Level - I

Chapter 1

The Solid State

Solutions (Set-1)

SECTION - A

School/Board Exam. Type Questions

Very Short Answer Type Questions

1. Define dislocation in crystals.

Sol. In crystals sometimes some of ions are shifted from their regular sites to interstitial spaces, this is called dislocation.

2. Why is Frenkel defect not found in pure alkali metal halides?

Sol. Because the size of cations is quite similar to size of anion, which cannot fit into the void.

3. How does density of a solid get affected by Frenkel defect?

Sol. Density of solid is not affected by Frenkel defect. It remain same, because ions do not escape from crystal.

4. What is non-stoichiometry defect occurs in crystals?

Sol. In crystals some metal cations are lost form their lattices and their charges are balanced by metal cations of same element in higher oxidation state. It causes metal deficiency and non-stoichiometric defect.

5. What is the radius for an ion to occupy tetrahedral site?

Sol. $r_{T.void} = 0.225\ R$ (R = radius of ion forming lattice)

$\therefore$ Radius of ion, which has to occupy void must be 0.225 R

6. Name one solid which has both Schottky and Frenkel defects.

Sol. AgBr is the solid which has both Schottky and Frenkel defects.

7. Why common salt is sometimes yellow instead of being pure white?

Sol. Common salt (NaCl) is sometimes converted in yellow colour due to metal excess defect caused by anion vacancy (F-center).

8. What is piezo electricity?

Sol. Some of the solids produces electricity upon applying pressure known as piezoelectricity.

9. How does temperature influence the conductivity of a semiconductor?

Sol. By increasing temperature conductivity of semiconductor increases.

Short Answer Type Questions

10. What is the coordination number of atom in HCP and CCP?

Sol. Coordination number of HCP = 12

Coordination number of CCP = 12

11. Why stoichiometric defects are also called intrinsic defects?

Sol. As all stoichiometric defects are caused due to internal reasons such as ions dislocation, loss of cations and anions etc. they are called intrinsic defects.

12. Why does zinc oxide exhibit enhanced electrical conductivity on heating?

Sol. Due to metal excess defect.

13. Do all the metals possess a close packed structure? Name the different structures exhibited and give their packing fractions.

Sol. Yes, most of the metals ((except Hg) possess close packed structures. These can be

Simple cubic-packing fraction 0.524 or 52.4%.

Body centred cubic PE = 0.68 or 68%

Face centred cubic PE = 0.74 or 74%

14. What type of substances would make better permanent magnets– Ferromagnetic or Ferrimagnetic? Justify your answer.

Sol. Ferromagnetic substances can make better permanent magnets. They have spontaneous alignment of magnetic moments of domains in same directions which persists even when the magnetic field is removed.

15. (a) What is the difference between Schottky and Frenkel defect?

(b) What is doping?

Sol. (a)

Schottky defect	**Frenkel defect**
1. Equal number of cation and anions are missing from their normal crystal sites in a whole ratio.	1. Some atoms or ions are displaced or dislocated from their sites.
2. It lowers the density of solid	2. No effect on density of solid.
3. Ionic compounds having high C.N. and Comparable radii of cation and anion show this defect. e.g., NaCl, CsCl	3. Ionic compounds with low C.N. and a large difference in cationic and anionic radii show this defect e.g., AgCl, ZnS

(b) Doping means addition of an appropriate amount of suitable impurity to a semiconductor to increase its conductance upto measurable limits is called doping e.g. Mixing of ‘P’ with Si.

16. What are voids? Discuss tetrahedral and octahedral interstitial voids in a close packed arrangement.

Sol. Inter particle vacant spaces in a three dimensional crystal lattice are called voids.

(a) Vacant space among four spheres having tetrahedral arrangement is called tetrahedral void and Its C.N. is 4.

(b) The vacant space form by placing six sphere at vertices of octahedran is called octahedral void. Its C.N. is 6.

17. Classify each of the following as p-type or n-type semi conductor.

(i) Ge doped with In

(ii) B doped with Si

Sol. (i) Ge (group 14) doped with In (group 13) causes p-type semiconductor while.

(ii) B(group - 13) doped with Si(group-14) causes n-type semiconductor.

18. What is F-centre?

Sol. The site where electron is entrapped in the anion vacancy is called F centre.

19. What do you understand by imperfections in ionic crystals? Name the types of imperfections which occur in ionic crystals?

Sol. Ionic solids show two types of defects i.e.

(a) **Electronic defects :** Caused due to electrons, they can cause n-type and p-type semiconductor.

(b) **Point defects**

(i) Stoichiometric defects. i.e., Schottky and Frenkel defect and

(ii) Non-stoichiometric defect.

20. Explain the antiferromagnetic substances have unpaired electrons but their dipole moment is zero.

Sol. In antiferromagnetic substances, although there are many unpaired electronic spins, still they get aligned in such a way that no electron remains unpaired hence, net dipole moment is zero.

21. Discuss the magnetic behaviour of transition metal oxides.

Sol. Generally transition metal oxides are para or ferromagnetic by nature e.g. TiO, Ti_2O_3, VO_2, CuO etc. are paramagnetic and CrO_2 is ferromagnetic.

22. The ions of NaF and MgO all have same number of electrons and the internuclear distances are about the same (235 pm and 215 pm). Why the melting point of NaF and MgO so different i.e. 982°C and 2642°C?

Sol. In NaF both sodium and fluorine ions have a charge of + 1 and – 1 respectively i.e. Na^+ and F^- but in MgO solid it contains Mg^{+2} and O^{-2} ions. Due to more magnitude of charge there are strong coulombic forces of attraction between magnetism and oxygen, hence its mp is quite high.

23. Explain the following :

(i) How does density of crystals change due to Schottky defect?

(ii) White ZnO becomes yellow on heating.

Sol. (i) In Schottky defect, there is a loss of matter due to loss of some cations and proportionate number of anions. It causes decrease in density.

