Very Short Answer Questions

Very Short Answer Questions (PYQ)

Q.1. Why does the window glass of the old buildings look milky?

[CBSE (F) 2016]

Ans. It is due to heating during the day and cooling at night, i.e., due to annealing over a number of years, glass acquires crystalline character.

Q.2. 'Crystalline solids are anisotropic in nature.' What does this statement mean?

[CBSE Delhi 2011; (F) 2011]

Ans. It means that some of their physical properties like electrical conductivity, refractive index, etc., are different in different directions.

Q.3. What type of interactions hold the molecules together in a polar molecular solid?

[CBSE (AI) 2010]

Ans. The interactions which hold the molecules together in a polar molecular solid are dipole-dipole attractions.

Q.4. Write a feature which will distinguish a metallic solid from an ionic solid.

[CBSE Delhi 2010; (F) 2010]

Ans. Metals are malleable and ductile whereas ionic solids are hard and brittle.

Q.5. Give an example each of a molecular solid and an ionic solid.

[CBSE Central 2016]

Ans. Molecular solids: CO_2, I_2, HCl

Ionic solids: NaCl, ZnS, CaF_2

Q.6. What is the two-dimensional coordination number of a molecule in a square close-packed layer?

[CBSE (F) 2013]

Ans. 4.

Q.7. Express the relationship between atomic radius (r) and the edge length (a) in the bcc unit cell.

[CBSE (F) 2014]

Ans.

$$r \text{ (atomic radius)} = \frac{\sqrt{3}}{4}\, a \text{ (edge length of unit cell)}.$$

Q.8. Which crystal defect lowers the density of a solid?

[CBSE Delhi 2009, 2010; (AI) 2009]

Ans. Schottky defect.

Q.9. Which point defect in crystals does not alter the density of the relevant solid?

[CBSE Delhi 2009, 2010]

Ans. Frenkel defect.

Q.10. Which point defect in its crystal units increases the density of a solid?

[CBSE Delhi 2009, 2011; (AI) 2012]

Ans. Interstitial defect.

Q.11. What type of stoichiometric defect is shown by AgCl?

[CBSE Delhi 2013]

Ans. Frenkel defect.

Q.12. What is meant by the term 'forbidden zone' in reference to band theory of solids?

[CBSE (F) 2012]

Ans. The energy gap between valence band and conduction band is known as forbidden zone.

Q.13. What type of semiconductor is obtained when silicon is doped with arsenic?

[CBSE (AI) 2010]

Ans. n-type semiconductor.

Q.14. What would be the nature of solid if there is no energy gap between valence band and conduction band?

[CBSE East 2016]

Ans. Conductor.

Q.15. What is meant by an 'intrinsic semiconductor'?

[CBSE (F) 2011]

Ans. Pure substances exhibiting conductivity similar to that of silicon and germanium are called intrinsic semiconductors.

Q.16. What type of substances would make better permanent magnets, ferromagnetic or ferrimagnetic?

[CBSE Delhi 2013]

Ans. Ferromagnetic.

Q.17. What is the formula of a compound in which the element Y forms *ccp* lattice and atoms of *X* occupy 2/3rd of tetrahedral voids?

[CBSE Allahabad 2015]

Ans.

Let the number of particles of element Y in *ccp* lattice = N

Number of tetrahedral voids = $2N$

Number of particles of element $X = \frac{2}{3} \times 2N = \frac{4}{3}N$

$X : Y = \frac{4}{3}N : N$

$X : Y = 4 : 3$

$\therefore$ Formula of the compound is $\boldsymbol{X_4Y_3}$.

Q.18. What is the formula of a compound in which the element P forms *ccp* lattice and atoms of *Q* occupy 2/3rd of tetrahedral voids?

[CBSE (F) 2017]

Ans.

Let the number of atoms of P in ccp arrangement = N

So, number of octahedral voids = $2N$

$$\therefore \text{ Number of } Q \text{ atoms} = \frac{2}{3} \times 2N = \frac{4}{3}N$$

$$Q{:}P = \frac{4}{3}N{:}N = 4{:}3$$

Hence, formula of the compound $= Q_4P_3$

Q.19. What is the formula of a compound in which the element P forms *hcp* lattice and atoms of *Q* occupy 2/3rd of octahedral voids?

[CBSE (F) 2017]

Ans.

Let the number of atoms of P in hcp lattice = N

So, number of octahedral voids = N

$$\therefore \text{Number of Q atoms} = \frac{2}{3} \times \text{N} = \frac{2}{3}\text{N}$$

$$\text{Q} : \text{P} = \frac{2}{3}\text{N} : \text{N} = 2 : 3$$

Hence, the formula of the compound is Q_2P_3.

Q.20. A metallic element crystallises into a lattice having a pattern of AB AB…… and packing of spheres leaves out voids in the lattice. What type of structure is formed by this arrangement?

[CBSE Delhi 2017 C]

Ans. *hcp.*

Q.21. What type of stoichiometric defect is shown by ZnS?

Ans. ZnS shows Frenkel defect as its ions have a large difference in size.

Q.22. Zinc oxide is white but it turns yellow on heating. Explain.

[CBSE North 2016] [HOTS]

Ans. On heating ZnO loses oxygen according to the following reaction:

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

Zn^{2+} ions are entrapped in the interstitial voids and electrons are entrapped in the neighbouring interstitial voids to maintain electrical neutrality. Due to presence of electrons in interstitial voids the colour is yellow.

Very Short Answer Questions (OIQ)

Q.1. What kind of attractive forces are present in the molecular crystalline solids?

Ans. Dispersion forces, dipole–dipole interactions and hydrogen bonds.

Q.2. How can a material be made amorphous?

Ans. By melting the material and then cooling it rapidly.

Q.3. Why is the window glass of old buildings thick at the bottom?

Ans. Glass is not a true solid but a supercooled liquid of high viscosity (called pseudo-solid). It has the property to flow.

Q.4. What are primitive unit cells and what are non-primitive unit cells?

Ans. Primitive unit cells have one atom per unit cell. On the other hand, non-primitive unit cells have more than one atom per unit cell.

Q.5. Define face-centred cubic structure.

