1. 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

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

(b) $\sqrt{2}a$

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

(d) $2a$

2. Sodium metal crystallizes in a body centred cubic lattice with a unit cell edge of 4.29 $\overset{0}{\mathrm{A}}$. The radius of
sodium atom is approximately

(a) 1.86 $\overset{0}{\mathrm{A}}$

(b) 3.22 $\overset{0}{\mathrm{A}}$

(c) 5.72 $\overset{0}{\mathrm{A}}$

(d) 0.93 $\overset{0}{\mathrm{A}}$

3. CsCl crystallises in body centred cubic lattice. If ‘a’ is its edge length then which of the following expressions is correct?

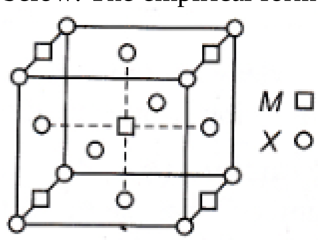
(a) $r_{Cs^+} + r_{Cl^-} = 3a$

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

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

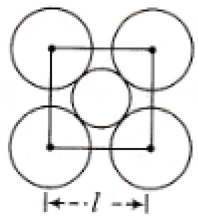
(d) $r_{Cs^+} + r_{Cl^-} = \sqrt{3}a$

4. A compound $M_p X_q$ has cubic close packing (ccp) arrangement of X. Its unit cell structure is shown below. The empirical formula of the compound is



(a) MX
(b) MX_2
(c) M_2X
(d) M_5X_{14}

5. The packing efficiency of the two-dimensional square unit cell shown below is



(a) 39.27%
(b) 68.02%
(c) 74.05%
(d) 78.54%

6. Which of the following fcc structure contains cations in alternate tetrahedral voids?
(a) NaCI
(b) ZnS
(c) Na_20
(d) CaF_2

7. A substance A_xB_y , crystallises in a face centred cubic (fcc) lattice in which atoms A occupy each corner of the cube and atoms B occupy the centres of each face of the cube. Identify the correct composition of the substance A_xB_y
(a) AB_3
(b) A_4B_3
(c) A_3B
(d) composition cannot be specified

8. In a solid, AB having the NaCI structure, A atoms occupy the corners of the cubic unit cell. If all the face centred atoms along one of the axes are removed, then the resultant stoichiometry of the solid is
(a) AB_2
(b) A_2B
(c) A_4B_3
(d) A_3B_4

9. The coordination number of a metal crystallises in hexagonal close-packed structure is
(a) 12
(b) 0
(c) 8
(d) 6

10. The correct statement regarding defects in solids is
(a) Frenkel defect is usually favoured by a very small difference in the sizes of cation and anion
(b) Frenkel defect is a not dislocation defect
(c) Trapping of an electron in the lattice leads to the formation of F-centre
(d) Schottky defects have no effect on the physical properties of solids

11. Which of the following statement is correct?

(a) The coordination number of each type of ion in CsCI crystal is 8
(b) A metal that crystallises in bcc structure has a coordination number of 12
(c) A unit cell of an ionic crystal shares all of its ions with other unit cells
(d) The length of the unit cell in NaCI is 52 pm.
$(r_{Na^+} = 95\,pm;\ r_{Cl^-} = 181\,pm)$

Assertion and Reason
Read the following questions and answer as per the direction given below:

(a) Statement I is correct
Statement II is correct
Statement II is the correct explanation of Statement I

(b) Statement I is correct
Statement II is correct
Statement II is not the correct explanation of Statement I

(c) Statement I is correct
Statement II is incorrect

(d) Statement I is incorrect
Statement II is correct

12. Statement I: In any ionic solid (MX) with Schottky defects, the number of positive and negative ions are same.
Statement II: Equal numbers of cation and anion vacancies are present.

Passage Based Questions
Passage

In hexagonal systems of crystals, a frequently encountered arrangement of atoms is described as a hexagonal prism. Here, the top and bottom of the cell are regular hexagons and three atoms are sandwiched in between them. A space-filling model of this structure, called hexagonal close-packed (hcp), is constituted of a sphere on a flat surface surrounded in the same plane by six identical spheres as closely as possible. Three spheres are then placed over the first layer so that they touch each other and represent the second layer. Each one of these three spheres touches three spheres of the bottom layer.

Finally, the second layer is covered with a third layer that is identical to the bottom layer in relative position. Assume radius of every sphere to be ‘r’.