(ii) On heating crystals of ZnO decompose.

$$ZnO \xrightleftharpoons{\Delta} Zn^{+2} + 2e^- + \frac{1}{2}O_2$$

Excess of Zn^{+2} ions formed are trapped in the interstitial space and electrons are trapped in neighbourhood. These electrons (causing F-centre) are responsible for absorbing radiations and emitting yellow light.

24. Assign reasons for the following :

(i) Phosphorous doped silicon is a semiconductor.

(ii) Some of very old glass objects appear slightly milky instead of being transparent.

Sol. (i) When Si is doped with 'P' 4 valence electrons of 'P' get involved in the formation of four covalent bonds with Si and the fifth valence electron of 'P' gets delocalised and conducts electricity. In this way Si becomes n-type semiconductor.

(ii) In very old samples of glass objects some constituent particles slowly undergo disordered in their arrangement. Hence, these objects appear slightly milky.

25. (a) What is anisotropy?

(b) What is doping?

Sol. (a) **Anisotropy :** Crystalline substances show different values of certain properties such as mechanical strength, conductance, refractive index etc. when measured through different angles and different planes. It is called anisotropy.

(b) **Doping :** Intermixing of some pure elements with impurities of certain elements is called doping e.g., pure Ge is doped with Al (p-type semiconductor).

26. Out of SiO_2(s), Si(s), NaCl(s) and Br_2(l) which is the best electrical conductor?

Sol. NaCl (Molten) is best electrical conductor among all.

27. What is meant by superconductivity?

Sol. At low temperature, where a substance offers no resistance to the flow of electricity is called superconductivity

Long Answer Type Questions

28. $CaCl_2$ will introduce Schottky defect if added to AgCl crystal. Explain.

Sol. Two Ag^+ ions will be replaced by one Ca^{2+} ion to maintain electrical neutrality. Thus a hole is created at the lattice site for every Ca^{2+} ion introduced.

29. Lithium metal has a body centred cubic structure. Its density is 0.53 g cm^{-3} and its molar mass is 6.94g/mol. Calculate the volume of a unit cell of lithium metal.

Sol. Given, Z = 2, ρ = 0.53 g/cc, M = 6.94 g/mol V = ?

$$\rho = \frac{Z \times M}{N_0 \times V} \qquad \therefore \quad V = \frac{Z \times M}{\rho \times N_0}$$

$$V = \frac{2 \times 6.94}{0.53 \times 6.02 \times 10^{23}} = 4.35 \times 10^{-23}\ cm^3$$

30. The unit of an element of atomic mass 96 and density 10.3 g/cm^3 is a cube with edge length of 314 pm. Find the structure of crystal lattice (simple cubic, fcc or bcc).

Sol. Given, A = 96 ρ = 10.3 g/cm^3

a = 314 pm $N_0 = 6.023 \times 10^{23}$

Z = ?

$$\rho = \frac{A \times Z}{N_0 \times V \text{ or } a^3} \quad \therefore Z = \frac{\rho \times N_0 \times a^3}{A}$$

$$Z = \frac{10.3 \times 6.02 \times 10^{23} \times \left(314 \times 10^{-10}\right)^3}{96} = 2$$

Hence, it is BCC crystal lattice.

31. Sodium metal is quite soft whereas sodium chloride crystals are quite hard. Explain why.

Sol. Sodium metal has pure metallic lattice which contains weak metallic bond between kernels and mobile sea of electrons. Its lattice is BCC whereas in NaCl, It is a three dimensional F.C.C. packing of Na^+ and Cl^- (C.N. = 6 each) containing strong coulombic or electrostatic forces of attraction, which is quite stronger than metallic bonding.

32. Sodium crystallizes in a cubic lattice and the edge of the unit cell is 430 pm. Calculate number of atoms in the unit cell. (A_{Na} = 23). Density of sodium metal is 0.9623 g/cm^3.

Sol. $Z = \dfrac{\rho \times N_0 \times a^3}{A} = \dfrac{0.9623 \times 6.02 \times 10^{23} \times \left(430 \times 10^{-10}\right)^3}{23}$

$\therefore$ Z = 2 (BCC)

33. A metallic element x exists as a cubic lattice. Each edge of the unit cell is 2.9 Å and density of metal is 7.2 g/cm^3. How many unit cells will be present in 100 g of the metal?

Sol. $N_0 = \dfrac{Z \times W}{a^3 \times \rho} = \dfrac{1 \times 100}{7.2 \times \left(2.9 \times 10^{-8}\right)^3}$

$N_0 = 5.7 \times 10^{23}$ (As for a simple cubic Z = 1)

$\therefore$ Number of lattice points = Number of unit cells.

34. Diamond and solid rhombic sulphur both are covalent solids but the latter has very low m.p. then the former. Explain why.

Sol. Diamond has all the 'C' atoms tetrahedrally and covalently bonded to four other carbon atoms making it a huge crystal structure which becomes very hard and high melting while in solid rhombic 'S', sulphur atoms combine covalently forming S_8 crown-shaped structures and all these S_8 units are bonded to each other by weak van der Waal's forces, hence has very low m.p.

35. Potassium iodide has cubic unit cell with edge length of 705 pm. The density of KI is 3.12 g/cm^3. How many K^+ and I^- ions are contained in the unit cell?

Sol. $\rho = \dfrac{Z \times M}{N_0 \times a^3}$ $\quad \therefore \quad Z = \dfrac{\rho \times N_0 \times a^3}{M}$ $\quad \rho = 3.12 \text{ g/cm}^3$

$Z = \dfrac{3.12 \times 6.02 \times 10^{23} \times \left(705 \times 10^{-10}\right)^3}{166}$ $\quad a = 705 \times 10^{-12}$ m $= 705 \times 10^{-10}$cm

$\therefore Z = 4$ $\quad M = 166$ for KI

It means each unit cell has $4K^+$ and $4I^-$ ions

36. Iron has body centred cubic unit cell edge of 286.65 pm. The density of iron is 7.87 g/cm^3. Calculate Avogadro's number by using this information.

