1. Iron exhibits *bcc* structure at room temperature. Above 900 °C, it transforms to *fcc* structure. The ratio of density of iron at room temperature to that at 900 °C (assuming molar mass and atomic radii of iron remains constant with temperature) is

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

(c) $\frac{3\sqrt{3}}{4\sqrt{2}}$ (d) $\frac{1}{2}$ *(2018)*

bcc $(z=2)$ $a=\frac{4r}{\sqrt{3}}$

fcc $(z=4)$ $a=2\sqrt{2}\,r$

$d=\frac{zM}{N_A a^3}$

11. Structure of a mixed oxide is cubic close packed (*ccp*). The cubic unit cell of mixed oxide is composed of oxide ions. One fourth of the tetrahedral voids are occupied by divalent metal *A* and the octahedral voids are occupied by a monovalent metal *B*. The formula of the oxide is

(a) ABO_2 (b) A_2BO_2

(c) $A_2B_3O_4$ (d) AB_2O_2 **(2012)**

n Sphere
n OV
2n TV

Lattice (O^{2-})

1 O^{2-}
1 OV
2 TV

$A^{2+} = \frac{1}{4} \times 2 = 2$

$B^{+} = 1$

$O^{2-} = 1$
$A^{2+} = 2$
$B^{+} = 1$

11. Structure of a mixed oxide is cubic close packed (*ccp*). The cubic unit cell of mixed oxide is composed of oxide ions. One fourth of the tetrahedral voids are occupied by divalent metal A and the octahedral voids are occupied by a monovalent metal B. The formula of the oxide is

(a) ABO_2 (b) A_2BO_2

(c) $A_2B_3O_4$ (d) AB_2O_2 ***(2012)***

eight

half

trivalent

AB_2O_4 ✓

$+2(+3)2 - 8 = 0$

$+2\ (+1)2\ -4 = 0$

1 O^{2-} $A^{2+} = \frac{1}{8} \times 2 = \frac{1}{4}$

1 OV

2 TV $B^{3+} = \frac{1}{2} \times 1 = \frac{1}{2}$

O^{2-} A^{2+} B^{3+}

1 $\frac{1}{4}$ $\frac{1}{2}$

AB_2O_4

1) What % of Tv is occupied by A^{2+}

2) What % of Ov is occupied by B^{3+}

$4O^{2-}$, 4 Ov, 8 Tv

% occupancy = $\frac{1}{8} \times 100$

$= 12.5\%$

% occupancy = $\frac{2}{4} \times 100 = 50\%$

57. Experimentally it was found that a metal oxide has formula $M_{0.98}O$. Metal M, is present as M^{2+} and M^{3+} in its oxide. Fraction of the metal which exists as M^{3+} would be

(a) 5.08% (b) 7.01%

(c) 4.08% (d) 6.05% ***(2013)***

$M^{3+} = x$, $M^{2+} = 0.98 - x$

$3x + 2(0.98 - x) = 2$, $x =$

$M_{0.98}O_1$

$0.98x - 2 = 0$

$x = \frac{200}{98} = 2.04$

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$M^{3+} = x$, $M^{2+} = 0.98 - x$

$3x + 2(0.98 - x) = 2$, $x = 0.04$

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

$M_{0.98}O_1$

$0.98x - 2 = 0$

$x = \frac{200}{98} = 2.04$

69. If the unit cell of a mineral has cubic close packed (*ccp*) array of oxygen atoms with m fraction of octahedral holes occupied by aluminium ions and n fraction of tetrahedral holes occupied by magnesium ions, m and n, respectively, are

(a) $\frac{1}{2}, \frac{1}{8}$ (b) $1, \frac{1}{4}$

(c) $\frac{1}{2}, \frac{1}{2}$ (d) $\frac{1}{4}, \frac{1}{8}$ *(2015)*

ccp (Z=4) = no of O atom

OV = 4 { no of Al^{+3} = m × 4

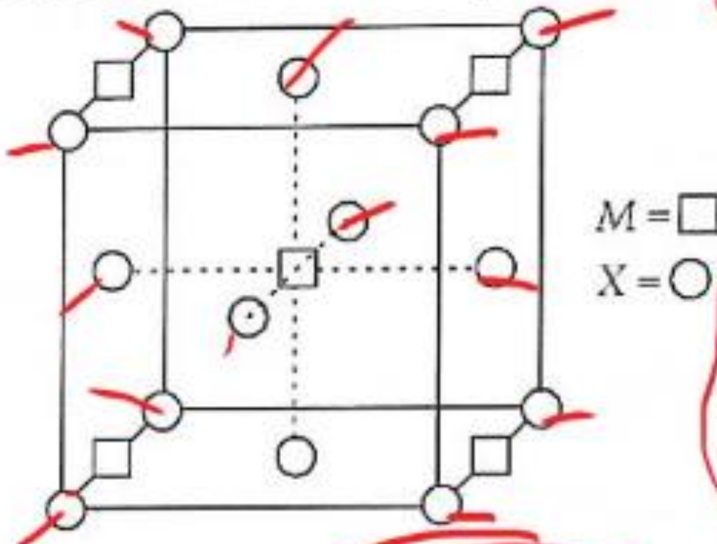
TV = 8 { no of Mg^{2+} = n × 8

formula $Al_{4m}Mg_{8n}O_4$

$4m(+3) + 8n(+2) + 4(-2) = 0$

$3m + 4n = 2$

71. A compound M_pX_q has cubic close packing (*ccp*) arrangement of *X*. Its unit cell structure is shown below. The empirical formula of the compound is