13. The number of atoms in one of this hcp unit cell
(a) 4
(b) 6
(c) 12
(d) 17

14. The volume of this hcp unit cell is
(a) $24\sqrt{2}r^3$
(b) $16\sqrt{2}r^3$
(c) $12\sqrt{2}r^3$
(d) $\frac{64r^3}{3\sqrt{3}}$

15. The empty space in this hcp unit cell is
(a) 74%
(b) 47.6 %
(c) 32%
(d) 26%

16.
Assertion and Reason
Read the following questions and answer as per the direction given below:
(a) Statement I is correct
Statement II is correct
Statement II is the correct explanation of Statement I
(b) Statement I is correct
Statement II is correct
Statement II is not the correct explanation of Statement I
(c) Statement I is correct
Statement II is incorrect
(d) Statement I is incorrect
Statement II is correct

Statement I: A metal that crystallises in bcc structure has a coordination number of 12
Statement II: The length of the unit cell in NaCI is 552 pm.

17. The number of hexagonal faces that are present in a truncated octahedron is
(a) 12
(b) 13
(c) 14
(d) 15

18. Silver (atomic weight =108 g mol^{-1}) has a density of 10.5g cm^{-3}. The number of silver atoms on a surface area $10^{-12}m^2$ can be expressed in scientific notation as y x 10^x. The value of x is
(a) 7
(b) 6
(c) 5
(d) 4

19. The edge length of unit cell of a metal having molecular weight 75 g/mol is 5 $\overset{0}{A}$ which crystallizes in cubic lattice. If the density is 2 g/cc then find the radius of metal atom. (N_A = 6 x 10^{23}). Give the answer in pm.
(a) 216 pm
(b) 217 pm
(c) 220 pm
(d) 554 pm

20. An element crystallizes in fcc lattice having edge length 400 pm. Calculate the maximum diameter of atom which can be placed in interstitial site without distorting the structure.
(a) 117 pm
(b) 118 pm
(c) 112 pm
(d) 115 pm

21. The crystal AB (rock salt structure) has molecular weight 6.023y u. Where, y is an arbitrary number in u. If the minimum distance between cation and anion is $y^{1/3}$ nm and the observed density is 20 kg / m^3. Find the density in kg /m^3

(a) 8 kg/m^{-3}
(b) 7 kg/m^{-3}
(c) 6 kg/m^{-3}
(d) 5 kg/m^{-3}

22. Marbles of diameter 10 mm are to be put in a square area of side 40 mm so that their centres are within this area. Deduce an expression for calculating maximum number of marbles per unit area it.

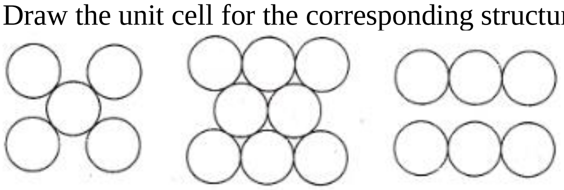
(a) $N = \left(\frac{x}{d} - 1\right)$

(b) $N = \left(\frac{x}{d} + 1\right)^2$

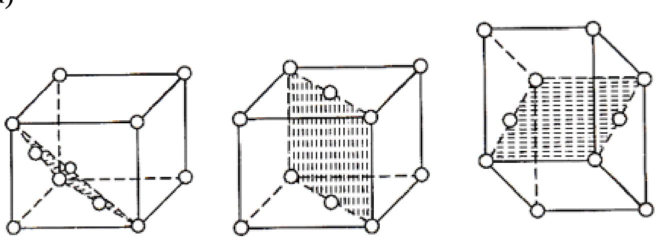
(c) $N = \left(\frac{x}{d} - 1\right)^2$

(d) $N = \left(\frac{x}{d} + 1\right)$

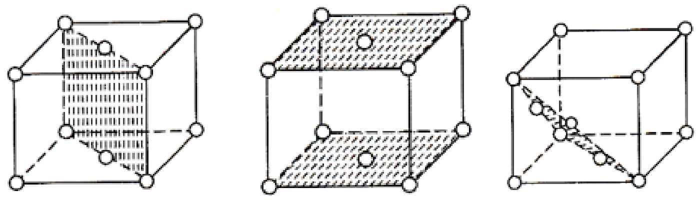
23. The figures given below show the location of atoms in three crystallographic planes in a fcc lattice. Draw the unit cell for the corresponding structures and identify these planes in your diagram.



