CHAPTER

01

The Solid State

A Quick Recapitulation of the Chapter

1. **Solids** have definite mass, volume and shape due to the fixed positions of their constituent particles.
2. They may be crystalline (i.e having long range order of constituents) or amorphous (i.e having short range order of constituents).
3. **Crystal lattice** is the three dimensional arrangement of constituents or points in a crystalline solid. The smallest repeating unit of the crystal lattice is called the **unit cell**.

   There are seven primitive unit cells whose possible variations as centred unit cells are listed below.

Systems	Parameters	Interaxial angles	Examples
Triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90°$	$K_2Cr_2O_7$, $CuSO_4 \cdot 5H_2O$, H_3BO_3
Monoclinic	$a \neq b \neq c$	$\alpha = \gamma = 90° \neq \beta$	$Na_2SO_4 \cdot 10H_2O$, $Na_2B_4O_7 \cdot 10H_2O$, Monoclinic sulphur
Orthorhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90°$	KNO_3, K_2SO_4, $BaSO_4$, $PbCO_3$, Rhombic sulphur
Tetragonal	$a = b \neq c$	$\alpha = \beta = \gamma = 90°$	White tin, SnO_2, TiO_2, $NiSO_4$
Cubic	$a = b = c$	$\alpha = \beta = \gamma = 90°$	NaCl, KCl, CsCl, ZnS, CaF_2, Diamond
Hexagonal	$a = b \neq c$	$\alpha = \beta = 90°, \gamma = 120°$	ZnO, CdS, HgS, Graphite
Rhombohedral (Trigonal)	$a = b = c$	$\alpha = \beta = \gamma \neq 90°$	$NaNO_3$, ICl, Calcite, Quartz

4. **Types of Cubic Unit Cell**
   - (i) In **Simple-Cubic Unit Cell** (sc) all the eight corners of the cube are occupied by atoms, ions or molecules.
   - (ii) In **Body-Centred Cubic Unit Cell** (bcc) the constituent particles occupy all the eight corners of the cube and one particle is located at the body centre of the cube.
   - (iii) In **Face-Centred Cubic Unit Cell** (fcc) the constituent particles occupy all the eight corners of the cube and also the centre of the six faces of the cube.
5. In **hcp structure** order is *ABABAB...*
6. In **ccp**, it is *ABCABC...*
7. Unit cell parameters

Type/feature	sc	bcc	fcc
Number of atom per unit cell, Z	1	2	4
Radius of atom, r	$a/2$	$\sqrt{3}\,a/4$	$a/2\sqrt{2}$
Packing fraction (total occupied space)	52.4%	68%	74%
CN	—	8	12

8. **Ionic radius** for **fcc** structure, $r_a + r_c = \frac{a}{2}$

   for **bcc** structure, $r_c + r_a = \frac{\sqrt{3}a}{2}$

   where, r_c and r_a = radius of cation and anion respectively.
9. Density of unit cell, $d = \frac{Z \times M}{a^3 \times N_A}$

   where, Z = number of atoms per unit cell
   M = atomic or molecular mass
   N_A = Avogadro's number
   a^3 = volume and a = edge length
10. If number of atoms = N,
    then, number of tetrahedral voids = $2 \times N$
    and number of octahedral voids = N
11. **Schottky defect** (a stoichiometric point defect) is due to missing of equal number of atoms from their sites and hence, results in decrease in density. It is found in NaCl, KCl, AgBr etc .
12. **Frenkel defect** (a stoichiometric defect) is due to occupation of an interstitial site by an atom leaving its original site vacant. Hence, density remains the same throughout, e.g. AgBr, AgCl etc.
13. ***F*-centres** (or *Farbenzenter*) are electron filled vacancy of anion, generated due to metal excess defect.
14. **Semiconductors** have conductivity in between conductors and insulators and are of two types:
    (i) *p*-type (group 13 element is added into element of group 14).
    (ii) *n*-type (group 15 element is added into element of group 14).
15. **Paramagnetic substances** show magnetic behaviour only under the influence of the applied magnetic field.
16. **Ferromagnetic substances** exhibit magnetism even when applied magnetic field is removed.
17. **Antiferromagnetic substances** have no magnetic moment since the electronic spins mutually cancel under the influence of external magnetic field.
18. **Ferrimagnetic substances** exhibit some magnetic character due to alignment of the electron spins in parallel and antiparallel directions in unequal numbers.

Objective Questions Based on NCERT Text

Topic 1

Introduction and Classification of Solids

1. Select the correct statement.
(a) Matter can exist only in solid, liquid and gaseous states
(b) At low temperature, intermolecular forces are strong enough to keep the constituents together
(c) Combined effect of intermolecular forces and intermolecular strength decides the phase of a substance
(d) All of the given statements are correct

2. Which of the following statement is incorrect?
(a) Solids have different types of structure
(b) Solids have different arrangements of particles
(c) Properties of solids are independent of nature of its particles
(d) Solids like biodegradable polymers are fit for packaging purposes

3. Which of the following properties tends to keep the solid particles apart by making them to move faster?
(a) Low temperature (b) Intermolecular forces
(c) Thermal energy (d) Both (b) and (c)

4. What is the necessary condition for the existence of solids?
(a) Intermolecular forces should be weaker than thermal energy
(b) Intermolecular forces should be stronger than thermal energy
(c) Intermolecular forces should be equal to the thermal energy
(d) No definite relationship between them

5. Which of the following statement(s) is not true about the properties of solids?
(a) They are compressible and rigid
(b) Intermolecular distances are short
(c) Intermolecular forces are strong
(d) They have definite shape, volume and mass

6. High density and low compressibility are responsible for which type of solid molecules?
(a) Highly packed solid (b) Low packed solid
(c) Flexible solid (d) None of these

7. The incorrect statement among the following is
(a) order of arrangement is the basic aspect to classify solids into amorphous or crystalline
(b) each constituent of a crystalline solid has a definite geometrical shape
(c) in crystalline as well as amorphous solid periodically repeating pattern of constituent can be observed
(d) None of the above

8. Quartz is crystalline silica but silica glass is
(a) amorphous (b) crystalline
(c) Both (a) and (b) (d) None of these

9. Which of the following statement(s) is/are true regarding crystalline solids?
(a) These possess long range order
(b) These have sharp melting point
(c) These are anisotropic
(d) All of the above

10. Which of the following statements about amorphous solids is incorrect?
(a) They melt over a range of temperature
(b) They are isotropic
(c) They are rigid and incompressible
(d) There is no orderly arrangement of particles

11. Select the correct statement.
(a) Melting point of quartz glass is sharp but of quartz is not
(b) Salt has long range order of constituents but ice does not
(c) Heat of fusion is definite for iron but not for rubber
(d) Glass can give two pieces with plain and smooth surfaces when cut with a sharp edged tool

12. Some of the physical properties of crystalline solids like refractive index show different values on measuring along different directions in the same crystals. This property is called
(a) isotropy
(b) cleavage property
(c) anisotropy
(d) None of the above

13. When cut with a sharp edged tool, crystalline solids split into two pieces and the newly generated surfaces are plain and smooth. This property is known as
(a) anisotropy (b) isotropy
(c) cleavage property (b) None of these

14. Hydrogen, chlorine belong to a class of crystalline solids. The true statement related to this class is
(a) the constituents are either atoms or molecules having polar dispersion forces
(b) they have low melting point and are hard
(c) they can exist only in gaseous state at room temperature and pressure
(d) the intermolecular forces are weak dispersion or London forces

15. Solid SO_2 and NH_3 are the examples of which of the following types of solids?
(a) Polar molecular solids
(b) Non-polar molecular solids
(c) Hydrogen bonded molecular solids
(d) None of the above

16. Which of the following can be regarded as molecular solid?
(a) AlN (b) SiC (c) I_2 (d) Diamond

17. Which one of the following forms a molecular solid when solidified?
(a) Silicon carbide (b) Calcium fluoride
(c) Rock salt (d) Methane

18. Which of the following is not the characteristic of ionic solids?
(a) Brittle nature
(b) Very low value of electrical conductivity in the molten state
(c) Anisotropic nature
(d) Very strong forces of attraction

19. Select the incorrect option regarding metallic solids.
(a) Positive ions are surrounded by a sea of free electrons
(b) These electrons are mobile
(c) Covalent bonds are strong and directional
(d) These are highly malleable and ductile

20. The luster of a metal is due to
(a) its high polishing (b) its high density
(c) chemical inertness (d) presence of free electrons

21. The lattice points of a crystal of hydrogen iodide are occupied by
(a) HI molecules
(b) H atoms and I atoms
(c) H^+ cations and I^- anions
(d) H_2 molecules and I_2 molecules

22. The false statement about giant molecules is
(a) these are very hard and brittle
(b) they may decompose before melting
(c) they are conductor of electricity
(d) graphite is an example of such molecules

23. Which of the following does not show electrical conduction in its physical states?
(a) Sodium (b) Diamond (c) Graphite (d) Calcium

24. A solid X is very hard and has a very high melting point. In solid state it is non-conductor but in molten state, it conducts electricity. Identify X.
(a) Molecular (b) Ionic (c) Covalent (d) Metallic

25. Which of the following exists as covalent crystals in the solid state? **(JEE Main 2013)**
(a) Iodine (b) Silicon
(c) Sulphur (d) Phosphorus

Topic 2

Crystal Lattices and Unit Cells

26. Select the incorrect statement.
(a) Crystal lattice is the regular three dimensional arrangement of constituents in space
(b) There are 7 crystal systems and 14 Bravais lattices
(c) Unit cell is the smallest repeating unit of the crystal lattice
(d) A unit cell is characterised by two parameters a bond angle and a bond length

27. Smallest portion of a crystal lattice which on repetition in different directions generates the entire lattice is called
(a) unit cell (b) crystal lattice
(c) lattice point (d) lattice site

28. When constituent particles are present only on the corner positions of a unit cell, it is called
(a) primitive unit cell (b) centred unit cell
(c) body-centred unit cell (d) face-centred unit cell

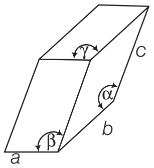
29. Which of the following crystal system has cinnabar as an example?
(a) Cubic (b) Monoclinic
(c) Trigonal (d) Triclinic

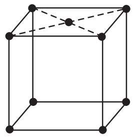
30. Identify the type of crystal system of the following
(A) KNO_3; (B) $CaCO_3$; (C) $CaSO_4$;
(D) $CuSO_4 \cdot 5H_2O$
(a) A-Cubic; B-Triclinic; C-Hexagonal; D-Rhombohedral
(b) A-Tetragonal; B-Monoclinic; C-Triclinic; D-Hexagonal
(c) A-Orthorhombic; B-Trigonal; C-Tetragonal; D-Triclinic
(d) A-Rhombohedral; B-Hexagonal; C-Trigonal; D-Orthorhombic

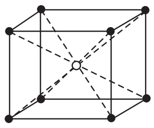
31. The axial angles in triclinic crystal system are
(a) $\alpha = \beta = \gamma = 90°$ (b) $\alpha = \gamma = 90°, \beta \neq 90°$
(c) $\alpha \neq \beta \neq \gamma \neq 90°$ (d) $\alpha = \beta = \gamma \neq 90°$

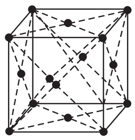
32. Which crystal system has no rotation of symmetry?
(a) Hexagonal (b) Orthorhombic
(c) Cubic (d) Triclinic

33. In which of the following structure unit cell shows the triclinic structure?

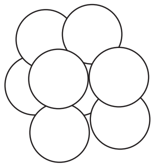
(a)


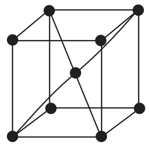
(b)


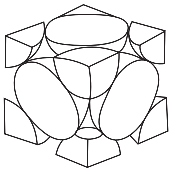
(c)


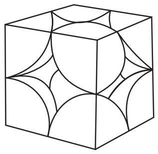
(d)


34. Which of the following figure shows space filling structure model of unit cell?

(a)


(b)


(c)


(d)


35.

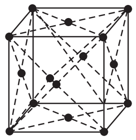


Fig. (i)

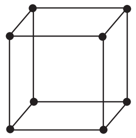


Fig. (ii)

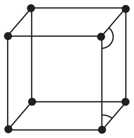
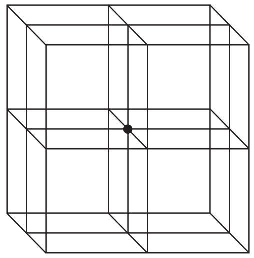


Fig. (iii)

Which of the above figure shows only primitive cubic structure of unit cell?
(a) Both (i) and (ii) (b) Both (i) and (iii)
(c) Both (ii) and (iii) (d) All of these

36.

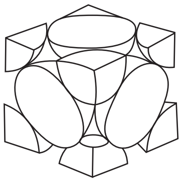


In the above figure, structure of unit cell represent that each corner atom is shared between
(a) 8 unit cell (b) 6 unit cell
(c) 4 unit cell (d) 2 unit cell

37. How much part of any corner constituent particle actually belongs to a particular unit cell?
(a) $\frac{1}{4}$th (b) $\frac{1}{6}$th
(c) $\frac{1}{8}$th (d) $\frac{1}{10}$th

38. Contribution of each atom per unit cell at face centre in a fcc unit cell is
(a) 1 (b) 2
(c) 0.5 (d) 2.5

39. How many number of atoms are present in the unit cell shown in the figure?



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

40. Number of atoms in the unit cell of Na (bcc) and Mg (fcc) are, respectively.

(a) 4 and 4 (b) 4 and 2
(c) 2 and 4 (d) 1 and 1

41. How many number of atoms are there in a cubic unit cell having one atom on each corner and two atoms on each body diagonal of cube?

(a) 8 (b) 6 (c) 4 (d) 9

42. The compound formed by elements P and Q has a cubic structure in which P atoms are at the corners of the cube and Q atoms are at the face centres. What is the formula of the compound?

(a) P_3Q (b) PQ_3 (c) PQ_4 (d) P_4Q

43. A cubic solid is made up of two elements A and B. Atoms of element B are present at the corners of the cube and atoms A at the body centre. Predict the formula of the compound.

(a) AB_2 (b) AB
(c) A_2B (d) None of these

44. 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 **(AIEEE 2011)**

(a) A_2B (b) AB_2
(c) A_2B_2 (d) A_2B_5

Topic 3

Close Packed Structures (with Voids)

45. What is the coordination number of body centre cube?

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

46. Coordination number of Zn in zinc blende is

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

47.

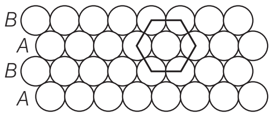


Fig. (i)

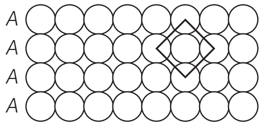


Fig. (ii)

In the above Fig. (i) and (ii) coordination numbers of close packing structure are respectively

(a) 4 and 6 (b) 6 and 4 (c) 8 and 4 (d) 6 and 8

48. The number of octahedral void(s) per atom present at a cubic close packed structure is **(CBSE AIPMT 2012)**

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

49. While placing the second layer over the first layer if the sphere of the second layer is above the void of the first layer, void thus obtained is

(a) tetrahedral (b) octahedral
(c) trigonal (d) None of these

50. Fig. (i) and (ii) represent structure of voids.

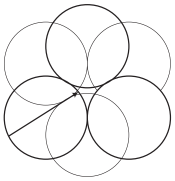


Fig. (i)

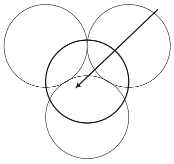


Fig. (ii)

Which of the following option is correct?

