SOLUTION OF SOLID STATE

EXERCISE # 1

PART - I

A-1. On the basis of classification of solid.

A-2. Contribution on the basis of angle and diagram.

B-1. Contribution of atom

At face center = $\frac{1}{2}$

At body center = 1

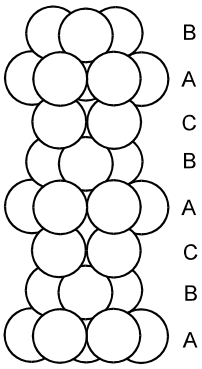
B-2. Coordination number of Li and Ag in given structure is 8. So it is a bcc arrangement.

B-3. We know for B.C.C. $4R = a\sqrt{3}$

$R = \frac{287 \times \sqrt{3}}{4}$ = 124.27 pm.

density = $\frac{2 \times 52}{6.023 \times 10^{23}\left(287 \times 10^{-10}\right)^3}$ = 7.30 gm / cm^3.

C-1.



(ccp) ABC–ABC .... Type

C-2. Packing efficiency of hcp = $\frac{6 \times \text{vol. of 1 atom}}{\text{Vol. of unit cell}}$

Volume of unit cell = $\frac{Z \times M}{N_A \times d}$ = $\frac{6 \times 24.31}{6.023 \times 10^{23} \times 1.74}$ = 13.9179 × 10^{-23} cm^3.

So, volume of 1 atom = $\frac{\text{Packing fraction} \times \text{Vol. of unit cell}}{6}$ = $\frac{0.741 \times 13.9179 \times 10^{-23}}{6}$

= 1.718 × 10^{-23} cm^3.

Volume of 1 atom = $\frac{4}{3}\pi r^3$.

Radius of 1 atom = (r) = $\left(\frac{\text{Volume of 1 atom} \times 3}{4\pi}\right)^{1/3}$ = $(0.41055 \times 10^{-23})^{1/3}$ = 1.60 Å.

C-3. Atom b,f and g are at equal distance from atom 1

C-4. **(i)** distance between 1 and 2 = 2r

2 and 3 = 2r

1 and 3 = $\sqrt{\left(2\sqrt{2}r\right)^2 + 2r^2}$ = $(2\sqrt{3})r$

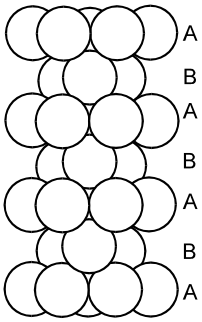
(ii) Shape = square and length of square = 2r

C-5. We know d = $\frac{Z \times M}{(a)^3}$ = $\frac{27}{16}$ = $\frac{Z \times 27amu}{\left(4.0Å\right)^3}$

Z = 4 Then unit cell f.c.c. and we know for f.c.c. 4r = a$\sqrt{2}$

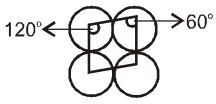
r = $\frac{4}{4}\sqrt{2}$ = $\sqrt{2}$ Å.

C-6.



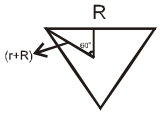
ABAB.....type arrangement (unit cell = HCP).

D-1.



Rhombous. 60° and 120°

Whole available space not occupy.
No. of void = 2
Type of void = Triangular



Sin 60 = $\frac{\sqrt{3}}{2}$ = $\frac{R}{(R+r)}$ $\Rightarrow$ r = 0.155 R

D-4. Number of octahedral voids in fcc = 4.
Number of tetrahedral voids in fcc = 8.

Distance between two octahedral voids = $\frac{a}{\sqrt{2}}$

Distance between two tetrahedral voids = $\frac{a}{2}$

E-4. (a) KBr is NaCl type, so no. of K^+ & Br^- are 4 each.

(b) a = $2\left(r_{K^+} + r_{Br^-}\right)$ = 2(1.33 + 1.95) = 6.56 Å

(c) density = $\frac{4 \times 119}{6.02 \times 10^{23} \times (6.65 \times 10^{-8})^3}$ = 2.80 g/cm^3

(d) for octahedral voids, $\frac{r_+}{r_-} = 0.414$

PART - II

A-1. KCl & $BaCl_2.2H_2O$ are ionic solids and not pseudo solids (amorphous solids).

A-2. **Unit cell:** Unit cell is the smallest portion of a crystal lattice which, when repeated in different directions, generates the entire lattice.