Sol. $N_0 = \dfrac{Z \times M}{\rho \times a^3} = \dfrac{2 \times 56}{7.87 \times \left(286.65 \times 10^{-10}\right)^3}$

$\therefore N_0 = 6.022 \times 10^{23}$

37. Copper crystallizes in an fcc lattice. Calculate the number of unit cells in 1.2g of copper (At. mass of Cu = 63.5 U.)

Sol. Cu in fcc unit cell means Z = 4

$\therefore$ Number of atoms of Cu $= \dfrac{w \times N_0}{A}$

Number of unit cells of Cu $= \dfrac{w \times N_0}{A \times Z}$

$= \dfrac{1.2 \times 6.02 \times 10^{23}}{63.5 \times 4} = 2.8 \times 10^{21}$

SECTION - B

Model Test Paper

Very Short Answer Type Questions

1. What type of forces hold molecules of camphor together and what kind of solid is it?

Sol. van der Waals forces hold comphor molecules together and this is a molecular solid.

2. LiCl acquires pink colour when heated in Li vapours. Why?

Sol. Cl^- ions diffuse to surface and form LiCl with oxidised vapours of Li and an electron is released which diffuses into the crystal and occupies vacant anionic site which is called F-centre or colour centre. These F-centres are responsible for pink colour.

3. What is the coordination number of an atom in hcp?

Sol. Its C.N. is 12

4. Write a feature which distinguishes a metallic solid from an ionic solid.

Sol. Constituents forming ionic solids are three-dimensional arrangement of cations and anions while kernels and mobile sea of electrons form metallic solids.

5. Crystalline solids are anisotropic in nature. What does this statement mean?

Sol. Many physical properties like refractive index, electrical resistance etc. are different in different directions. Which is called anisotropy.

Short Answer Type Questions

6. What is the effect of Schottky defect on the density of solid?

Sol. Density of solid decreases as there is loss of matter.

7. Calculate the packing efficiency of a metal crystal for a simple cubic lattice.

Sol. Let each side of a cube is 'a' and radius of each particle is 'r' then a = 2r

The number of effective particles per unit cell is = $8 \times \frac{1}{8}$ = 1

$$PE = \frac{\text{Volume occupied by lattice points}}{\text{Total volume of a cubic unit cell}}$$

$$PE = \frac{\frac{4}{3}\pi r^3}{a^3 \text{or} (2r)^3} = \frac{\pi}{6} = 0.524$$

∴ Percentage PE = 52.4%

8. Define the following terms in relation to crystalline solids.

(i) Unit Cell

(ii) Coordination Number

Sol. (i) Unit cell : It is the smallest portion of a crystal lattice, which when repeated in different directions, generate the entire lattice.

(ii) Coordination number : Number of atoms to which a particular atom is linked in a crystal lattice in a solid is called its coordination number.

9. How would you determine the atomic mass of an unknown metal if you know its mass density and dimensions of unit cell of its crystal?

Sol. Density = $\frac{\text{Mass of unit cell}}{\text{Volume of unit cell}}$

Mass of unit cell = $\frac{Z \times M}{N_0}$ gram

∴ $\rho = \frac{Z \times M}{N_0 \times a^3}$, a = Edge length in cm

10. What is a semiconductor? Describe two main types of impure semiconductors.

Sol. Solids having conductivity ranging 10^{-6} to 10^4 $ohm^{-1}m^{-1}$ are semicoductors.

Semiconductors are of two types.

(a) **n-type semiconductor :** When elements of group-14 (i.e., Si and Ge) are doped with an element of group–15 (i.e., As or P) n-type semiconductor is obtained. The 5th valence electron in As or P is freelly available for their conductance.

(b) **p-type semiconductor :** When elements of group-14 (i.e., Si & Ge) are doped with elements of group-13(i.e., B and Al or Ga) etc. it causes p-type semiconductor. In them an electron deficient point or hole is responsible for conductance.

Short Answer Type Questions

11. Sodium crystallises in a bcc unit cell. Calculate the approximate number of unit cell in 9.2 g of sodium.

(Atomic mass of Na = 23)

Sol. $n_{Na} = \frac{9.2}{23} = 0.4$

Number of atoms of Na = 0.4 × 6.022 × 10^{23} = 2.4088 × 10^{23}

One BCC unit cell contains = 2 atoms

∴ Number of unit cells in 9.2 g Na = $\frac{2.4088 \times 10^{23}}{2}$ = 1.2044 × 10^{23}

12. Give reasons

(a) Why is Frenkel defect found in AgCl?

(b) What is the difference between semiconductor formed when P-doped silicon and Ga-doped silicon semiconductor?

Sol. (a) Frenkel defect is obtained in compound having low Coordination No. (smaller cation and larger anion) and that is the case of AgCl, hence Ag^+ ions get dislocated and cause Frenkel defect.

(b) A phosphorous doped is n-type semiconductor and Ga -doped is p-type semiconductor.

13. Three elements A, B and C crystallise into a cubic solid lattice. Atoms A occupy the corners, B occupy the cube centres and C occupy the edges centre. What is the formula of the compound?

Sol. Element A occupying corners = 1 Effective Number of A per unit cell = $8 \times \frac{1}{8} = 1$

Element B occupying body centre = 1 Effective Number of B per unit cell 1 × 1 = 1

Element C occupying edge centres = 3 Effective Number of C per unit cell = $12 \times \frac{1}{4} = 3$

$\therefore$ Formula of compound = ABC_3

14. The density of lead is 11.35 g/cm^3 and metal crystallizes with fcc unit cell. Estimate the radius of lead atom. (Pb = 207, $N_A = 6.02 \times 10^{23}$ mol^{-1})

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

$a^3 = \frac{4 \times 207}{11.35 \times 6.02 \times 10^{23}}$ $\therefore a = 4.948 \times 10^{-8}$ cm

For fcc, $r = \frac{\sqrt{2}a}{4} = \frac{1.414 \times 4.95 \times 10^{-8}}{4}$

$r = 1.75 \times 10^{-8}$ cm or 175 pm

15. Tungsten crystallizes in a body-centred cubic lattice. Calculate the number of unit cells in 1.5 g of tungsten (W = 184U.)