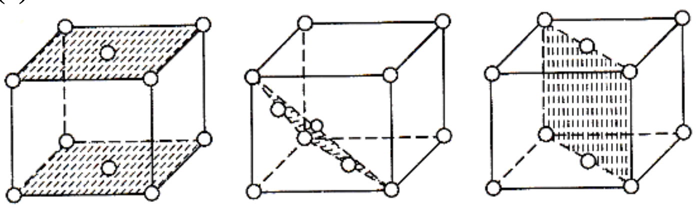
(a)



(b)



(c)



(d) None of the above

24. A metal crystallises into two cubic phases, face centred cubic (fcc) and body centred cubic (bcc), whose unit cell lengths are 3.5 and 3.0 $\overset{0}{\mathrm{A}}$, respectively. Calculate the ratio of densities of fcc and bcc.
(a) 1
(b) 1.5
(c) 1.3
(d) 1.26

25. Chromium metal crystallises with a body centred cubic lattice. The length of the unit edge is found to be 287 pm. Calculate the atomic radius . What would be the density of chromium in g/cm^3?
(a) 7.3
(b) 5.2
(c) 6.9
(d) 7.1

26. A metallic element crystallises into a lattice containing a sequence of layers of ABABAB….. Any packing of layers leaves out voids in the lattice. What percentage of this lattice is empty space?
(a) 25%
(b) 26%
(c) 27%
(d) 28%

27. Sodium crystallises in a bcc cubic lattice with the cell edge. a = 4.29 $\overset{0}{\mathrm{A}}$. What is the radius of sodium atom?
(a) 1 $\overset{0}{\mathrm{A}}$

(b) 1.86 $\overset{0}{A}$

(c) 2 $\overset{0}{A}$

(d) 1.5 $\overset{0}{A}$

28. Sodium (Na = 23) crystallizes in bcc arrangement with the interfacial separation between the atoms at the edge 53.6 pm. The density of sodium crystal is:
(a) 2.07 g/cc
(b) 2.46 g/cc
(c) 1.19 g/cc
(d) none of these

29. In F.C.C. arrangement of identical spheres, distance between two nearest octahedral voids is 8.51 $\overset{0}{A}$. The distance between two nearest tetrahedral voids would be ?

(a) 6 $\overset{0}{A}$

(b) 9 $\overset{0}{A}$

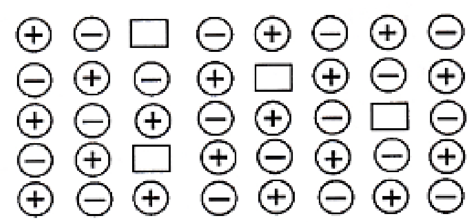
(c) 12 $\overset{0}{A}$

(d) 39 $\overset{0}{A}$

30.

Which of the following is incorrect

(a) The defect is known as schottky defect
(b) Density of compound in the defect decreases
(c) NaCl(s) is example which generally shows this defect
(d) Stoichoimetry of compound will change slightly.



31.

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

32.

The density of KBr is 2.75 gm/cc length of the unit cell is 654 pm (atomic masses of K = 38, Br = 80) then *what is true about the predicted nature of the solid.*
(a) Solid has F.C.C. structure with co-ordination number = 6
(b) Solid has simple cubic structure with co-ordination number = 4
(c) Solid has F.C.C. structure with co-ordination numbers-1
(d) None of these

33.

A hypothetical ionic compound AB (mol. wt. = 240 g/mole), having co-ordination number of anion equal to 6, has a closest anion-anion distance of $4\sqrt{2}$ Å. Determine the density of ionic compound AB in gm/cc.

(a) 6.24 (b) 3.12 (c) 1.56 (d) 0.78

34.

A fcc lattice has lattice parameter a = 400 pm. Calculate the molar volume of the lattice including all the empty space:

(a) 10.8 mL (b) 96 mL (c) 8.6 mL (d) 9.6 mL

35.

A metal crystallizes in two cubic phases i.e., FCC and BCC whose unit cell lengths are 3.5Å and 3.0 Å respectively. The ratio of their densities is :

(a) 3.12 (b) 2.04 (c) 1.26 (d) 0.72

36.

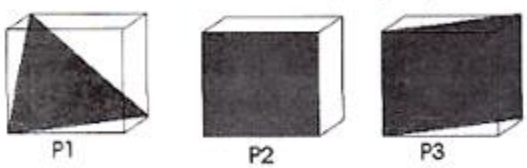
The arrangement ABC ABC ABC .... packing of identical spheres is referred as :

(a) Octahedral close packing (b) hexagonal close packing

(c) tetrahedral close packing (d) cubic close packing.

37.

Following three planes(P_1, P_2, P_3) in an FCC unit cell are shown:



Figure

Consider the following statements and choose the correct option that follow:

(i) P_1 contains no voids of three dimensions.

(ii) P_2 contains only Octahedral voids.

(iii) P_3 contains both Octahedral and Tetrahedral voids.

(a) All are true (b) Only (i) & (ii) are true

(c) (i) & (iii) are true (d) Only (iii) is true.

38.