Ans. A face-centred cubic structure has one atom at each corner and one atom at each face centre.

Q.6. Define void.

Ans. The empty spaces present between the atoms or the ions when they are packed within the crystal are called voids.

Q.7. What is the coordination number of a particle present in an octahedral void?

Ans. Six.

Q.8. How many effective sodium ions are located at the edge centre of a unit cell in a sodium chloride crystal?

Ans. $12 \times \frac{1}{4} = 3.$

Q.9. What is the meaning of the term imperfection in solids?

Ans. Imperfection refers to the irregularities in the arrangement of atoms, ions or molecules in the structure of crystalline substances.

Q.10. In spite of long range order in the arrangement of particles, why are the crystals usually not perfect?

[NCERT Exemplar]

Ans. Crystals have long range repeated pattern of arrangement of constituent particles but in the process of crystallisation some deviations from the ideal arrangement (i.e., defects) may be introduced. That is why crystals are usually not perfect.

Q.11. What are the types of lattice imperfections found in crystals?

Ans. (a) Stoichiometric defects, *viz*., Schottky defect and Frenkel defect **(b**) Non-stoichiometric defects, *viz*., metal excess, metal deficiency, and **(c)** impurity defects.

Q.12. What are interstitials in a crystal?

Ans. Atoms or ions that fill the normal vacant interstitial voids in a crystal are called interstitials.

Q.13. What is the non-stoichiometric defect in crystals?

Ans. If, as a result of the imperfections in the crystal, the ratio of the cations to the anions becomes different from that indicated by the ideal chemical formula, then the defects are termed as non-stoichiometric defects.

Q.14. What is Schottky defect?

Ans. When some ions (usually cations) are missing from the lattice sites and they occupy the interstitial sites so that electrical neutrality as well as stoichiometry is maintained, it is called Frenkel defect.

Q.15. What is Frenkel defect?

Ans. When some ions (usually cations) are missing from the lattice sites and they occupy the interstitial sites so that electrical neutrality as well as stoichiometry is maintained, it is called Frenkel defect.

Q.16. Why does Frenkel defect not change the density of AgCl crystals?

Ans. Because of the Frenkel defect, no ion is missing from the crystal, therefore there is no change in density.

Q.17. Name the non-stoichiometric point defect responsible for colour in alkali metal halides.

[CBSE Sample Paper 2016]

Ans. Metal excess defect due to anionic vacancies.

Q.18. What are F-centres?

Ans. The free electrons trapped in the anion vacancies are called F-centres.

Q.19. Why is FeO(s) not formed in stoichiometric composition?

[NCERT Exemplar]

Ans. In the crystals of FeO, some of the Fe^{2+} cations are replaced by Fe^{3+} ions. Three Fe^{2+} ions are replaced by two Fe^{3+} ions to make up for the loss of positive charge. Eventually there would be less amount of metal as compared to stoichiometric proportion.

Q.20. What type of crystal defect is produced when sodium chloride is doped with $MgCl_2$?

Ans. A cation vacancy is formed, so impurity defect is produced. A substitutional solid solution is formed (because $2Na^+$ ions are replaced by one Mg^{2+} ion at the lattice site).

Q.21. How does the electrical conductivity of semiconductors vary with temperature?

Ans. Electrical conductivity of semiconductors increases with increase in temperature as more electrons can jump from valence band to conduction band.

Q.22. Define superconductivity of a substance.

Ans. The property of a substance to offer no resistance to the flow of electricity at a particular temperature is known as superconductivity.

Q.23. What is the difference in the semiconductors obtained by doping silicon with Al and with P?

Ans. Silicon doped with Al forms p-type semiconductors, while silicon doped with P produces n-type semiconductors.

Q.24. Name the type of semiconductor obtained when silicon is doped with boron.

[CBSE Sample Paper 2017]

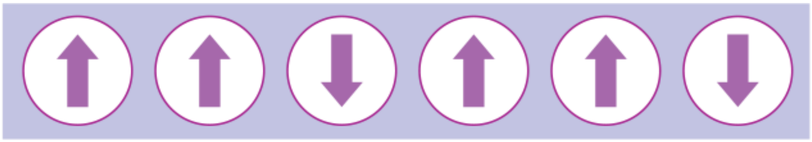
Ans. p-type semiconductor.

Q.25. What is the difference between 13-15 and 12-16 compounds?

Ans. Group 13-15 compounds, viz., AlP, GaAs, etc. have large covalent character whereas Group 12-16 compounds, *viz.*, ZnS, CdS, HgTe, etc. do not possess covalent character but have sufficient ionic character. However, all of them are semiconductors.

Q.26. What type of substances exhibit antiferromagnetism?

Ans. Substances in which domains are oppositely oriented and cancel out each other's magnetic moments exhibit antiferromagnetism.



Q.27. A compound formed by elements *A* and *B* has a cubic structure in which *A* atoms are at the corners of the cube and *B* atoms are at the face centres. Derive the formula of the compound.

Ans.

Number of A atoms per unit cell = 8 (at the corners) $\times \frac{1}{8} = 1$

Number of B atoms per unit cell = 6 (at the face centres) $\times \frac{1}{2} = 3$

A : B = 1 : 3

$\therefore$ The formula of the compound = $\mathbf{AB_3}$.

Q.28. A solid is made up of two elements P and Q. Atoms of Q are in ccp arrangement while atoms of P occupy all the tetrahedral sites. What is the formula of the compound?

Ans. Suppose number of atoms of Q in *ccp* arrangement = *N*

So, number of tetrahedral sites = 2 *N*

$\therefore$ Number of *P* atoms = 2 *N*

$\therefore$ $P : Q = 2N : N = 2 : 1$

Hence, formula of compound is $\mathbf{P_2Q}$.

Q.29. A compound is formed by two elements *X* and *Y*. Atoms of the element *Y* (as anions) make *ccp* and those of the element *X* (as cations) occupy all the octahedral voids. What is the formula of the compound?