Sol. For BCC, Z = 2

$n_w = \frac{w}{A} = \frac{1.5}{184}$

Number of atoms = $\frac{1.5 \times 6.02 \times 10^{23}}{184}$

Number of unit cells = $\frac{1.5 \times 6.02 \times 10^{23}}{184 \times 2}$

$= 2.45 \times 10^{21}$

16. Write two differences each for given pairs

(a) Crystalline solids and amorphous solids

(b) Ferromagnetic and antiferromagnetic substances

(c) Schottky and Frenkel defects

Sol. (a)

Crystalline Solid	**Amorphous Solid**
1. Have three dimensional regular geometrical pattern of constituent particles.	1. Have random arragement of constituent particles.
2. Anisotropic long range order solids e.g., NaCl, CsCl	2. Isotropic, short range order solids e.g. Rubber, glass

(b)

Ferromagnetic	**Antiferromagnetic**
1. Strongly attracted by magnetic field and show permanent magnetism.	1. These substances lose their magnetic behaviour due to alignment of magnetic moments of domain in compensatory.

2. They have alignment of magnetic moments of domain in same direction	2. Magnetic moments of domains are aligned in antiparallel directions to cancel out each other e.g. MnO, MnO_2, Mn_2O_3

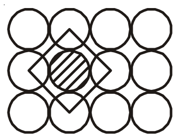
(c)

Schottky Defect	**Frenkel Defect**
1. It arises due to equal number of cations and anions missing from their regular sites.	1. It is caused due to dislocation of certain ions from their regular sites to interstitial sites.
2. It decreases density and present in high Co-ordination Number compounds e.g., NaCl, KCl.	2. No decrease in density is observed and present in low Co-ordination Number compound e.g., AgCl, ZnS

17. (a) Explain with the help of figures-square close packing and hexagonal close packing of particles in a solid in two dimensions

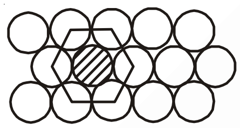
(b) What is Coordination Number of a particle in 2D packings?

Sol. (a)



Square close packing

2D



Hexagonal close packing

(b) C.N. = 4 C.N. = 6

Long Answer Type Questions

18. (a) Mineral calcium fluoride has $4Ca^{+2}$ ion and $8F^{-}$ ions in one unit cell. All Ca^{+2} are arranged in fcc lattice and F^{-} ions fill all tetrahedral voids. The edge of unit cell is 5.46×10^{-8} cm. Density of solid is 3.18 g/cm^3. Calculate the value of Avogadro's number If molar mass of CaF_2 = 78 g/mol.

(b) Calculate the efficiency of packing in case of metal crystal for body centred cubic.

Sol. (a) Number of molecules per unit cell = 4

$$N_A = \frac{Z \times M}{a^3 \times \rho} \qquad N_A = \frac{4 \times 78}{\left(5.46 \times 10^{-8}\right)^3 \times 3.18}$$

$N_A = 6.03 \times 10^{23}$

(b) Packing effeciency = $\dfrac{\text{Volume occupied by lattice points}}{\text{Total volume of unit Cell}}$

$$= \frac{2 \times \frac{4}{3}\pi r^3}{\left(\frac{4r}{\sqrt{3}}\right)^3} = \frac{\sqrt{3}\pi}{8} = 0.68$$

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Solutions (Set-2)

Objective Type Questions

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

1. Which of the following crystal is represented by $a \neq b \neq c$ and $\alpha \neq \beta \neq \gamma \neq 90°$?

   (1) Orthorhombic

   (2) Monoclinic

   (3) Triclinic

   (4) Tetragonal

Sol. Answer (3)

$a \neq b \neq c$, $\alpha \neq \beta \neq \gamma \neq 90° \rightarrow$ is the parameter for crystal triclinic.

2. Copper belongs to a crystal system represented by the crystal dimensions as

   (1) $\alpha = \beta = \gamma = 90°$, $a = b = c$

   (2) $\alpha \neq \beta \neq \gamma$, $a = b = c$

   (3) $\alpha = \beta = 90°$, $\gamma \neq 90°$, $a = b = c$

   (4) $\alpha = \beta = \gamma = 90°$, $a \neq b \neq c$

Sol. Answer (1)

Cu $\rightarrow$ belongs to cubic crystal which has dimensions $a = b = c$ and $\alpha = \beta = \gamma = 90°$

3. A compound formed by element A and B crystallizes in the cubic structure, where A atoms are at the corners of a cube and B atoms are at the centre of the body. The formula of the compounds is

   (1) AB

   (2) AB_2

   (3) A_2B_3

   (4) AB_3

Sol. Answer (1)

A $\rightarrow$ corners of cube $\Rightarrow$ Total 8 atoms at corner, which have contribution at corner $\frac{1}{8}$

$$\text{So} \Rightarrow 8 \times \frac{1}{8} = 1 \rightarrow \text{number of atoms of A per unit cell.}$$

B $\rightarrow$ centre of body $\rightarrow$ at centre of body one atom contributed completely.

