Exercise-1

Marked Questions may have for Revision Questions.

OBJECTIVE QUESTIONS

Section (A) : Basics of Solid State

A-1. Sol. Intermolecular forces are strong.

A-5. Sol. Due to rapid or suddenly cooling of the liquid generate the amorphous solid.
Rubber, Glass, Plastic, starch etc. are examples of amorphous solids.

A-7. Sol. For Tetraagonal crystal system
Features is $a = b \neq c$
$\alpha = \beta = \gamma = 90^o$

A-8. Sol. Refer Theory.

Section (D) : Face Centered Cubic (FCC)

D-1. Sol. In a face centered cubic unit cell has 8 corners i.e.,

(i) Contribution from one corner lattice point = $\frac{1}{8}$ th.

(ii) Contribution from one face centered lattice point = 1/2.

D2. Sol. Nearest distance between two atoms = $\frac{a}{\sqrt{2}} = \frac{508}{\sqrt{2}}$ = 360 pm

D-6. Sol. for X, $8 \times \frac{1}{8} = 1$; for Y, $6 \times \frac{1}{2}$
so AB_3

Section (E) : Void

E-3. Sol. No. of octahedral holes = No. of close packed atoms
& No. of Tetrahedral holes = 2× No. of close packed atoms.

Section (F) : Radius Ratio & Ionic Structure

F-2. Sol. $2(Na^+ + Cl^-)$ = edge length
2a = edge length

F-6. Sol. It is a fact.

Section (G) : Crystal Defects and Properties of Solid & Thier Magnetic Behaviour

G-2. Sol. Equal no. of Na^+ & Cl^- are missing completely,
⇒ Schottky defect.

Exercise-2

Marked Questions may have for Revision Questions.

Section (A) : Basics of Solid State

2. **Sol.** Iodine crystal are molecular solid. I_2 is non-polar and having dispersion force.

5. **Sol.** Wax is an example of molecular crystal.

Section (B) : Body Centered Cubic (BCC) & Simple Cubic (SC)

11. **Sol.** 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

13. **Sol.** d = $\frac{ZM}{N_A a^3}$ = 2 × $\frac{100}{6.02 \times 10^{23}}$ × $\frac{1}{(4 \times 10^{-8})^3}$ = 5.188 g/cc.

14. **Sol.** $\sqrt{3}$ a = 4r

a = $\frac{4 \times 75\text{pm}}{\sqrt{3}}$ = $\frac{4 \times 75\text{pm}}{1.73}$ = 173.2 pm

16. **Sol.** 8 – 2 = 6

21. **Sol.** a = 2R

V = $(2R)^3$

= 8 × R^3

= 8 × $(1.0 \times 10^{-10})^3$

= 8 × 10^{-10} m^3

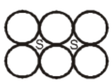
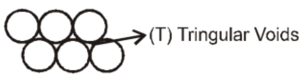
Section (C) : Hexagonal Close Packing (HCP)

Section (D) : Face Centered Cubic (FCC)

31. **Sol.** $\sqrt{2}a$ = 4r

a = $\frac{4R}{1.41}$ = $\frac{4 \times 500}{1.414}$ =1414 Pm

Section (E) : Type of Voids

36. **Sol.**  

2 Square Voids (4)

42. **Sol.** It is a octahedral void.

Section (F) : Radius Ratio & Ionic Structure

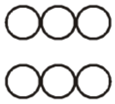
44. **Sol.** Overall it is zero (0) electronic charge.

45. **Sol.** 100% octahedral voids are occupied.

Section (G) : Defects

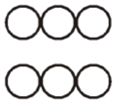
54. **Sol.** S^{2-} ion form fcc lattice

–→ Zn^{+2} ion ocupy alternate four tetrahedral void i.e.



S^{2-} vk;u fcc tkyd cukrs gS %

–→ Zn^{+2} vk;u ,dkUrjhr pkj prq"Qydh; fjfDr;ksa dks ?ksjrs gSA vFkkZr~



56. **Sol.** Zinc oxide losses oxygen reversible at high temperature and turn yellow.