Ans. Suppose the number of atoms Y in *ccp* = *N*

$\therefore$ Number of octahedral voids = $N \times 1 = N$

$\therefore$ Number of atoms of $X = N$

Ratio of *X* : *Y* = *N* : *N* = 1 : 1

Hence, formula of the compound = ***XY***

Q.30. In corundum, oxide ions are arranged in hexagonal close packing and aluminium ions occupy two-third of the octahedral voids. What is the formula of corundum?

Ans.

Let the number of oxide ions in the packing be *N*.

Then octahedral voids = *N*. Therefore, Al^{3+} ions = $\frac{2}{3} \times N = \frac{2N}{3}$.

$\therefore$ Ratio of $Al^{3+} : O^{2-} = \frac{2N}{3} : N = 2 : 3$

Hence, formula of corundum is $\mathbf{Al_2O_3}$.

Q.31. Why is Frenkel defect found in AgCl?

Ans. This is because the cation Ag^+ and anion Cl^- differ in their size to a larger extent, therefore cations occupy voids due to its smaller size**.**

Q.32. A cubic solid is made up of two elements A and B. Atoms A are present at the corners of the cube and B are at the alternate face centres. What is the formula of the solid?

[HOTS]

Ans.

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

Number of B atoms per unit cell = $2 \times \frac{1}{2} = 1$

$\therefore$ Formula of the compound = **AB**

Q.33. In NaCl crystal, Cl^- ions are in *fcc* arrangement. Calculate the number of Cl^- ions in its unit cell.

***HOTS*]**

Ans.

$$Cl^{-} \text{ ions per unit cell } = 8 \times \frac{1}{8}(\text{from corners}) + 6 \times \frac{1}{2}(\text{From face corners}) = 4$$

Q.34. A compound AB_2 possesses the CaF_2 type crystal structure. Write the coordination number of A^{2+} and B^{-} ions in its crystals.

[*HOTS*]

Ans. Coordination no. of A = 8, Coordination no. of B = 4.

Q.35. Why does table salt, NaCl, sometimes appear yellow in colour?

[*NCERT Exemplar*] [*HOTS*]

Ans. Yellow colour in sodium chloride is due to metal excess defect due to which unpaired electrons occupy anionic sites. These sites are called F-centres. These electrons absorb some energy from the visible white light for the excitation which makes crystal appear yellow.

Q.36. How does the electrical conductivity of metallic conductors vary with temperature?

Ans. Electrical conductivity decreases with rise in temperature because kernels begin to vibrate and create hindrance in the flow of electrons.

Short Answer Questions-I

Short Answer Questions-I (PYQ)

Q.1. How will you distinguish between the following pairs of terms:

[CBSE (AI) 2014]

Q. Tetrahedral and octahedral voids

Ans. A void surrounded by four spheres occupying the corners of tetrahedron is called a tetrahedral void. It is much smaller than the size of spheres in the close packing. A void surrounded by six spheres along the corners of an octahedral is called octahedral void. The size of the octahedral void is smaller than that of the spheres in the close packing but larger than the octahedral void.

Q. Crystal lattice and unit cell

Ans. The regular three dimensional arrangement of identical points in the space which represent how the constituent particles (atoms, ions, molecules) are arranged in a crystal is called a crystal lattice.

A unit cell is the smallest portion of a crystal lattice, which when repeated over and again in different directions produces the complete crystal lattice.

Q.2. What change occurs when AgCl is doped with $CdCl_2$?

[*CBSE (AI) 2013*]

What type of semiconductor is produced when silicon is doped with boron?

Ans.

- **i.** A cationic vacancy is generated.
- **ii.** *p*-type semiconductor.

Q.3. Account for the following:

Q. Schottky defects lower the density of related solids.

Ans. In Schottky defect as the number of ions are missing from their normal lattice sites, the mass decreases whereas the volume remains the same. Due to this the density decreases.

Q. Conductivity of silicon increases on doping it with phosphorus.

Ans. This is due to availability of additional unpaired electrons on doping with phosphorous.

Q.4. Answer the following questions.

Q. Why does presence of excess of lithium makes LiCl crystals pink?

[CBSE (AI) 2013]

Ans. Excess of lithium leads to metal excess defect. Lithium atoms lose electrons to form Li^+ ions. These electrons diffuse into the crystal and form F-centres. Therefore, LiCl crystals become pink.

Q. A solid with cubic crystal is made of two elements P and Q. Atoms of Q are at the corners of the cube and P at the body-centre. What is the formula of the compound?

Ans.

Number of P atoms per unit cell = 1 (at the body centre) × 1 = 1

Number of Q atoms per unit cell = 8 (at the corners) $\times \frac{1}{8} = 1$

Hence, the formula of the compound = ***PQ***.

Q.5. Answer the following questions.

Q. Based on the nature of intermolecular forces, classify the following solids:

[*CBSE (AI) 2014*]

Sodium sulphate, Hydrogen

Ans. Sodium sulphate—Ionic solid, Hydrogen—Molecular solid (non-polar)

Q. What happens when $CdCl_2$ is doped with AgCl?

Ans. It results impurity defect. Each Cd^{2+} replaces two Ag^+ ions. It occupies the site of one ion and the other site remains vacant.

Q.6. An element with density 11.2g cm^{-3} forms a f.c.c. lattice with edge length of 4 × 10^{-8} cm.

Calculate the atomic mass of the element.

(Given: $N_A = 6.022 \times 10^{23}\ mol^{-1}$)

[*CBSE Delhi 2014*]

Ans.

For *fcc* lattice number of atoms per unit cell, $z = 4$

Here, $d = 11.2\ g\ cm^{-3}$, $a = 4 \times 10^{-8}$ cm, $N_A = 6.022 \times 10^{23}\ mol^{-1}$

$$\text{Atomic mass, } M = \frac{d \times a^3 \times N_A}{z}$$

$$= \frac{11.2 g\ cm^{-3} \times (4 \times 10^{-8}\ cm)^3 \times 6.022 \times 10^{23}\ mol^{-1}}{4} = \mathbf{107.9\ g\ mol^{-1}} \text{ or } \mathbf{107.9\ u}$$

Q.7. Tungsten crystallises in body centred cubic unit cell. If the edge of the unit cell is 316.5 pm, what is the radius of tungsten atom?

