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.

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

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

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

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

$= 8.94$ 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.

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

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

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

$$r = \mathbf{174.95 \ pm}$$

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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2.421×10^{24} atoms