A-3. Orthorhombic crystal system has $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90^o$.

A-4. For rhombohedral system, axial distance and axial angles are $a = b = c$, $\alpha = \beta = \gamma \neq 90^0$

A-5. In Bravais lattices, each point has identical surroundings.

A-6. For hexagonal unit cell $\Rightarrow a = b \neq c$; $\alpha = \beta = 90^o$; $\gamma = 120^o$.

B-1. For bcc unit cell coordination number = **8** (In bcc crystal structure, the co-ordination no. is 8 because each atom touches four atom in the layer above it, four in the layer below it and none in its own layers).

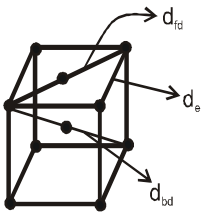
B-2. For bcc structure $\sqrt{3}\,a = 4r$, $r = \frac{\sqrt{3}a}{4} = \frac{1.732 \times 286}{4} = 123.8 \approx 124$ pm.

B-3. Distance between two nearest neighbours in bcc $= \frac{\sqrt{3}a}{2} = \frac{\sqrt{3} \times \sqrt{2}}{2} = \frac{1.732 \times \sqrt{2}}{2} = 4.503$ Å.

B-4. Density of $P_0 = \frac{1 \times 207}{(3)^3} = \frac{23}{3}$ Amu / Å^3

B-5. Number of next nearest neighbours of Li (in bcc) = 6.
(These atoms present at the corner of bcc unit cell).

B-6.



$d_e = a$

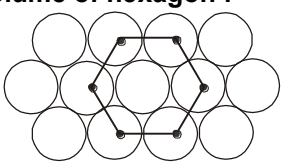
$d_{fd} = \sqrt{2}a$

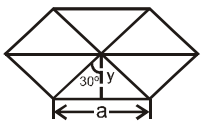
$d_{bd} = \frac{\sqrt{3}a}{2}$

$\therefore d_{fd} > d_e > d_{bd}$

C-2. The shortest distance between Ist and Vth layer of HCP arrangement is $= 2C = 2 \times 4\sqrt{\frac{2}{3}}\,r = 8\sqrt{\frac{2}{3}}\,r$.

C-3. **Volume of hexagon :**





$\tan 30^\circ = \frac{a}{2 \times y}$ So, $y = \frac{a \times \sqrt{3}}{2 \times 1} = \frac{\sqrt{3}}{2} a$ and area of hexagonal surface $= 6 \left[\frac{1a}{2} \times \frac{\sqrt{3}\, a}{2} \right] = \frac{6\sqrt{3}a^2}{4}$

Volume of hexagon = area of base × height

$= \frac{6.\sqrt{3}}{4} \times a^2 \times 2\sqrt{\frac{2}{3}}\, a = \frac{6.\sqrt{3}}{4} \times (2r)^2 + 2 \sqrt{\frac{2}{3}} \times (2r) = 24\sqrt{2}\, r^3$

C-4. P.F. of ABAB arrangement in 3D = 74%.
% of vacant space = 26% = 0.26.

C-6. Total number of atoms per unit cell in fcc structure = 4 atoms.

C-7. The arrangement of sphere is shown by body diagonal plane.

C-8. $4r = a\sqrt{2}$

$a = \frac{4r}{\sqrt{2}} = \frac{4 \times 1.28}{\sqrt{2}}$ Å = 3.62 Å

C-9. Packing efficiency of FCC or CCP = 74%.

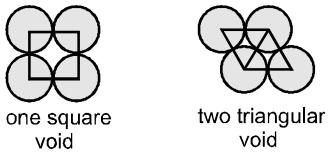
C-10. Coordination number of sphere in fcc or ccp = 12.

C-11. In ABB AABB A, there is no close packing as there are repeated planes adjacent to each other.

D-1. No. of A atoms = 6.

No. of C atoms = $6 \times \frac{2}{3} = 4$. $\therefore$ Formula = C_4A_6 or C_2A_3.

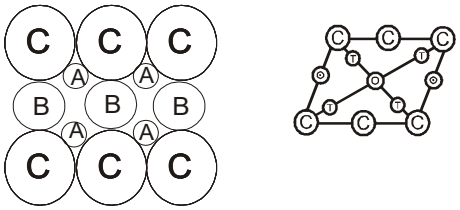
D-2.



D-3. It is a octahedral void.