[CBSE Delhi 2012]

Ans.

$a = 316.5$ pm

For *bcc* unit cell, $r = \frac{\sqrt{3}}{4}a$

$$r = \frac{\sqrt{3}}{4} \times 316.5 \text{ pm} = \mathbf{137.04\ pm}$$

Q.8. Calculate the efficiency of packing in case of a metal crystal for simple cubic (with the assumption that atoms are touching each other).

[*CBSE (AI) 2011*]

Ans.

$$\text{Packing efficiency} = \frac{z \times \text{volume of one atom}}{\text{Volume of cubic unit cell}} \times 100 = \frac{z \times \frac{4}{3}\pi r^3}{a^3} \times 100$$

For a simple cubic lattice, $a = 2r$ and $z = 1$

$$\therefore \quad \text{Packing efficiency} = \frac{1 \times \frac{4}{3}\pi r^3}{(2r)^3} \times 100$$

$$= \frac{\pi}{6} \times 100 = 52.36\% = \mathbf{52.4\%}$$

Short Answer Questions-I (OIQ)

Q.1. Answer the following questions.

Q. Why is Frenkel defect found in AgCl?

Ans. Due to smaller size of Ag^+ cation.

Q. What is the difference between phosphorus doped and gallium doped semiconductors?

Ans. Silicon doped with phosphorus gives *n*-type whereas silicon doped with gallium are *p*-type semiconductors.

Q.2. In terms of band theory, what is the difference between

i. **a conductor and an insulator?**
ii. **a conductor and a semiconductor?**

Ans. (i) The energy gap between the valence band and conduction band in an insulator is very large while in a conductor, the energy gap is very small or there is overlapping between valence band and conduction band.

(ii) In a conductor, there is a very small energy gap or there is overlapping between valence band and conduction band whereas in semiconductor there is always a small energy gap between them.

Q.3. Write the coordination number of each ion in the following crystals:

i. **NaCl**
ii. **CsCl**

Ans.

i. $Na^+ = 6$, $Cl^- = 6$
ii. $Cs^+ = 8$, $Cl^- = 8$

Q.4. If three elements A, B and C crystallise in a cubic solid lattice with A atoms at the corners, B atoms at the cube centres and C atoms at the centre of the faces of the cube, then write the formula of the compound.

[HOTS]

Ans.

Atoms of A per unit cell = $8 \times \frac{1}{8} = 1$

Atoms of B per unit cell = 1

Atoms of C per unit cell = $6 \times \frac{1}{2} = 3$

Hence, the formula is $\boldsymbol{ABC_3}$.

Q.5. Calculate the following

i. **Number of NaCl units in a unit cell of NaCl.**
ii. **Number of CsCl unit in a unit cell of CsCl.**

[*HOTS*]

Ans.

i. (*i*) Number of Na^+ ions = 12 (at edge centres) × $\frac{1}{4}$ + 1 (at body centre) × 1 = 4
Number of Cl^- ions = 8 (at the corners) × $\frac{1}{8}$ + 6 (at face centres) × $\frac{1}{2}$ = 4
∴ umber of NaCl units per unit cell (z) = **4**

ii. Number of Cs^+ ion = 1 (at the body centre) × 1 = 1Number of Cl^- ions = 8 (at the corners) × $\frac{1}{8}$ = 1
∴ umber of CsCl units per unit cell (z) = **1**

Q.6. Calculate the following

i. Number of ZnS units in a unit cell of ZnS.
ii. Number of CaF_2 units in a unit cell of CaF_2. **[*HOTS*]**

Ans. (i) Number of Zn^{2+} ions = 4 (within the body) × 1 = 4
Number of S^{2-} ions = 8 (at the corners) × $\frac{1}{8}$ + 6 (at face centres) × $\frac{1}{2}$ = 4
∴ umber of ZnS units per unit cell (z) = **4**

(ii) Number of Ca^{2+} ions = 8 (at the corners) × $\frac{1}{8}$ + 6 (at face centres) × $\frac{1}{2}$ = 4
Number of F– ions = 8 (within the body) × 1 = 8
Number of CaF_2 ions per unit cell (z) = **4**.

Q.7. A crystalline solid has a cubic structure in which tungsten (W) atoms are located at cube corners of the unit cell, oxygen atoms at the cube edges and sodium atom at the centre. What is the molecular formula of the compound?

[HOTS]

Ans.

Number of W atoms per unit cell = 8 (at the corners) × $\frac{1}{8}$ = 1

Number of O atoms per unit cell = 12 (at the edge centres) × $\frac{1}{4}$ = 3

Number of sodium atoms per unit cell = 1 (at the cube centre) × 1 = 1

Hence, the formula of the compound = $\mathbf{NaWO_3}$

Q.8. In a cubic close packed structure of a mixed oxide one-eighth of tetrahedral voids are occupied by divalent ions X^{2+}, while one half of the octahedral voids are occupied by trivalent ions Y^{3+}. What is the formula of the compound?

[*HOTS*]

Ans.

Let the number of O^{2-} ions in the crystal = N

∴ Number of tetrahedral voids = $2N$

Number of octahedral voids = N

∴ Number of X^{2+} ions = $\frac{1}{8} \times 2N = \frac{N}{4}$

Number of Y^{3+} ions = $\frac{1}{2} \times N = \frac{N}{2}$

$X^{2+} : Y^{3+} : O^{2-} = \frac{N}{4} : \frac{N}{2} : N = 1 : 2 : 4$

Hence, the formula of the compound is $\mathbf{XY_2O_4}$.

Q.9. The radius of an atom of an element is 75 pm. If it crystallizes as a body-centred cubic lattice, what is the length of the side of the unit cell?

Ans.

For bcc, $a = \frac{4}{\sqrt{3}} r = \frac{4}{\sqrt{3}} \times 75$

$= \frac{4}{\sqrt{3}} \times 75 \times \frac{\sqrt{3}}{\sqrt{3}} = 100 \times 1.732 = 173.2 \text{ pm}$

Q.10. Lithium metal crystal has body-centred cubic structure. Its density is 0.53 g cm^{-3} and its molar mass is 6.94 g mol^{-1}. Calculate the volume of a unit cell of lithium metal. [N_A = 6.023 × 10^{23} mol^{-1}]

Ans.

