^3$

$= (5 \times 10^{-8})^3$

$= 1.25 \times 10^{-22}$ cm^3

Given, Density = 4 g/cm^3

$$\text{The mass of the unit cell} = 4 \times 1.25 \times 10^{-22}$$
$$= 5 \times 10^{-22} \text{ g}$$

The mass of 1 mol of FeO is = 55.8 + 16 = 71.8 g

So the mass of 1 molecule of FeO will be

$$= \frac{71.8}{6.022 \times 10^{23}} = 1.192 \times 10^{-22} \text{g}$$

Number of FeO formula unit per unit cell

$$\frac{5 \times 10^{-22}}{1.192 \times 10^{-22}} \approx 4$$

So, the amount of Fe^{2+} and O^{2-} ions in each unit cell will be 4 Fe^{2+} and $4O^{2-}$.

87. (*d*) In KCl, co-ordination number of cation and anion is 6 and 6 respectively. The Frenkel defect is shown by the compounds having low coordination number while Schottky defect is shown by the ionic coordination number.

88. (*c*)

$$1 \text{ mole of compound} = 6.022 \times 10^{23} \text{ particles}$$
$$0.5 \text{ mole of compound} = 0.5 \times 6.022 \times 10^{23} \text{ particles}$$
$$\text{No. of tetrahedral voids} = 2 \times \text{Number of particles}$$
$$= 2 \times 3.011 \times 10^{23}$$
$$= 6.022 \times 10^{23}$$
$$\text{No. of octahedral voids} = \text{Number of particles}$$
$$= 3.011 \times 10^{23}$$

Hence, $\text{Total no. of voids} = 6.022 \times 10^{23} + 3.011 \times 10^{23}$
$$= 9.03 \times 10^{23}$$

89. (*c*) Anions A form *hcp* So, number of anions (A) = 6

Cations are 75% Octahedral voids

So, number of cations $(C) = 6 \times \frac{3}{4}$
$$= \frac{18}{4} \Rightarrow \frac{9}{2}$$

So, the formula of compound is $C_{9/2}\,A_6$ or $C_9\,A_{12}$ or C_3H_4

90. (*c*)

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

for *fcc*, Z = 4, So, $\rho = \frac{4 \times M}{N_A \times (3.5 \times 10^{-8})^3}$ ...(*i*)

for *bcc*, Z = 2, So, $\rho = \frac{2 \times M}{N_A \times (3 \times 10^{-8})^3}$ ...(*ii*)

By dividing equation (*ii*), we get

$$\rho_{fcc} : \rho_{bcc} = 1.259 : 1$$

91. (*a*) In *bcc* unit cell, lattice atoms occupies the corners and body center of a cube.

Each corner has a contribution of $\frac{1}{8}$ and there are 8 corners in a cube.

Effective number of atoms in a cube = $\frac{1}{8} \times 8 = 1$

Also, a body centre will have contribution of 1 and each cube will have 1 body centre.

So effective number of atoms in a cube= 1

Therefore, total number of atoms in *bcc* unit cell = 1 + 1 = 2

92. (*c*) The number of octahedral voids in a cubic close packed structure is the same as effective number of atoms. In *ccp*, effective number of atoms are 4, so there are 4 octahedral voids.

93. (*b*) The radius ratio of the given voids is

- Triangular — 0.155 – 0.225
- Cubic — 0.732 – 1
- Tetrahedral — 0.225 – 0.414
- Octahedral — 0.414 – 0.732

Hence, the largest void is cubic void.

94. (*a*) Close packing is maximum in the crystal lattice of face-centred cubic lattice with 74% packing efficiency.