D-4. For close packed structure of AB type solid
$r^+ / r^- = 0.225 - 0.7342$
Minimum value of $r^- = r^+ / 0.732 = 75 / 0.732 = 102.5$ pm
Maximum value $r^- = r^+ / 0.225 = 75 / 0.225 = 333.3$ pm

D-5.



⊙→ Octahedral void, at edge center & body center.

Ⓣ→ Tetrahedral voids on body diagonal.

D-6. Refer theory octahedral & tetrahedral voids about positions of P_1, P_2 and P_3.

D-7. No. of tetrahedral voids $= 8 \times \frac{1}{8} = 1$

No. of octahedral voids = 1×1 = 1 (at body center).

E-1. $\frac{r_+}{r_-} = \frac{126}{216} = 0.58$, octahedral voids so C.N. = 6.

E-2. In rock salt structure, Cl^- forms fcc (ccp) lattice & Na^+ occupies octahedral voids, So tetrahedral voids are vacant.

E-3. It is a fact.

E-4. Coordination number of Zn^{2+} ion in Zinc blende = 4.
Zn^{2+} ion present in half of tetrahedral void formed by S^{2-} in fcc unit cells.

E-5. $SrCl_2$ is AB_2 type in which cation is of large size.

E-6. $A \rightarrow \frac{1}{8} \times 8 = 1$, $B \rightarrow 4 \times \frac{1}{2} = 2$ and $O^{2-} = 4$ so formula of spinal = AB_2O_4

E-7. Only two tetrahedral holes are occupied in diamond.

E-8. On increasing temp^r C.N. decreases.
$\therefore$ CsCl (8 : 8) structure changes into (6 : 6) NaCl type structure.

F-1. In a solid lattice the cation has left a lattice site and is located at an interstitial position, the lattice defect is called Frenkel defect.

F-2. Since Ag^+ (cation) is smaller than Cl^- (anion) & hence cation is present in voids.
In CaF_2, F^-_{anion} is smaller.

F-3. F-centers are the electrons trapped in anionic vacancies.

F-4. p-type semiconductors acquire no charge because a 13 group atom replaces a 14 group atom.

PART - III

1. Covalent $\rightarrow$ Diamond ; Ionic $\rightarrow$ NaCl
Dipole-dipole $\rightarrow$ HCl ; Metallic $\rightarrow$ Al

2. Refer theory

3. (A) ZnS crystal $\begin{cases} \rightarrow \text{Zinc blende} \rightarrow \text{fcc} \\ \rightarrow \text{Wurtzite} \rightarrow \text{hcp} \end{cases}$

S^{2-} ion are present in fcc lattice & Zn^{2+} ion occupy all the tetrahedral voids distance of tetrahedral voids from corner = $\frac{\sqrt{3}a}{4}$

(B) $CaF_2 \rightarrow$ Fluorite structure
Ca^{2+} ion are present in ccp lattice & F^- ion are present in all tetrahedral voids.
(C) NaCl $\rightarrow$ Rock salt Type structure
Cl^- ion are present in ccp lattice & Na^+ ion occupy all the octahedral voids.
(D) Diamond crystal $\rightarrow$ C atom present in fcc lattice in which alternate tetrahedral voids are occupied by C atom.

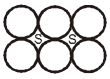
EXERCISE # 2

PART - I

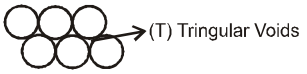
1. Grey Cast Iron is metallic solid.

3. Density = $\frac{Z \times M}{N_A \times a^3} = \frac{2 \times 100}{6 \times 10^{23} \times (400 \times 10^{-10})^3}$ = 5.2 g/cm^3

5. X = 7x $\frac{1}{8} = \frac{7}{8}$; Y = $\frac{1}{2}$ x 6 = 3. ; Z = $\frac{1}{8}$ $\Rightarrow$ $X_{7/8}\, Y_3\, Z_{1/8} = X_7\, Y_{24}\, Z$

6. 

2 Square Voids



(4)

7. For (bcc) = r^+/r^- = 0.732 and a = $\frac{2(r^+ + r^-)}{\sqrt{3}}$

and diameter of cubical void $(2r^+) = a(\sqrt{3} - 1) = 2.888 \times 0.732 = 2.108$ Å.

