CHAPTER 15

The Solid State

1. Na and Mg crystallize in BCC and FCC type crystals respectively, then the number of atoms of Na and Mg present in the unit cell of their respective crystal is **[2002]**

(a) 4 and 2 (b) 9 and 14
(c) 14 and 9 (d) 2 and 4.

2. How many unit cells are present in a cube-shaped ideal crystal of NaCl of mass 1.00 g ? **[2003]**

[Atomic masses : Na = 23, Cl = 35.5]

(a) 5.14×10^{21} unit cells
(b) 1.28×10^{21} unit cells
(c) 1.71×10^{21} unit cells
(d) 2.57×10^{21} unit cells

3. What type of crystal defect is indicated in the diagram below? **[2004]**

$Na^+Cl^-Na^+Cl^-Na^+Cl^-$
$Cl^-\square\ Cl^-Na^+\square\ Na^+$
$Na^+Cl^-\square Cl^-Na^+Cl^-$
$Cl^-Na^+Cl^-Na^+\square\ Na^+$

(a) Interstitial defect
(b) Schottky defect
(c) Frenkel defect
(d) Frenkel and Schottky defects

4. An ionic compound has a unit cell consisting of A ions at the corners of a cube and B ions on the centres of the faces of the cube. The empirical formula for this compound would be **[2005]**

(a) A_3B (b) AB_3
(c) A_2B (d) AB

5. Total volume of atoms present in a face-centred cubic unit cell of a metal is (r is atomic radius) **[2006]**

(a) $\frac{12}{3}\pi r^3$ (b) $\frac{16}{3}\pi r^3$
(c) $\frac{20}{3}\pi r^3$ (d) $\frac{24}{3}\pi r^3$

6. In a compound, atoms of element Y form ccp lattice and those of element X occupy 2/3rd of tetrahedral voids. The formula of the compound will be **[2008]**

(a) X_4Y_3 (b) X_2Y_3
(c) X_2Y (d) X_3Y_4

7. Copper crystallises in *fcc* with a unit cell length of 361 pm. What is the radius of copper atom? **[2009]**

(a) 127 pm (b) 157 pm
(c) 181 pm (d) 108 pm

8. The edge length of a face centered cubic cell of an ionic substance is 508 pm. If the radius of the cation is 110 pm, the radius of the anion is

(a) 288 pm (b) 398 pm **[2010]**
(c) 618 pm (d) 144 pm

9. Percentages of free space in cubic close packed structure and in body centered packed structure are respectively **[2010]**

(a) 30% and 26% (b) 26% and 32%
(c) 32% and 48% (d) 48% and 26%

10. Copper crystallises in fcc lattice with a unit cell edge of 361 pm. The radius of copper atom is : **[2011RS]**

(a) 108 pm (b) 128 pm
(c) 157 pm (d) 181 pm

11. Lithium forms body centred cubic structure. The length of the side of its unit cell is 351 pm. Atomic radius of the lithium will be : **[2012]**

(a) 75 pm (b) 300 pm
(c) 240 pm (d) 152 pm

12. Which of the following exists as covalent crystals in the solid state ? **[2013]**

(a) Iodine (b) Silicon
(c) Sulphur (d) Phosphorus

13. CsCl crystallises in body centered cubic lattice. If 'a' is its edge length then which of the following expressions is correct? **[2014]**

(a) $r_{Cs^+} + r_{Cl^-} = 3a$

(b) $r_{Cs^+} + r_{Cl^-} = \frac{3a}{2}$

(c) $r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$

(d) $r_{Cs^+} + r_{Cl^-} = \sqrt{3}a$

14. The correct statement for the molecule, CsI_3 is:

(a) It is a covalent molecule. **[2014]**

(b) It contains Cs^+ and I_3^- ions.

(c) It contains Cs^{3+} and I^- ions.

(d) It contains Cs^+, I^- and lattice I_2 molecule.

15. Sodium metal crystallizes in a body centred cubic lattice with a unit cell edge of 4.29Å. The radius of sodium atom is approximately: **[JEE M 2015]**

(a) 5.72Å (b) 0.93Å

(c) 1.86Å (d) 3.22Å

16. A metal crystallises in a face centred cubic structure. If the edge length of its unit cell is 'a', the closest approach between two atoms in metallic crystal will be: **[JEE M 2017]**

(a) 2a (b) $2\sqrt{2}$ a

(c) $\sqrt{2}$ a (d) $\frac{a}{\sqrt{2}}$

Answer Key														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(d)	(d)	(b)	(b)	(b)	(a)	(a)	(d)	(b)	(b)	(d)	(b)	(c)	(b)	(c)
16														
(d)														

SOLUTIONS

1. **(d)** In bcc - points are at corners and one in the centre of the unit cell.