Volume of the crystal, $a^3 = \frac{z \times M}{d \times N_A}$

$$a^3 = \frac{2 \times 6.94}{0.53 \times 6.023 \times 10^{23}} = 4.348 \times 10^{-23} \text{ cm}^3$$

Short Answer Questions-II

Short Answer Questions-II (PYQ)

Q.1. Answer the following

Q. Based on the nature of intermolecular forces, classify the following solids:

Silicon carbide, Argon

Ans. Silicon carbide: Covalent solid

Argon: Molecular solid (non-polar)

Q.2. Answer the folloing questions.

Q. Frenkel defects are not found in alkali metal halides.

Ans. This is because alkali metal ions have larger size which cannot fit into interstitial sites.

Q. Schottky defects lower the density of related solids.

Ans. As the number of ions decreases as a result of Schottky defect, the mass decreases whereas the volume remains the same.

Q. Impurity doped silicon is a semiconductor.

Ans. This is due to additional electron or creation of an electron hole on doping with impurity. Creation of electron hole results in *p*-type semiconductor whereas additional electron results in *n*-type semiconductor.

Q.3. Answer the following questions.

Q. What type of stoichiometric defect is shown by KCl and why?

Ans. KCl shows schottky defect as the cation, K^+ and anion, $Cl^–$ are of almost similar sizes.

Q. What type of semiconductor is formed when silicon is doped with As?

Ans. n-type semiconductor.

Q.4. Answer the following questions.

Q. What is the radius of sodium atom if it crystallises in bcc structure with the cell edge of 400 pm?

Ans.

$$\text{For a bcc structure}, r = \frac{\sqrt{3}}{4}a$$

$$\therefore \quad r = \frac{1.732}{4} \times 400 \text{ pm} = 173.2 \text{ pm}$$

Q.5. Examine the given defective crystal:

X+	Y–	X+	Y–	X+
Y–	Z2+	Y–	X+	Y–
X+	Y–		Y–	X+
Y–	X+	Y–	X+	Y–

(a) Write the term used for this type of defect.

(b) What is the result when XY crystal is doped with divalent (Z^{2+}) impurity?

[CBSE (F) 2017]

Ans.

i. Impurity defect.
ii. Each Z^{2+} replaces two X^+ ions. It occupies the site of one X^+ ion and other site remain vacant. The vacancies results in the higher electrical conductivity of the solid.

Q.6. Examine the given defective crystal:

X^+ Y^- X^+ Y^- X^+

Y^- X^+ Y^- X^+ Y^-

X^+ Y^- X^+ e^- X^+

Y^- X^+ Y^- X^+ Y^-

Answer the following questions:

Q. Is the above defect stoichiometric or non-stoichiometric?

Ans. Non-stoichiometric defect

Q. Write the term used for the electron occupied site.

Ans. F-centre

Q. Give an example of the compound which shows this type of defect.

[*CBSE Ajmer 2015*]

Ans. When crystals of NaCl are heated in an atmosphere of Na vapours or when crystals of KCl are heated in an atmosphere of K vapours.

Q.7. Iron has a body centred cubic unit cell with a cell dimension of 286.65 pm. The density of iron is 7.874 g cm^{-3}. Use this information to calculate Avogadro's number.

(At. mass of Fe = 55.845 u)

[*CBSE Delhi 2012; (F) 2012*]

Ans.

$a = 286.65\text{ pm} = 286.65 \times 10^{-10}\text{ cm};\ M = 55.845\text{ g mol}^{-1};\ d = 7.874\text{ g cm}^{-3}$

For *bcc* unit cell, $z = 2$

Substituting the values in the expression, $N_A = \frac{z \times M}{a^3 \times d}$, we get

$$N_A = \frac{2 \times 55.845\ g\ \text{mol}^{1}}{(286.65 \times 10^{10}\ \text{cm})^3 \times 7.874\ g\ \text{cm}^{3}}$$

$N_A = \mathbf{6.022 \times 10^{23}\ mol^{-1}}$

Q.8. The density of copper metal is 8.95 g cm^{-3}. If the radius of copper atom is 127.8 pm, is the copper unit cell a simple cubic, a body-centred cubic or a face-centred cubic structure?

(Given: At. mass of Cu = 63.54 g mol^{-1} and N_A = 6.022 × 10^{23} mol^{-1})

[*CBSE Delhi 2010; (AI) 2010*]

Ans.

Suppose copper has *fcc* structure

$\therefore \quad z = 4, a = 2\sqrt{2}r$

$d = \frac{z \times M}{a^3 \times N_A} \quad ...(i)$

Here, $M = 63.54$ g mol^{-1}, $N_A = 6.022 \times 10^{23}$ mol^{-1}

$a = 2\sqrt{2}r = 2\sqrt{2} \times 127.8 \text{ pm} = 2\sqrt{2} \times 127.8 \times 10^{-10} \text{ cm}$

$a = 3.614 \times 10^{-8}$ cm

Substituting these values in the expression (i), we get

$$d = \frac{4 \times 63.54 \ g \ \text{mol}^{-1}}{(3.614 \times 10^{-8} \ \text{cm})^3 \times 6.022 \times 10^{23} \ \text{mol}^{-1}}$$

$= 8.94$ g cm^{-3}

As the calculated value of density (8.94 g cm^{-3}) is in agreement with the given value (8.95 g cm^{-3}).

Therefore, copper unit cell has face-centred cubic structure.

Q.9. The density of lead is 11.35 g cm^{-3} and the metal crystallises with *fcc* unit cell. Estimate the radius of lead atom.

[*CBSE Delhi 2011*]

(At. mass of lead = 207 g mol^{-1} and N_A = 6.02 × 10^{23} mol $^{-1}$)

Ans.