8. No. of octahedral holes = No. of close packed atoms
& No. of Tetrahedral holes = 2× No. of close packed atoms.

9. no. of oxide ions = 4

no. of A particles = $\frac{1}{6} \times 8 = \frac{4}{3}$

no. of B particles = $\frac{1}{3} \times 4 = \frac{4}{3}$

so formula is $A_{4/3}\, B_{4/3} O_4$ or ABO_3

10. Distance between nearest neighbours is along the face diagonal = $\frac{a\sqrt{2}}{2}$.

11. Density = $\frac{Z \times M}{N_A \times a^3} = \frac{4 \times 195}{6.02 \times 10^{23} \times (3.9231 \times 10^{-8})^3}$ = 21.86 g/cm^3

for fcc lattice, $4r = a\sqrt{2}$

so, $r = \frac{a\sqrt{2}}{4} = \frac{3.9231\sqrt{2}}{4}$ Å = 1.387 Å.

12. Closest distance is = $\frac{a\sqrt{2}}{2} = \frac{4.070 \times \sqrt{2}}{2}$ Å = 2.878 Å

13. In NaCl structure, C.N. of each cation & anion is six.

14. It is a fact.

15. On increasing pressure, C.N. increases. $\Rightarrow$ 6 : 6 changes to 8 : 8.

16. It is a fact.

18. Ions are displaced from one place to another.

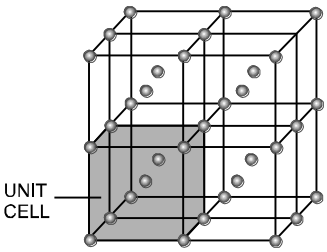
19. Some of O^{2-} combine with each other forming O_2 gas which is liberated learning behind electrons at the site vacated by oxide ions.

PART - II

1. SiO_2, Diamond, Si, AlN, SiC.

2. Number of atom effectively present in a cubic unit formed by arrangement of eight B.C.C unit cell =

$8 \times \frac{1}{8} + 12 \times \frac{1}{4} + 6 \times \frac{1}{2} + 1 + 8 = 16.$



3. a = 2 × diameter of the ball.
number of balls = 2 × 2 × 2 = 8

5. 3 + 3 = 6

7. No. of oxide ions = 4

No. of A particles = $\frac{1}{6} \times 8 = \frac{4}{3}$

No. of B particles = $\frac{1}{3} \times 4 = \frac{4}{3}$

So formula is $A_{4/3}\ B_{4/3}O_4$ or ABO_3

$ABO_3 = x + y + z = 1 + 1 + 3 = 5$

8. Cation and anion in Fluorite CaF_2 and Zinc blende ZnS are respectively x : y and a : b ≡ 8 : 4 and 4 : 4
8 + 4 + 4 + 4 = 20

9. Number of octahedral void in ccp = Z; Number of tetrahedral void in ccp = 2Z.
For A_2B, Number of anion B = 4.
Cataion (A) present in all octahedral void (100% occupied) and half tetrahedral void (50% occupied), then number of cation (A) in unit cell = $4 + 8 \times \frac{1}{2} = 8$.

So, formula of compound = A_2B.

PART - III

1. Randomness (entropy) in amorphous solids is more than that in crystalline solids.

3. Edge length = AB = AD = BC = CD = a

Also, $AC = \sqrt{AB^2 + BC^2} = \sqrt{a^2 + a^2} = \sqrt{2}a$

$AG = \sqrt{AC^2 + CG^2} = \sqrt{2a^2 + a^2} = \sqrt{3}a$

4. In bcc $r = \frac{\sqrt{3}a}{4}$

also, edge length of unit cell = a

radius of atom = r

$\therefore$ Edge length not covered by atom = a – 2r

or $a - \frac{\sqrt{3}}{2}.a = a\left[\frac{2-\sqrt{3}}{2}\right]$

$\therefore$ Percentage fraction not covered = $\frac{a\left[\frac{2-\sqrt{3}}{2}\right]}{a} \times 100 = 0.134 \times 100 = 13.4\%$

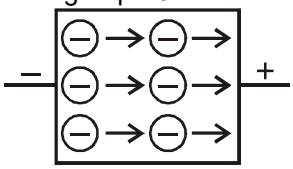
$\therefore$ Percentage fraction of covered = (100 – 13.4) % = 86.6%