Number of atoms per unit cell

$= 8 \times \frac{1}{8} + 1 = 2$.

In fcc - points are at the corners and also centre of the six faces of each cell.

Number of atoms per unit cell

$= 8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4$.

2. **(d)** Since in NaCl type of structure 4 formula units form a cell. Number of formulas in cube shaped crystals $= \frac{1.0}{58.5} \times 6.02 \times 10^{23}$

No. of unit cells present in a cubic crystal

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

$\therefore$ units cells $= \frac{1.0 \times 6.02 \times 10^{23}}{58.5 \times 4} = 2.57 \times 10^{21}$

unit cells.

3. **(b)** When equal number of cations and anions are missing from their regular lattice positions, we have schottky defect.

This type of defects are more common in ionic compounds with high co-ordination number and where the size of positive and negative ions are almost equal e.g. NaCl KCl etc.

4. **(b)** Number of A ions in the unit cell.

$= \frac{1}{8} \times 8 = 1$

Number of B ions in the unit cell

$= \frac{1}{2} \times 6 = 3$

Hence empirical formula of the compound $= AB_3$

5. **(b)** The face centered cubic unit cell contains 4 atom

$\therefore$ Total volume of atoms $= 4\times\frac{4}{3}\pi r^3 = \frac{16}{3}\pi r^3$

6. **(a)** From the given data, we have

Number of Y atoms in a unit cell = 4

Number of X atoms in a unit cell $= 8\times\frac{2}{3} = \frac{16}{3}$

From the above we get the formula of the compound as $X_{16/3}Y_4$ or X_4Y_3

7. **(a)** For *fcc* unit cell, $4r = \sqrt{2}\,a$

$$r = \frac{\sqrt{2}\times 361}{4} = 127 \text{ pm}$$

8. **(d)** For an Fcc crystal

$$r_{cation} + r_{anion} = \frac{\text{edge length}}{2}$$

$$110 + r_{anion} = \frac{508}{2}$$

$$r_{anion} = 254 - 110 = 144 \text{ pm}$$

9. **(b)** Packing fraction is defined as the ratio of the volume of the unit cell that is occupied by the spheres to the volume of the unit cell.

P.F. for ccp and bcc are 0.74 and 0.68 respectively.

So, the free space in ccp and bcc are 26% & 32% respectively.

10. **(b)** fcc lattice

$a = 361$ pm

$a\sqrt{2} = 4r$

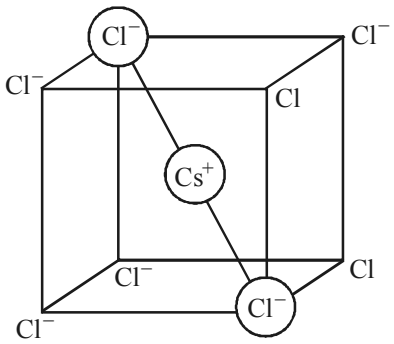
$$r = \frac{361\times\sqrt{2}}{4} = 127.6 \approx 128 \text{ pm}$$

11. **(d)** For BCC structure $\sqrt{3}\,a = 4r$

$$r = \frac{\sqrt{3}}{4}a = \frac{\sqrt{3}}{4}\times 351 = 152 \text{ pm}.$$

12. **(b)**

13. **(c)**



Relation between radius of cation, anion and edge length of the cube

$$2r_{Cs^+} + 2r_{Cl^-} = \sqrt{3}a$$

$$r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}a}{2}$$

14. **(b)** CsI_3 dissociates as $CsI_3 \rightarrow Cs^+ + I_3^-$

15. **(c)** In bcc the atoms touch along body diagonal

$\therefore$ $2r + 2r = \sqrt{3}a$

$\therefore$ $r = \frac{\sqrt{3}a}{4} = \frac{\sqrt{3}\times 4.29}{4} = 1.857\text{Å}$

16. **(d)** For a FCC unit cell

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

$\therefore$ closest distance (2r) $= \frac{\sqrt{2}\,a}{4} = \frac{a}{\sqrt{2}}$