So, $\Rightarrow 1 \times 1 = 1$

i.e., A_1B_1 = AB

4. A solid with formula ABC_3 would probably have

(1) A at body centre, B at face centres and C at corners of the cube

(2) A at corners of cube, B at body centre, C at face centre

(3) A at corners of hexagon, B at centres of the hexagon and C inside the hexagonal unit cell

(4) A at corner, B at face centre, C at body centre

Sol. Answer (2)

ABC_3

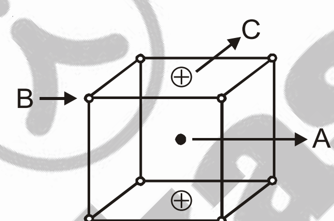
At corners number of atom = $8\times\frac{1}{8}=1$ (contribution at corner) $\rightarrow A$

At body centre = 1 × 1 = 1 $\rightarrow B$

At face centre = $\underset{\text{(Total face)}}{6}\times\underset{\text{(Contribution at face)}}{\frac{1}{2}}=3$ $\rightarrow C$

ABC_3

5. A solid ABC has A, B and C arranged as below. The formula of solid is



(1) ABC (2) AB_2C_2 (3) A_2BC (4) AB_8C_2

Sol. Answer (1)

A $\rightarrow$ present at body centre in given figure

So, its number = 1 × 1 = 1 (contributed completely) $\rightarrow A$

B $\rightarrow$ present at corners = $\underset{\text{(Total atom)}}{8}\times\underset{\text{(Contribution)}}{\frac{1}{8}}=1$ $\rightarrow B$

C $\rightarrow$ Present at two opposite face $\rightarrow$ $\underset{\text{(Total 2 atoms at face)}}{2}\times\underset{\text{(Contribution at each face)}}{\frac{1}{2}}=1$ $\rightarrow C$

So, formula ABC

6. 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

(1) Cu_4Ag_2Au (2) Cu_4Ag_4Au (3) Cu_4Ag_3Au (4) CuAgAu

Sol. Answer (3)

$$Cu \rightarrow ccp \begin{cases} \text{Present at corners} = 8 \times \frac{1}{8} = 1 \\ \text{Present at centres of each face} = 6 \times \frac{1}{2} = 3 \end{cases} \text{Total 4 Cu}$$

Ag $\rightarrow$ at edge centre $\rightarrow \underset{\text{(Total atoms at edge)}}{12} \times \underset{\text{(contribution)}}{\frac{1}{4}} \Rightarrow 3$

Au $\rightarrow$ at body centre $\rightarrow$ contributed completely = 1 × 1 $\Rightarrow$ 1

$Cu_4Ag_3Au_1$

7. In a face centred cubic arrangement of A and B atoms, atoms of A are at the corner of the unit cell and atoms of B are at the face centres. One of the A atom is missing from one corner in unit cell. The simplest formula of compound is

(1) A_7B_3

(2) AB_3

(3) A_7B_{24}

(4) $A_{7/8}B_3$

Sol. Answer (3)

$A \rightarrow \underset{\text{(Total atoms)}}{8} \times \underset{\text{(contribution)}}{\frac{1}{8}} = 1$

$B \rightarrow$ face centre $\rightarrow \underset{\text{(Total atoms)}}{6} \times \underset{\text{(contribution)}}{\frac{1}{2}} = 3$

Now, one atom is missing from one corner $\Rightarrow \underset{\text{(total atoms)}}{8} - 1 = 7$

So, $7 \times \underset{\text{(contribution at corner)}}{\frac{1}{8}} = \frac{7}{8} \rightarrow A$

$A_{\frac{7}{8}}B_3 \rightarrow A_7B_{24}$

8. A solid has a structure in which A atoms are located at the cube corners of the unit cell, B atoms are located at the cube edges of unit cell and the C atoms at the body centre. Formula of the compound

(1) CAB_3 (2) C_2AB_3 (3) CA_3B (4) C_2A_3B

Sol. Answer (1)

$A \rightarrow$ corners $\Rightarrow 8\times\frac{1}{8} = 1 \quad \rightarrow A_1$

$B \rightarrow$ edges = $12\times\frac{1}{4} = 3 \quad \rightarrow B_3$

$C \rightarrow$ body centre $\Rightarrow$ 1 × 1 = 1 .$\rightarrow C_1$

AB_3C

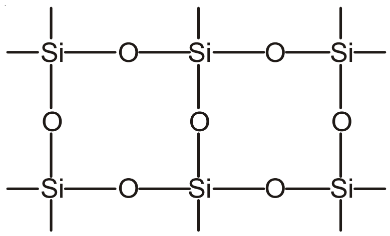
9. Which type of solids will have the highest melting point?

(1) Ionic crystals (2) Network covalent solid

(3) Molecular solids (4) Metallic crystals

Sol. Answer (2)

Network covalent solids have highest melting point due to network structure in which bonds are tightly held like SiO_2.



Layered structure so, it require very high temperature to melt it.

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

10. In any ionic crystal A has formed cubical close packing and B atoms are present at every tetrahedral voids. If any sample of crystal contain 'N' number of B atoms then number of A atoms in that sample is

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

Sol. Answer (2)

$A \rightarrow ccp \rightarrow \text{total atoms} = 4 \left[8\times\frac{1}{8}+6\times\frac{1}{2}=4\right]$

$B \rightarrow$ at tetrahedral voids $\Rightarrow$ double of number of atoms $\Rightarrow 2 \times 4 = 8$

given $B \Rightarrow 8 \Rightarrow N$.

So, number of A atoms is half the number of (B) atoms, *i.e.*, $\frac{8}{2} \Rightarrow 4$ or $\left(\frac{N}{2}\right) = 4$

11. A binary solid A^+B^- has a structure with B^- ions constituting the lattice and A^+ ions occupying 25% tetrahedral holes. Formula of the solid is

(1) A_2B (2) AB (3) AB_2 (4) AB_4

Sol. Answer (3)

$A^+B^- \rightarrow$ Rock salt type $\rightarrow$ f.c.c. $\rightarrow$ number of atoms = 4

$B^- \rightarrow$ constituting the lattice $\rightarrow$ *i.e.*, $\Rightarrow 4$

$A^+ \rightarrow$ 25% of tetrahedral void

$\left[\text{Tetrahedral void} \Rightarrow 2\times\text{no. of atoms} = 2\times 4 = 8\right]$

$\Rightarrow \frac{25}{100}\times 8 \Rightarrow 2$

$A_2^+B_4^-$ or AB_2

12. In a crystalline solid anions B are arranged in cubic close packing. Cation A are equally distributed between octahedral and tetrahedral voids. If all the octahedral voids are occupied, the formula for the solid is