95. (*b*) The formula for determination of density of cubic unit cell is

$$\rho = \frac{n \times M}{N_0 \times a^3} \text{ g cm}^{-3}$$

ρ = Density

n = Number of moles

M = Molar mass

N_0 = Avogadro's number

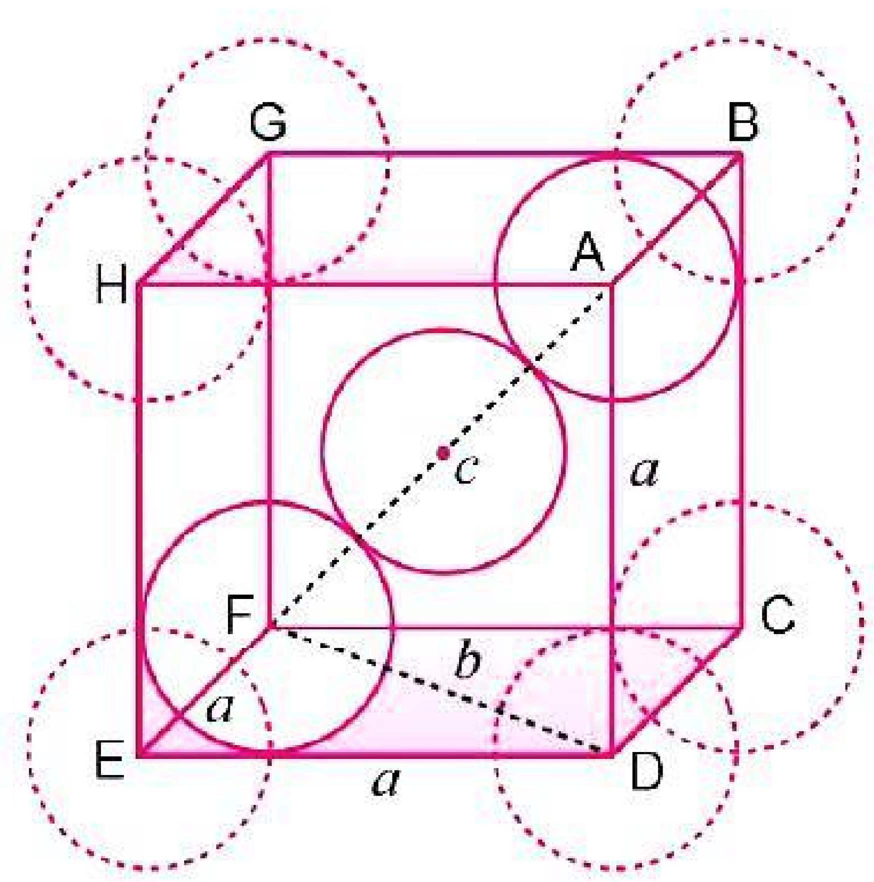
a = Edge length

96. (*c*) If the number of close-packed spheres is n, then the number of tetrahedral voids is $2n$.

97. (*b*) Molecular solids refer to those solids which are composed of molecules held together by the london or dispersion forces, dipole-dipole interactions and hydrogen bonding.

The dry ice (CO_2) is an example of a molecular solid. Graphite is a covalent solid, sodium chloride is a ionic solid and Fe is a metallic solid.

98. (*c*) **Efficiency of packing in bcc structures:** In this case the atom at the centre is in touch with other two atoms which are diagonally arranged (see below figure). The spheres along the body diagonal are shown with solid boundaries.



In ΔEFD,

$$b^2 = a^2 + a^2 = 2a^2$$

$$\therefore \quad b = \sqrt{2}\,a$$

In ΔAFD,

$$c^2 = a^2 + b^2 = a^2 + 2a^2 = 3a^2$$

$\therefore \quad c = \sqrt{3}a$

The length of the body diagonal c is equal to $4r$, r being the radius of the sphere (atom). As all the three spheres along the diagonal touch each other,

$$c = 4r$$

Therefore, $c = 4r = \sqrt{3}a$

$$a = \frac{4r}{\sqrt{3}} \text{ or } r = \frac{\sqrt{3}}{4}a$$

As already calculated, the total number of atoms associated with a *bcc* unit cell is 2, the volume(v) is, therefore,

$$2 \times \frac{4}{3}\pi r^3 = \frac{8}{3}\pi r^3$$

Volume of the unit cell (V) $= a^3 = \left(\frac{4r}{\sqrt{3}}\right)^3 = \frac{64r^3}{3\sqrt{3}}$

Packing efficiency $= \frac{v}{V} \times 100 = \frac{(8/3)\pi r^3}{(64/3\sqrt{3}) \times r^3} \times 100 = \frac{\sqrt{3}}{8}\pi \times 100 = 68\%$

Therefore, 68% of unit cell is occupied by atoms and the rest 32% is empty space.

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