PHYSICAL / INORGANIC CHEMISTRY

DPP
DAILY PRACTICE PROBLEMS

DPP No. 45

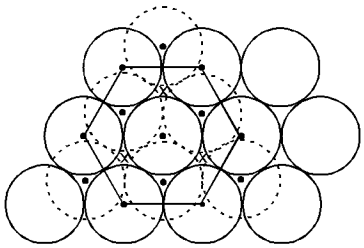
Total Marks : 50

Max. Time : 57 min.

Topic : Solid State

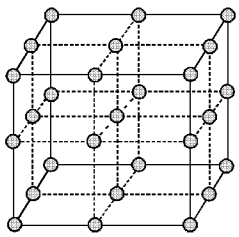
Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.2	(3 marks 3 min.)	[6, 6]
Multiple choice objective ('–1' negative marking) Q.3	(4 marks 4 min.)	[4, 4]
Comprehension ('–1' negative marking) Q.4 to Q.6	(3 marks 3 min.)	[9, 9]
Assertion and Reason (no negative marking) Q.7	(3 marks 3 min.)	[3, 3]
Subjective Questions ('–1' negative marking) Q.8 to Q.12	(4 marks 5 min.)	[20, 25]
Match the Following (no negative marking) Q. 13	(8 marks 10 min.)	[8, 10]

1. **(a)** In hexagonal close packing of sphere in three dimensions.



(A) In one unit cell there are 12 octahedral voids and all are completely inside the unit cell.
(B) In one unit cell there are six octahedral voids and all are completely inside the unit cell.
(C) In one unit cell there are six octahedral void and of which three are completely inside the unit cell and other three are partially inside the unit cell.
(D) In one unit cell there are 12 tetrahedral voids, all are completely inside the unit cell.

(b) The following diagram shows arrangement of lattice point with a = b = c and $\alpha = \beta = \gamma = 90^{\circ}$. Choose the correct options.

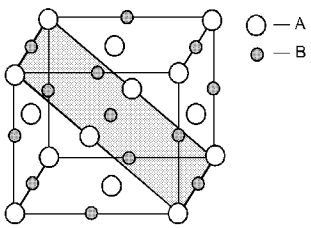


(A) The arrangement is SC with each lattice point surrounded by 6 nearest neighbours.
(B) The arrangement is SC with each lattice point surrounded by 8 nearest neighbours.
(C) The arrangement is FCC with each lattice point surrounded by 12 nearest neighbours.
(D) The arrangement in BCC with each lattice point surrounded by 8 nearest neighbours

2. **(a)** A crystal is made of particle X, Y & Z. X forms FCC packing, Y occupies all octahedral voids of X and Z occupies all tetrahedral voids of X, if all the particles along one body diagonal are removed then the formula of the crystal would be -

(A) XYZ_2 (B) X_2YZ_2 (C) $X_8Y_4Z_5$ (D) $X_5Y_4Z_8$

(b) A crystal is made of particles A and B. A forms FCC packing and B occupies all the octahedral voids. If all the particles along the plane as shown in figure are removed, then, the formula of the crystal would be :



(A) AB (B) A_5B_7
(C) A_7B_5 (D) None of these.

3.* In the fluorite structure if the radius ratio is $\left(\sqrt{\frac{3}{2}}-1\right)$, how many ions does each cation touch ?

(A) 4 anions (B) 12 cations (C) 8 anions (D) No cations

Comprehension # (Q.4 to Q.6)

Only those atoms which form four covalent bonds produce a repetitive three dimesional structure using only covalent bonds, e.g., diamond structure. The latter is based on a **FCC** lattice where lattice points are occupied by carbon atoms. Every atom in this structure is surrounded tetrahedrally by four others. Germanium, silicon and grey tin also crystallize in the same way as diamond. (Given : $N_A = 6 \times 10^{23}$, sin 54°44′ = 0.8164).

4. If edge length of the cube is 3.60Å, then radius of carbon atom is

(A) 0.78 Å (B) 0.92 Å (C) 0.64 Å (D) 0.35 Å.