(1) AB (2) AB_2 (3) A_2B (4) A_2B_3

Sol. Answer (3)

$$B \rightarrow ccp \rightarrow \underset{(N)}{4} \left[\underset{\text{(corners)}}{8\times\frac{1}{8}} + \underset{\text{(face centred)}}{6\times\frac{1}{2}}\right]$$

$$A\begin{cases}\text{Octahedral} \Rightarrow \text{no. of atoms} = N = 4 \\ \text{Tetrahedral} \Rightarrow \text{double of no. of atoms}(2N) \Rightarrow 8\end{cases}\text{given all octahedral voids are occupied}$$

and A - equally distributed between both

voids so, $A\begin{cases}4(\text{octahedral})\\4(\text{tetrahedral})\end{cases}$ equal no. $\Rightarrow$ total = 8

(according to octahedral)

$A_8B_4 \rightarrow A_2B$

13. In a cubic close packed structure of mixed oxides, the lattice is made up of oxide ions, one-eighth of tetrahedral voids are occupied by divalent (X^{2+}) ions, while one-half of the octahedral voids are occupied by trivalent ions (Y^{3+}), then the formula of the oxide is

(1) XY_2O_4 (2) X_2YO_4 (3) $X_4Y_5O_{10}$ (4) $X_5Y_4O_{10}$

Sol. Answer (1)

$$O^{-2} \rightarrow ccp \Rightarrow 4\left[8\times\frac{1}{8}+6\times\frac{1}{2}\right]$$

$X^{+2} \rightarrow \underset{\text{(given)}}{\frac{1}{8}} \times 8(\text{tetrahedral void}) \Rightarrow 1$

$Y^{+3} \rightarrow \underset{\text{(given)}}{\frac{1}{2}} \times 4\ (\text{octahedral void}) \Rightarrow 2$

So, formula $X_1Y_2O_4$

14. Titanium crystallizes in a face centred cubic lattice. It reacts with carbon or hydrogen interstitially by allowing atoms of these elements to occupy holes in the host lattice. Hydrogen occupies tetrahedral holes but carbon occupies octahedral holes the formula of titanium carbide and hydride are

(1) TiC_2, TiH_4 (2) TiC, TiH_2 (3) Ti_3C, TiH_2 (4) TiC_2, TiH

Sol. Answer (2)

$$Ti \rightarrow ccp = fcc \rightarrow 4\left[8\times\frac{1}{8}+6\times\frac{1}{2}\right]$$

given $\rightarrow$ carbon $\rightarrow$ at octahedral holes = equal to no. of atoms $\Rightarrow 4$

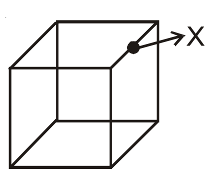
So, $Ti_4C_4 \rightarrow TiC$

given $\rightarrow$ hydrogen $\rightarrow$ at tetrahedral holes $\Rightarrow$ double of number of atoms

$\Rightarrow 2 \times 4 = 8$

$Ti_4H_8 \rightarrow TiH_2$

15. The site labelled as 'X' in fcc arrangement is



(1) Face with $\frac{1}{4}$ contribution (2) Edge with $\frac{1}{4}$ contribution

(3) Corner with $\frac{1}{4}$ contribution (4) Tetrahedral void with $\frac{1}{8}$ contribution

Sol. Answer (2)

In given figure (X) is present at centre of edge which contributed $\left(\frac{1}{4}\right)$

16. A unit cell is obtained by closed packing layers of atoms in ABAB....... pattern. The total number of tetrahedral and octahedral voids in the unit cell are respectively

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

Sol. Answer (4)

In ABAB....... *i.e.*, hexagonal close packing, number of atoms = 6.

So, tetrahedral voids = 6 × 2 = 12

octahedral voids = 6

17. In certain solid, the oxide ions are arranged in ccp. Cations A occupy $\frac{1}{6}$ of the tetrahedral voids and cations B occupy one-third of the octahedral voids. The probable formula of the compound is

(1) ABO_3 (2) AB_2O_3 (3) A_2BO_3 (4) $A_2B_2O_3$

Sol. Answer (1)

$O^{-2} \rightarrow$ ccp $\Rightarrow$ 4 (no. of atoms)

$$A \rightarrow \underset{\text{given}}{\frac{1}{6}} \times \underset{\text{(tetrahedral void)}}{8} = \frac{8}{6}$$

$$B \rightarrow \underset{\text{given}}{\frac{1}{3}} \times \underset{\text{(octahedral)}}{4} = \frac{4}{3}$$

$A_{\frac{8}{6}}B_{\frac{4}{3}}O_4$ or ABO_3

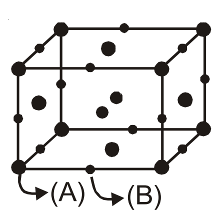
18. The number of octahedral sites in a cubical close pack array of N spheres is

(1) N/2 (2) 2 N (3) 4 N (4) N

Sol. Answer (4)

Number of octahedral sites $\Rightarrow$ number of spheres = N

19. For a solid with the following structure, the coordination number of the point B is

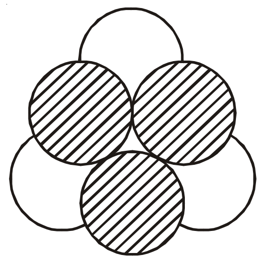


(1) 3 (2) 4 (3) 5 (4) 6

Sol. Answer (4)

(B) is located at edge centre which shown C.N. = 6

20. The empty space between the shaded balls and hollow balls as shown in the diagram is called



(1) Hexagonal void (2) Octahedral void (3) Tetrahedral void (4) Double triangular void

Sol. Answer (2)

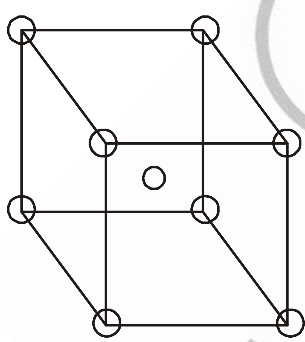
The empty space in figure is octahedral void because it is surrounded by six spheres.