(a) Tetrahedral and octahedral void respectively
(b) Octahedral and tetrahedral void respectively
(c) Both are octahedral voids
(d) Both are tetrahedral voids

51. Percentage of free space in cubic close packed structure and in body centred packed structure are respectively **(AIEEE 2011)**

(a) 30% and 26% (b) 26% and 32%
(c) 32% and 48% (d) 48% and 26%

52. In which of the following arrangements octahedral voids are formed?

(a) hcp, fcc (b) bcc, hcp
(c) simple cubic (d) None of the above

53. Which of the following is correct when atoms are closely packed ?

(a) The size of tetrahedral void is smaller than that of octahedral void
(b) The size of tetrahedral void is greater than that of octahedral void
(c) The size of tetrahedral void may be greater or smaller or equal to that of octahedral void depending upon the size of atoms
(d) The size of tetrahedral void is equal to that of octahedral void

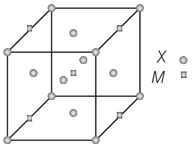
54. Each ion or atom that forms an fcc unit cell is surrounded by

(a) eight octahedral voids and four tetrahedral voids
(b) six octahedral voids and six tetrahedral voids
(c) eight octahedral voids and six tetrahedral voids
(d) six octahedral voids and eight tetrahedral voids

55. The false statement among the following is.

(a) Coordination number is the number of nearest neighbours of a particle
(b) Coordination number is 2 for one dimensional close packed arrangement
(c) Coordination number is 6 for a body centred cubic system
(d) Trigonal voids are formed in two dimensional closed packed structure

56. A compound $M_p\ X_q$ has cubic close packing (ccp) arrangement of X. Its unit cell structure is shown below. The empirical formula of the compound, is **(IIT JEE 2012)**



(a) MX (b) MX_2
(c) M_2X (d) M_5X_{14}

57. An alloy of copper, silver and gold is found to have copper constituting the ccp lattice. If silver atoms occupy the edge centres and gold is present at body centre, the alloy has a formula

(a) CuAgAu (b) Cu_4Ag_2Au
(c) Cu_4Ag_3Au (d) Cu_4Ag_4Au

58. 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 oxide is **(CBSE AIPMT 2012)**

(a) ABO_2 (b) A_2BO_2
(c) $A_2B_3O_4$ (d) AB_2O_2

Topic 4

Packing Efficiency and Calculations Involving Unit Cell Dimensions

59. The percentage of total space filled by the particles is known as

(a) packing efficiency (b) interstitials
(c) void (d) None of these

60. If a is the length of the side of a cube, the distance between the body centred atom and one corner atom in the cube will be **(CBSE AIPMT 2014)**

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

61. Total volume of atoms present in a fcc unit cell of a metal is (r = atomic radius).

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

62. In which of the following packing, 74% space is occupied by the atoms with *ABC, ABC* packing of atoms?

(a) Hexagonal closed packing
(b) Simple cube packing
(c) Body- centred cubic
(d) Cubic closed packing

63. The vacant space in bcc lattice cell is **(CBSE AIPMT 2015)**

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

64. Sodium metal crystallises in a body centred cubic lattice with a unit cell edge of 4.29 Å. The radius of sodium atom is approximately **(JEE Main 2015)**

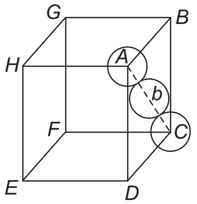
(a) 1.86 Å (b) 3.22 Å
(c) 5.72 Å (d) 0.93 Å

65. The ratio of the volume of a tetragonal lattice unit cell to a hexagonal lattice unit cell is
(both having same respective lengths)

(a) 1 (b) $\frac{2}{\sqrt{3}}\frac{a^2c}{\sqrt{3}b}$

(c) $\frac{\sqrt{3}}{2}abc$ (d) $\frac{2}{3\sqrt{3}}$

66. What is the packing efficiency of unit cell which is represented in the figure?



(a) 74 % (b) 68 % (c) 52 % (d) 38 %

67. What will be the per cent fraction of edge length not covered by atoms when a metal crystallises in bcc lattice?

(a) 11.4% (b) 10.4% (c) 13.4% (d) 12.4%

68. Maximum packing efficiency (or most efficient packing) is of

(a) hcp, ccp (b) bcc, ccp

(c) bcc, hcp (d) None of these

69. A metal crystallises with a face-centred cubic lattice. The edge of the unit cell is 408 pm. The diameter of the metal atom is **(CBSE AIPMT 2012)**

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

70. Which of the following is the ratio of packing density of fcc, bcc and cubic structures ?

(a) 0.92 : 0.70 : 1 (b) 0.70 : 0.92 : 1

(c) 1 : 0.92 : 0.70 (d) 1 : 0.70 : 0.92

71. 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, what is the radius of one atom? **(CBSE AIPMT 2015)**

(a) 40 pm (b) 127 pm (c) 80 pm (d) 108 pm

72. Suppose the radius of an atom of an element is 75 pm and the lattice type is body centred cubic, what is the edge of the unit cell?

(a) 173.2 pm (b) 137.2 pm

(c) 123.7 pm (d) 153.2 pm

73. A metal has bcc structure and the edge length of its unit cell is 3.04 Å. The volume of the unit cell in cm^3 will be

(a) $1.6\times 10^{-21}\ \text{cm}^3$ (b) $2.81\times 10^{-23}\ \text{cm}^3$

(c) $6.02\times 10^{-23}\ \text{cm}^3$ (d) $6.6\times 10^{-24}\ \text{cm}^3$

74. What will come in place of 'x' if the total number of atoms present in an unit cell is 4?

$$d = \frac{x}{a^3 N_A}$$

(a) M (b) $4M$

(c) Z/M (d) $Z+M$

75. Which of the following relation is true about mass of atom (m), molar mass (M) and Avogadro constant (N_A)?

(a) $M = \frac{m}{N_A}$ (b) $N_A = mM$

(c) $m = \frac{N_A}{M}$ (d) $m = \frac{M}{N_A}$

76. Find the correct formula regarding relation between density, mass, edge length and number of atoms in a unit cell of crystal lattice.

(a) $d = \frac{M}{a^3 N_A}$ (b) $a = \left[\frac{ZM}{N_A d}\right]^{\frac{1}{2}}$

(c) $a = \left[\frac{Z \cdot M}{N_A \cdot d}\right]^{\frac{1}{3}}$ (d) None of these

77. X-ray diffraction studies show that Cu crystallises in face centred cubic unit cell with cell edge of 3.608×10^{-8} cm. An another experiment shows that Cu is determined to have a density of 8.92 g/cm^3. Find out the atomic mass of copper.

(a) 61.3 u (b) 62.3 u (c) 63.1 u (d) 64.1 u

78. The metal has a fcc lattice. The edge length of the unit cell is 404 pm. The density of the metal is 2.72 g/cm^3. The molar mass of the metal is (N_A = Avogadro's constant $= 6.02\times 10^{23}\ \text{mol}^{-1}$). **(NEET 2013)**

(a) 40 g / mol (b) 30 g / mol

(c) 27 g / mol (d) 20 g / mol

79. A metal crystallises in a bcc lattice. Its unit cell edge length is about 300 pm and its molar mass is about 50 g mol^{-1}. What would be the density of the metal (in g cm^{-3})?

(a) 3.1 (b) 6.2 (c) 9.3 (d) 12.4

80. An element has a body centred cubic (bcc) structure with a cell edge of 444 pm. The density of the element is 7.2 g/cm^3. How many atoms are present in 404 g of the element?

(a) 3.12×10^{24} unit cells

(b) 9.24×10^{24} unit cell

(c) 6.41×10^{23} unit cells

(d) 12.08×10^{23} unit cells

81. How many unit cells are present in a cube shaped lattice crystal of NaCl of mass 1.00 g?

[Atomic mass : $Na = 23, Cl = 35.5$]

(a) 2.57×10^{21} (b) 5.14×10^{21}

(c) 1.28×10^{21} (d) 1.71×10^{21}

82. A metallic element has a cubic lattice. Each edge of the unit cell is 2 Å. The density of the metal is 2.5 g cm^{-3}. The unit cells in 200 g of metal are

(a) 1×10^{24} (b) 1×10^{20}

(c) 1×10^{22} (d) 1×10^{25}

83. The cubic unit cell of Al (molar mass 27 g mol^{-1}) has an edge length of 405 pm. Its density is 2.7 g cm^{-3}. The cubic unit cell is

(a) face centred

(b) body centred

(c) primitive

(d) edge centred

84. Xenon crystallises in the fcc lattice and the edge of the unit cell is 620 pm. The nearest neighbour distance of Xe is

(a) 438.5 pm (b) 219.25 pm

(c) 420 pm (d) 261.5 pm

85. Volume occupied by single CsCl ion pair in a crystal is $7.014 \times 10^{-23} \text{ cm}^3$. The smallest Cs — Cs internuclear distance is equal to length of the side of the cube corresponding to volume of one CsCl ion pair. The smallest Cs to Cs internuclear distance is nearly

(a) 4.4 Å (b) 4.3 Å (c) 4 Å (d) 4.5 Å

86. An organic compound crystallises in an orthorhombic cell in the ratio of 2:1. The dimensions of the cell are 12.05, 15.05 and 2.69 Å and density is 1.419 g/cm^3. Find molar mass of the compound.

(a) 207 g/mol (b) 209 g/mol

(c) 308 g/mol (d) 317 g/mol

Topic 5

Imperfections in Solids

87. Choose the correct statement.

(a) Defects are generated in a crystal, if crystallisation occurs at extremely slow rate

(b) Point defect are the irregularities around a point whereas line defect involve irregularities in complete row of points

(c) Intrinsic defects are non-stoichiometric defects found in non-ionic crystals

(d) None of the above

88. Some of the statements related to stoichiometric defects are given, which of these is not true?

(a) In vacancy defect, density of substance decreases while in interstitial defect, it increases

(b) Vacancy and interstitial defects are shown by non-ionic solids

(c) Frenkel defect always appear in ionic solids

(d) Frenkel defect results in increased density

89. Which one is the best example which exhibits both Frenkel and Schottky defects?

(a) AgCl (b) AgBr

(c) NaCl (d) NaBr

90. In a solid lattice, the cation has left a lattice site and is located at an interstitial position, the lattice defect is

(a) Frenkel defect

(b) dislocation defect

(c) *F*-centre defect

(d) Both (a) and (b)

91. Which kind of defect is shown by the given crystal?

K^+ Cl^- K^+ Cl^- K^+ Cl^-
Cl^- □ Cl^- K^+ □ K^+
K^+ Cl^- □ Cl^- K^+ Cl^-
Cl^- K^+ Cl^- K^+ □ K^+

(a) Schottky defect

(b) Frenkel defect

(c) Schottky and Frenkel defects

(d) Substitution disorder

92. The correct statement regarding defects in the crystalline solid is **(CBSE AIPMT 2015)**

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

(b) Frenkel defects decreases the density of crystalline solids

(c) Frenkel defect is a dislocation defect

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

93. Schottky defect generally appears in

(a) NaCl (b) KCl

(c) CsCl (d) All of these

94. The correct statement among the following is

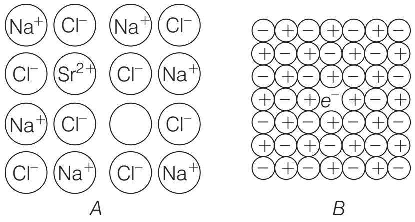
(a) Schottky defect is also called a dislocation defect which is shown by AgBr

(b) ZnS shows Schottky defect

(c) ZnS shows Frenkel defect

(d) All of the above

95. Which of the two properties of solids are illustrated in the figures *A* and *B* below?



A	*B*
(a) Impurity defect ;	*F*-centre
(b) *F*-centre ;	Impurity defect
(c) Schottky defect ;	Impurity defect
(d) Schottky defect ;	Frenkel defect

96. What is the similarity between solid solutions of
I. $SrCl_2$ and NaCl?
II. $CdCl_2$ and AgCl?

(a) Both show stoichiometric defects
(b) Both show non-stoichiometric defects
(c) Both show impurity defects
(d) None of the above

97. The flame colour of metal ions is due to

(a) Frenkel defect
(b) Schottky defect
(c) metal deficiency defect
(d) metal excess defect

98. Which of the following defects is generally possessed by FeO?

(a) Metal excess
(b) Metal deficiency
(c) Impurity
(d) Stoichiometric

99. An analysis shows that the oxide of nickel consists of nickel ion with 96% ions having d^8 configuration and 4% having d^7 configuration.

Which one of the following represents the formula of the oxide best?

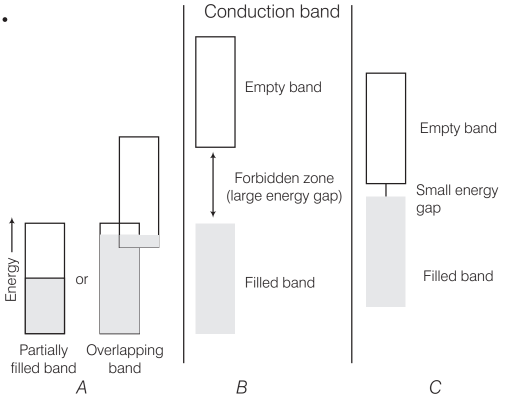
(a) $Ni_{0.98}O_{0.98}$
(b) $Ni_{1.02}O_{1.02}$
(c) $Ni_{1.02}O_{1.00}$
(d) $Ni_{0.98}O_{1.00}$

Topic 6
Electrical and Magnetic Properties of Solids

100. Insulators are the solids with very low conductivities ranging between

(a) 10^4 to 10^7 Ω^{-1} m^{-1} (b) 10^{-20} to 10^{-5} Ω^{-1} m^{-1}
(c) 10^{-20} to 10^{-10} Ω^{-1} m^{-1} (d) 10^{-6} to 10^4 Ω^{-1} m^{-1}

101.