5. If the edge length is 3.60Å, density of diamond crystal is :

(A) 3.92 gm/cc (B) 2.40 gm/cc (C) 3.37 gm/cc (D) 2.58 gm/cc.

6. Total number of diamond unit cells in 1.2 gm of diamond sample is :

(A) 6.0×10^{21} (B) 6.0×10^{22} (C) 7.5×10^{21} (D) 5.0×10^{22}.

7. **(a) Statement-1 :** In ZnS zinc blende structure Zn^{2+} form FCC while alternate tetrahedral voids are occupied by S^{2-}.

Statement-2 : Positions of Zn^{2+} and S^{2-} in zinc blende structure are similar.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False.
(D) Statement-1 is False, Statement-2 is True.

(b) Statement-1 : In ZnS crystal, Zn^{2+} ions are placed at 50% of tetrahedral voids (at alternate positions) created by S^{2-} ion in c.c.p. lattice.

Statement-2 : Ratio of number of S^{2-} ion and number of tetrahedral voids is 2 : 1 where as ratio of number of S^{2-} ion and number of Zn^{2+} ion is 1 : 1 in zinc blende.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False.
(D) Statement-1 is False, Statement-2 is True.

8. Lithium forms a b.c.c lattice. If the lattice constant is 3.50×10^{-10} m and the experimental density is 5.30×10^2 kg m^{-3} and, calculate the percentage occupancy of Li metal. (Li = 7)

9. In a cubic lattice, the closed packed structure of mixed oxides of the lattice is made up of oxide ions ; one eighth of the tetrahedral voides are occupied by divalent ions (A^{2+}) while one half of the octahedral voids are occupied by trivalent ions (B^{3+}). What is the formula of the oxides ?

10. A cubic unit cell contains manganese ions at the corners and fluoride ions at the centre of each edge.

(a) What is the empirical formula
(b) What is the C.N. of the Mn ion ?
(c) Calculate the edge length of the unit cell if the radius of a Mn ion is 0.65Å and that of F^- ion is 1.36Å.

11. Metallic gold crystallizes in the face-centred cubic lattice. The edge length of the cubic unit cell, a = 4. 070 Å. Calculate the closest distance between gold atoms and the density of gold. Atomic mass of Au = 197 amu.

12. A certain metal forms a face centered cubic lattice. The edge of unit cell is 4.07 Å and its density is 19.4 g/cm^3.

(i) What is the shortest distance between the metal atoms ?
(ii) How many nearest neighbours are there for each atom of the metal?
(iii) What is the molar mass of the metal?
(iv) What is the ratio of the volume occupied by the atoms of the total volume the unit cell?

13.

Column - I	**Column - II**
(A) 74% occupancy of space	(p) Coordination No. of cation in fluorite structure
(B) Coordination No -8	(q) Cubic close packing
(C) Ca^{2+} ion in CaF_2	(r) Hexagonal close packing
(D) Coordination No. – 12	(s) body centred cubic packing.

Answer Key

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1.	**(a)** (B)	**(b)** (A)	**2.**	**(a)** (D)	**(b)** (A)	**3.***	(B,C)	**4.**	(A)	**5.**	(C)
6.	(C)	**7.**	**(a)** (A)	**(b)** (C)		**8.**	97.78 %.	**9.**	AB_2O_4		
10.	(a) MnF_3 (b) 6 (c) a = 2(1.36 + 0.65) = 4.02 Å							**11.**	2.878 Å, 19.40 g /cc.		
12.	(i) 2.878 Å, (ii) 12, (iii) 197, (iv) 0.74					**13.**	(A → q,r) ; (B → p,s) ; (C → q) ; (D → q,r)				

Hints & Solutions

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1. **(a)** HCP = AB AB AB .....pattern repeat
For calculating voids between two layers A and B.
Total tetrahedral voids = 12 (represented by dots) out of which 8 are completely inside but rest are shared by other unit cells.
Total octahedral voids = 6 (represented by cross). All are completely inside.
(b) According to figure, it shows a simple cubic lattice. Now observe the center atom , its has 6 nearest neighbours

2. **(a)** When all particle along one body diagonal are removed, these 2 X particles from corner are removed, one Y particle removed & 2 Z particle removed.