KCl has NaCl type face centred cubic crystal structure and CsF has CsCl type cubic crystal structure. Calculate the ratio of densities of CsF and KCl. It is given that the molar mass of CsF is twice that of KCl and edge length of KCl unit cell is 1.5 times that for CsF.

(a)1.68 (b) 2.72 (c) 3.12 (d) 4.62

39.

In an ionic solid $r_{(+)} = 1.6$ Å and $r_{(-)} = 1.864$ Å. Use the radius ratio rule to determine the edge length of the cubic unit cell in Å.

(a) 4 (b) $2\sqrt{3}$ (c) $3\sqrt{3}$ (d) $\frac{4}{\sqrt{3}}$

40.

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) $X_5Y_4Z_8$

41.

A compound alloy of gold and copper crystallizes in a cubic lattice in which the gold atoms occupy the lattice points at the corners of a cube and the copper atoms occupy the centers of each of the cube faces. What is the formula of this compound ?

(a) AuCu (b) Au_3Cu (c) $AuCu_3$ (d) $AuCu_2$

42.

A solid has a b.c.c. structure. If the distance of closest approach between the two atoms is 1.73 Å. The edge length of the cell is ;

(a) $\sqrt{2}$ pm (b) $\sqrt{(3/2)}$ pm (c) 200 pm (d) 142.2 pm

43.

The radius of metal atom can be expressed in terms of the length of a unit cell is :

(a) it is a/2 for simple cubic lattice
(b) it is ($\sqrt{3}$a/4) for b.c.c. lattice
(c) it is (a/2$\sqrt{2}$) for F.C.C. lattice
(d) All of the above.

44.

Fraction of the total volume occupied by atoms in a simple cube is

(a) $\pi/6$ (b) $\sqrt{3}\pi/8$ (c) $\sqrt{2}\pi/6$ (d) $\pi/3$

45.

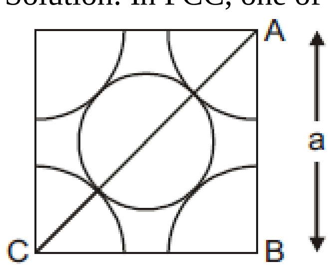
Lithium borohydride crystallizes in an orthorhombic system with 4 molecules per unit cell. The unit cell dimensions are a = 6.8 Å, b = 4.4 Å and c=7.2 Å. If the molar mass is 21.76, then the density of crystals is :
(a) 0.6708 g cm^{-2} (b) 1.6708 g cm^{-3} (c) 2.6708 g cm^{-3} (d) None of these.

Answer Key

1. c	2. a	3. c	4. b	5. d
6. b	7. a	8. d	9. a	10. c
11. a	12. a	13. b	14. a	15. d
16. d	17. c	18. a	19. b	20. a
21. d	22. b	23. c	24. d	25. a
26. b	27. b	28. c	29. a	30. d
31. b	32. a	33. b	34. d	35. c
36. d	37. a	38. a	39. a	40. d
41. c	42. c	43. d	44. a	45. a

Solution

1.
Solution: In FCC, one of the faces is like



By ΔABC,

$$2a^2 = 16r^2$$

$$\Rightarrow r^2 = \frac{1}{8}a^2$$

$$\Rightarrow r = \frac{1}{2\sqrt{2}}a$$

Distance of closest approach $= 2r = \dfrac{a}{\sqrt{2}}$

2.

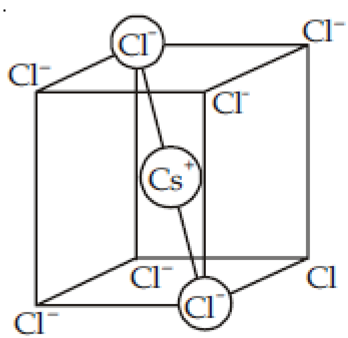
Solution: Edge length of BCC is $4.29\,\overset{0}{\mathrm{A}}$.
In BCC,

edge length $= \dfrac{4}{\sqrt{3}}r$

$$4.29 = \frac{4}{\sqrt{3}}r$$

$$r = \frac{4.29}{4}\sqrt{3} \approx\sim 1.86\,\overset{0}{\mathrm{A}}$$

3.
Solution:



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

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

4.
Solution:

Contribution of atom from the edge centre is 1/4. Therefore, number of

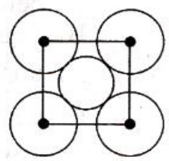
$$M = \frac{1}{4} \times 4 \text{ (from edge centre)} + 1 \text{ (from body centre)} = 2$$

$$\text{Number of } X = \frac{1}{8} \times 8 \text{ (from corners)} + \frac{1}{2} \times 6 \text{ (from face centre)} = 4$$

$\Rightarrow$ Empirical formula $= M_2X_4 = MX_2$

5.
Solution:

Contribution of circle from corner of square $= \frac{1}{4}$



$\Rightarrow$ Effective number of circle per square

$$= \frac{1}{4} \times 4 + 1 \text{ (at centre)} = 2$$

$\Rightarrow$ Area occupied by circle $= 2\pi r^2$, $r =$ radius.

