Blue Print (As per PU Board)

Topic	1 mark questions	2 marks questions	3 marks questions	5 marks questions	Total Marks
The Solid State	–	1	–	1	7

One mark questions

1. **What is the structure of the crystal with co-ordination number 8?**
   Answer: Body centred cubic
2. **What is the co-ordinations number of each ion, if the radius ratio of the crystal is 0.83?**
   Answer: 8
3. **Solid A is a very hard electrical insulator in solid as well as in molten state and melts at extremely high temperature. What type of solid is it?**
   Answer: It is a covalent Network solid

Two marks questions

4. **How many tetrahedral and octahedral voids are possible if the number of close packed spheres in two layers is N?**
   Answer: Number of tetrahedral voids $= 2\,\text{N}$ (1 mark)
   Number of octahedral voids $= N$ (1 mark)
5. **Atoms of element B form hcp lattice and those of the element A occupy $\frac{2}{3}^{\text{rd}}$ of tetrahedral voids what is the formula of the compound formed by the elements A and B ?**
   Answer: No of tetrahedral voids $= 2 \times$ No of atoms of B
   $\therefore$ Ratio of the number of atoms of A and B is $2 \times \left(\frac{2}{3}\right) : 1 = 4 : 3$ (1 mark)
   $\therefore$ Formula of the compound is $A_4 B_3$ (1 mark)
6. **Sodium metal crystallise in a BCC structure. Its cell edge length is 420 pm. Calculate its density (atomic mass of sodium $= 23, N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$**
   Answer: Density $d = \dfrac{zM}{a^3 N_A} = \dfrac{2 \times 23\, g/mol^{-1}}{\left(420 \times 10^{-10}\, cm\right)^3 \times 6.022 \times 10^{23}\, mol^{-1}}$ (1 mark)
   $d = 1.031\,\text{g/cm}^3 \qquad \left[\because 1\text{pm} = 10^{-12}\, m = 10^{-10}\ \text{cm}\right]$ (1 mark)

7. **Give any two difference between schottky and frenkel defects in ionic solids**
   Answer:

	Schottky Defect		Frenkel Defect	
(1)	Equal number of cations and anions are missing from lattice points.	(1)	Here, the smaller ion (usually cation) is dislocated from its normal site to an interstitial site.	(1 mark)
(2)	It decreases the density of the solid.	(2)	It does not change the density of the solid.	(1 mark)

Three marks questions

8. **Calculate the packing efficiency in a simple cubic lattice.**
   Answer: For cubic unit cell; edge length $a = 2r$

$\therefore$ Volume of the cell $= a^3 = (2r)^3 = 8r^3$ (1 mark)

Simple cubic unit cell has one atom

$\therefore$ volume of one atom $= \frac{4}{3}\pi r^3$ (1 mark)

Packing efficiency $= \frac{\text{volume of one atom}}{\text{volume of unit cell}} \times 100$

$= \frac{\frac{4}{3}\pi r^3}{8r^3} \times 100$ (1 mark)

$= 52.36\%$

9. **An element X has a density of $6.23\,\text{g/cm}^3$. If the edge length of the unit cell is 400 pm, identify the type of cubic unit cell. (Molar mass of $X = 60\,\text{g/mol}, N_A = 6.022 \times 10^{23}\,\text{mol}^{-1}$)**

Answer: Density $\rho = \frac{zm}{a^3 N_A}$

$z = \frac{\rho \times a^3 \times N_A}{M} = \frac{6.23\text{g/cm}^3 \times \left(400 \times 10^{-10}\,\text{cm}\right)^3 \times 6.022 \times 10^{23}\,\text{mol}^{-1}}{60\,\text{g/mol}}$ (1 mark)

$z = 4$ (1 mark)

Since $z = 4$ type of unit cell is FCC (face centred cubic unit cell)

Five marks questions

10. **What is packing efficiency in a crystal? Draw the unit cell of a simple cubic lattice and calculate the packing efficiency in a simple cubic lattice.**

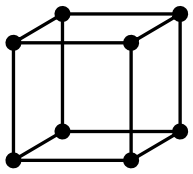
Answer: Packing efficiency is the percentage of total space filled by the particles in a crystal. (1 mark)

In a simple cubic lattice, the atoms are located only on the corners of the cube.