6. These are facts.

9. In bcc coordination number is 8.

10. These are facts.

11. When silcon is doped with some group-15 element, the some of the positions in the lattice are substituted by atoms of groups-15 elements have five valence electrons. After forming the four covalent bonds with silicon (or anyother group-14 element such as germanium). One excess electron is left on them.
Since this electron is not involed in bonding it becomes delocalized and contributre to electrical conduction. Silicon dped with group-15 element behaves as a n-type semconductor.



n-type semiconductor

PART - IV

1. In FCC lattice each edge center act as octahedral void.

2. No. of X = $8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4$ $\Rightarrow$ 4 XY unit per cell.

No. of Y = $1 + 12 \times \frac{1}{4} = 4$

3. At edge center, there is octahedral void in f.c.c. lattice.
$\Rightarrow$ C.N. of Y = 6
(6 : 6) C.N. $\Rightarrow$ NaCl Structure.

4. Some Cl^- ions leave the lattice and combine with Li vapour to release electron, which is trapped into the anion vacancy giving rise to metal excess defect $Cl^- + Li_{(g)} \longrightarrow LiCl_{(s)} + e^-$

5. On heating, $ZnO_{(s)}$ dissociates reversibly as $ZnO \rightleftharpoons Zn^{2+} + \frac{1}{2} O_2 + 2e^-$

Zn^{2+} ions occupy certain interstitial sites whereas the electrons released are present at the neighbouring sites, which act as F-centers.

6. In the crystallization, some Ag^+ ions will get replaced by as many half of Cd^{2+} ions. Thus the cation vacancies will be the same as the number of Cd^{2+} is ions incorporated.

7. AgBr can show both shottky and frenkel defect.

EXERCISE # 3

PART - I

1. In the figures given below draw the unit cell of the corresponding structure and identify these plane in your diagram (out of fcc and simple cubic).
(i) Face plane (ii) Body diagonal plane (iii) Plane passing through the face diagonals.

2. The No. of atom of A for unit cell = $\left(\frac{1}{8}\times 8+4\times\frac{1}{2}\right)$ = 3

Then formula = A_3B_4.

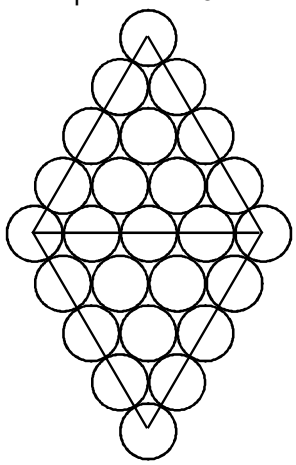
3. Calculate no. of atoms of A & B per unit cell.

No. of atoms of A/ unit cell = $8\times\frac{1}{8}=1$.

No. of atoms of B/ unit cell = $6\times\frac{1}{2}=3$.

$\therefore$ Formula is AB_3.

4. Again to have the maximum number of spheres the packing must be *hcp*.
Maximum number of spheres = 25



Area of the figure = 2 × Area of equiletral tringle of side = 4 cm

$= 2\times\frac{\sqrt{3}}{4}\times(4)^2 = 13.856$

$\frac{25 \text{ marbel}}{13.856 \text{ cm}^2} = 1.804 \text{ marbles/cm}^2$

5. **(a)** $\frac{a}{2}=Y^{\frac{1}{3}}$

$a = 2Y^{\frac{1}{3}}$

density (d) = $\frac{4\times 6.023\times Y\times 10^{-3}}{6.023\times 10^{23}\left(2Y^{1/3}\times 10^{-9}\right)^3} = 5.0 \text{ Kg/M}^3$

(b) Observed density of AB is 20 Kg/M^3
Which is Higher then calculate density 5kg/m^3 thus AB has either interstitial impurity defect or substitutional impurity defect.

6. In cubic close packing no. of tetrahedral void = 2 × no of atom. As there are 4 S^{2-} ions at lattice point and they need 4 Zn^{+2}, which adjusted in alternate tetrahedral void ($0.225 < \frac{r^+}{r^-} < 0.414$).

7. For f.c.c. $\left(\frac{r_1}{r_2} = 0.414\right)$ octahedral void

$\frac{r_1}{r_2}$ = 0.225 tetrahedral void

We know along face diagonal for f.c.c. $4r_2 = a\sqrt{2}$ $\Rightarrow$ $r_2 = \frac{a\sqrt{2}}{4}$

Required diameter of interstitial sites = $2r_1 = 2 \times 0.414 r_2$

Diameter = $\frac{2 \times .414 \times \sqrt{2} \times a}{4} = \frac{2 \times .414 \times \sqrt{2} \times 400}{4}$ = 117.1 pm.