Also, diagonal of square $4r = \sqrt{2}\, L$, where $L =$ side of square.

$$\Rightarrow \text{Packing fraction} = \frac{\text{Area occupied by circles}}{\text{Area of square}}$$

$$= \frac{2\pi r^2}{L^2} = \frac{2\pi r^2}{8r^2} = \frac{\pi}{4} = 0.785$$

$\Rightarrow$ % packing efficiency = 78.5%.

6.
Solution: In ZnS, S^{2-} (sulphide ions) are present at fcc positions giving four sulphide ions per unit cell. To comply with 1 : 1 stoichiometry, four Zn^{2+} ions must be present in four alternate tetrahedral voids out of eight tetrahedral voids present.
In NaCl, Na^+ ions are present in octahedral voids while in Na_2O, Na^+ ions are present in all its tetrahedral voids giving the desired 2 : 1 stoichiometry. In CaF_2, Ca^{2+} ions occupy fcc positions and all the tetrahedral voids are occupied by fluoride ions.

7.
Solution:

In cubic system, a corner contribute $\frac{1}{8}$th part of atom to one unit cell and a face centre contribute $\frac{1}{2}$ part of atom to one unit cell.

Therefore,

Number of A per unit cell $= \frac{1}{8} \times 8 = 1$

Number of B per unit cell $= \frac{1}{2} \times 6 = 3$

$\Rightarrow$ Formula $= AB_3$

8.
Solution: In NaCI, Na^+ occupies body centre and edge centre while Cl^- occupies corners and face centres, giving four Na^+ and four CI^- per unit cell. In the present case, A represents Cl^- and B represents Na^+ . Two face centres lie on one axis.

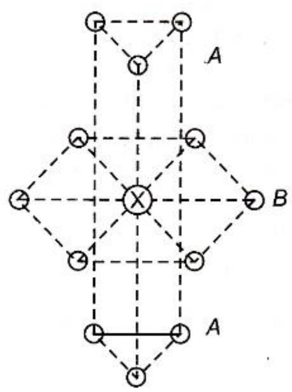
$\Rightarrow$ Number of A removed $= 2 \times \frac{1}{2} = 1$

Number of B is removed because it is not present on face centres.

$\Rightarrow A$ remaining $= 4 - 1 = 3$, B remaining $= 4$,

Formula $= A_3 B_4$

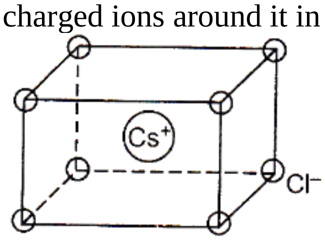
9.
Solution: Three consecutive layers of atoms in hexagonal close packed lattice is shown below:



Atom X is in contact of 12 like atoms, 6 from layer B and 3 from top and bottom layers of A each.

10.
Solution:
(c) Correct statement: In F-centre defect, some anions leave the lattice and the vacant sites hold the electrons trapped in it maintaining the overall electroneutrality of solid.

11.
Solution:
(a) The unit cell of CsCI has bcc arrangement of ions in which each ion has eight oppositely charged ions around it in the nearest neighbours as shown below :



Unit cell of CsCl

Assertion and Reason

Read the following questions and answer as per the direction given below:

(e) Statement I is correct
Statement II is correct
Statement II is the correct explanation of Statement I

(f) Statement I is correct
Statement II is correct
Statement II is not the correct explanation of Statement I

(g) Statement I is correct
Statement II is incorrect

(h) Statement I is incorrect
Statement II is correct

12.
Solution: In ionic solid *MX* (1 : 1 solid) same number of M^{n+} and X^{n-} ions are lost in Schottky defect to maintain electroneutrality of the solid.

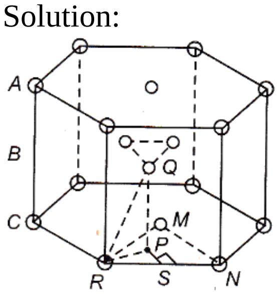
Passage Based Questions

Passage

In hexagonal systems of crystals, a frequently encountered arrangement of atoms is described as a hexagonal prism. Here, the top and bottom of the cell are regular hexagons and three atoms are sandwiched in between them. A space-filling model of this structure, called hexagonal close-packed (hcp), is constituted of a sphere on a flat surface surrounded in the same plane by six identical spheres as closely as possible. Three spheres are then placed over the first layer so that they touch each other and represent the second layer. Each one of these three spheres touches three spheres of the bottom layer.