The figure *A*, *B* and *C* illustrate

(a) metal ; semiconductor ; insulator
(b) metal ; insulator ; semiconductor
(c) insulator ; metal ; semiconductor
(d) insulator ; semiconductor ; metal

102. In case of semiconductors, the gap between the valence band and conduction band is

(a) large (b) small
(c) medium (d) None of these

103. Which of the following statement is incorrect about metals?

(a) Valence band overlaps with conduction band
(b) The gap between valence band and conduction band is negligible
(c) The gap between these bands cannot be determined
(d) Valence band may remains partially filled

104. Electrical conductivity of semiconductors increases with increase in

(a) temperature
(b) pressure
(c) volume
(d) None of the above

105. The elements commonly used for making transistors are

(a) C and Si (b) Ga and In
(c) P and As (d) Si and Ge

106. Which of the following has the highest value of energy gap?
(a) Aluminium (b) Silver (c) Germanium (d) Diamond

107. If silicon is dopped with group 13 and group 15 member elements respectively which of the following semiconductor is/are obtained?
(a) *n*-type (b) *p*-type
(c) *n*-type, *p*-type (d) *p*-type, *n*-type

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

109. Doping of silicon (Si) with boron (B) leads to
(a) *n*-type semiconductor (b) *p*-type semiconductor
(c) metal (d) insulator

110. Identify the incorrect statement.
(a) Every substance has some magnetic properties associated with it
(b) Origin of magnetic properties lie in electrons
(c) Each electron behaves like a tiny magnet
(d) Its magnetic moment originates from three types of motions

111. The value of Bohr magneton, μ_B is
(a) 9.27×10^{-24} A m^2 (b) 9.27×10^{-22} A m^2
(c) 11.27×10^{-22} A m^2 (d) 11.27×10^{-24} A m^2

112. Which of the following statement(s) is not true?
(a) Ferromagnetic substances cannot be magnetised permanently
(b) Paramagnetic substances are weakly attracted by magnetic field
(c) Pairing of electrons cancels their magnetic moment in the diamagnetic substances
(d) The domains in antiferromagnetic substances are oppositely oriented with respect to each other

113. Which type of magnetic behaviour, $MgFe_2O_4$ is exhibited ?
(a) Diamagnetic (b) Paramagnetic
(c) Ferromagnetic (d) Ferrimagnetic

114. Which one is not a ferroelectric compound?
(a) KH_2PO_4 (b) $K_4[Fe(CN)_6]$
(c) Rochelle salt (d) $BaTiO_3$

115. Which of the following is not an antiferromagnetic compound?
(a) MnO (b) MnO_2 (c) Mn_2O_3 (d) CrO_2

Special Format Questions

I. More Than One Correct Option

116. Which of the following statements are correct?
(a) Crystalline solids have definite heat of fusion whereas amorphous solids lack it
(b) Crystalline solids have definite geometrical shape whereas amorphous solids have no definite shape
(c) Crystalline solids are anisotropic whereas amorphous solids are isotropic
(d) Crystalline solids do not have sharp melting point whereas amorphous solids have sharp melting point

117. The true statement among the following are
(a) non-polar molecular solids are formed by non-polar covalent bonds
(b) in non-polar molecular solids, the atoms or molecules are held by weak dispersion forces or London forces
(c) these solids are soft and non-conductors of electricity
(d) HCl, SO_2 are formed by non-polar covalent bonds

118. Which of the following statements are correct regarding covalent solids?
(a) Covalent solids are also called giant molecules
(b) Diamond and silicon carbide belong to this class of solid
(c) These have extremely high melting points
(d) These are very hard but brittle

119. Which of these statements are correct?
(a) Deviations from ideal arrangement in entire rows of lattice points are called point defects
(b) Deviations from ideal arrangement around a point or an atom in crystalline substance are called line defects
(c) The irregularities in the crystal structure are called crystal defects
(d) *F*-centre gives lilac colour to KCl crystal

120. Which of the following defects decreases the density?
(a) Schottky defects
(b) Vacancy defects
(c) Frenkel defects
(d) Interstitial defects

121. Consider the following statements. The true statements about in Schottky defect are.
(a) Number of missing cations and anions are equal
(b) it increases the density of the substance
(c) there is one Schottky defect per 10^{16} ions
(d) cations and anions are of different sizes

122. Consider the following statement(s). Identify the correct ones.

(a) Diode is a combination of *n*-type and *p*-type semiconductors
(b) Diode is used as rectifier
(c) *n-p-n* and *p-n-p* are the types of rectifier
(d) *n-p-n* and *p-n-p* are used to detect or amplify radio or audio signals

123. Which of the following statements are correct?

(a) Regarding dielectric properties, barium titanate is ferroelectric
(b) Regarding magnetic behaviour, magnetite is ferromagnetic
(c) Antiferromagnetic substances have not no magnetic moment
(d) Paramagnetic substances lose their magnetism in the absence of the same direction of electrons

124. Choose the correct one among the following statements regarding ferromagnetism.

(a) In solids, metal ions of such substances are grouped together in domains
(b) Each domain acts as a tiny magnet
(c) In the absence of magnetic field, these domains are randomly oriented whereas in magnetic field, these get oriented in the direction of the magnetic field
(d) This ordered arrangement persist even after the removal of magnetic field

125. Which of the following statements are not true?

(a) Fe, Co, Ni and CrO_2 are ferrimagnetic substances
(b) MnO is ferrimagnetic in nature
(c) H_2O and NaCl are diamagnetic in nature
(d) $MgFe_2O_4$ and $ZnFe_2O_4$ are antiferromagnetic in nature

II. Statement Based Questions Type I

■ **Directions** (Q. Nos. 126-139) *In the following questions, a Statement* I *is followed by a corresponding Statement* II. *Of the following Statements, choose the correct one.*

(a) Both Statement I and II are correct and Statement II is the correct explanation of Statement I.
(b) Both Statement I and II are correct and Statement II is not the correct explanation of Statement I.
(c) Statement I is correct, Statement II is incorrect.
(d) Statement II is correct, Statement I is incorrect.

126. Statement I Each solid material has its characteristic properties.

Statement II Temperature and pressure play an important role in the determination of properties of solid.

127. Statement I Melting point of a solid depends on the structure of solid.

Statement II Melting point is used for the identification of type of solids.

128. Statement I All solids have sharp melting points.

Statement II Some solids have sharp melting points.

129. Statement I True solids are anisotropic.

Statement II True solids have short range order in arrangement of constituent particles.

130. Statement I Amorphous solids soften over a range of temperature.

Statement II These can be moulded and blown into various shapes.

131. Statement I Graphite is a good conductor of electricity.

Statement II It happens due to its structure.

132. Statement I A bcc unit cell has two atom at its body centre.

Statement II A fcc unit cell has no such atom at its body centre.

133. Statement I There is only one way of arranging spheres in a one dimensional close packed structure.

Statement II In one dimensional close packed arrangement, the coordination number is 2.

134. Statement I Both hcp and ccp are equally efficient.

Statement II Packing efficiency of hcp is 74%.

135. Statement I Density of the unit cell is same as the density of the substance.

Statement II Density of the unit cell has no relation with the volume of unit cell.

136. Statement I Conductors are the solids with conductivities ranging between 10^4 to $10^7\ \text{ohm}^{-1}\text{m}^{-1}$.

Statement II Metals possess conductivities in the order of $10^7\ \text{omh}^{-1}\ \text{m}^{-1}$ are good conductors.

137. Statement I Metal conduct electricity in both solid as well as molten state.

Statement II Conductivity of metals depend upon the number of valence electrons available per atom.

138. Statement I Magnitude of magnetic moment of electron is very small.

Statement II It is measured in the unit called, Bohr magneton, μ_B.

139. Statement I Antiferromagnetic substances have domain structure similar to ferromagnetic substance.

Statement II Antiferromagnetic substances have oppositely oriented domains which cancel out each other's magnetic moment.

III. Statement Based Questions Type II

140. I. Thermal energy tends to keep the solid molecules apart.
II. Intermolecular forces tends to keep the solid molecules closer.
The true statement(s) is /are
(a) Only I (b) Only II
(c) Both I and II (d) None of these

141. Which of the following statement(s) is/are correct?
I. Diffusion in solids is very slow.
II. Solids have high density.
III. Vapour pressure of solids is generally higher than that of liquids at definite temperature.
Choose the correct codes.
(a) I, II and III (b) I and III
(c) II and III (d) I and II

142. Consider the following characteristic of a crystal lattice.
I. Each point in a lattice is called lattice point.
II. Each point in a lattice represents one constituent particle (atom, molecule or ion).
III. Lattice points are joined by straight lines to bring out the geometry of the lattice.
Which of the above statement(s) is/are true?
(a) I and II
(b) II and III
(c) I and III
(d) I, II and III

143. I. Possible variations for a cubic crystal system is primitive only.
II. The axial angles of a hexagonal crystal system are $\alpha = \beta = 90^\circ$ and $\gamma = 120^\circ$.
Which of the above statement(s) is/are true?
(a) Only I (b) Only II
(c) Both I and II (d) None of these

144. In a monoclinic lattice,
I. sides are unequal.
II. two faces have angles different from 90°.
Which of these fact(s) is/are correct?
(a) Only I (b) Only II
(c) Both I and II (d) None of these

145. Consider the following statements related to centred unit cells.
I. It contains one or more constituent particles present at positions other than corners.
II. It also contains constituent particles at corners.
III. It is of five types.
Which of the above statement(s) is/are true?
(a) I and II (b) II and III
(c) I and III (d) Only III

146. I. Space-filling representation of the unit cell depicts the actual particle size.
II. The arrangement of particles is easier to follow in open structures.
Which of these statement(s) is/are true?
(a) Only I (b) Only II
(c) Both I and II (d) None of these

147. In a fcc unit cell,
I. atoms are present at all the corners.
II. atoms are present at the centre of all the faces of the cube.
III. each atom at the face centre is shared between two unit cells.
Identify the correct statements.
(a) I and II (b) II and III
(c) I and III (d) All of these

148. I. bcc structure has maximum packing efficiency.
II. Percentage of total space filled by the particles is called packing efficiency.
Which of the above statement(s) is/are true?
(a) Only I (b) Only II
(c) Both I and II (d) None of these

149. I. NaCl and KCl show metal excess defect due to anionic vacancies.
II. *F*-centres are the anionic sites occupied by unpaired electrons.
III. *F*-centres is derived from the German word '*Farbenzenter*' for colour centre.
IV. *F*-centres impart yellow colour to the NaCl crystals.
Which of the above statement(s) is/are correct?
(a) II, III and IV (b) I, III and IV
(c) I, II and III (d) All of these

150. Consider the following statement(s).
I. Metal deficiency defect occurs when the metal shows variable valency.
II. Transition metal shows metal deficiency defect.
III. Because of metal deficiency, the compounds obtained are non-stoichiometric.
Which of these statement(s) are incorrect?
(a) Only III (b) Only II
(c) Only I (d) None of these

151. I. Those point defects that do not disturb the stoichiometry of the solid are called stoichiometric defects.
II. These are also called intrinsic or thermodynamic defects.
III. For ionic solids these are of two types, vacancy and interstitial defects.
Which of these statement(s) is/are correct?
(a) I and II (b) II and III
(c) I and III (d) All of these

152. Consider the following statements.

I. Impurity defects arise when foreign atoms are present at the lattice site in place of host atoms or at the vacant interstitial sites.

II. Addition of impurities alters the properties of the crystal.

III. Doping is the process of adding impurities to a crystalline substance so as to change its properties.

Which of the above statement(s) is/are correct?

(a) I and II
(b) II and III
(c) I and III
(d) I, II and III

153. I. Solids exhibit an amazing range of electrical conductivities.

II. Its magnitude ranges from 10^{-20} to 10^{7} omh^{-1} m^{-1}.

Which of the above statement(s) is/are correct?

(a) Only I
(b) Only II
(c) Both I and II
(d) None ot these

154. Consider the following statements.

I. When Si is doped with P or As, four electrons of both Si and P or As are involved in covalent bond formation.

II. The fifth electron of Si is delocalised.

III. Delocalisation increases the conductivity of doped Si.

Which of these statement(s) is/are correct?

(a) I and III
(b) II and III
(c) I and II
(d) I, II and III

155. Magnetic moment originates from

I. its orbital motion around the nucleus.

II. its spin around its axis.

Which of the above fact(s) is/are true?

(a) Only I
(b) Only II
(c) Both I and II
(d) Neither I nor II

156. Diamagnetic substances are

I. weakly repelled by magnetic field.

II. weakly magnetised in a magnetic field in opposite direction.

III. those which have no unpaired electron.

IV. pairing of electrons cancels their magnetic moment.

Which of the above statement(s) is incorrect?

(a) Only I
(b) Only II
(c) Only III
(d) None of these

157. Consider the following statements.

I. Ferromagnetic substances show permanent magnetism.

II. Paramagnetic substances show permanent magnetism.

Which of these statement(s) is/are true?

(a) Only I
(b) Only II
(c) Both I and II
(d) None of these

IV. Assertion-Reason Type Questions

■ **Directions** (Q. Nos. 158-175) *In the following questions, an Assertion* (A) *is followed by a corresponding Reason* (R). *Use the following keys to choose the appropriate answer.*

(a) Both A and R are correct; R is the correct explanation of A.
(b) Both A and R are correct; R is not the correct explanation of A.
(c) A is correct; R is incorrect.
(d) R is correct; A is incorrect.

158. **Assertion** (A) Solids are rigid in nature.

Reason (R) In solids, the constituent particles are free to move.

159. **Assertion** (A) Crystalline solids are isotropic.

Reason (R) These have different arrangement of particles along different directions.

160. **Assertion** (A) In covalent solids, atoms are held very strongly.

Reason (R) Covalent bonds are strong and directional in nature.

161. **Assertion** (A) HCl, SO_2 are the examples of polar molecular solids.

Reason (R) These are good conductors of electricity.

162. **Assertion** (A) Ionic solids are hard and brittle.

Reason (R) In molten state, ionic solids are conductor of electricity.

163. **Assertion** (A) On heating metallic solids, heat is uniformly spread throughout.

Reason (R) There are no free electron in metallic solids.

164. **Assertion** (A) Graphite is an example of tetragonal crystal system.

Reason (R) For a tetragonal system, $a = b \neq c$, $\alpha = \beta = \gamma = 90°$.

165. **Assertion** (A) Each simple cubic unit cell has 8 atoms.

Reason (R) The total number of atoms in one cubic unit cell is 1.

166. **Assertion** (A) For N atoms adopting bcc arrangement, there are $2N$ tetrahedral voids.

Reason (R) In CsCl crystal, $Cs^{\oplus}$ ions adopt bcc arrangement.

167. **Assertion** (A) The packing efficiency of hcp and fcc arrangement is equal.

Reason (R) In hcp packing each sphere is surrounded by twelve other spheres.

168. **Assertion** (A) Solids with *F*-centres conduct electricity and it is *n*-type semiconductor.

Reason (R) Solids containing *F*-centres are paramagnetic.

169. **Assertion** (A) On heating NaCl and ZnO turn yellow.

Reason (R) This happens due to metal excess defect due to anionic vacancies.

170. **Assertion** (A) In certain cases metals have a characteristic colour and lustre.

Reason (R) Free electrons are present in metals.

171. **Assertion** (A) Group 13 (metal) doped with crystals of Si are called a *p*-type semiconductor.

Reason (R) For this semiconducting properties holes are responsible.

172. **Assertion** (A) Si doped with electron rich impurity is called *n*-type semiconductor.

Reason (R) Conductivity of Si increases due to the negatively charged electron.

173. **Assertion** (A) Diamagnetic substances have no magnetic moment.

Reason (R) Pairing of electrons cancels their magnetic moment.

174. **Assertion** (A) As compared to ferromagnetic substances, ferrimagnetic substances are weakly attracted by magnetic field.

Reason (R) Ferrimagnetic substances lose ferrimagnetism on heating and becomes paramagnetic.

175. **Assertion** (A) O_2, Cu^{2+}, Fe^{3+} are paramagnetic substances.

Reason (R) They have one or more unpaired electrons which are attracted by magnetic field.