$d = \frac{z \times M}{a^3 \times N_A} \quad \Rightarrow \quad a^3 = \frac{z \times M}{d \times N_A} \quad ...(i)$

For a *fcc* unit cell, $z = 4$

$M = 207$ g mol^{-1}, $N_A = 6.02 \times 10^{23}$ mol $^{-1}$, $d = 11.35$ g cm^{-3}

Substituting these values in equation (i), we get

$$a^3 = \frac{4 \times 207 \ g \ mol^{-1}}{11.35 \ g \ cm^{-3} \times 6.02 \times 10^{23} \ mol^{-1}}$$

$$a^3 = \frac{4 \times 207 \times 10}{11.35 \times 6.02 \times 10^{24}} \ cm^3$$

$$a = \left(\frac{8280}{11.35 \times 6.02}\right)^{1/3} \times 10^{-8} \ cm$$

$$\text{Let } x = \left(\frac{8280}{11.35 \times 6.02}\right)^{1/3}$$

$$\log x = [\log 8280 - \log 11.35 - \log 6.02]$$

$$= [3.9180 - 1.0549 - 0.7796]$$

$$\log x = [2.0835] = 0.6945$$

$$x = \text{Antilog } (0.6945) \quad \Rightarrow \quad x = 4.949$$

$$\therefore \quad a = 4.949 \times 10^{-8} \ cm \quad \Rightarrow \quad a = 494.9 \ pm$$

For a *fcc* unit cell, $r = \frac{a}{2\sqrt{2}}$

$$r = \frac{494.9}{2\sqrt{2}} \ pm = \frac{494.9\sqrt{2}}{4} \ pm = \frac{494.9 \times 1.414}{4} \ pm$$

r = **174.95 pm**

Q.10. An element crystallizes in a *fcc* lattice with cell edge of 400 pm. Calculate the density if 200 g of this element contain 2.5 × 10^{24} atoms.

[*CBSE (F) 2016*]

Ans.

$$\text{Moles of the element} = \frac{\text{Atoms of the element}}{N_A}$$

$$\text{or} = \frac{\text{Mass of the element}}{\text{Molar mass}} = \frac{2.5 \times 10^{24} \text{ atoms}}{6.022 \times 10^{23} \text{ atoms mol}^{-1}}$$

$$\frac{200\text{ g}}{\text{Molar mass}} = \frac{2.5 \times 10^{24}}{6.022 \times 10^{23}\ \text{mol}^{-1}}$$

$$\text{Molar mass} = \frac{200\ g \times 6.022 \times 10^{23}\ \text{mol}^{-1}}{2.5 \times 10^{24}}$$

Molar mass, $M = 48.18\ \text{g mol}^{-1}$

Here, $z = 4$, $M = 48.18\ \text{g mol}^{-1}$, $N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

$a = 400\ \text{pm} = 400 \times 10^{-10}\ \text{cm} = 4 \times 10^{-8}\ \text{cm}$

Substituting these values in the expression,

$d = \frac{z \times M}{a^3 \times N_A}$, we get

$$d = \frac{4 \times 48.18\ g\ \text{mol}^{-1}}{(4 \times 10^{-8}\ \text{cm})^3 \times 6.022 \times 10^{23}\ \text{mol}^{-1}}$$

$= \mathbf{5\ g\ cm^{-3}}$

Short Answer Questions-II (OIQ)

Q.1. Answer the following questions.

Q. What type of semiconductor is obtained when Ge is doped with In?

Ans. *p*-type semiconductor

Q.2. What type of magnetism is shown in the following alignment of magnetic moments?

↑ ↑ ↑ ↑ ↑ ↑

Ans. Ferromagnetism

Q.3. What type of point defect is produced when AgCl is doped with $CdCl_2$?

Ans. Impurity defect

Q.2. What are the reasons of electrical conductivity in (*i*) metals, (*ii*) ionic solids, and (*iii*) semiconductors?

Ans.

- **i.** It is due to flow of electrons.
- **ii.** It is due to flow of ions in solution or molten state and defects in the solid state.
- **iii.** It is due to the presence of impurities and defects.

Q.3. Answer the following questions.

Q. simple cubic unit cell?

Ans. 8 (corner atoms) $\times \frac{1}{8}$ (atom per unit cell) = 1

Q. body centred cubic unit cell?

Ans. 8 (corner atoms) $\times \frac{1}{8}$ + 1 (body centre atom) × 1 = 1 + 1 = 2

Q. face centred cubic unit cell?

Ans. 8 (corner atoms) $\times \frac{1}{8}$ + 6 (face centre atoms) $\frac{1}{2}$ = 1 + 3 = 4

Q.4. What is the coordination number of

- **i. zinc in zinc blende (ZnS)?**
- **ii. oxide ion in sodium oxide (Na_2O)?**
- **iii. calcium in calcium fluoride (CaF_2)?**

Ans. (*i*) 4 (***ii***) 8 ***iii*)** 8

Q.5. Write the coordination number of each ion in the following crystals:

- i. **ZnS**
- ii. **CaF_2**
- iii. **Na_2O**

Ans.

- **i.** Zn^{2+} = 4, S^{2-} = 4
- **ii.** Ca^{2+} = 8, F^{-} = 4
- **iii.** Na^{+} = 4, O^{2-} = 8

Q.6. Sodium has a *bcc* structure with nearest neighbour distance 365.9 pm. Calculate its density (Atomic mass of sodium = 23).

Ans.

For the *bcc* structure, nearest neighbour distance (d) is related to the edge (a) as

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

or, $$a = \frac{2}{\sqrt{3}}d = \frac{2}{1.732} \times 365.9 = 422.5 \text{ pm}$$

For *bcc* structure, $z = 2$

For sodium, $M = 23$

Density, $$d = \frac{z \times M}{a^3 \times N_A}$$

$$= \frac{2 \times 23 \; g \; \text{mol}^{-1}}{(422.5 \times 10^{-10} \; \text{cm})^3 \times (6.02 \times 10^{23} \; \text{mol}^{-1})} = \mathbf{1.013 \; g/cm^3}$$

Q.7. Chromium crystallises in *bcc* structure. If its atomic diameter is 245 pm, find its density. Atomic mass of Cr = 52 amu and $N_A = 6.02 \times 10^{23}$ mol^{-1}.

Ans.