57. **Sol.** In schottky defect density decreases while interstitial defect density increases.

Exercise-3

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

OFFLINE JEE-MAIN

1. **Sol.** BCC - points are at corners and one in the center of the unit cell.

Number of atoms per unit cell = $8 \times \frac{1}{8} + 1 = 2$.

FCC - Points are at the corners and also center 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. **Sol.** mass (m) = density × volume = 1.00 g

Mol. wt. (M) of NaCl = 23 + 15.5 = 58.5

Number of unit cells present in a cube shaped crystal of NaCl of

mass 1.00 g = $\frac{\rho \times a^3 \times N_A}{M \times Z} = \frac{m \times N_A}{M \times Z} = \frac{1 \times 6.023 \times 10^{23}}{58.5 \times 4}$

(In NaCl each unit cells has 4 NaCl units. Hence Z = 4)

∴ Number of unit cells = 0.02573×10^{23} = 2.57×10^{21} unit cells.

3. **Sol.** When an atom or ion is missing from its normal lattice site, a lattice vacancy is created. This defect is known as Schottky defect . Here equal number of Na^+ and Cl^- ions are missing from their regular lattice position in the crystal. So it is Schottky defect.

4. **Sol.** Number of A ions per unit cell = $\frac{1}{8} \times 8 = 1$

Number of B ions per unit cell = $\frac{1}{2} \times 6 = 3$ Empirical formula = AB_3.

5. **Sol.** In case of a face-centerd cubic structure, since four atoms are present in a unit cell, hence volume.

V = 4

6. **Sol.** According to question : Number of Y atom in ccp unit cell = 4

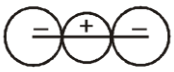
Number of X atom in ccp unit cell = $8 \times \frac{2}{3} = \frac{16}{13}$

Formula of compound = $X_{16/3}Y_4 = X_{16}Y_{12} = X_4Y_3$

7. **Sol.** In fcc unit cell $4r = \sqrt{2}a$ [r = radius of Cu atom, a = edge length]

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

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

8. **Sol.** 

$2 \times 110 + 2 \times r_- = 508$

$2r_- = 288$

$r_- = 144$ pm

9. **Sol.** Packing fraction of CCP = $\frac{\pi}{3\sqrt{2}} = 0.74 \Rightarrow 74\%$

∴ Percentage of free space in CCP = 100 – 74 = 26%

Packing fraction of BCC = $\frac{\pi\sqrt{3}}{8} = 0.68 \Rightarrow 68\%$

∴ Percentage of free space in BCC = 100 – 68 = 32%

10. **Sol.** $A_{8\times\frac{1}{8}}B_{5\times\frac{1}{2}}$

Formula of compound A_2B_5.

11. **Sol.** FCC lattice

a = 361 pm

$a\sqrt{2}$ = 4r

r = $\frac{361 \times \sqrt{2}}{4}$ = 127.6 ≈ 128 pm.

12. Sol. For BCC structure $\sqrt{3}$ a = 4r r = $\frac{\sqrt{3}}{4}a$ = $\frac{\sqrt{3}}{4} \times 351$ = 152 pm.

13. Sol. $M_{0.98}O$

consider one mole of the oxide.

Moles of M = 0.98, Moles of O^{2-} = 1

Let moles of M^{3+} = x

⇒ Moles of M^{2+} = 0.98 – x

⇒ Doing charge balance

(0.98 – x) × 2 + 3x – 2 = 0

⇒ 1.96 – 2x + 3x – 2 = 0

⇒ x = 0.04

⇒ % of M^{3+} = $\frac{0.04}{0.98} \times 100$ = 4.08%

14. Sol. In CsCl, Cl^- lie at corners of simple cube and Cs^+ at the body centre.

Hence, along the body diagonal, Cs^+ & Cl^- touch each other so $\frac{\sqrt{3}a}{2} = r_{Cs^+} + r_{Cl^-}$

15. Sol. R = $\frac{\sqrt{3}}{4}$ a = 1.86 Å or a = 4.29Å

16. Sol. NCERT based (Solid state).

17. Sol. For FCC, $\sqrt{2}a = 4R$

So, 2R = $\frac{a}{\sqrt{2}}$

PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. Sol. 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.