Finally, the second layer is covered with a third layer that is identical to the bottom layer in relative position. Assume radius of every sphere to be 'r'.

13.
Solution:



A hcp unit cell

Contribution of atoms from corner = 1/6

Contribution from face centre = 1/2

$$\Rightarrow \text{Total number of atoms per unit cell} = 12 \times \frac{1}{6} + 2 \times \frac{1}{2} + 3 = 6$$

14.
Solution:

In close packed arrangement, side of the base = $2r$

$\Rightarrow \qquad RS = r$

Also MNR is equilateral triangle, $\angle PRS = 30°$

In triangle PRS, $\cos 30° = \frac{RS}{PR} = \frac{\sqrt{3}}{2}$

$$\Rightarrow \qquad PR = \frac{2}{\sqrt{3}} RS = \frac{2}{\sqrt{3}} r$$

In right angle triangle PQR : $PQ = \sqrt{QR^2 - PR^2} = 2\sqrt{\frac{2}{3}}\, r$

$\Rightarrow$ Height of hexagon = $2PQ = 4\sqrt{\frac{2}{3}}\, r$

$\Rightarrow$ Volume = Area of base × height = $6\,\frac{\sqrt{3}}{4}\,(2r)^2 \times 4\sqrt{\frac{2}{3}}\, r$

$$= 24\sqrt{2}\, r^3$$

15.
Solution:

$$\text{Packing fraction} = \frac{\text{Volume occupied by atoms}}{\text{Volume of unit cell}}$$

$$= 6 \times \frac{4}{3} \pi r^3 \times \frac{1}{24\sqrt{2}\, r^3} = 0.74$$

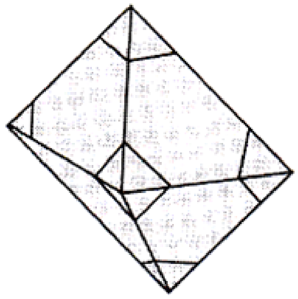
$\Rightarrow$ Fraction of empty space = $1 - 0.74 = 0.26 = 26\%$

16.
Solution: (I) In bcc, the coordination number is 8.
(II) In NaCI unit cell;

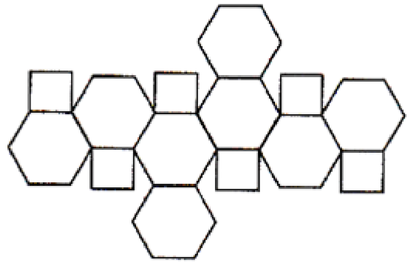
$$2(r_{Na^+} + r_{Cl^-}) = a$$

a= 2 (95 + 181)= 552 pm

17.
Solution: The truncated octahedron is the 14-faced Archimedean solid, with 14 total faces 6 squares and 8 regular hexagons. The truncated octahedron is formed by removing the six right square pyramids one from each point of a regular octahedron as:



Truncated octahedron



Truncated octahedron unfolded in two-dimension

18.
Solution:

Ag crystallises in fcc unit cell with 4 atoms per unit cell.

$$\rho = \frac{4 \times 108}{6.023 \times 10^{23} \times a^3} = 10.5 \text{ g cm}^{-3}.$$

$\Rightarrow a^3$ (Volume of unit cell) $= 6.83 \times 10^{-23}$ cm^3

$\Rightarrow a = 4 \times 10^{-8}$ cm $= 4 \times 10^{-10}$ m

$\Rightarrow$ Surface area of unit cell $= a^2 = 1.6 \times 10^{-19}$ m^2

$\Rightarrow$ Number of unit cells on 10^{-12} m^2 surface

$$= \frac{10^{-12}}{1.6 \times 10^{-19}} = 6.25 \times 10^6$$

$\because$ There are two atoms (effectively) on one face of unit cell
Number of atoms on 10^{-12} m^2 surface $= 2 \times$ number of unit cell
$= 1.25 \times 10^7$. $\qquad [\because \quad y \times 10^x]$

$\Rightarrow \qquad x = 7 \Rightarrow y = 1.25$

Subjective Questions

19.
Solution: From the given information, the number of atoms per unit cell and therefore, type of unit cell can be known as

$$\rho = \frac{NM}{N_A a^3}$$

$$\Rightarrow \quad N = \frac{\rho N_A a^3}{M} = \frac{2 \times 6 \times 10^{23} \times (5 \times 10^{-8}\ \text{cm})^3}{75}$$

