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.

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

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

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

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

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.**

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

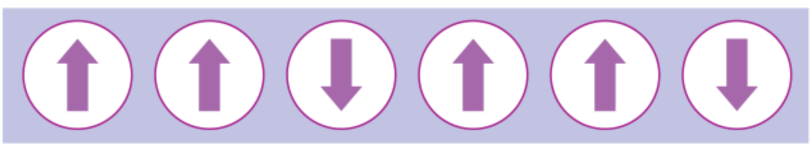
(b) When Si is doped with P, which has five valence electrons, it forms four covalent bonds with four neighbouring Si atoms. The fifth extra electron becomes delocalised and increase the conductivity of Si. Here, the increase in conductivity is due to the negatively charged electron, hence Si doped with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

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

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

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

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

$\therefore$ 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 = $4r$

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

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/cm^3. 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 g cm^{-3}, $N_A = 6.022 \times 10^{23}$ mol^{-1}, M = 63 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

$$z = \frac{8.92 \text{ gcm}^{3} \times (3.608\times10^{8} \text{ cm})^{3} \times 6.022\times10^{23} \text{ mol}^{1}}{63 \; g \text{ mol}^{1}} = 4$$

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= $\frac{Massofunitcell}{Volumeofunitcell}$

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