21. An element crystallises in a 'bcc' lattice. Nearest neighbours and next nearest neighbours of the elements are respectively

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

Sol. Answer (2)

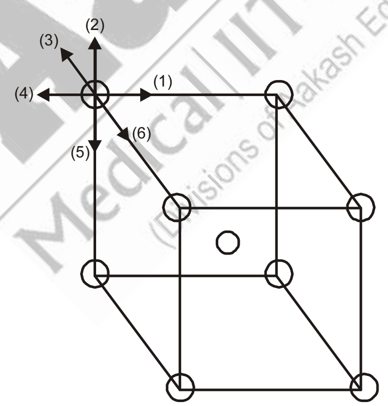
[4 atoms above and 4 atoms below]



In B.C.C.

→ Nearest neighbours = 8

→ Next nearest neighbours = 6
(6 edge atoms at corner)



22. The total number of elements of symmetry in a cubic crystal is

(1) 9

(2) 23

(3) 10

(4) 14

Sol. Answer (2)

Total number of elements of symmetry = 23

Rectanglular plane of symmetry = 3 + Diagonal plane of symmetry = 6 + centre of symmetry = 1 + axis of symmetry = 13

[3 fold = 4, 2 - fold = 6, 4 fold = 3] $\rightarrow$ axis of symmetry.

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

23. If ‘a’ is the length of unit cell, then which one is correct relationship?

(1) For simple cubic lattice, Radius of metal atom = $\frac{a}{2}$

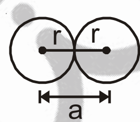
(2) For bcc lattice, Radius of metal atom = $\frac{\sqrt{3}a}{4}$

(3) For fcc lattice, Radius of metal atom = $\frac{a}{2\sqrt{2}}$

(4) All of these

Sol. Answer (4)

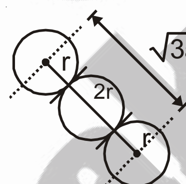
for S.C.C., $r = \frac{a}{2}$ $\rightarrow$



$2r = a$

$r = a/2$

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

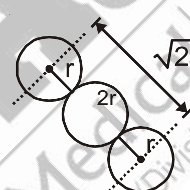


$\sqrt{3}a$ = Body diagonal

$4r = \sqrt{3}a$

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

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



$\sqrt{2}a$ = face diagonal

$4r = \sqrt{2}a$

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

So, all three options are correct.

24. For face centered cubic structure edge length ‘a’ can be related with radius ‘r’ as

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

Sol. Answer (3)

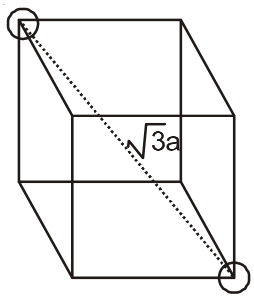
For f.c.c. $\boxed{\sqrt{2}a = 4r}$

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

25. Polonium adopts cubic structure with edge length of cube being 0.336 nm. The distance between the polonium atoms which lie at the corners along the body diagonal is

(1) 0.336 nm (2) 0.291 nm (3) 0.582 nm (4) 0.481 nm

Sol. Answer (3)



$$\sqrt{3}a = \sqrt{3}\times 0.336 \text{ nm}$$
$$= 0.5819 \text{ nm} \simeq 0.582 \text{ nm}$$

26. Ice crystallises in a hexagonal lattice having the volume of unit cell as 132 × 10^{-24} cm^3. If density is 0.92 g cm^{-3} at a given temperature, then number of H_2O molecules per unit cell is

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

Sol. Answer (4)

$$\rho = \frac{Z\times M}{N_A \times a^3}$$ $$M_{H_2O} = 18$$

$$\Rightarrow \quad 0.92 = \frac{Z\times 18}{6.022\times 10^{23}\times 132\times 10^{-24}};$$ a^3 = volume of unit cell = 132 × 10^{-24} cm^3

$$\therefore \quad Z = \frac{0.92\times 6.022\times 10^{23}\times 132\times 10^{-24}}{18} = 4$$

27. Lithium metal has a body centred cubic structure. Its density is 0.53 g cm^{-3} and its molar mass is 6.94 g mol^{-1}. Calculate the edge length of a unit cell of Lithium metal

(1) 153.6 pm (2) 351.6 pm (3) 527.4 pm (4) 263.7 pm

Sol. Answer (2)

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

$\therefore$ z = 2 (for B.C.C.)

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

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

$= 4.34 \times 10^{-23}$

$a = (4.34 \times 10^{-23})^{1/3}$

$\simeq 351.6$ pm

28. What is the volume of a face centred cubic unit cell, when its density is 2.0 g cm^{-3} and the molar mass of the substance is 60.23 g mol^{-1}?

(1) 4 × 10^{-22} cm^3

(2) 2 × 10^{-22} cm^3

(3) 44 × 10^{-22} cm^3

(4) 22 × 10^{-22} cm^3

Sol. Answer (2)

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

a^3 = volume of unit cell = V

$$\rho = \frac{Z \times M}{N_A \times V}$$

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

$$V = \frac{Z \times M}{N_A \times \rho} = \frac{4 \times 60.23}{6.022 \times 10^{23} \times 2}$$

$\Rightarrow$ 20×10^{-23}

$\Rightarrow$ 2×10^{-22} g/cm^3

29. The C–C and Si–C interatomic distances are 154 pm and 188 pm. The atomic radius of Si is

(1) 77 pm (2) 94 pm

(3) 114 pm (4) 111 pm

Sol. Answer (4)

Diameter = 154 pm (internuclear distance)

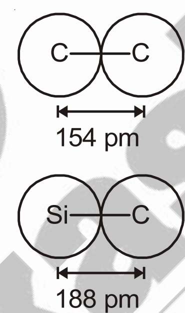
so, radius of one carbon atom $= \frac{154}{2} \Rightarrow 77$ pm

Diameter (internuclear distance) $\Rightarrow$ 188

so, radius of Si + radius of carbon = 188

Radius of Si + 77 = 188

$r_{Si} = 188 - 77 \Rightarrow 111$ pm



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

30. Pyroelectric crystals produce feeble electric current

(1) On deformation (2) On dissolving in a solvent

(3) On heating (4) On sublimation

Sol. Answer (3)

Pyroelectric crystal produce feeble electric current on heating.