$= 2$ (bcc)

$\Rightarrow$ In bcc, $4r = \sqrt{3}a$

$$\Rightarrow \quad r = \frac{\sqrt{3}}{4}a = \frac{\sqrt{3}}{4} \times 5 \times 10^{-10}\text{m}$$

$$= 2.17 \times 10^{-10}\ \text{m} = 217\ \text{pm}$$

20.
Solution: In a cubic crystal system, there are two types of voids known as octahedral and tetrahedral voids. If r_1 is the radius of void and r_2 is the radius of atom creating these voids then

$$\left(\frac{r_1}{r_2}\right)_{\text{octa}} = 0.414 \quad \text{and} \quad \left(\frac{r_1}{r_2}\right)_{\text{tetra}} = 0.225$$

The above radius ratio values indicate that octahedral void has larger radius, hence for maximum diameter of atom to be present in interstitial space :

$$r_1 = 0.414\ r_2$$

Also in fcc, $\quad 4r_2 = \sqrt{2}a$

$\Rightarrow$ Diameter required $(2r_1) = (2r_2) \times 0.414$

$$= \frac{a}{\sqrt{2}} \times 0.414 = \frac{400 \times 0.414}{\sqrt{2}} = 117\ \text{pm}$$

21.
Solution:
(a)
In rock salt like crystal AB, there are four AB units per unit cell. Therefore, density (d) is

$$d = \frac{4 \times 6.023\, y}{6.023 \times 10^{23} \times 8\, y \times 10^{-27}}$$

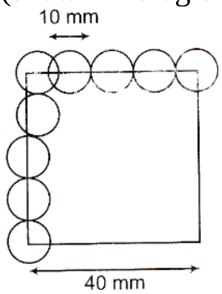
$$[\because a = 2y^{1/3}\,\text{nm} = 2y^{1/3} \times 10^{-9}\ \text{m}]$$

$$= 5 \times 10^3\ \text{g/m}^3 = 5\ \text{kg/m}^3$$

(b) Since, observed density is greater than theoretical density as expected, there must be some excess metal occupying interstitial spaces. This type of defect is known as **metal excess defect.**

22.
Solution:
(a) Side of square = 40 mm

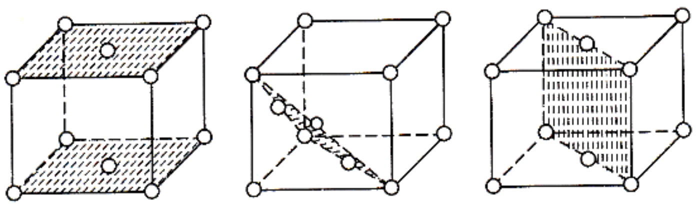
Diameter of marble = IO mm
Number of marble spheres along an edge of square with their centres within the square = 5 (shown in diagram)



Maximum number of marbles per unit area = 5 x 5 = 25
(b) If *x* mm is the side of square and d is diameter of marble then maximum number of marbles on square area with centres within square area can be known by the following general formula

$$N = \left(\frac{x}{d} + 1\right)^2$$

23.
Solution:



24.
Solution:

$$\text{Density} \propto \frac{N}{a^3}$$

$$\Rightarrow \qquad \frac{d_1}{d_2} = \frac{N_1}{N_2}\left(\frac{a_2}{a_1}\right)^3$$

$$= \frac{4}{2}\left(\frac{3}{3.5}\right)^3 = 1.26$$

25.
Solution:

In bcc unit cell, $4r = \sqrt{3}a$

$\Rightarrow \quad r\,(\text{Cr}) = \frac{\sqrt{3}a}{4} = \frac{\sqrt{3}}{4} \times 287 \text{ pm} = 124.3 \text{ pm}$

Density of solid $= \frac{NM}{N_A \cdot a^3}$

N = Number of atoms per unit cell, M = Molar mass

a^3 = Volume of cubic unit cell, N_A = Avogadro's number

$$= \frac{2 \times 52 \text{ g}}{6.023 \times 10^{23}} \times \left(\frac{1}{2.87 \times 10^{-8} \text{ cm}}\right)^3 = 7.3 \text{ g/cm}^3$$

26.

Solution: The given arrangement: ABABAB….. represents hexagonal close-packed unit cell in which there are six atoms per unit cell. Also, volume of unit cell = $24\sqrt{2}r^3$

$\Rightarrow$ Packing fraction $= \frac{\text{Volume occupied by atoms}}{\text{Volume of unit cell}}$

$$= 6 \times \frac{4}{3}\pi r^3 \times \frac{1}{24\sqrt{2}r^3} = 0.74$$

$\Rightarrow$ Percent empty space = 100 (1 – 0.74) = 26%

27.