The particles touch each other along the edge. Edge length or side of a cube $= a$, radius of a particle $= r$

$= \therefore a = 2r$ (1 mark)

$\therefore$ volume of the cubic unit cell $= a^3 = (2r)^3 = 8r^3$ (1 mark)



Since a simple cubic unit cell contains only 1 atom

Volume of the occupied space $= \frac{4}{3}\pi r^3$

$\therefore$ Packing efficiency $= \frac{\text{volume of one atom}}{\text{volume of cubic unit cell}} \times 100\%$

$= \frac{\frac{4}{3}\pi r^3}{8r^3} \times 100$ (1 mark)

$= \frac{\pi}{6} \times 100 = 52.36\%$ (1 mark

11. **Calculate the packing efficiency in hexagonal close packing arrangement.**

Answer: In ΔABC,

$AC^2 = b^2 = BC^2 + AB^2$

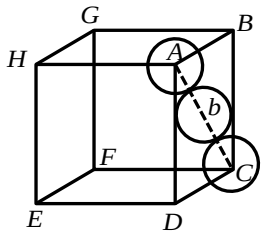
$\therefore b^2 = a^2 + a^2 = 2a^2$ (1 mark)

$b = \sqrt{2a}$ [a = unit cell edge length and face diagonal $AC = b$]

If r is the radius of the sphere, then $b = \sqrt{2a} = 4r$

or $a = \frac{4r}{\sqrt{2}} = 2\sqrt{2r}$ (1 mark)

Each unit cell in *hcp* has effectively 4 spheres



$\therefore$ Total volume of 4 spheres $= 4 \times \left(\frac{4}{3}\right)\pi r^3$

and volume of cube $= a^3 = \left(2\sqrt{2}r\right)^3$

(1 mark)

$\therefore$ Packing efficiency $= \frac{\text{Volume occupied by 4 spheres in the unit cell}}{\text{Total volume of unit cell}} \times 100\%$

$$= \frac{4 \times \left(\frac{4}{3}\right)\pi r^3}{\left(2\sqrt{2}r\right)^3} \times 100\%$$

$$\frac{\left(\frac{16}{3}\right)\pi r^3 \times 100}{16\sqrt{2}r^3} = 74\%$$ (1 mark)

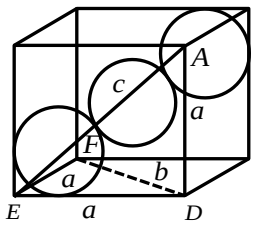
12. **Calculate the packing efficiency in a body centred cubic lattice.**

Answer: In BCC, the atom at the centre will be in touch with the other two atoms diagonally arranged. (1 mark)

In ΔEFD,

$b^2 = a^2 + a^2 = 2a^2$

$b = \sqrt{2a}$



Now in ΔAFD

$c^2 = a^2 + b^2 = a^2 + 2a^2 = 3a^2$

$c = \sqrt{3}a$ (1 mark)

The length of the body diagonal $C = 4r$

Where, r is the radius of the sphere.

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

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

$\therefore$ volume of the unit cell $= a^3 = \left(\frac{4r}{\sqrt{3}}\right)^3 = \frac{64r^3}{3\sqrt{3}}$

$\therefore$ Packing efficiency $= \frac{\text{volume occupied by 2 spheres in the unit cell}}{\text{total volume of unit cell}} \times 100\%$

$$= \frac{2\left(\frac{4}{3}\pi r^3\right)}{\frac{64r^3}{3\sqrt{3}}} \times 100\%$$ (1 mark)

$= 68\%$ (1 mark)