$8 \times \frac{1}{8} = 1$, $6 \times \frac{1}{2} = 3$

$X = 4$

edge contribution $= 1/4$

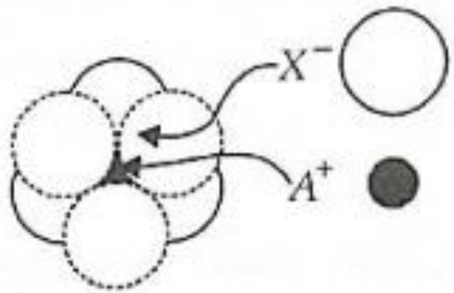
$4/4 = 1$

Body center $= 1$

2

(a) MX (b) MX_2
(c) M_2X (d) M_5X_{14} ***(2012)***

70. The arrangement of X^- ions around A^+ ion in solid AX is given in the figure (not drawn to scale). If the radius of X^- is 250 pm, the radius of A^+ is



$\frac{r_c}{r_a} = 0.414$

$\frac{r_c}{250} = 0.414$

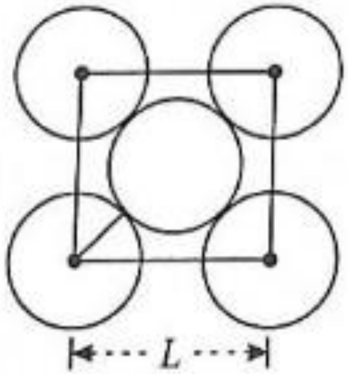
(a) 104 pm
(b) 125 pm
(c) 183 pm
(d) 57 pm
(2013)

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

Packing efficiency = $\frac{\text{Area covered}}{\text{Total area}}$

radius of circle = r

edge length of Sq = a



(a) 39.27% (b) 68.02%

(c) 74.05% (d) 78.54% ✓ *(2010)*

area covered = $\frac{2 \times \pi r^2}{a^2}$ $\frac{2\pi r^2}{(2\sqrt{2}r)^2} = \frac{\pi}{4} =$

58. Ferrous oxide has a cubic structure. The length of edge of the unit cell is 5 Å. The density of the oxide is $4.0\ g\ cm^{-3}$. Then the number of Fe^{2+} and O^{2-} ions present in each unit cell will be

(a) four Fe^{2+} and four O^{2-} (b) two Fe^{2+} and two O^{2-}
(c) four Fe^{2+} and two O^{2-} (d) two Fe^{2+} and four O^{2-}

$d = \frac{ZM}{NV}$ → 4

61. Number of unit cells in 4 g of X (atomic mass = 40) which crystallises in *bcc* pattern is (N_A = Avogadro number)

(a) $0.1\,N_A$ (b) $2 \times 0.1\,N_A$

(c) $\dfrac{0.1\,N_A}{2}$ (d) $2 \times N_A$

$40g \longrightarrow N_A$ 2 atoms forms 1 unit cell

$4g \longrightarrow 0.1\,N_A$ $0.1\,N_A \longrightarrow \dfrac{0.1\,N_A}{2}$

65. The density of a pure substance 'A' whose atoms are in cubic close packed arrangement is 1 g/cm^3. If all the tetrahedral voids are occupied by 'B' atom, what is the density of resulting solid in g/cm^3. [Atomic mass $(A) = 30$ g/mol and atomic mass $(B) = 50$ g/mol]