V. Matching Type Questions

176. Match the following columns.

Column I (Type of solids)	**Column II** (Properties)
A. Ionic solid	1. Malleable and ductile
B. Metallic solid	2. Dipole-dipole interactions
C. Polar molecular solid	3. Graphite
D. Network solid	4. Coloumbic forces of attraction

Codes

	A	B	C	D
(a)	4	1	2	3
(b)	1	2	3	4
(c)	2	3	4	1
(d)	3	4	1	2

177. Match the following columns.

Column I	**Column II**
A. Ionic solids	1. Giant molecules
B. Network solids	2. Volatile liquids or soft solids at room temperature
C. Metallic solids	3. No free ions to move in solid state
D. Hydrogen bonded molecular solid	4. Positive ions surrounded by sea of electrons.

Codes

	A	B	C	D		A	B	C	D
(a)	4	2	3	1	(b)	3	2	4	1
(c)	3	1	4	2	(d)	4	1	3	2

178. Match the following columns.

Column I (Type of solids)		**Column II** (Examples)
A. Non-polar molecular	1.	CCl_4
B. Metallic	2.	ZnS
C. Network	3.	SiO_2
D. Ionic	4.	Mg

Codes

	A	B	C	D
(a)	1	2	3	4
(b)	1	4	3	2
(c)	3	4	1	2
(d)	3	2	1	4

179. Match the following columns.

Column I (Crystal system)	**Column II** (Edge length)	**Column III** **(Axial angles)**
(A) Tetragonal	(i) $a \neq b \neq c$	(1) $\alpha = \gamma = 90°$; $\beta \neq 90°$
(B) Trigonal	(ii) $a = b = c$	(2) $\alpha = \beta = \gamma = 90°$
(C) Monoclinic	(iii) $a = b \neq c$	(3) $\alpha = \beta = \gamma \neq 90°$

Codes

	A	B	C
(a)	(i)(1)	(ii)(2)	(iii)(3)
(b)	(iii)(2)	(ii)(3)	(i)(1)
(c)	(ii)(1)	(iii)(2)	(i)(3)
(d)	(iii)(1)	(i)(3)	(ii)(2)

180. Match the following columns.

Column I (Cubic system)	**Column II** (Examples)
A. Cubic	1. $K_2Cr_2O_7$
B. Triclinic	2. NaCl
C. Tetragonal	3. ZnO
D. Hexagonal	4. TiO_2

Codes

	A	B	C	D
(a)	4	3	2	1
(b)	2	1	4	3
(c)	3	2	1	4
(d)	1	4	3	2

181. Match the following columns.

Column I	Column II
A. Unit cell contains one constituent particle at its body-centre besides the ones that are at its corners.	1. Face centred unit cells
B. Unit cell contains one constituent particle at the centre of each face, besides the ones that are at its corners.	2. End centred unit cells
C. Unit cell contains one constituent particle at the centre of any two opposite faces besides the ones that are at its corners.	3. Body centred unit cells

Codes

	A	B	C
(a)	1	2	3
(b)	2	3	1
(c)	3	1	2
(d)	1	3	2

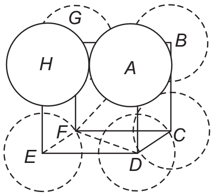
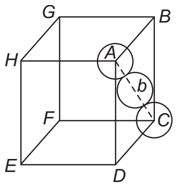
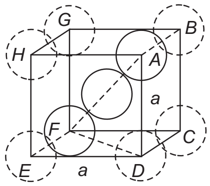
182. Match the following columns.

Column I (Distribution of particles A and B)	Column II (Formula)
A. A = At the corners and face centres B = At the edge centres and body centre	1. AB_3
B. A = At the corners B = One on each body diagonal	2. AB
C. A = At the corners B = At face centres	3. AB_4

Codes

	A	B	C
(a)	1	3	2
(b)	2	3	1
(c)	2	1	3
(d)	3	2	1

183. Match the following columns.

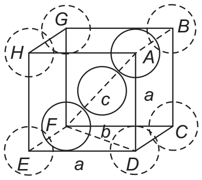
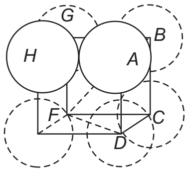
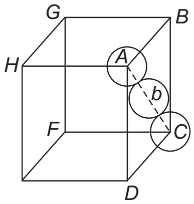
Column I (Packing efficiency)		Column II
A. 52%	1.	
B. 68%	2.	
C. 74%	3.	

Which of the following is correct?

Codes

	A	B	C
(a)	1	2	3
(b)	3	2	1
(c)	1	3	2
(d)	3	1	2

184. Match the following columns.

Column I (Radius of unit cell)		Column II (Unit cell)
A. $\frac{a}{2\sqrt{2}}$	1.	
B. $\frac{\sqrt{3}}{4}a$	2.	
C. $\frac{a}{2}$	3.	

Codes

	A	B	C
(a)	1	2	3
(b)	3	1	2
(c)	3	2	1
(d)	2	3	1

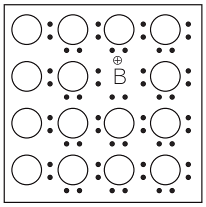
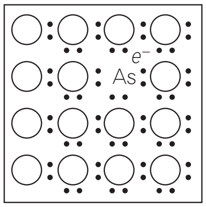
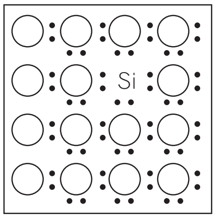
185. Match the following columns.

Column I (Properties of defects)	**Column II** (Types of defects)
A. It maintains electrical neutrality	1. Vacancy defects
B. It is also known as dislocation defect	2. Interstitial defect
C. This intrinsic defect results in decrease in density in non-ionic solids.	3. Frenkel defect
D. This defect increases the density in non-ionic solids.	4. Schottky defect

Codes

	A	B	C	D
(a)	3	2	4	1
(b)	4	3	1	2
(c)	1	4	2	3
(d)	1	4	3	2

186. Match the following columns.

Column I	**Column II**
A. Perfect crystal	1.  ⊕ B
B. *n*-type	2.  e^- As
C. *p*-type	3.  Si

Codes

	A	B	C
(a)	1	2	3
(b)	3	2	1
(c)	3	1	2
(d)	2	3	1

187. Match the following columns.

Column I (Schematic alignment of magnetic moments)	**Column II** (Substances)
A. ↑ ↑ ↑ ↑ ↑ ↑	1. Ferromagnetic
B. ↑ ↓ ↑ ↓ ↑ ↓	2. Ferrimagnetic
C. ↑ ↑ ↓ ↑ ↑ ↓	3. Anti-ferromagnetic

Codes

	A	B	C
(a)	1	3	2
(b)	1	2	3
(c)	2	3	1
(d)	3	1	2

VI. Matrix Matching Type Questions

188. Match the following columns.

Column I	**Column II** (Property/characteristics)
A. Carborundum	p. Hard and insulator
B. Zinc sulphide	q. Molecular solids
C. Ice	r. Soft
D. Hydrogen	s. Low melting point

Codes

	A	B	C	D
(a)	p	q	r	r, s
(b)	p	p	p, q, s	r, s
(c)	p, q, s		p, r	q, s, p
(d)	q	q	r	r, s

189. Match the following columns.

Column I	**Column II** (Property/characteristics)
A. Simple cubic and face centred cubic	p. Have these cell parameters $a = b = c$ and $\alpha = \beta = \gamma$.
B. Cubic and rhombohedral	q. Are two crystal systems.
C. Cubic and tetragonal	r. Have only two crystallographic angles of 90°.
D. Hexagonal and monoclinic	s. Belong to same crystal system.

Codes

	A	B	C	D
(a)	p, s	p, q	q	q, r
(b)	p, s	p	s, q	q, p
(c)	s	q	r	p
(d)	p, q	r, s	r, q	q, s

190. Match the following columns.

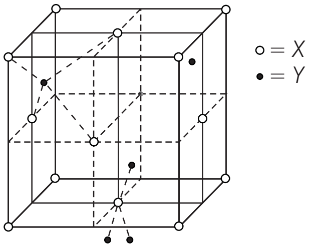
Column I (Molecule)		Column II (Structure/defect)	
A.	Sodium chloride	p.	Schottky defect
B.	Silver bromide	q.	Frenkel defect
C.	Zinc sulphide	r.	Packing efficiency 74 %
D.	Caesium chloride	s.	hcp crystal lattice

Codes

	A	B	C	D
(a)	r, q	p	q, r	q
(b)	p	r	p	q
(c)	p, r	p, q	q, r	p
(d)	q	r	q	r

VII. Passage Based Questions

■ **Directions** (Q. Nos. 191-192) *These questions are based on the following situation. Choose the correct options from those given below.*



191. The unit cell shown in the figure belongs to

(a) NaCl type (b) ZnS type
(c) CsCl type (d) Ca F_2 type

192. The coordination number of Y will be

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

■ **Directions** (Q. Nos. 193-195) *These questions are based on the following situation. Choose the correct options from those given below.*

A unit cell contains atoms (A) at all the corners and atoms (B) at alternate faces and all edge centres. Atom (C) are present at face centres left from (B) and one at each body diagonal at distance of 1/4th of body diagonal from corner.

193. Formula of the compound is

(a) $A_3B_8C_7$ (b) AB_4C_6
(c) $A_6B_4C_8$ (d) $A_2B_9C_{11}$

194. A tetrad axis is passed from the given unit cell and all the atoms touching the axis are removed. The possible formula of the compound left is

(a) AB_3C_6 and AB_4C_5
(b) $A_3B_6C_7$ and $A_3B_6C_5$
(c) $A_4B_5C_8$ and $A_4B_5C_7$
(d) AB_2C and ABC_2

195. Total fraction of voids occupied are

(a) 0.58
(b) 0.25
(c) 0.48
(d) 0.86

■ **Directions** (Q. Nos. 196-198) *Answer the following questions from the information given below.*

By adding impurity, the conductivity of Si or Ge can be increased. Introduction of these impurities generate defects in their crystal lattice. The semiconductors generated are of two types depending upon the nature of impurity.

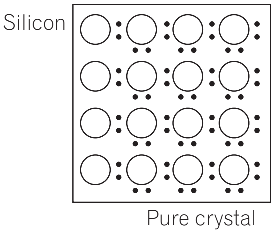
196. From which process the paragraph is related?

(a) Conductivities
(b) Impurity defect
(c) Doping
(d) Vacancy defect

197. Identify the incorrect statement.

(a) Si doped with electron rich impurity is a n-type semiconductor
(b) Si doped with electron deficit impurity is a p-type semiconductor
(c) Conductivity of doped silicon is increased by delocalised electrons
(d) An electron vacancy increases the conductivity of n-type semiconductors

198. Addition of impurity of arsenic in the following pure crystal results in the formation of



(a) a p-type semiconductor
(b) an impurity defect
(c) a semiconductor having free electrons as carrier
(d) electron deficient semiconductor

NCERT & NCERT Exemplar Questions

NCERT

199. Which of the following conditions favours the existence of a substance in the solid state?

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

200. 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

201. Which of the following is an amorphous solid?

(a) Graphite (C) (b) Quartz glass (SiO_2)
(c) Chrome alum (d) Silicon carbide (SiC)

202. Which of the following statement is not true about amorphous solids?

(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

203. 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

NCERT Exemplar

204. 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

205. Iodine molecules are held in the crystal lattice by ....

(a) London forces (b) dipole-dipole interactions
(c) covalent bonds (d) coulombic forces

206. Which of the following is a network solid?

(a) SO_2 (solid) (b) I_2
(c) Diamond (d) H_2O (ice)

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

1. $Mg(s)$ 2. $TiO(s)$
3. $I_2(s)$ 4. $H_2O(s)$

(a) Only 1 (b) Only 2
(c) 3 and 4 (d) 2, 3 and 4

208. Which of the following is not the characteristic of ionic solids?

(a) Very low value of electrical conductivity in the molten state
(b) Brittle nature
(c) Very strong forces of interactions
(d) Anisotropic nature

209. Graphite cannot be classified as ....

(a) conducting (b) network solid
(c) covalent solid (d) ionic solid

210. The lattice site in a pure crystal cannot be occupied by

(a) molecule (b) iron
(c) electron (d) atom

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

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

212. Which of the following statement is not true about the hexagonal close packing?

(a) The coordination number is 12
(b) It has 74% packing efficiency
(c) Tetrahedral voids of the second layer are covered by the spheres of the third layer
(d) In this arrangement spheres of the fourth layer are exactly aligned with those of the first layer

213. Which of the following is not true about the ionic solids?

(a) Bigger ions form the close packed structure
(b) Smaller ions occupy either the tetrahedral or the octahedral voids depending upon their size
(c) Occupation of all the voids is not necessary
(d) The fraction of octahedral or tetrahedral voids occupied depends upon the radii of the ions occupying the voids

214. The edge lengths of the unit cells in terms of the radius of spheres constituting fcc, bcc and simple cubic unit cells are respectively ....

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

215. The correct order of the packing efficiency in different types of unit cell is …*A*…. Here, *A* refers to

(a) fcc< bcc< simple cubic
(b) fcc> bcc> simple cubic
(c) fcc< bcc >simple cubic
(d) bcc< fcc> simple cubic

216. Cations are present in the interstitial sites in

(a) Frenkel defect
(b) Schottky defect
(c) vacancy defect
(d) metal deficiency defect

217. Schottky defect is observed in crystals when

(a) some cations move from their lattice site to interstitial sites
(b) equal number of cations and anions are missing from the lattice
(c) some lattice sites are occupied by electrons
(d) some impurity is present in the lattice

218. To get a *n*-type semiconductor from silicon, it should be doped with a substance with valency ....

(a) 2
(b) 1
(c) 3
(d) 5

219. Which of the following defects is also known as dislocation defect?

(a) Frenkel defect
(b) Schottky defect
(c) Non-stoichiometric defect
(d) Simple interstitial defect

220. Which of the following point defects are shown by AgBr(*s*) crystals?

I. Schottky defect
II. Frenkel defect
III. Metal excess defect
IV. Metal deficiency defect

(a) I and II
(b) III and IV
(c) I and III
(d) II and IV

221. Which of the following represents correct order of conductivity in solids?

(a) $\kappa_{\text{metals}} >> \kappa_{\text{insulators}} < \kappa_{\text{semiconductors}}$
(b) $\kappa_{\text{metals}} << \kappa_{\text{insulators}} < \kappa_{\text{semiconductors}}$
(c) $\kappa_{\text{metals}}\ \kappa_{\text{semiconductors}} > \kappa_{\text{insulators}} = \text{zero}$
(d) $\kappa_{\text{metals}} < \kappa_{\text{semiconductors}} > \kappa_{\text{insulators}} \neq \text{zero}$

222. Which of the following oxides behaves as conductor or insulator depending upon temperature?

(a) TiO
(b) SiO_2
(c) TiO_3
(d) MgO

223. Which of the following oxides shows electrical properties like metals?

(a) SiO_2
(b) MgO
(c) SO_2(s)
(d) CrO_2

224. Which kind of defects are introduced by doping?

(a) Dislocation defect
(b) Schottky defect
(c) Frenkel defect
(d) Electronic defect

225. Which of the following statements is not true?

(a) Paramagnetic substances are weakly attracted by magnetic field
(b) Ferromagnetic substances cannot be magnetised permanently
(c) The domains in antiferromagnetic substances are oppositely oriented with respect to each other
(d) Pairing of electrons cancels their magnetic moment in the diamagnetic substances

226. A ferromagnetic substance becomes a permanent magnet when it is placed in a magnetic field because ....

(a) all the domains get oriented in the direction of magnetic field
(b) all the domains get oriented in the direction opposite to the direction of magnetic field
(c) domains get oriented randomly
(d) domains are not affected by magnetic field

227. Amorphous solids can also be called ....

(a) pseudo solids
(b) true solids
(c) super cooled liquids
(d) super cooled solids

228. Which of the following cannot be regarded as molecular solid?

(a) SiC (silicon carbide)
(b) AlN
(c) Diamond
(d) I_2

229. Which of the following features are not shown by quartz glass?

(a) This is a crystalline solid
(b) Refractive index is same in all the directions
(c) This has definite heat of fusion
(d) This is also called super cooled liquid

230. The number of tetrahedral voids per unit cell in NaCl crystal is ....

(a) 4
(b) 8
(c) twice the number of octahedral voids
(d) four times the number of octahedral voids

231. In which of the following arrangements octahedral voids are formed?

(a) hcp
(b) bcc
(c) simple cubic
(d) fcc

232. Which of the following is not true about the voids formed in three dimensional hexagonal close packed structure?

(a) A tetrahedral void is formed when a sphere of the second layer is present above triangular void in the first layer
(b) All the triangular voids are not covered by the spheres of the second layer
(c) Tetrahedral voids are formed when the triangular voids in the second layer lie above the triangular voids in the first layer and the triangular shapes of these voids do not overlap
(d) Octahedral voids are formed when the triangular voids in the second layer exactly overlap with similar voids in the first layer

233. Which of the following statements are not true?

(a) Vacancy defect results in a decrease in the density of the substance

(b) Interstitial defects result in an increase in the density of the substance

(c) Impurity defect has no effect on the density of the substance

(d) Frenkel defect results in an increase in the density of the substance

234. An excess of potassium ions makes KCl crystals to appear violet or lilac in colour since ....

(a) some of the anionic sites are occupied by an unpaired electron

(b) some of the anionic sites are occupied by a pair of electrons

(c) there are vacancies at some anionic sites

(d) *F*-centres are created which impart colour to the crystals

235. Under the influence of electric field, which of the following statement is true about the movement of electrons and holes in a *p* -type semiconductor?