Solution:

In bcc arrangement of atoms : $4r = \sqrt{3}a$, atoms on body diagonal remain in contact

$\Rightarrow \quad r = \frac{\sqrt{3}\,a}{4} = \frac{\sqrt{3} \times 4.29}{4} = 1.86 \text{ Å}$

28.

Solution:

$a - 2r = 53.6$ pm

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

$\Rightarrow \quad a - \frac{\sqrt{3}}{2}a = 53.6 \quad \Rightarrow \quad a = \frac{53.6 \times 2}{2 - \sqrt{3}} = 400$ pm

Density (ρ) $= \frac{2 \times 23}{6.023 \times 10^{23} \times 4^3 \times 10^{-24}} = 1.19$ g/cc

29.

Solution:

distance between two octahedral void = $\frac{a}{\sqrt{2}} = 8.51$

$$a = 8.51 \times 1.41 = 12Å$$

distance between two tetrahedral void = a/2 = 6Å

30.
Solution: In Schottky defect, stoichiometry of the compound remains unchanged.

31.
Solution:
In flourite structure, cations form the lattice & anions occupy each of tetrahedral voids.

32.
Solution:

$$2.75 = \frac{Z \times 118}{(6.54 \times 10^{-8})^3 \times 6.023 \times 10^{23}} \quad \Rightarrow \quad Z = 4 \text{ (fcc with NaCl type structure)}$$

33.
Solution:

$$d = \frac{Z \times M}{N_A a^3} = \frac{4 \times 240}{6.02 \times 10^{23} \times 8^3 \times 10^{-24}} = 3.12$$

34.
Solution:
volume of 4 atoms = a^3
= $(4 \times 10^{-8})^3$ cm^3

$$\text{volume of } N_A \text{ atoms} = \frac{(4 \times 10^{-8})}{4} \times 6.023 \times 10^{23} = 9.6 \text{ ml}$$

35.
Solution:

$$d = \frac{ZM}{a^3 N_A} \qquad \frac{d_1}{d_2} = \frac{4}{(3.5)^3} \times \frac{(3)^3}{2} = 1.26$$

36.
Solution:
(d) It represents ccp arrangement.

37.
Solution:
Refer theory octahedral & tetrahedral voids about positions of P_1, P_2 and P_3

38.
Solution:
$a_{KCl} = 1.5\ a_{CsF}$
$2M_{KCl} = M_{CsF}$

$$\rho_{KCl} = \frac{4M_{KCl}}{N_A\ a_{KCl}^3}$$

$$\rho_{CsF} = \frac{1M_{CsF}}{N_A\ a_{CsF}^3}$$

$$\frac{\rho_{CsF}}{\rho_{KCl}} = \frac{M_{CsF}}{a_{CsF}^3} \cdot \frac{a_{KCl}^3}{4M_{KCl}} = \frac{2}{4} \times \left(\frac{3}{2}\right)^3 = \frac{27}{16} = 1.6875$$

39.
Solution:

$$\frac{r_+}{r_-} = \frac{1.6}{1.864} = 0.858$$

So, it is CsCl type of unit cell

So $\sqrt{3}\,a = 2(r_+ + r_-)$

$$\text{So, } a = \frac{2(1.864 + 1.6)}{\sqrt{3}}\ Å = 2 \times 2Å = 4Å$$

40.
Solution:
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 = $X_{15/4}Y_3Z_6 = X_{5/4}YZ_2 = X_5Y_4Z_8$

41.
Solution:

$\frac{1}{8} \times 8 = 1$Au atom/unit cell; $\frac{1}{2} \times 6 = 3$ Cu atoms/ unit cell

The empirical formula is $AuCu_3$.

42.

Solution:

$$2r = \frac{\sqrt{3}\,a}{2} \Rightarrow a = \frac{2(2r)}{\sqrt{3}} = \frac{2 \times 1.73}{1.73} = 2\text{Å} = 200 \text{ pm}$$

43.
Solution:

44.
Solution:

$$\frac{1 \times \frac{4}{3}\pi r^3}{a^3} = \frac{\frac{4}{3}\pi r^3}{(2r)^3} = \frac{\pi}{6}$$

45.
Solution:

$$d = \frac{ZM}{a^3 N_A} = \frac{4 \times 21.76}{6.8 \times 10^{-8} \times 4.4 \times 10^{-8} \times 7.2 \times 10^{-8} \times 6.023 \times 10^{23}} = 0.6708 \text{ g cm}^{-2}$$