2. Sol. Calculate no. of atoms of A & B per unit cell.

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

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

∴ Formula is AB_3 .

3. Sol. 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 ($0.225 < \frac{r^+}{r^-} < 0.414$).

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

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

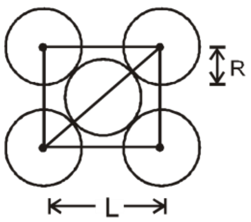
Base area = $6 \times \frac{\sqrt{3}}{4}(2r)^2$.

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

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

⇒ empty space **=** 100 – 74 = 26%.

7. Sol.



$4R = L\sqrt{2}$

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

8. Sol. 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 = $M_2X_4 = MX_2$

9. **Sol.** The given arrangement is octahedral void arrangement.

→ $\frac{r_{A^+}}{r_{x^-}} \geq 0.414$ ⇒ $r_{A^+} \geq 0.414 \times 250$

$r_{A^+} \geq 103.5$ pm.

& $\frac{r_{A^+}}{r_{A^-}} < 0.732$ ⇒ $r_{A^+} < 183$ 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.

10. **Sol.** 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

⇒ 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.

⇒ 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)

11.* **Sol.** (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

12. **Ans.** **2**

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

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

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

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

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

APSP Solutions

PART - I

1. At corner = $\frac{1}{8}$ (for per atom)

$\Rightarrow X_{1-\frac{1}{8}}Y$ (one X atom removed)

$\Rightarrow X_{7/8}\,y$

$\Rightarrow x_7y_8$

2. Packing efficiency = $\dfrac{2\times\frac{4}{3}\pi R^3}{\left(\frac{4R}{\sqrt{3}}\right)^3} = \dfrac{\sqrt{3}\pi}{8}$ = 68%

vacent space = 100 – 68 = 32 %

3. When NaCl crystal is heated in sodium vapors, then it attains yellow colour. It is due to F-centres, which is electron trapped in anion vacancy created by Cl^-.

4. Packing efficiency of ccp is 74% so it best packing is cubic packing.

5. In 3D close packed structure for every 100 atoms it contain 100 octahedral voids.

6. $2(r^+ + r^-) = a$ or $r^+ = x$ = radius of Na^+

$2(x + y) = a$ $r^- = y$ = radius of Cl^-

7. C.N. of Cu^{2+} ion = 8

C.N. of F^- ion = 4

$\therefore$ C.N. of CaF_2 type structure is = 8 : 4

8. Sr^{2+} are at the corners and face centre of the cubic arrangement.

9. Triclinic $a \neq b \neq c$

$\alpha \neq \beta \neq \gamma$

10. Schottky defect ocure in electrovalent compound which has same bond size positive and negative ion.

11. For tetrahedral void r_+/r_- range will be $0.225 \leq \frac{r^+}{r^-} \leq 0.414$

12. Malleability and ductility is tendency of metal ion layer Slide over the other layer.

13. NaCl and KCl has octahedral structure

$\frac{r_{Na^+}}{r_{C^-}} = 0.55$ and $\frac{r_{K^+}}{r_{Cl^-}} = 0.74$

In octahedral edge length = $r_{cation} + r_{anion}$

$$\frac{r_{Na^+} + r_{Cl^-}}{r_{Cl^-}} = 1.55 \qquad ....(1)$$

$$\frac{r_{K^+} + r_{Cl^-}}{r_{Cl^-}} = 1.74 \qquad ....(2)$$

a = edge length of KCl octahedral.