(a) Electron will move towards the positively charged plate through electron holes

(b) Holes will appear to be moving towards the negatively charged plate

(c) Both electrons and holes appear to move towards the positively charged plate

(d) Movement of electrons is not related to the movement of holes

236. Which of the following statements are true about semiconductors?

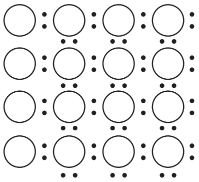
(a) Silicon doped with electron rich impurity is a *p*-type semiconductor

(b) Silicon doped with an electron rich impurity is an *n*-type semiconductor

(c) Delocalised electrons increase the conductivity of doped silicon

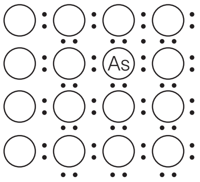
(d) An electron vacancy increases the conductivity of *n*-type semiconductor

237. A perfect crystal of silicon (fig) is doped with some elements as given in the options. Which of these options shows *n* -type semiconductors?

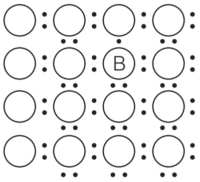


Pure crystal

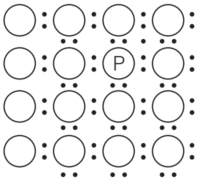
(a)



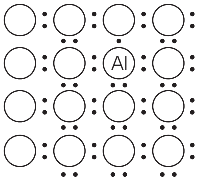
(b)



(c)



(d)



238. The value of magnetic moment is zero in the case of antiferromagnetic substances because the domains ....

(a) get oriented in the direction of the applied magnetic field

(b) get oriented opposite to the direction of the applied magnetic field

(c) are oppositely oriented with respect to each other without the application of magnetic field

(d) cancel out each other's magnetic moment

239. Which of the following statements are correct?

(a) Ferrimagnetic substances lose ferrimagnetism on heating and become paramagnetic

(b) Ferrimagnetic substances do not lose ferrimagnetism on heating and remain ferrimagnetic

(c) Antiferromagnetic substances have domain structures similar to ferromagnetic substances and their magnetic moments are not cancelled by each other

(d) In ferromagnetic substances, all the domains get oriented in the direction of magnetic field and remain as such even after removing magnetic field

240. Match the type of unit cell given in Column I with the features given in Column II.

Column I	Column II
A. Primitive cubic unit cell	1. Each of the three perpendicular edges compulsorily have the different edge length, i.e. $a \neq b \neq c$.
B. Body centred cubic unit cell	2. Number of atoms per unit cell is one.
C. Face centred cubic unit cell	3. Each of the three perpendicular edges compulsorily have the same edge length, i.e. $a = b = c$.
D. End centred orthorhombic unit cell	4. In addition to the contribution from the corner atoms the number of atoms present in a unit cell is one.
	5. In addition to the contribution from the corner atoms the number of atoms present in a unit cell is three.

Codes

	A	B	C	D
(a)	1,2	2,3	3,4	3,5
(b)	2,3	3,4	3,5	1,4
(c)	1,2,3	2,3	3,4,5	3,5
(d)	1,3	1,3	3,5	1,4

241. Match the type of packing given in Column I with the items given in Column II.

Column I	Column II
A. Square close packing in two dimensions	1. Triangular voids
B. Hexagonal close packing in two dimensions	2. Pattern of spheres is repeated in every fourth layer
C. Hexagonal close packing in three dimensions	3. Coordination number = 4
D. Cubic close packing in three dimensions	4. Pattern of sphere is repeated in alternate layers

Codes

	A	B	C	D		A	B	C	D
(a)	1	2	3	4	(b)	3	1	4	2
(c)	1	3	4	2	(d)	3	1	2	4

242. Match the defects given in Column I with the statements given in Column II.

Column I	Column II
A. Simple vacancy defect	1. Shown by non-ionic solids and increases density of the solid.
B. Simple interstitial defect	2. Shown by ionic solids and decreases density of the solid.
C. Frenkel defect	3. Shown by non-ionic solids and density of the solid decreases.
D. Schottky defect	4. Shown by ionic solids and density of the solid remains the same.

Codes

	A	B	C	D		A	B	C	D
(a)	3	1	2	4	(b)	3	1	4	2
(c)	1	3	4	2	(d)	1	3	2	4

243. Match the types of defect given in Column I with the statement given in Column II.

Column I	Column II
A. Impurity defect	1. NaCl with anionic sites called *F*-centres
B. Metal excess defect	2. FeO with Fe^{3+}
C. Metal deficiency defect	3. NaCl with Sr^{2+} and some cationic sites vacant

Codes

	A	B	C		A	B	C
(a)	1	2	3	(b)	3	2	1
(c)	1	3	2	(d)	3	1	2

244. Match the items given in Column I with the items given in Column II.

Column I	Column II
A. Mg in solid state	1. *p*-type semiconductor
B. $MgCl_2$ in molten state	2. *n*-type semiconductor
C. Silicon with phosphorus	3. Electrolytic conductor
D. Germanium with boron	4. Electronic conductor

Codes

	A	B	C	D
(a)	4	3	2	1
(b)	1	2	3	4
(c)	4	3	1	2
(d)	3	4	1	2

■ **Directions** (Q. Nos. 245-248 *In the following questions a statement of Assertion* (A) *followed by a statement of Reason* (R) *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 the correct explanation for Assertion.
(c) Assertion is correct statement but Reason is wrong statement.
(d) Assertion is incorrect statement but Reason is correct statement.

245. 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.

246. 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.

247. Assertion (A) The packing efficiency is maximum for the fcc structure.

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

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

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

Answers

1.	(b)	**2.**	(c)	**3.**	(c)	**4.**	(b)	**5.**	(a)	**6.**	(a)	**7.**	(d)	**8.**	(a)	**9.**	(d)	**10.**	(c)	**11.**	(c)	**12.**	(c)	**13.**	(c)	**14.**	(c)	**15.**	(a)
16.	(c)	**17.**	(d)	**18.**	(b)	**19.**	(c)	**20.**	(d)	**21.**	(a)	**22.**	(c)	**23.**	(b)	**24.**	(b)	**25.**	(b)	**26.**	(d)	**27.**	(a)	**28.**	(a)	**29.**	(c)	**30.**	(c)
31.	(c)	**32.**	(d)	**33.**	(a)	**34.**	(a)	**35.**	(c)	**36.**	(a)	**37.**	(c)	**38.**	(c)	**39.**	(c)	**40.**	(c)	**41.**	(d)	**42.**	(b)	**43.**	(b)	**44.**	(d)	**45.**	(a)
46.	(b)	**47.**	(b)	**48.**	(a)	**49.**	(a)	**50.**	(b)	**51.**	(b)	**52.**	(a)	**53.**	(a)	**54.**	(d)	**55.**	(c)	**56.**	(b)	**57.**	(c)	**58.**	(d)	**59.**	(a)	**60.**	(d)
61.	(a)	**62.**	(d)	**63.**	(d)	**64.**	(a)	**65.**	(a)	**66.**	(a)	**67.**	(c)	**68.**	(a)	**69.**	(a)	**70.**	(c)	**71.**	(b)	**72.**	(a)	**73.**	(b)	**74.**	(b)	**75.**	(d)
76.	(c)	**77.**	(c)	**78.**	(c)	**79.**	(b)	**80.**	(c)	**81.**	(a)	**82.**	(d)	**83.**	(a)	**84.**	(a)	**85.**	(c)	**86.**	(b)	**87.**	(b)	**88.**	(d)	**89.**	(b)	**90.**	(a)
91.	(a)	**92.**	(c)	**93.**	(d)	**94.**	(c)	**95.**	(a)	**96.**	(c)	**97.**	(d)	**98.**	(b)	**99.**	(d)	**100.**	(c)	**101.**	(b)	**102.**	(b)	**103.**	(c)	**104.**	(a)	**105.**	(d)
106.	(d)	**107.**	(d)	**108.**	(b)	**109.**	(b)	**110.**	(d)	**111.**	(a)	**112.**	(a)	**113.**	(d)	**114.**	(b)	**115.**	(d)	**116.**	(abc)	**117.**	(abc)	**118.**	(abcd)	**119.**	(cd)	**120.**	(ab)
121.	(ac)	**122.**	(abd)	**123.**	(ad)	**124.**	(abcd)	**125.**	(abd)	**126.**	(b)	**127.**	(b)	**128.**	(d)	**129.**	(c)	**130.**	(b)	**131.**	(a)	**132.**	(d)	**133.**	(b)	**134.**	(b)	**135.**	(c)
136.	(b)	**137.**	(b)	**138.**	(b)	**139.**	(b)	**140.**	(c)	**141.**	(d)	**142.**	(d)	**143.**	(b)	**144.**	(c)	**145.**	(a)	**146.**	(c)	**147.**	(d)	**148.**	(b)	**149.**	(d)	**150.**	(d)
151.	(a)	**152.**	(d)	**153.**	(c)	**154.**	(a)	**155.**	(c)	**156.**	(d)	**157.**	(a)	**158.**	(c)	**159.**	(d)	**160.**	(a)	**161.**	(c)	**162.**	(b)	**163.**	(c)	**164.**	(d)	**165.**	(a)
166.	(d)	**167.**	(b)	**168.**	(b)	**169.**	(c)	**170.**	(a)	**171.**	(a)	**172.**	(a)	**173.**	(a)	**174.**	(b)	**175.**	(a)	**176.**	(a)	**177.**	(c)	**178.**	(b)	**179.**	(b)	**180.**	(b)
181.	(c)	**182.**	(b)	**183.**	(c)	**184.**	(b)	**185.**	(b)	**186.**	(b)	**187.**	(a)	**188.**	(b)	**189.**	(a)	**190.**	(c)	**191.**	(b)	**192.**	(d)	**193.**	(b)	**194.**	(a)	**195.**	(a)
196.	(c)	**197.**	(d)	**198.**	(c)	**199.**	(b)	**200.**	(b)	**201.**	(b)	**202.**	(d)	**203.**	(b)	**204.**	(a)	**205.**	(a)	**206.**	(c)	**207.**	(c)	**208.**	(a)	**209.**	(d)	**210.**	(c)
211.	(d)	**212.**	(d)	**213.**	(d)	**214.**	(a)	**215.**	(b)	**216.**	(a)	**217.**	(b)	**218.**	(d)	**219.**	(a)	**220.**	(a)	**221.**	(a)	**222.**	(c)	**223.**	(d)	**224.**	(d)	**225.**	(b)
226.	(a)	**227.**	(ac)	**228.**	(abc)	**229.**	(ac)	**230.**	(bc)	**231.**	(ad)	**232.**	(cd)	**233.**	(cd)	**234.**	(ad)	**235.**	(ab)	**236.**	(bc)	**237.**	(ac)	**238.**	(cd)	**239.**	(ad)	**240.**	(b)
241.	(b)	**242.**	(b)	**243.**	(d)	**244.**	(a)	**245.**	(a)	**246.**	(c)	**247.**	(b)	**248.**	(c)														

Hints & Explanations

1. (*b*) Plasma and Bose Einstein Condensate are the other two states of matter which appear only in extreme conditions of temperature and pressure. Thermal energy and intermolecular forces together play a key role in deciding the state of matter.

5. (*a*) Solids are incompressible.

9. (*d*) Crystalline solids have long range order of constituent atoms and hence, have sharp melting point. These are anisotropic in nature, i.e. their physical properties are different in different directions.

10. (*c*) Amorphous solids are neither rigid nor incompressible.

11. (*c*) Quartz glass being an amorphous solid does not have sharp melting point but quartz being crystalline solid have sharp melting point. Salt and ice both have long range order of arrangement of constituent particles.

Glass gives two pieces having irregular surface when cut with sharp edged tool.

15. (*a*) Solid SO_2 and solid NH_3 are polar molecules, so form polar molecular solids.

16. (*c*) Diamond, AlN and SiC are covalent solids because of the presence of covalent bonds between constituent atoms whereas I_2 is a molecular solid as in it London forces exist between the I_2 molecules.

17. (*d*) Molecular solids are formed when the constituent particles are molecules/atoms and the interparticle forces are van der Waals' forces. Thus, methane (CH_4) is a molecular solid.

18. (*b*) Ionic solids have high electrical conductivity in molten state due to the presence of free ions.

19. (*c*) In metallic solids, positive ions are surrounded by and held together by a sea of free electrons. These electrons are mobile and are evenly spread throughout the crystal. These solids are highly malleable and ductile. Covalent bonds are strong and directional but found in covalent solids, not in metallic solids.

21. (*a*) Since, HI is a covalent molecule, so HI molecules are present at the lattice points of the crystal.

22. (*c*) With the exception of graphite, giant molecules, i.e. covalent solids are non-conductor of electricity.

23. (*b*) Graphite contains free electrons and hence, shows electrical conduction in its natural physical state. Sodium and calcium being metals are also the conductors of electricity.

24. (*b*) The given characteristics belong to ionic solid. Hence, the solid *'X'* is ionic.

25. (*b*) In silicon, constituent particles are bonded together by covalent bonds, therefore, it exists as covalent crystals in the solid state.

26. (*d*) A unit cell is characterised by six parameters three edges; a,b and c and angles between the edges, i.e. α,β,γ.