Diameter = 245 pm

$$\therefore \quad \text{Radius} = \frac{245}{2} \text{ pm} = 122.5 \text{ pm}$$

In a *bcc* structure, $r = \frac{\sqrt{3}}{4}a$ or $a = \frac{4r}{\sqrt{3}}$

$$a = \frac{4 \times 122.5}{\sqrt{3}} = \frac{490}{1.732} = 282.91 \text{ pm}$$

$$d = \frac{z \times M}{a^3 \times N_A} = \frac{2 \times 52}{(282.91 \times 10^{-10} \; cm)^3 \times 6.02 \times 10^{23}}$$

$$= \frac{104}{2.264 \times 10^{-23} \times 6.02 \times 10^{23}} = \frac{104}{2.264 \times 6.02}$$

$$= \mathbf{7.63 \; g \; cm^{-3}}$$

Q.8. The edge length of unit cell of a metal having molecular weight 75 g/mol is 5Å which crystallises in cubic lattice. If the density is 2 g/cm^3 then find the radius of metal atom. ($N_A = 6.022 \times 10^{23}$)

[*HOTS*]

Ans.

$M = 75\ \text{g mol}^{-1},\ a = 5\text{Å} = 5 \times 10^{-8}\ \text{cm},\ N_A = 6.022 \times 10^{23}\ \text{mol}^{-1},\ d = 2\ \text{g cm}^{-3}$

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

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

$$= \frac{2\ g/\text{cm}^3 \times (5 \times 10^{-8}\ \text{cm})^3 \times 6 \times 10^{23}\ \text{mol}^{-1}}{75\ g/\text{mol}} = 2$$

As the metal $(z = 2)$ has *bcc* structure

$$r = \frac{\sqrt{3}}{4}a = \frac{\sqrt{3}}{4} \times 5$$

$$= \frac{1.732 \times 5}{4} = 2.165\ \text{Å}$$

$$= 2.165 \times 10^{-8}\ \text{cm} = \mathbf{216.5\ pm}$$

Q.9. An element has a body-centred cubic *bcc* structure with a cell edge of 288 pm. The density of the element is 7.2 g/cm^3. How many atoms are present in 208 g of the element? [*CBSE Sample Paper 2016*]

[*HOTS*]

Ans.

Density of unit cell, $d = \frac{z \times M}{a^3 \times N_A}$ or $M = \frac{d \times a^3 \times N_A}{z}$ ...(i)

Here, $z = 2,\ d = 7.2\ \text{g cm}^{-3},\ N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

$a = 288\ \text{pm} = 288 \times 10^{-10}\ \text{cm} = 2.88 \times 10^{-8}\ \text{cm}$

Substituting these values in expression (i), we get

$$M = \frac{7.2\ g\ \ cm^{-3} \times (2.88 \times 10^{-8}\ cm)^3 \times 6.022 \times 10^{23}\ \ mol^{-1}}{2} = 51.78 \text{ g mol}^{-1}$$

Moles of element= $\frac{Massofelement}{Molarmass} = \frac{208\ g}{51.78\ g\ \ mol^{-1}}$ = 4.02 mol

∴ toms present in 208 g of element = $6.022 \times 10^{23} \times 4.02$ atoms

2.421×10^{24} atoms

Long Answer Questions

Long Answer Questions (PYQ)

Q.1. Answer the following questions.'

Q. An element has atomic mass 93 g mol^{-1} and density 11.5 g cm^{-3}. If the edge length of its unit cell is 300 pm, identify the type of unit cell.

Ans.

Number of atoms per unit cell, $z = \frac{d \times a^3 \times N_A}{M}$ ...(i)

Here, d = 11.5 g cm^{-3}, M = 93 g mol^{-1}, N_A = 6.022 × 10^{23} mol^{-1},

a = 300 pm = 300 × 10^{-10} cm = 3 × 10^{-8} cm

Substituting these values in the expression (i), we get

$$z = \frac{11.5\ g\ cm^{-3} \times (3 \times 10^{-8}\ cm)^3 \times 6.022 \times 10^{23}\ mol^{-1}}{93\ g\ mol^{-1}} = 2.01$$

As there are 2 atoms of the element present per unit cell, therefore, the cubic unit cell must be body centred.

Q. Write any two differences between amorphous solids and crystalline solids.

[CBSE Delhi 2017]

Ans. Distinction between Crystalline and Amorphous Solids

Property	Crystalline Solids	Amorphous Solids
Shape	Definite characteristics and geometrical shape.	Irregular shape.
Melting point	Melt at a sharp and characteristic temperature.	Gradually soften over a range of temperature.
Cleavage property	When cut with a sharp edged tool, they split into two pieces and the newly generated surfaces are plain and smooth.	When cut with a sharp edged tool, they cut into two pieces with irregular surfaces.

Heat of fusion	They have a definite and characteristic heat of fusion.	They do not have a definite heat of fusion.
Isotropy	Anisotropic in nature.	Isotropic in nature.
Nature	True solids.	Pseudo solids or super cooled liquids.
Order in arrangement of constituent particles	Long range order.	Only short range order.

Q.2. Answer the following questions.

Q. Calculate the number of unit cells in 8.1 g of aluminium if it crystallizes in a *fcc* structure.

(Atomic mass of Al = 27 g mol^{-1})

Ans.

$$\text{Moles of aluminium} = \frac{\text{Mass of aluminium}}{\text{Molar mass}}$$

$$= \frac{8.1\ g}{27\ g\ mol^{-1}} = 0.3\ \text{mol}$$

$$\text{Total number of Al atoms} = 6.022 \times 10^{23}\ \text{atoms mol}^{-1} \times 0.3\ \text{mol}$$

$$1.8066 \times 10^{23}\ \text{atoms}$$

For *fcc*, $z = 4$

$$\text{Number of unit cells} = \frac{\text{Total number of atoms}}{4}$$

$$= \frac{1.8066 \times 10^{23}}{4} = 4.5 \times 10^{22}$$

Q. Give reasons:

a. **In stoichiometric defects, NaCl exhibits Schottky defect and not Frenkel defect.**
b. **Silicon on doping with phosphorus forms *n*-type semiconductor.**
c. **Ferrimagnetic substances show better magnetism than antiferromagnetic substances.**

[*CBSE Delhi 2017*]

Ans. (a) This is because Na^+ ion has large size so it cannot fit into interstitial sites.