8. $d = \frac{ZM}{N_A a^3}$ $\Rightarrow$ $Z = 20 \times 10^{-1} = 2$

So its is a bcc unit cell. Hence $\sqrt{3}\, a = 4R$ so $R = \frac{\sqrt{3}}{4} \times 5\text{Å} = 216.5$ pm.

9. (A) Simple cubics and fcc (i) have the cell parameters a = b = c & $\alpha = \beta = \gamma$ (choice P) and belong to the same crystal system (choice (s)).
(B) Cubic & rhombohedral (i) have the cell parameters a = b = c and $\alpha = \beta = \gamma$ (choice P) and (ii) are two crystal systems (choice (q)).
(C) Cubic and tetragonal are two crystal system (q).
(D) Hexagonal & monocubic (i) two crystal system choice (q) p (ii) have only two crystallographite angles of 90º choices.

10. Total no. of atoms in 1 unit cell = $\left(12 \times \frac{1}{6}\right) + 3 + \left(2 \times \frac{1}{2}\right) = 6$

11. $C = \sqrt{\frac{2}{3}}\, 4r$ = Height of the unit cell.

Base area = $6 \times \frac{\sqrt{3}}{4}(2r)^2$.

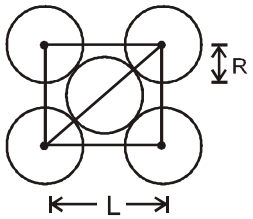
Volume of the hexagon = Area of base x Height = $6.\frac{\sqrt{2}}{3} a^2 \times c = 4r^2 \times \frac{\sqrt{2}}{3} 4r = 24.\sqrt{2}\, r^3$

12. Packing fraction = $\frac{\text{volume of the atoms in one unit cell}}{\text{volume of one unit cell}} = \frac{6 \times \frac{4}{3}\pi r^3}{24\sqrt{2}\, r^2} = \frac{\pi}{3\sqrt{2}} = 0.74 = 74\%$

$\Rightarrow$ empty space = 100 – 74 = 26%.

13. Frenkel defect is a dislocation defect.
Trapping of an electron in the lattice leads to the formation of F-center.

14.



$4R = L\sqrt{2}$

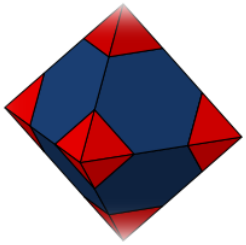
so, $L = 2\sqrt{2}\,R$

Area of square unit cell = $(2\sqrt{2}\,R)^2 = 8R^2$

Area of atoms present in one unit cell = $\pi R^2 + 4\left(\frac{\pi R^2}{4}\right) = 2\pi R^2$

so, packing efficiency = $\frac{2\pi R^2}{8R^2} \times 100 = \frac{\pi}{4} \times 100 = 78.54\%$

15.



16. No. of M atoms = $\frac{1}{4} \times 4 + 1 = 1 + 1 = 2$

No. of X atoms = $\frac{1}{2} \times 6 + \frac{1}{8} \times 8 = 3 + 1 = 4$

so formula = $M_2X_4 = MX_2$

17. The given arrangement is octahedral void arrangement.

$\rightarrow \quad \frac{r_A^+}{r_{x^-}} \geq 0.414 \quad \Rightarrow r_A^+ \geq 0.414 \times 250$ pm.

& $\frac{r_A^+}{r_A^-} < 0.732 \quad \Rightarrow \quad r_A^+ < 183$ pm

So, we have to choose from 104 pm and 125 pm. As no other information is given, we consider exact fit, and hence 104 pm is considered as answer.

18. In ccp, O^{2-} ions are 4.
Hence total negative charge = –8
Let Al^{3+} ions be x, and Mg^{2+} ions be y.
Total positve charge = 3x + 2y
$\Rightarrow$ 3x + 2y = 8
This relation is satisfied only by x = 2 and y = 1.
Hence number of Al^{3+} = 2.
and number of Mg^{2+} = 1.