29. (*c*) Cinnabar $a = b = c$ and $\alpha = \beta = \gamma \neq 90°$.

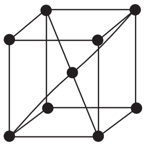
So, it is an example of trigonal (Rhombohedral) crystal system.

30. (*c*) KNO_3 — Orthorhombic
$CaCO_3$ — Trigonal
$CaSO_4$ — Tetragonal
$CuSO_4 \cdot 5H_2O$ — Triclinic

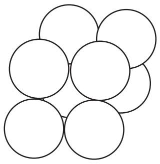
32. (*d*) Triclinic system is totally asymmetric, i.e. $a \neq b \neq c$ and $\alpha \neq \beta \neq \gamma = 90°$. So, it has no rotation of symmetry.

33. (*a*) Fig. (a) represents structure of triclinic crystal system as $\mathrm{a} \neq b \neq c$ and $\alpha \neq \beta \neq \gamma \neq 90°$

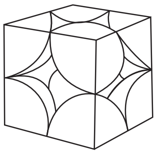
34. (*a*) Primitive cubic unit cell can be represented by three model structure.



(i) Open structure model



(ii) Space filling structure model



(iii) Actual portions of atoms model

35. (*c*) Fig. (ii) and (iii) show the structure of primitive cubic unit cell (simple cubic unit cell). Fig. (i) shows the structrure of fcc unit cell.

36. (*a*) Given figure. shows the structure of simple cubic unit cell.

In simple cubic (sc) unit cell each corner atom is shared between 8 unit cells.

38. (*c*) Contribution of each atom per unit cell located at face-centre in a fcc unit cell is 0.5 or $\frac{1}{2}$.

41. (*d*) There are four body diagonals. Atoms on the body diagonals are not shared by any other unit cell. Contribution by atoms on corners $= 8 \times \frac{1}{8} = 1$ and

Contribution by atoms on body diagonal $= 2 \times 4 = 8$

Hence, total number of atoms $= 8 + 1 = 9$

42. (*b*) As P atoms are at the 8 corners of the cube,

$\therefore$ Number of P atoms per unit cell $= 8 \times \frac{1}{8} = 1$

As Q atoms are at the face centres of the 6 faces of the cube,

$\therefore$ Number of Q atoms per unit cell $= \frac{1}{2} \times 6 = 3$

$\therefore$ Ratio of atoms $P : Q = 1 : 3$

Thus, the formula of the compound is PQ_3.

43. (*b*) As atoms B are present at the 8 corners of the cube,

$\therefore$ Number of B atoms per unit cell $= 8 \times \frac{1}{8} = 1$

As atom A are present at the body centre,

$\therefore$ Number of A atoms per unit cell $= 1$

$\therefore$ Ratio of atoms $A : B = 1 : 1$

Thus, the formula of the compound is AB.

44. (*d*) Number of effective A atoms

$= 8$ corners $\times 1/8$ per corner atom share

$= 1$ atoms/unit cell

Number of atoms on faces of a cube = 6 atoms

If one B atom is missing from one face, number of B atoms left = 5

$\therefore$Number of effective B atoms = 5 faces $\times 1/2$ per face atom share $= \frac{5}{2}$ per unit cell

The formula of the compound is A_2B_5.

45. (*a*) The unit cell of body centred cube has one atom at each of the eight corners and one atom at the centre of the body. Hence, the atom at centre remains in contact with 8 corner atoms. Thus, the coordination number of bcc is 8.

46. (*b*) In ZnS (zinc blende), each sulphide ion is tetrahedrally surrounded by four zinc ions and each zinc ion is surrounded by four sulphide ions. Thus, zinc sulphide possesses 4 : 4 coordination.

48. (*a*) Number of octahedral voids = Number of atoms in the close packed structure

Since, number of atom = 1

So, number of octahedral void = 1

49. (*a*) A tetrahedral void is formed by joining the centre of four spheres.

50. (*b*) Octahedral voids are surrounded by six spheres.

Tetrahedral void is formed when the centres of four spheres are joined.

51. (*b*) Packing fraction of ccp $= \frac{\pi}{3\sqrt{2}} = 0.74 \Rightarrow 74\%$

per cent free space in ccp = 26%

Packing fraction of bcc $= \frac{\pi\sqrt{3}}{8} = 0.68\%$

per cent free space in bcc = 32%

53. (*a*) For a given radius of anion (r_s)

Radius ratio for octahedral void and tetrahedral void is as follows

$$\left(\frac{r_+}{r_-}\right)_{\mathrm{OV}} > \left(\frac{r_+}{r_-}\right)_{\mathrm{TV}} \quad \left(\begin{array}{l}\text{For OV}, \frac{r_+}{r_-} = 0.414 - 0.732 \\[2ex] \text{For TV}, \frac{r_+}{r_-} = 0.225 - 0.414\end{array}\right)$$

54. (*d*) In fcc unit cell, a corner atom can support 8 unit cells. In each cube, at a distance of $\sqrt{3}\,a/4$ from corner atom, there is tetrahedral void; it implies each atom is surrounded by eight tetrahedral voids.

At the centre of edge, there is an octahedral void. Each corner can support six edges and hence it is surrounded by six octahedral voids.

56. (*b*) Contribution of atom from the edge centre is 1/4.

Therefore number of atoms $M = 1/4 \times 4$ (from edge centre) $+1$ (from body centre) $= 2$

Number of atoms X

$= \frac{1}{8} \times 8$ (from corners) $+ \frac{1}{2} \times 6$ (from face centre)

$= 4$

Empirical formula $= M_2X_4 = MX_2$

57. (*c*) In ccp lattice number of atoms = 4

So, number of Cu atoms = 4

Number of edge centred atoms $= 12 \times \frac{1}{4} = 3$

$\therefore$ Number of silver atoms = 3

Number of gold atoms = 1

$\therefore$ Formula is $\mathrm{Cu_4Ag_3Au}$.

58. (*d*) From ccp arrangement, number of O^{2-} ions = 4

Number of octahedral voids = 4

Thus, number of tetrahedral voids = $4 \times 2 = 8$

$\therefore$ Number of tetrahedral voids occupied by divalent

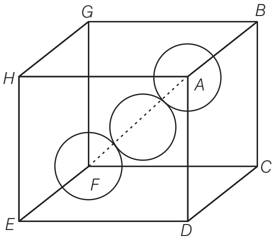
Metal $A = \frac{1}{4} \times 8 = 2$

Number of monovalent metal B = Number of octahedral void = 4

$\therefore$ Formula is $A_2B_4O_4 = AB_2O_2$.

60. (*d*) In bcc, 2 atoms are present. One atom lie at the centre of cube while, other lies at the corner of the cube.

Hence, the distance between the body centred and one corner atom is half of the body diagonal, i.e. $\frac{\sqrt{3}}{2}a$.



61. (*a*) Total number of atom (s) in the unit cell of fcc = 4

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

$\therefore$ Total volume of atoms in the fcc unit cell

$$= 4 \times \frac{4}{3}\pi r^3 = \frac{16}{3}\pi r^3$$

62. (*d*) In cubic close packing 74% space is occupied by the atoms with *ABCABC* packing of atoms.

63. (*d*) In case of bcc lattice cell, packing efficiency = 68%

$\therefore$ Per cent vacant space = 100 − 68 = 32%

64. (*a*) When Na metal crystallises in bcc unit cell with unit cell edge, $a = 4.29\,\text{Å}$

We have the formula for radius, $r = \frac{\sqrt{3}}{4} \times 4.29\,\text{Å} = 1.86\,\text{Å}$

65. (*d*) Ratio $= \dfrac{abc}{6 \times \left(\frac{\sqrt{3}}{4}a^2\right) \times c} = \dfrac{2}{3\sqrt{3}}$

[$\because$ Volume of tetragonal lattice unit cell = abc and of hexagonal lattice unit cell = $6 \times \left(\frac{\sqrt{3}}{4}a^2\right) \times c$]

66. (*a*) This figure represents fcc unit cell, therefore, it has 74% packing efficiency.

67. (*c*) For bcc, radius, $r = \frac{\sqrt{3}}{4}a$

Edge length not covered by atoms = $a - 2r$

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

$$\therefore \text{ \% of fraction not covered by atoms } = \frac{a\left[\frac{2-\sqrt{3}}{2}\right] \times 100}{a}$$

$$= 0.134 \times 100 = 13.4\%$$

68. (*a*) Maximum packing efficiency (PE) is of hcp and ccp structure, i.e. 74% in each case.

69. (*a*) For fcc lattice $4r = \sqrt{2}a$

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

$$= \frac{408}{2\sqrt{2}} = 144 \text{ pm}$$

Diameter, $d = 2r = 2 \times 144$ pm = 288 pm

70. (*c*) Packing fraction in fcc, bcc and sc are 0.74, 0.68, and 0.52 respectively.

$$\text{Ratio} = \frac{0.74}{0.74} : \frac{0.68}{0.74} : \frac{0.52}{0.74} = 1 : 0.92 : 0.70$$

71. (*b*) Given, edge length = 361 pm

Four metal atoms in one unit cell

i.e. effective number of atoms in a unit cell $(z) = 4$ (given)

$\therefore$ It is a fcc structure.

$\therefore$ Face diagonal, $\sqrt{2}a = 4r$

$$\Rightarrow \qquad r = \frac{\sqrt{2} \times 361}{4} = 127 \text{ pm.}$$

72. (*a*) For bcc, $r = \frac{\sqrt{3}}{4}a$

or $\qquad a = \frac{4r}{\sqrt{3}} = \frac{4 \times 75}{1.732} = 173.2$ pm

73. (*b*) Edge length, $a = 3.04\,\text{Å} = 3.04 \times 10^{-8}$ cm

Volume of bcc unit cell = a^3

$$= (3.04 \times 10^{-8})^3 = 2.81 \times 10^{-23} \text{ cm}^3$$

74. (*b*) We know that

Density, $d = \dfrac{Z \times M}{N_A \times a^3}$

Given, $Z = 4$ $\qquad$ So, $d = \dfrac{4M}{a^3 N_A}$

75. (*d*) The correct relation among mass of atom (m), molar mass (M) and Avogadro's constant (N_A) is $m = \dfrac{M}{N_A}$

76. (*c*) We know that,

Density, $d = \dfrac{ZM}{a^3 N_A}$ $\quad\therefore\quad$ $a = \left[\dfrac{ZM}{N_A d}\right]^{\frac{1}{3}}$

77. (*c*) In case of fcc lattice, number of atoms per unit cell, $Z = 4$.

We know that, $M = \dfrac{dN_A a^3}{Z}$

$$\therefore\ M = \frac{8.92 \text{ g/cm}^3 \times 6.022 \times 10^{23} \text{atom mol}^{-1} \times (3.608 \times 10^{-8} \text{ cm})^3}{4 \text{ atom}} = 63.1 \text{ g/mol}$$

78. (*c*) Given, cell is fcc. So, $Z = 4$

Edge length, $a = 404 \text{ pm} = 4.04 \times 10^{-8}$ cm

Density of metal, $d = 2.72 \text{ g/cm}^3$

$$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$$

Molar mass of the metal, $M = ?$

We know that density,

$$d = \frac{Z \times M}{a^3 \cdot N_A} \Rightarrow M = \frac{d \cdot a^3 N_A}{Z}$$

$$= \frac{2.72 \times (4.04 \times 10^{-8})^3 \times 6.02 \times 10^{23}}{4}$$

$$= 27 \text{ g/mol}$$

$\therefore$ Atomic mass of copper (Cu) = 63.1 u.

79. (*b*) Given,

Molar mass, $M = 50$ g / mol, $N_A = 6.02 \times 10^{23}$

$$Z = 2 \text{ (for bcc lattice)}$$

Edge length, $a = 300 \text{ pm} = 3 \times 10^{-8}$ cm

$$d = \frac{ZM}{N_A . a^3}$$

$$= \frac{2 \times 50}{6.02 \times 10^{23} \times (3 \times 10^{-8})^3} = 6.2 \text{ g cm}^{-3}$$

80. (*c*) Volume of the unit cell $= (444 \text{ pm})^3$

$$= (444 \times 10^{-10} \text{ cm})^3$$

$$= 8.75 \times 10^{-23} \text{ cm}^3$$

Volume of 404 g of the element $= \dfrac{\text{mass}}{\text{density}}$

$$= \frac{404 \text{ g}}{7.2 \text{ g cm}^{-3}}$$

$$= 56.11 \text{ cm}^3$$

$\therefore$ Number of unit cells in this volume

$$= \frac{56.11 \text{ cm}^3}{8.75 \times 10^{-23} \text{ cm}^3 \text{ / unit cell}}$$

$$= 6.41 \times 10^{23} \text{ unit cells}$$

81. (*a*) Mass of one unit cell (m) = volume × density

$$= a^3 \times d = a^3 \times \frac{MZ}{N_A a^3} = \frac{MZ}{N_A}$$

$$m = \frac{58.5 \times 4}{6.02 \times 10^{23}} \text{ g}$$

$\therefore$Number of unit cells in 1 g $= \dfrac{1}{m}$

$$= \frac{6.02 \times 10^{23}}{58.5 \times 4} = 2.57 \times 10^{21}$$

82. (*d*) Number of unit cells $= \dfrac{\text{mass of metal}}{\text{mass of one unit cell}}$

Given, edge length of unit cell $= 2 \text{ Å} = 2 \times 10^{-8}$ cm

Mass of metal = 200 g

Density of metal = 2.5 g cm^{-3}

Volume of unit cell = (edge length)$^3 = (2 \times 10^{-8})^3$

$$= 8 \times 10^{-24} \text{ cm}^3$$

Mass of one unit cell = volume × density

$$= 8 \times 10^{-24} \times 2.5 = 20 \times 10^{-24}$$

$\therefore$ Number of unit cells in 200 g metal

$$= \frac{\text{mass of metal}}{\text{mass of one unit cell}}$$

$$= \frac{200}{20 \times 10^{-24}} = 1.0 \times 10^{25}$$

83. (*a*) Density $(d) = \dfrac{Z \times M}{a^3 \times N_A}$

$$2.7 = \frac{Z \times 27}{(405 \times 10^{-10})^3 \times 6.022 \times 10^{23}}$$

$$Z = \frac{2.7 \times (405)^3 \times 10^{-30} \times 6.022 \times 10^{23}}{27} = 4$$

For face centred cubic unit cell, number of atoms are 4.