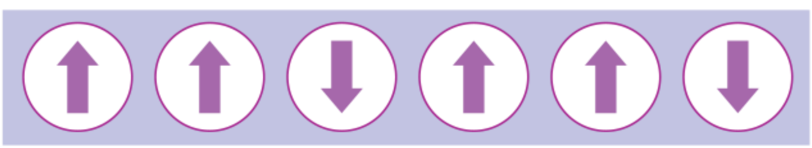
(b) When Si is doped with P, which has five valence electrons, it forms four covalent bonds with four neighbouring Si atoms. The fifth extra electron becomes delocalised and increase the conductivity of Si. Here, the increase in conductivity is due to the negatively charged electron, hence Si doped with P is called *n*-type semiconductor.

(c) In ferrimagnetic substances, domains are aligned in opposite direction in unequal number and hence they have some net magnetic moment. On the other hand, in antiferromagnetic substances, the domains aligned in opposite directions are equal in number so they cancel magnetic moment completely and hence have zero magnetic moment. For diagram Refer to Fig. 1.20.

Long Answer Questions (OIQ)

Q.1. Answer the following questions.

Q. Identify the type of magnetism. What happens when these substances are heated?



Following is the schematic alignment of magnetic moments:

Ans. Ferrimagnetism.

These substances lose ferrimagnetism on heating and become paramagnetic. This is due to randomisation of domains (spins) on heating.

Q. If the radius of the octahedral void is 'r' and radius of the atoms in close packing is 'R'. What is the relation between 'r' and 'R'?

Ans. $r = 0.414\ R$

Q. Tungsten crystallizes in body centred cubic unit cell. If the edge of the unit cell is 316.5 pm. What is the radius of tungsten atom?

[*CBSE Sample Paper 2017*]

Ans.

For *bcc* structure, $r = \frac{\sqrt{3}}{4}a$

$$r = \frac{1.732}{4} \times 316.5 \text{ pm} = 137.04 \text{ pm}$$

Q.2. Answer the following questions.

Q.

a. **Why are crystalline solids anisotropic?**
b. **What type of semiconductor is formed when silicon is doped with boron?**
c. **Define the term coordination number. What is the coordination number of atoms in a cubic closed packed structure?**

Ans.

a. It arises from different arrangement of particles in different direction.
b. Silicon is group 14 element and boron is group 13 element, therefore, an electron deficient hole is created. Thus, semiconductor is of *p*-type.
c. Coordination number is defined as the number of nearest neighbours in a closed packed structure. The coordination number of an atom in *ccp* structure is 12.

Q. Sodium crystallises in a bcc unit cell. Calculate the approximate number of unit cells in 9.2 g of sodium. (Atomic Mass of Na = 23 u)

Ans.

For *bcc* structure, $r = \frac{\sqrt{3}}{4}a$

$$r = \frac{1.732}{4} \times 316.5 \text{ pm} = 137.04 \text{ pm}$$

Q.3. Answer the following questions.

Q. Name the non-stoichiometric point defect responsible for colour in alkali metal halides.

Ans. Metal excess defect due to anion vacancies or F-centres.

Q. An ionic compound made of atoms X and Y has a face centred cubic arrangement in which atoms A are at the corners and atoms Y are at the face centres. If one of the atoms is missing from the corner, what is the simplest formula of the compound?

Ans.

$$\text{Number of X atoms per unit cell} = 7\,(\text{at the corners}) \times \frac{1}{8} = \frac{7}{8}$$

$$\text{Number of Y atoms per unit cell} = 6\ (\text{at the face centres}) \times \frac{1}{2} = 3$$

$$X : Y = \frac{7}{8} : 3 = 7 : 24$$

$$\frac{7}{8} : 3 = 7 : 24$$

$\therefore$ Formula of the compound = X_7Y_{24}

Q. What type of semiconductor is obtained when silicon is doped with arsenic?

Ans. n-type of semiconductor is obtained.

Q. Sodium metal crystallises in bcc lattice with the cell edge, 4.29 Å. What is the radius of sodium metal? What is the length of the body diagonal of the unit cell?

Ans.

For *bcc* lattice,

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

$$r = \frac{1.732}{4} \times 4.29\ \text{Å} = 1.86\ \text{Å}$$

Length of the body diagonal = $4r$

$$4 \times 1.86\ \text{Å} = \mathbf{7.44\ Å}$$

Q.4. An element with molar mass 63 g/mol forms a cubic unit cell with edge length of 360.8 pm. If its density is 8.92 g/cm³. What is the nature of the cubic unit cell?

Ans.

$$d = \frac{z \times M}{a^3 \times N_A} \quad \text{or} \quad z = \frac{d \times a^3 \times N_A}{M} \quad ..(i)$$

Here, $d = 8.92\ \text{g cm}^{-3}$, $N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$, $M = 63\ \text{g mol}^{-1}$

$$a = 360.8\ \text{pm} = 360.8 \times 10^{-10}\ \text{cm} = 3.608 \times 10^{-8}\ \text{cm}$$

Substituting these values in expression (i), we get

$$z = \frac{8.92 \ gcm^{3} \times (3.608 \times 10^{8} \ cm)^{3} \times 6.022 \times 10^{23} \ mol^{1}}{63 \ g \ mol^{1}} = 4$$

The unit cell is face centred cubic.

Q.5. An element has *fcc* structure with a cell edge 200 pm. Calculate the density of element, if 200 g of the element contains 24×10^{23} atoms.

Ans.

$a = 200 \text{ pm} = 200 \times 10^{-10} \text{ cm} = 2 \times 10^{-8} \text{ cm}, z = 4$ (for *fcc*)

Mass of unit cell $= \frac{200 \times 4}{24 \times 10^{23}}$

$= 33.33 \times 10^{-23}$ g

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

$= \frac{33.33 \times 10^{23} g}{(2 \times 10^{8} \ cm)^{3}} = \mathbf{41.6 \ g \ cm^{-3}}$