$a = r_{K^+} + r_{Cl^-}$

b = edge length of NaCl octahedral

$b = r_{Na^+} + r_{Cl^-}$

$$\frac{a}{b} = \frac{r_{K^+} + r_{Cl^-}}{r_{Na^+} + r_{Cl^-}} = \frac{1.74}{1.55} = 1.123$$

14. At corner = $\frac{1}{8}$ × (for per atom) = $\frac{X}{8} \times 8$

At body center = 1 × (for per atom) = Y

At face center = $\frac{1}{2}$ × (for per atom) = $\frac{Z}{2} \times 6$

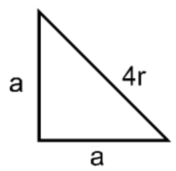
Simple ration of all there

XYZ_3

15. Copper has F.C.C. structure.

17. AgBr show schottky and frenkel defect.

18.✍



$(4r)^2 = a^2 + a^2$; $a = \frac{4}{\sqrt{2}} r$

19.✍ In antifluorite structure anion form F.C.C. structure and cation occupy all tetrahedral void.

20. In F.C.C. structure tetrahedral void = No. of corner = 8

21.✍ p-type material is electrically neutral.

22. CsCl have simple cubic structure. In this structure body idagenal of simple cube $\sqrt{3}\,a = 2 \times (r_{Cs^+} + r_{Cl^-})$

So interionic distance = $2 \times (r_{Cs^+} + r_{Cl^-})$

24. A at corner A = $\frac{1}{8} \times 8 \times A = A$

B at face center B = $\frac{1}{2} \times 6 \times B = 3B = AB_3$

25. $d = \frac{Z \times M}{N_A a^3}$

$N_A = \frac{4 \times 100}{10 \times (2 \times 10^{-8})^3}$ (here : 200 Pm = 2×10^{-8} cm.)
$= 5 \times 10^{24}$

29. Cubic system have three unit cell
(1) Simple cubic (2) F.C.C. (3) B.C.C
H_2O is a paramagnetic substance.
Graphit is a covalent soid in layer form. In these layer vanderwaal's forces present.

30. S_1 : edge length = 2 (r_{Na^+}+ r_{Cl^-})
distance b/w Na^+ and Cl^- is less than edge length
S_2 : 4 triangular void.
S_3 : In Zns structure $4zn^{+2}$ and $4s^{-2}$ present in each unit cell.

PART - II

1. For graphite a ≠ b ≠ c
α = β = 90º, y = 120 (hexagonal system)

2. $\frac{r}{R}$ = 0.225 (R = radius of sphere, r = radius of tetrahedral)
r = 0.225 R

3. Ionic solid will be a cubical void
i.e. value of radius ratio will be greater than 0.732.

4. In Diamond four valence electrons are bonded to other carbon atom by covalent bond.

5. $\ell = \frac{Z \times 27}{a^3 \times Na}$

$2.8 = \frac{Z \times 27}{(405)^3 \times 10^{-3} \times 6.023 \times 10^{23}}$

Z = 4
face center cubic unit cell contain 4 atom.

6. For simple cubic Z = 1
$\ell = \frac{Z \times M}{a^3 \times Na}$
for simple cubic a = 2r
$a^3 = \frac{1 \times 250}{7.2 \times 6.023 \times 10^{23}}$
a = 2r = 3.86 × 10m
$r = 1.93 \times 10^{-8}$ cm

7. packing effeciency of C.C.P. = 74%
free space = 100 – 74 = 26%

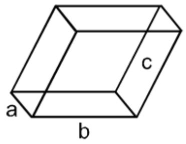
8. Metallic lustre is due to oscillation of loose electron.

9. SiC is the hardest substance among the following.

10. In triclinic unit sell.

$a \neq b \neq c$

$\alpha \neq \beta \neq \gamma$



14. The distance between successive atoms along the body diagonal in a unit cell is greater than edge and face diagonal i.e. order is

$d_3 > d_2 > d_1$

16. Refer Notes.

19. These are isomorphous.