84. (*a*) As xenon (Xe) crystallises in fcc lattice, nearest neighbouring distance $(d) = \dfrac{a}{\sqrt{2}} = \dfrac{620}{\sqrt{2}} = \dfrac{620}{1.414} = 438.5$ pm

85. (*c*) Volume, $V = 7.014 \times 10^{-23} \text{ cm}^3$

As smallest Cs to Cs internuclear distance is equal to length of the side of the cube, i.e. a, therefore,

$$a^3 = 7.014 \times 10^{-23} \text{cm}^3$$

or $$a = \sqrt[3]{7.014 \times 10^{-23}} \text{cm}^3$$

$$= 4.125 \times 10^{-8}$$

$$= 4.12 \text{Å} \approx 4 \text{Å}$$

86. (*b*) Density $(d) = \dfrac{Z \times M}{a^3 \times N_A}$

According to question,the length (l), breadth (w) and height (h) of orthorhombic cell are different.

$$a_h = 12.05 \overset{\circ}{\text{A}} = 12.05 \times 10^{-8} \text{ cm}$$

$$a_l = 15.05 \overset{\circ}{\text{A}} = 15.05 \times 10^{-8} \text{ cm}$$

$$a_w = 2.69 \overset{\circ}{\text{A}} = 2.69 \times 10^{-8} \text{ cm}$$

Each cell has 2 molecules $Z = 2$ and $N_A = 6.022 \times 10^{23}$

Hence, molar mass

$$M = \frac{d \times a_h \times a_w \times a_l \times N_A}{Z}$$

$$= \frac{1.419 \times 12.05 \times 10^{-8} \times 15.05 \times 10^{-8} \times 2.69 \times 10^{-8} \times 6.023 \times 10^{23}}{2}$$

$$= 2084.6 \times 10^{-1} = 209 \text{ g/ mol}$$

87. (*b*) Defects are generated in a crystal, if crystallisation occurs at fast or moderate rate. Intrinsic defects are stoichiometric defects.

88. (*d*) Frenkel defect is simply a dislocation defect, so has no effect over density.

89. (*b*) AgBr exhibits both Frenkel and Schottky defects.

90. (*d*) When an ion (generally cation due to its small size) is missing from its normal position and occupy an interstitial site between the lattice points, the lattice defect obtained is known as Frenkel defect, which is also called dislocation defect.

91. (*a*) In the given crystal structure, equal number of cations and anions are missing (two K^+ and two Cl^-) from their normal lattice sites and the crystal maintains its electrical neutrality. Hence, this is Schottky defect.

92. (*c*) Due to missing of ions Schottky defect results in decreased density but Frenkel defect has no effect over density because in it only ions dislocate from its original position to interstitial site.

93. (*d*) Ionic solids containing cations and anions of comparable size, show Schottky defect. Thus, all the given solids show this defect.

94. (*c*) Frenkel defect is called dislocation defect. It is shown by ZnS, AgBr etc.

95. (*a*) The figure *A* is of impurity defect while figure *B* is of *F*-centre.

96. (*c*) Both the solutions show impurity defect. When molten NaCl containing a little amount of $SrCl_2$ is crystallised, some of the sites of Na^+ ions are occupied by Sr^{2+}. Each Sr^{2+} replaces two Na^+ ions. It occupies the site of only one ion and the other site remains vacant. The cationic vacancies, hence produced are same in number as that of Sr^{2+} ions. Same case is with the solid solution of $CdCl_2$ and AgCl.

97. (*d*) Flame colour of metal ions is due to the *F*-centre generated in metal excess defect.

98. (*b*) FeO generally possess metal deficiency defect with a composition of $Fe_{0.95}O$.

99. (*d*) $Ni = 3d^8\ 4s^2$ (Atomic number = 28)

$\therefore Ni^{2+} = 3d^8$ and $Ni^{3+} = 3d^7$

Hence, 96% Ni^{2+} ion and 4% of Ni^{3+} ions are present. Let number of O^{2-} ion present in the crystal $= x$

Applying electroneutrality rule,

$$\text{Total positive charge} = \text{Total negative charge}$$

$$0.96 \times 2\ (\text{+ve charge}) + 0.04 \times 3\ (\text{+ve charge}) = x \times 2\ (\text{–ve charge})$$

$$\therefore\ 0.96 \times 2 + 0.04 \times 3 - 2x = 0$$

$$\therefore\ x = 1.02$$

So, formula of crystal $Ni_{1.00}O_{1.02}$ or $Ni_{0.98}O_{1.00}$

101. (*b*) In conductors, both conduction band (CB) and valence band (VB) overlap to each other (metal).

In semiconductor, small energy gap is present between CB and VB. In insulator, large energy gap is present between CB and VB.

103. (*c*) Valence band overlaps with conduction band. The gap between valence band and conduction band is negligible but can be determined.

104. (*a*) Electrical conductivity of semiconductors increases with rise in temperature since electrons can jump to the conduction band by absorbing energy.

105. (*d*) Si and Ge being semiconductors are used for making transistors.

106. (*d*) Diamond has the highest value of energy gap as it is an insulator.

108. (*b*) On adding a pentavalent impurity with Ge, we get *n*-type semiconductor because excess of electrons is responsible for conduction.

109. (*b*) Doping of B with Si leads to *p*-type semiconductors because of generation of hole as carrier.

110. (*d*) Every substance has some magnetic properties associated with it. Origin of magnetic properties lie in electrons. Each electron behaves like a tiny magnet. Its magnetic moment originates from the two types of motions (a) its orbital motion around the nucleus and (b) its spin around its own axis.

111. (*a*) The value of Bohr magneton, μ_B is $9.27 \times 10^{-24}\ \text{A m}^2$.

112. (*a*) Ferromagnetic substances act as permanent magnet even in the absence of magnetic field.

114. (*b*) $K_4[Fe(CN)_6]$ is not a ferroelectric compound. It is a diamagnetic substance .

115. (*d*) CrO_2 is a ferromagnetic substance in nature.

116. (*a*,*b*,*c*) Crystalline solids have definite heat of fusion, definite geometrical shape, sharp melting point and are anisotropic while amorphous solids are isotropic and these properties are not definite in their case.

117. (*a*,*b*,*c*) Non-polar molecular solids are formed by non-polar covalent bonds. In these solids, the atoms or molecules are held by weak dispersion or London forces. These are soft and non-conductors of electricity. e.g. H_2, Cl_2 and I_2.
HCl and SO_2 are formed by polar covalent bonds.

118. (*a*,*b*,*c*, *d*) All the given statements are correct.

119. (*c,d*) Irregularities or deviations from ideal arrangement in the entire rows of lattice points are called line defects, whereas deviations or irregularities from ideal arrangement around a point or an atom in crystalline substance are called point defects. All these irregularities are called crystal defects.

F-centre are responsible for the lilac colour of KCl.

120. (*a,b*) Schottky and vacancy defects result in decreased density due to missing of ions from the crystal.

121. (*a*,*c*) When cation and anion are of comparable size, the crystal shows Schottky defect, i.e. equal number of cations and anions are missing from their lattice sites. It results in decreased density. There is only one Schottky defect per 10^{16} ions.

122. (*a*,*b*,*d*) Various combinations of *n*-type and *p*-type semiconductors are used for making electronic components. Diode is a combination of *n*-type and *p*-type semiconductors and is used as rectifier. Transistors are made by sandwiching a layer of one type of semiconductor between two layers of the other type of semiconductors. *n-p-n* and *p-n-p* type of transistors are used to detect or amplify radio or audio signals.

123. (*a*,,*d*) Antiferromagnetic substances have zero magnetic moment and magnetite (Fe_3O_4) is ferrimagnetic.

124. (*a*,*b*,*c*,*d*) All the given statements are correct.

125. (*a*,*b*,*d*) Fe, Co, Ni, CrO_2 are ferromagnetic in nature.

MnO is antiferromagnetic in nature.

H_2O, NaCl are diamagnetic in nature.

$MgFe_2O_4$ and $ZnFe_2O_4$ are ferrimagnetic in nature.

126. (*b*) Properties of different solids are different and are decided by the conditions of temperature and pressure.

127. (*b*) Melting point of a solid depends upon the type of intermolecular force and hence, structure of solids. That's why it plays a key role in the identification of the type of solid.

128. (*d*) Melting point of only crystalline solids is sharp, hence only some solids have sharp melting points.

129. (*c*) True solids are anisotropic due to long range order in arrangement of constituent particles.

130. (*b*) Amorphous solids soften over a range of temperature due to their short range order of arrangement of constituents. These can be moulded and blown into various shapes.

131. (*a*) Graphite is a good conductor of electricity due to its structure. In it carbon atoms are arranged in different layers and each atom is covalently bonded to three of its neighbouring atoms in the same layer. The fourth valence electron is present between different layers and is free to move about. These free electrons make graphite a good conductor of electricity.

132. (*d*) A bcc unit cell contains only 8 corner atoms and one atom at body centre. fcc unit cell has no such atom. It contains 8 corner atoms and 6 face centred atoms.

134. (*b*) Both hcp and ccp are equally efficient. Packing efficiency of hcp and ccp is

$$\text{PE} = \frac{4 \times (4/3)\pi r^3 \times 100}{(2\sqrt{2}r)^3}\%$$

$$= \frac{(16/3)\pi r^3 \times 100}{16\sqrt{2}\ r^3}\% = 74\%$$

135. (*c*) Density of the unit cell is related with its volume as

$$\text{Volume of the unit cell} = \frac{\text{mass of unit cell}}{\text{density of unit cell}}$$

Further the density of unit cell also represent the density of the substance.

139. (*b*) Antiferromagnetic and ferromagnetic substances have similar domain structure but antiferro magnetic substances have opposite oriented domains which cancel out each other's magnetic field.

141. (*d*) Solids have slow diffusion rate and high density too. Vapour pressure of solids is generally lower than that of liquids at definite temperature.

142. (*d*) All the given statements are true for crystal lattice.

143. (*b*) For a cubic crystal system, the possible variations are primitive, body-centred and face-centred. The axial angles of a hexagonal crystal system are $\alpha = \beta = 90°$ and $\gamma = 120°$.

144. (*c*) In a monoclinic lattice, sides are unequal and two faces have angles different from 90°.

145. (*a*) When a unit cell comprises of one or more constituent particles present at positions other than corners in addition to those at corners, it is called centred unit cell. Centred unit cells are of three type : body centred, face centred and end centred unit cells.

146. (*c*) In open structures, each small sphere represents only the centre of the particle occupying that position and not its actual size but the arrangement of particles is easier to follow in open structures.

These are too space-filling representation that shows the actual particle size.

147. (*d*) A fcc unit cell contains 8 atoms one at each corner having contribution 1/8 and 6 atoms one at each face having contribution 1/2. Hence, atoms present at each face is shared between two unit cells.

148. (*b*) hcp and ccp unit cells have maximum packing efficiency (i.e. 74%), which shows the percentage of total space filled by the particles.

149. (*d*) Alkali metals solid like KCl and NaCl show non-stoichiometric defect. When crystals of NaCl are heated in an atmosphere of sodium vapour, the sodium atoms are deposited on the surface of the crystal. The Cl^- ions get diffused to the surface of the crystal and combine with Na atoms to give NaCl. This happens by loss of electron by Na atoms to form Na^+ ions. The released electron diffused into the crystal and occupy anionic sites. Hence, the crystal now has anionic sites. Therefore, the crystal now has an excess of sodium. These anionic sites occupied by unpaired electrons are called *F*-centres (derived from the German word ***Farbenzenter*** for colour centre). These *F*-centres impart yellow colour to the NaCl crystal.

150. (*d*) Metal deficiency defect is shown by a metals which show variable valency, e.g. transition metal elements. It leads to the formation of non-stoichiometric compounds.

151. (*a*) Vacancy and interstitial defects are the two types of stoichiometric defects observed in non-ionic solids.

In case of ionic solids, there defects are called Schottky defect and Frenkel defect.

Other two statements are true.

152. (*d*) All the given statements are true.

154. (*a*) When Si is doped with P or As, four electrons of both Si and P or As are involved in covalent bond formation. The fifth electron of P or As is extra and becomes delocalised. Delocalisation increases the conductivity of doped Si.

156. (*d*) Diamagnetic substances are weakly repelled by magnetic field. H_2O, NaCl and C_6H_6 are some of diamagnetic substances. They are weakly magnetised in a magnetic field in opposite direction. These have no unpaired electrons. Pairing of electrons cancels their magnetic moment and they lose their magnetic character.

157. (*a*) Paramagnetic substances do not show permanent magnetism.

158. (*c*) In solids, the constituent particles have fixed positions and hence, they can only oscillate about their mean positions.

159. (*d*) Crystalline solids are anisotropic as these have different arrangement of particles along different directions.

160. (*a*) In covalent solids, atoms are held very strongly due to strong and directional nature of covalent bonds.

161. (*c*) Although HCl and SO_2 are polar molecular solids but they have neither free electrons nor free ions. Due to the absence of free electrons or ions these are non-conductors of electricity.

162. (*b*) Ionic solids have strong intermolecular forces of attraction which make them hard and brittle. Because of the presence of free ions, these can conduct electricity in molten state or in aqueous solution.

163. (*c*) Metallic solids are conductors of electricity because of the presence of free electrons. Heat in informly spread throughout when such a solid is heated.

164. (*d*) Like quartz and ice, graphite is an example of hexagonal system.

For this $\alpha = \beta = 90°$ and $\gamma = 120°$ and $a = b \neq c$.

For a tetragonal system $\alpha = \beta = \gamma = 90°$ and $a = b \neq c$.

165. (*a*) Each cubic unit cell has 8 atom (s) at its corners. Since, each corner atom is shared by 8 unit cells, so total number of atom in one unit cell is $8 \times \frac{1}{8} = 1$ atom.

166. (*d*) For N atoms adopting fcc arrangement, there are $2N$ tetrahedral voids.

167. (*b*) In hcp as well as ccp packing each sphere is surrounded by twelve other spheres. Thus, the packing efficiency of hcp and fcc arrangement is equal.

168. (*b*) Solids with F-centre conduct electricity due to the presence of unpaired electrons, Hence, paramagnetic.

169. (*c*) On heating both NaCl and ZnO turn yellow. It happens due to metal excess defect due to anionic vacancies in case of NaCl and due to the presence of extra cations at interstitital sites in case of ZnO.

170. (*a*) In certain cases, metals have a characteristic colour and lustre due to the presence of free electrons.

171. (*a*) Group 13 metal doped with crystal of Si are called *p*-type semiconductor because holes are responsible for their conducting properties.

173. (*a*) In diamagnetic substances all the electrons are paired, so their magnetic moment is zero.

174. (*b*) Ferrimagnetic substance is weakly attracted by magnetic field as in ferrimagnetic substances, some domain are cancel out.

They become paramagnetic on heating.

175. (*a*) O_2, Cu^{2+}, Fe^{3+} are paramagnetic substances due to the presence of one or more unpaired electrons which are attached by magnetic field.

177. (*c*) In ionic solids, strong coulombic forces binds the ions together, so they are not free to move. However, in aqueous state or in molten state, these forces get weaker or and ions get free to move so they can conduct electricity.

Network solids are infact giant molecules due to their large three dimensional structure. In metallic solids, positive ions are surrounded by the sea of electrons.

Hydrogen bonded molecular solids may be volatile liquids or soft solids at room temperature.

178. (*b*) $A \to 1;\ B \to 4;\ C \to 3;\ D \to 2$

179. (*b*) In tetragonal system two sides are equal but one is different. In it all the axial angles are 90° so, $a = b \neq c$ and $\alpha = \beta = \gamma = 90°$.

In trigonal system, all the sides and axial angles are equal but not equal to 90°, i.e. $a = b = c$ and $\alpha = \beta = \gamma \neq 90°$

In monoclinic system, all the sides are unequal and one bond angle (axial angle) is not equal to 90°, i.e.

$$a \neq b \neq c$$

and $$\alpha = \gamma = 90°, \beta \neq 90°$$

180. (*b*) $A \to 2;\ B \to 1;\ C \to 4;\ D \to 3$.

181. (*c*) $A \to 3;\ B \to 1;\ C \to 2$.