31. Zinc oxide on heating changes to yellow. This is because

(1) Zinc oxide is a stoichiometric compound (2) Zinc oxide is a covalent compound

(3) Zinc oxide shows metal excessive defect (4) It shows metal deficiency defect

Sol. Answer (3)

$$ZnO \xrightarrow{\Delta} Zn^{+2} + 2e^- + \frac{1}{2}O_2$$

It causes excess of Zn in the lattice causing metal excess (defect) $\rightarrow$ it changes its colour

32. F-centres in an ionic crystals are

(1) Lattice sites containing electrons (2) Interstitial sites containing electrons

(3) Lattice sites that are vacant (4) Interstitial sites containing cations

Sol. Answer (1)

In some defect, negative ions may be missing from their lattice sites leaving holes in which electrons remain trapped to maintain electrical neutrality. The holes with entrapped electrons are called F-centres.

They impart colour to the crystal lattice *e.g.*, heating crystals of NaCl in vapours of Na

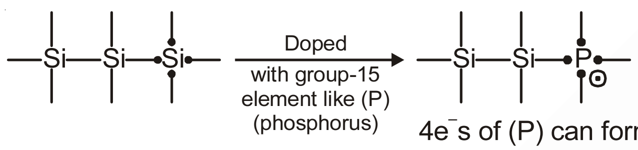
33. When an element of group 14 is doped with an element of group 15

(1) p-type of semi-conductors are formed (2) n-type of semi-conductors are formed

(3) Zeolites are formed (4) Electrolytes are formed

Sol. Answer (2)

Group-14 element e.g. $\rightarrow$ Si $\rightarrow$ 4-valence electrons.



$4e^-$s of (P) can form bond with $4e^-$s of Si but one e^- remain free, so, it n-type of semi conductor due to negative nature of e^-.

34. Antiferromagnetic property is given as

(1) ↑ ↑ ↑ ↑ (2) ↑ ↑ ↓ ↑ (3) ↑ ↓ ↑ ↓ (4) ↓ ↓ ↓ ↓

Sol. Answer (3)

If magnetic moments are aligned in compensatory way so that all cancel out each other and net magnetic moment becomes zero, these are antiferromagnetic substances ↑ ↓ ↑ ↓.

35. Substances which are magnetic but having less magnetic moment than theoretically calculated value are called

(1) Ferromagnetic (2) Ferrimagnetic (3) Antiferromagnetic (4) Diamagnetic

Sol. Answer (2)

When magnetic moments of domains are aligned in parallel and antiparallel directions in unequal number, it results in some net magnetic moment. Ferrimagnetic ↑ ↑ ↓ ↑ ↑ ↓ $\rightarrow$ less magnetic moment than theoritically calculated value.

36. In antiferromagnetism

(1) Alignments of magnetic moments is additive

(2) Alignments of magnetic moments in one direction is compensated by alignments in the opposite directions

(3) Alignments of magnetic moments does not take place

(4) Alignments of magnetic moments varies with the nature of the material

Sol. Answer (2)

In antiferromagnetism $\rightarrow$ ↑ ↓ ↑ ↓ $\rightarrow$ equal and opposite. So net magnetic moment = 0.

37. Which is true about Piezoelectric crystals?

(1) They produce an electric current on heating

(2) They produce an electric current when a mechanical stress is applied

(3) They are insulators

(4) They are magnetic in nature

Sol. Answer (2)

Piezoelectric crystals produce an electric current when a mechanical stress is applied.

38. When a crystal having rock salt type geometry is heated in the presence of it's metal vapour then defect in it will be

(1) Stoichiometric defect (2) Metal excess defect (3) Anion excess defect (4) Frenkel defect

Sol. Answer (2)

Metal excess defect → heated in the presence of its metal vapour e.g., heating of NaCl in Na vapour.

39. The mass percentage of Fe^{3+} ion present in $Fe_{0.93}$ $O_{1.00}$ is

(1) 15% (2) 5.5% (3) 10.0% (4) 11.5%

Sol. Answer (4)

$Fe_{0.93}O_{1.00}$ → Fe^{+3} $(0.93 - x)$ and Fe^{+2} x

Let Fe^{+3} $(0.93 - x)$, Fe^{+2} x

$$\left\{\begin{array}{c} Fe^{+2} = x = 0.79 \\ Fe^{+3} = 0.14 \end{array}\right\}$$

according to charge balance $2x + 3[0.93 - x] = 2$

$x = 0.79$

Total mass of $Fe_{0.93}O = 56 \times 0.93 + 16 = 68.08$ amu

mass of $Fe^{+3} = 0.14 \times 56 = 7.84$ amu

mass percentage of $Fe^{+3} = \frac{7.84}{68.08} \times 100 = 11.5\%$

40. If 1 mole of NaCl is doped with 10^{-3} mole of $SrCl_2$. What is the number of cationic vacancies per mole of NaCl?

(1) 10^{-3} mole^{-1} (2) 6.02×10^{18} mole^{-1} (3) 10^{50} mole^{-1} (4) 6.02×10^{20} mole^{-1}

Sol. Answer (4)

1 mole of $SrCl_2$ → creates one mole cation vacancy.

given 10^{-3} mole of $SrCl_2$ → creates $10^{-3} \times N_A$ number of vacancy.

$= 6.02 \times 10^{20}$ mol^{-1}

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