$\Rightarrow$ n = fraction of octahedral holes occupied by $Al^{3+} = \frac{2}{4} = \frac{1}{2}$

and m = fraction of tetrahedral holes occupied by $Mg^{2+} = \frac{1}{8}$

Hence, answer is (A)

19. (A) For any atom in top most layer, coordination number is not 12 since there is no layer above top most layer
(B) Fact
(C) Fact
(D) $\sqrt{2}\,a = 4R$
So $a = 2\sqrt{2}\,R$

20. $d = \dfrac{Z \times \frac{M_0}{N_A}}{a^3}$ (d = density)

$8 = \dfrac{4 \times \frac{M_0}{6 \times 10^{23}}}{(4 \times 10^{-10})^3}$

$M_0 = \dfrac{1}{8 \times 6 \times 1.6}$

Number of moles in 256 g = $\dfrac{256}{8 \times 6 \times 1.6} = \dfrac{10}{3}$

Number of atoms = $\dfrac{10}{3} \times 6 \times 10^{23} = 2 \times 10^{24}$

21. As per given information cation form FCC lattice and anion occpy all the octahedral void.

So	M^+	X^- & Formula MX
	4 ion	4 ion
After step I	4 ion	1 ion
After step II	1 ion	4 ion
After step III	0 ion	4 ion
After step IV	1 ion	3 ion

So ratio of $\dfrac{\text{No. of anion}}{\text{No. of cation}} = \dfrac{3}{1}$

PART - II

5. Substances which are expected to possess para-magnetism or ferro-magnetism on the basis of unpaired electrons but actually they possess zero net magnetic moment are called anti ferromagnetic substance.

6. LiCl, NaCl and RbCl have rocksalt structure CsCl has simple cubic structure of Cl^- ions.

7. Piezoelectric material are those that produce an electric current when they are placed under mechanical stress

8. $d = \dfrac{Z \times M}{N_A \times a^3}$ or, $d = \dfrac{4 \times 63.55}{6 \times 10^{23} \times (x \times 10^{-8})^3}$ or, $d = \dfrac{422}{x^3}$ g/ml.

9. Factual

10. B forms HCP $\quad \therefore$ No. of B = 6
A occupies $\dfrac{1}{3}$ TV $\quad \therefore$ No. of A = $\dfrac{1}{3} \times 12 = 4$
$\therefore$ Formula = $A_4B_6 = A_2B_3$

11. $d = \dfrac{Z \times M}{N_A \times a^3}$

$$9 \times 10^3 = \frac{4 \times \frac{M_0}{6 \times 10^{23}}}{(200 \times \sqrt{2} \times 10^{-12})^3}$$

$$9 \times 10^3 = \frac{4 \times \frac{M_0}{6 \times 10^{23}}}{2^3 \times 2 \times \sqrt{2} \times 10^{-30}}$$

$$M_0 = \frac{9 \times 10^3 \times 6 \times 10^{23} \times 2^4 \times \sqrt{2} \times 10^{-30}}{4} = 9 \times 6 \times 10^{-4} \times 4 \times \sqrt{2} = 0.03 \text{ kg}$$

12. $\dfrac{a}{2} = R + r$

$\sqrt{3}a = 4R$

$0.5\ a = 0.433\ a + r$

$r = 0.067\ a$

13. Effective number of A = 4

Effective number of B = $4 \times \dfrac{1}{2} = 2$

Effective number of O = 8

Formula is $A_4B_2O_8$ or A_2BO_4

14. $\sqrt{3}a = 2r + 2(2r) = 6r$

$$a = \frac{6r}{\sqrt{3}} = 2\sqrt{3}\ r$$

$$\text{P.F.} = \frac{\frac{4}{3}\pi r^3 + \frac{4}{3}\pi(2r)^3}{a^3} = \frac{\frac{4}{3}\pi(r^3 + 8r^3)}{(2\sqrt{3}r)^3} = \frac{4\pi \times 9r^3}{3 \times 8 \times 3\sqrt{3}r^3} = \frac{\pi}{2\sqrt{3}} = 0.906$$

% of packing efficiency = 0.906 × 100 = 90.6%

15. Nearest distance between two nearest tetrahedral voids in a FCC lattice is a/2.

16. In sc, $Z = 8 \times \dfrac{1}{8} = 1 \Rightarrow Z = 1$

In bcc $Z = 8 \times \dfrac{1}{8} + 1 = 2 \Rightarrow Z = 2$

In fcc, $Z = 8 \times \dfrac{1}{8} + 6 \times \dfrac{1}{2} = 4 \quad \Rightarrow Z = 4$

17. Only AgBr can exhibit both Schottky and Frenkel defect.

18. $CCl_4 \rightarrow$ Non-conductor in solid and liquid phase.