182. (*b*) A. A atoms are at the corners and face centres, so number of A atoms $= \underset{\text{Corner atoms}}{8 \times \frac{1}{8}} + \underset{\text{Face centre atoms}}{\frac{1}{2} \times 6} = 1 + 3 = 4$

B atoms are at the edge centres and body centre, so number of B atoms per unit cell $= 12 \times \frac{1}{4} + 1 = 3 + 1 = 4$

Ratio of A and $B = 4 : 4 = 1 : 1$ so formula is AB.

B. A atoms are at the corners, so number of A atoms per unit cell $= 8 \times \frac{1}{8} = 1$ atom.

B atoms are at the body diagonals, so number of B atoms per unit cell $= 4 \times 1 = 4$

$\therefore$ Formula of molecule $= AB_4$.

C. When A atoms are at the corners and B atoms are at face centres, the formula is AB_3.

183. (*c*) $A \to 1;\ B \to 3;\ C \to 2$.

184. (*b*) $A \to 3;\ B \to 1;\ C \to 2$ [∵ 2 is sc, 3 is fcc and 1 is bcc].

185. (*b*) $A \to 4;\ B \to 3;\ C \to 1;\ D \to 2$

186. (*b*) $A \to 3;\ B \to 2;\ C \to 1$

187. (*a*) $A \to 1;\ B \to 3;\ C \to 2$

188. (*b*) $A \to p;\ B \to p;\ C \to p, q, s;\ D \to r, s$

Carborundum, zinc sulphide and ice are hard and insulator. Out of these, carborundum is a covalent solid, zinc sulphide is an ionic solid and ice and hydrogen are molecular solids.

Melting point of molecular solids is low so H_2 and ice have low melting point. Only H_2 is soft.

189. (*a*) $A \to p, s;\ B \to p, q;\ C \to q;\ D \to q, r$

For cubic system all the sides and angles are equal.

Cubic, rhombohedral, tetragonal, hexagonal and monoclinic are the types of crystal system.

For hexagonal and monoclinic system only two crystallographic angles are of 90°, i.e. $\alpha = \beta = 90°$ or $\alpha = \gamma = 90°$.

190. (*c*) $A \to p, r;\ B \to p, q;\ C \to q, r;\ D \to p,$

Sodium chloride and caesium chloride because of the similar size of cations and anions, show Schottky defect while, AgBr and ZnS show Frenkel defect (as their cation is smaller). AgBr also shows Schottky defect.

NaCl and ZnS crystallises in fcc lattice and have packing efficiency 74%.

191. (*b*) In the given unit cell, Y atoms are present at the corners and at the centre of each face whereas X atoms occupy half of the tetrahedral sites. This is the condition of ZnS type structure.

192. (*d*) ZnS has 4 : 4 coordination.

193. (*b*) Number of A atoms $= 8\,(\text{corner}) \times \frac{1}{8}\,(\text{per corner share}) = 1$

Number of B atoms $= 2\,(\text{alternate face}) \times \frac{1}{2}\,(\text{face centre share})$

$+12\,(\text{edge}) \times \frac{1}{4}(\text{edge centre share})$

$= 1 + 3 = 4$

Number of C atoms $= 4$ (face centres left from B)

$\times \frac{1}{2}\,(\text{face centre share}) + 1\,(\text{at body diagonal})$

$\times 4\,(\text{body diagonal})$

$= 2 + 4 = 6$

Formula AB_4C_6.

194. (*a*) **Case I** If the tetrad axis passes through the face centres where B lies, then

Number of B atoms $= 4 - \left(\frac{1}{2} \times 2\right) = 3$

The formula of the compound left is AB_3C_6.

Case II If the tetrad axis passes through the face centres where C lies, then

Number of C atoms $= 6 - \left(\frac{1}{2} \times 2\right) = 5$

The formula of the compound left is AB_4C_5.

195. (*a*) There are 8 effective tetrahedral voids, out of which 4 are occupied (one at each body diagonal) and 4 effective octahedral voids such that one is not filled (body centre). So, out of 12(8 tetrahedral voids + 3 octahedral voids)

the fraction of void occupied $= \frac{7}{12} = 0.58$

196. (*c*) The process of addition of impurity in intrinsic semiconductors like Si or Ge to increase their conductivity is called doping.

197. (*d*) Electronic excess is responsible for the conductivity of *n*-type semiconductors. This is achieved by adding electron rich impurity.

198. (*c*) When arsenic is added to the pure crystal of silicon, its four electrons bind with four electrons of Si but the fifth remains free and is responsible for making it a *n*-type semiconductor.

199. (*b*) At low temperature existence of a substance in solid state is due to

(a) slow molecular motion and

(b) strong cohesive forces

These two forces hold the constituent particles together thus causes existence of substance in solid state.

200. (*b*) Crystalline solids are anisotropic, i.e. they show different physical properties such as electrical resistance, refractive index in different directions.

201. (*b*) Quartz glass (SiO_2) is an amorphous solid due to its short range order of constituent particles.

202. (*d*) Amorphous solids are isotropic in nature because they have no long range order and value of any physical property will be same in all the directions.

On the other hand, anisotropic nature is a characteristic feature of crystalline solid.

203. (*b*) Crystalline solid has regular arrangement of constituent particles over a long distance in the crystal lattice. Due to this regular arrangement crystalline solid have sharp melting point.

204. (*a*) Since, quartz glass is an amorphous solid having short range order of constituents. Hence, value of refractive index for it is same in all the directions. It can be measured and may or may not be equal to zero.

205. (*a*) Iodine molecule belongs to a class of non-polar molecular solid in which constituent molecules are held together by London or dispersion forces.

206. (*c*) Diamond is a giant molecule in which constituent atoms are held together by covalent bonds. Hence, it is a network solid.

207. (*c*) Iodine is a non-polar molecular solid in which iodine molecules are held together by London or dispersion forces. This is soft and non-conductor of electricity.

Water(*s*), i.e. ice is a hydrogen bonded molecular solid in which H and O are held together by polar covalent bond and each water molecule is held together by hydrogen bonding. Due to non-ionic nature, it is not electrical conductor.

208. (*a*) Ionic solids are easily dissociated into its ions in molten state and hence, show high electrical conductivity. They are anisotropic and brittle and the ions are linked together by very strong forces of interactions.

209. (*d*) Graphite can not be classified as ionic solid as graphite is not made up of ions. It is made up of carbon atoms covalently bonded to three other carbon atoms so, it is a covalent solid.

Since, the formation of covalent bond occurs throughout the crystal therefore, it is a type of network solid. Due to the presence of free electrons, graphite is also classified as conducting solid.

210. (*c*) Each point in a lattice, i.e. lattice point (which are either atom or molecule or ion) are joined together by a straight line to bring out geometry of lattice. In pure crystal constituents are arranged in fixed stoichiometric ratio.

Hence, existence of free electrons are not possible, in case of pure crystals. It is possible only in case of imperfection in solid.

211. (*d*) Since, number of atoms in fcc unit cell = 4.

$\therefore$ Number of tetrahedral voids $= 2 \times$ number of atoms

$= 2 \times 4 = 8$

212. (*d*) In hexagonal close packing, arrangement is $ABAB\ldots\ldots$ type and not ABC, ABC …… type.

213. (*d*) The fraction of octahedral or tetrahedral voids occupied depends upon the radii of the ions present at the lattice points. As we know the radii of octahedral or tetrahedral void is related to radii of atoms (r) as

Radius of octahedral void $(R_o) = 0.414\ r$

Radius of tetrahedral void $(R_t) = 0.225\,r$

where, $r =$ radius of bigger atom involved.

214. (*a*) Edge length for different types of unit cells can be tabulated as:

Types of unit cell	Edge length
fcc	$2\sqrt{2}r$
bcc	$\frac{4}{\sqrt{3}}r$
sc	$2r$

215. (*b*) In fcc unit cell packing efficiency is 74%; in case of bcc, it is 68% and in sc it is 52.4%, so the order of packing efficiency is $\text{fcc} > \text{bcc} > \text{sc}$.

216. (*a*) In Frenkel defect, the smaller ion, generally the cations, left its position and occupy the interstitial site.

217. (*b*) When equal number of cations and anions are missing from their lattice points, the defect is called Schottky defect.

218. (*d*) Since, silicon belongs to group 14 and has valency 4. Hence, to make a *n*-type semiconductor, a substance with valency 5 (greater than 4) should be added.

220. (*a*) AgBr shows both Schottky as well as Frenkel defect. In AgBr, both Ag^+ and Br^- ions are absent from the lattice causing Schottky defect.

However, Ag^+ ions are mobile, so they have a tendency to move aside the lattice and trapped in interstitial site, hence cause Frenkel defect.

221. (*a*) Metals are conductor, semiconductors conduct very less electricity, while insulators have conductivities in the range of $10^{-20} - 10^{10} \Omega^{-1} m^{-1}$.

222. (*c*) Oxides like VO, VO_2, VO_3 and TiO_3 show metallic or insulating properties depending on temperature.

223. (*d*) Metallic oxides like TiO, CrO_2, ReO_3 behave like metals.

224. (*d*) Doping creates electronic defect because it results in an extra electron or in a hole.

225. (*b*) Ferromagnetic substances can be magnetised by applying magnetic field and this magnetic property persist within it even after removal of magnetic field.

227. (*a*, *c*) Amorphous solids have short range order of arrangement of constituent particles and hence, have a tendency to flow very slowly. That's why they are also known as pseudo solids or super cooled liquids.

228. (*a*, *b*, *c*) SiC, AlN and diamond are the examples of network solid as they have three dimensional structure while, I_2 is a molecular solid, because in it the particles are held together by dipole-dipole interactions.

229. (*a*, *c*) Quartz glass is an amorphous solid so it has no definite heat of fusion. This is due to short range order of molecules. It is also known as super cooled liquid and is isotropic in nature.

230. (*b*, *c*) NaCl has a rock salt type structure having fcc arrangement.

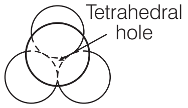
Total number of atoms per unit cell = 4

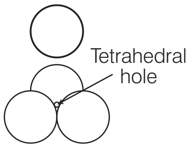
$\therefore$ Number of tetrahedral voids $= 2 \times 4 = 8$

Number of octahedral voids = 4

231. (*a*, *d*) In hcp and fcc arrangements, octahedral voids are formed. In fcc, the octahedral voids are observed at edges and centre of cube, while in bcc and simple cubic, no octahedral void is observed.

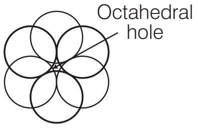
232. (*c*, *d*) Tetrahedral voids are formed when the sphere of the second layer lie exactly above the triangular voids in the first layer.

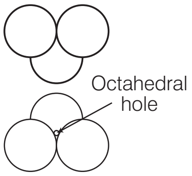




Octahedral voids are formed when triangular void of second layer lie above the triangular voids in the first layer but it does not cover the void completely.

The triangular shape of there voids are opposite of each other.





233. (*c*, *d*) Impurity defect changes the density of substance as impurity has different density than the ion present in perfect crystal.

Frenkel defect has no effect on density of the substance.

234. (*a*, *d*) When KCl crystals are heated, it leads to the deposition of potassium ion on the surface of KCl. The Cl^- ions diffuse to the surface of crystal and loss of electron convert potassium atom in to K^+ ion. The released electron occupies anionic site which is known as *F*-centre and impart colour to the crystal**.**

235. (*a*, *b*) In a *p*-type semiconductor, the conductivity is due to existence of hole. When electric field is applied to a *p*-type semiconductor and the hole appears to move towards negatively charged plate and the electron moves towards positively charged plate.

236. (*b*, *c*) Silicon doped with an electron rich impurity is a *n*-type semiconductor. Conductivity of *n*-type semiconductor is due to the presence of free electron. Delocalisation of electrons increases the conductivity of doped silicon due to increase in mobility of electron.

237. (*a*, *c*) When group 15 elements are doped into a perfect crystal of Si, it leads to the formation of *n*-type semiconductor.

Here, in (a) As (group 15, period 3) is doped to perfect Si crystal and in (c) P (group 15, period 2) is doped to perfect Si-crystal.

238. (*c*, *d*) In case of antiferromagnetic substances, the magnetic moment becomes zero because the domains are oppositely oriented with respect to each other without the application of magnetic field and hence their magnetic moment cancel out each other.

239. (*a*, *d*) Ferrimagnetic substances lose ferrimagnetism on heating and become paramagnetic. In ferrimagnetic substance domains are alligned in parallel and antiparallel direction in unequal numbers.

In ferromagnetic substances, all the domains get oriented in the direction of magnetic field and remain as such even after removing magnetic field.

240. (*b*) **A.** → (2, 3) **B.** → (3, 4) **C.** → (3, 5) **D.** → (1, 4)

A. For primitive unit cell, $a = b = c$
Total number of atoms per unit cell $= 1/8 \times 8 = 1$
Here, 1/8 is due to contribution of each atom present at corner.

B. For body centred cubic unit cell, $a = b = c$
This lattice contain atoms at corner as well as body centre.
Contribution due to atoms at corner $= 1/8 \times 8 = 1$ Contribution due to atoms at body centre = 1

C. For face centred unit cell, $a = b = c$

Total constituent ions per unit cell present at corners

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

Total constituent ions per unit cell present at face centre

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

D. For end centered orthorhombic unit cell, $a \neq b \neq c$
Total contribution of atoms present at corner

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

Total contribution of atoms present at end centre

$$= \frac{1}{2} \times 2 = 1$$

Hence, other than corner it contain total one atom per unit cell.

241. (*b*) **A.** → (3) **B.** → (1) **C.** → (4) **D.** → (2)

242. (*b*) **A.** → (3) **B.** → (1) **C.** → (4) **D.** → (2)

243. (*d*) **A.** → (3) **B.** → (1) **C.** → (2)

A. Impurity defect arises due to replacement of one common ion present in any crystal by another uncommon ion.

B. Metal excess defect is due to missing of cation from ideal ionic solid which lead to create a *F*-centre generally occupied by unpaired electrons, e.g. NaCl with anionic site.

C. In FeO and Fe^{3+} exists along with Fe^{2+} which lead to decrease in metal ion(s) so this is a type of metal deficiency defect.

244. (*a*) **A.** → (4) **B.** → (3)
C. → (2) **D.** → (1)

A. Mg in solid state show electronic conductivity due to the presence of free electrons hence, it is known as electronic conductor.

B. $MgCl_2$ in molten state show electrolytic conductivity due to the presence of ions in molten state.

C. Silicon doped with phosphorus contain one extra electron due to which it shows conductivity under the influence of electric field and is known as *p*-type semiconductor.

D. Germanium doped with boron contain one hole due to which it shows conductivity under the influence of electric field and is known as *n*-type semiconductor.

245. (*a*) In simple cubic unit cell each atom is present at corners having contribution 1/8.

Hence, total number of atoms present per unit cell in sc unit cell is $\frac{1}{8} \times 8 = 1$.

246. (*c*) Since, octahedral void present at body centre contribute 1 void while voids present at each edge contribute 1/4 hence total number of octahedral void can be calculated as number of octahedral void $= 1/4 \times 12 + 1 = 4$.

248. (*c*) Semiconductors are solids with conductivities in the intermediate range vary from $10^{-6} - 10^{4}\ \Omega^{-1}\,\text{m}^{-1}$.

Intermediate conductivity is due to small energy gap between valence band and conduction band.