Hence new arrangement, X particle = $\frac{1}{8}\times 6+\frac{1}{2}\times 6=\frac{15}{4}$; Y particle = 3 ; Z particle = 6

Hence formula = $X_{15/4}Y_3Z_6 = X_{5/4}YZ_2 = X_5Y_4Z_8$

(b) In new arrangement, A particles = $\left(\frac{1}{8}\times 8+\frac{1}{2}\times 6\right)-\left(\frac{1}{8}\times 4+\frac{1}{2}\times 2\right)=\frac{5}{2}$

& B particles = $\left(\frac{1}{4}\times 12+1\right)-\left(1+\frac{1}{4}\times 2\right)=\frac{5}{2}$

So, formula is AB

3.* In flourite structure, cations form the lattice & anions occupy each of tetrahedral voids.

4. $4\, d_{C-C} \sin(54°44') = \sqrt{2}\, a \quad \Rightarrow \quad r = \frac{d_{C-C}}{2} = 0.78$

5. $d = \frac{8 \times 12}{N_A \times a^3} = 3.37$ gm/cc.

6. Total number of unit cells $= \frac{1.2 \times N_A}{12 \times 8} = 7.5 \times 10^{21}$.

7. **(a)** In zinc blende S^{2-} from FCC while alternate tetrahedral voids are occupied by Zn^{2+}.

(b) S^{2-} ion : number of tetrahedral void

1 : 2

8. We have theoretical density $= \frac{zM}{NV} = \frac{zM}{N(a^3)}$

For a b.c.c lattice: z = 2 and given that $a = 3.50 \times 10^{-10}$ and $M = 7 \times 10^{-3}$ kg / mole

$$d_{cal} = \frac{2 \times (7 \times 10^{-3})}{6.022 \times 10^{23} \times (3.50 \times 10^{-10})^3} = 5.42 \times 10^2 \text{ kg m}^{-3}$$

$$\therefore \quad \text{percentage occupancy} = \frac{\rho_{exp}}{\rho_{cal}} = \frac{5.30 \times 10^2}{5.42 \times 10^2} \times 100 = 97.78\ \%.$$

9. Let there be 80 O^{2-} in the crystal.

$\therefore$ Octahedral voids = 80 ; Tetrahedral voids = 160

$$A^{2+} \text{ ions} = \frac{1}{8} \times 60 = 20$$

$$B^{3+} \text{ ions} = \frac{1}{2} \times 80 = 40$$

$A^{2+} : B^{3+} : O^{2-} = 20 : 40 : 80 = 1 : 2 : 4$

$\therefore$ Formula is AB_2O_4.

11. In a face -centred cubic cell,

$$\text{radius} = \frac{\sqrt{2}a}{4}$$

$\therefore$ the closest distance between two atoms = diameter = $2 \times \frac{\sqrt{2}a}{4} = \frac{a}{\sqrt{2}}$

$= \frac{4.070}{\sqrt{2}}$ Å = 2.878 Å .

Number of atoms in a face-centred unit cell = $8\left(\frac{1}{8}\right) + 6\left(\frac{1}{2}\right) = 4$

Mass of 4 atom per unit cell = 4×197 amu

$= 4 \times 197 \times (1.66 \times 10^{-24})$g

$= 1.308 \times 10^{-21}$g

Volume of the unit cell = a^3

$= (4.07 \times 10^{-8})^3$cc.

$\therefore$ density of gold = $\frac{1.308 \times 10^{-21}}{(4.07 \times 10^{-8})^3}$ = 19.40 g /cc.

12. (i) $2r = \frac{a}{\sqrt{2}} = \frac{4.07}{\sqrt{2}}$ = 2.878 Å (ii) 12 (iii) $19.4 = \frac{4 \times m}{(4.07 \times 10^{-8})^3 \times 6.023 \times 10^{23}}$ or M = 197 (iv) 0.74