(a) 3.33 (b) 4.33 (c) 2.33 (d) 5.33

Let volume of ccp/fcc = V

$$d_A = \frac{4 \times M_A}{N_A V}$$

$$d_B = \frac{8 \times M_B}{N_A V}$$

$$\frac{d_A}{d_B} = 0.3$$

$$d_B = \frac{d_A}{0.3} = 3.33$$

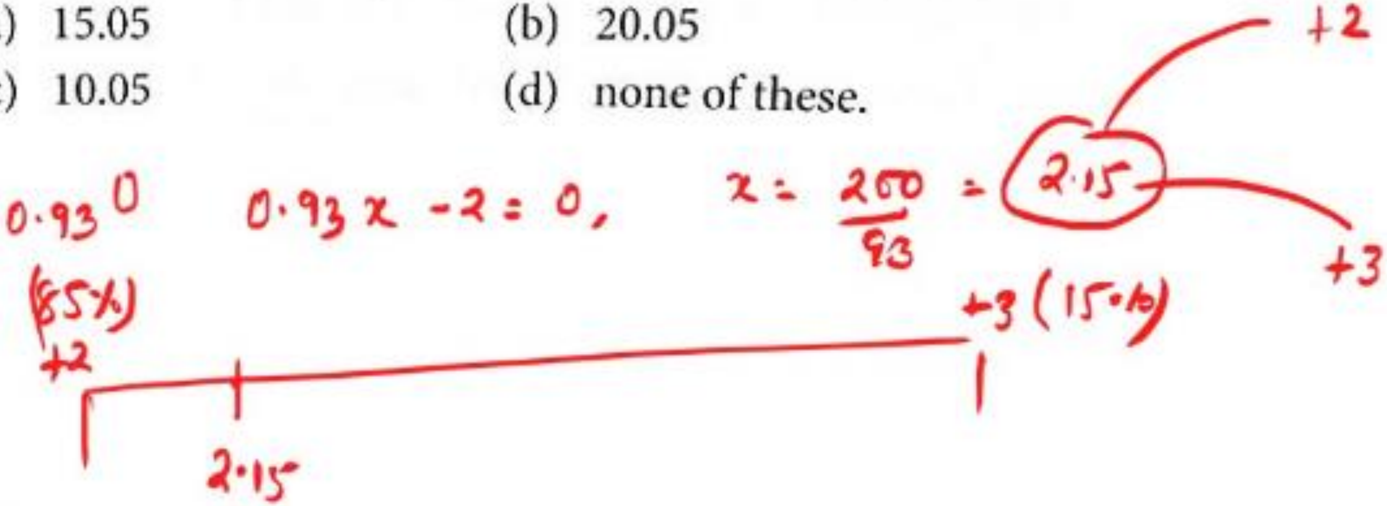
Total density = 4.33 g/cm^3

84. The composition of a sample is $Fe_{0.93}O_{1.00}$. The percentage of the iron present in the form of Fe (III) is

(a) 15.05 (b) 20.05

(c) 10.05 (d) none of these.

$Fe_{0.93}O$ $0.93x - 2 = 0$, $x = \frac{200}{93} = 2.15$



$3x + 2(100 - x) = 2.15 \times 100$

85. An analysis shows that the oxide of nickel consists of nickel ion with 96% ions having d^8 configuration and 4% having d^7 configuration. Which one of the following represents the formula of the oxide best?

(a) $Ni_{0.98}O_{0.98}$

(b) $Ni_{1.02}O_{1.02}$

(c) $Ni_{1.02}O_{1.00}$

(d) $Ni_{0.98}O_{1.00}$

Ni^{0} $(4s^2\ 3d^8)$ $Ni^{2+} = 3d^8$, $Ni^{+3} = 3d^7$

96% 4%

A compound formed by A, B and C in which A is arranged in ccp, B is present in 25% of the tetrahedral voids and C is present in all the remaining voids (tetrahedral as well as octahedral). Determine formula of compound

$A = 1$, $OV = 1$, $TV = 2$

$A_1 B_{1/2} C_{5/2}$

$2 \times \frac{25}{100} = B = \frac{1}{2}$

$OV = 1$, $\frac{3}{2}$

A compound is consist of A, B and C. The distribution of A, B, C in unit cell is as follows

A is at corner

B is at body centre

C is at face centre

(i) Estimate the formula. → (ABC_3) ✓

(ii) Estimate the formula if :

(a) all the atoms along one of the face diagonal are removed. ($A_3B_4C_{10}$)

(b) all the atoms along one of body diagonal are removed.

(c) all the atoms along one of axis is removed if body centre is at origin.

(d) all atoms along one of axis is removed if origin is at any of the corner

a) $A_3B_4C_{10}$

b) AC_4

c) AC_2

4) $A_3B_4C_{12}$

A_2BC_2 ✓

In a crystalline solid, anions C are arranged in cubic close-packing. Cations A occupy 50% of the tetrahedral voids and cations B occupy 50% of the octahedral voids. What is the formula of the solid?

$C = 1$

$OV = 1$

$TV = 2$

$2 \times \frac{50}{100} = A = 1$

$1 \times \frac{50}{100} = B = 1/2$

$A_1 B_{1/2} C_1$

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PROBLEM 13 *Chromium metal crystallizes with a body-centred cubic lattice. The length of the unit cell edge is found to be 287 pm. Calculate the atomic radius. What would be the density of chromium in g/cm³?*

(IIT July 1997)

BCC Lattice $r = \frac{\sqrt{3}a}{4} = \frac{\sqrt{3} \times 287}{4} = 125$

$d = \frac{ZM}{NV} \rightarrow 7.3\, g/ml$

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PROBLEM 16 *A compound AB has a rock type structure with $A:B=1:1$. The formula weight of AB is $6.023\,y$ amu and the closest $A-B$ distance is $y^{1/3}$ nm.*

(*a*) *Calculate the density of lattice.*

(*b*) *If the observed density of lattice is found to be $20\ \text{kg m}^{-3}$, then predict the type of defect.* **(IIT 2004)**

$$a = 2(a^+ + b^-) = 2y^{1/3}\times 10^{-9}\ m$$

$$D = \frac{ZM}{NV} = \frac{4\times y\times 10^{-3}}{6.023\times 10^{23}\times (2y^{1/3}\times 10^{-9})^3} = 5$$