CHEMISTRY

BOOKS - PRADEEP CHEMISTRY (HINGLISH)

SOLID STATE

Problem

1. Calculate the number of atoms per unit cell present in simple, fcc and bcc unit cells.

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2. A compound formed by elements A and B has a cubic structure in which A atoms are at the corner of the cube and B atoms are at the face centres. Derive the fomula of the compound.

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3. A cubic solid is made up iof two elements X and Y . Atoms Y are present at the corners of the cube and atoms X at the body centre. What is the formula of the compound ? What are the coordination number of X and Y ?

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4. An ionic compand made up of atoms A and B has a face- centred cubic arrangement in which atoms A are at the cornere and atoms B

are at the face- centres. If one of the atoms is missing from the corrner, what is the simplest formula of the compound ?

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5. Calculate the number of unit cells in 8.1 g of aluminium if it crystalliz3es in aface cented cubic (f.c.c) structure. (Atomic mass of Al= 27 $gmol^{-1}$)

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Sample Problem

1. A compound is formed by two elements X and Y. Atoms of the element Y (as anion) make ccp and those of element X (as cation) occupy all the octahedral voids. What is the formula of the compound?

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2. Atoms of elements B from hcp lattice and those of element A occupy two-thirds of

tetrahedral voids. What is the formula of the compound formed by elements A and B?

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3. In a crystalline solid anions B are arranged in cubic close packing. Cation A are equally distributed between octahedral and tetrahedral voids. If all the octahedral voids are occupied, the formula for the solid is

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4. In the mineral, spinel, having the formula $MgAl_2O_4$ oxide ions ar arranged , in the cubic close packing, Mg^{2+} ions occupy the tetrahedrel voids while Al^{3+} ions occupy the octahedral voids.

(i) What precnetage of tetrahedral voids is occupied by Mg^{2+} ions ?

(ii) What precentage of octahedral voids is occupied by Al^{3+} ions ?

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5. What is the percent by mass of titanium in rutile, a mineral that contain Titanium and oxygen, if structure can be described as a closet packed array of oxide ions, with titanium in one half of the octahedral holes. What is the oxidation number of titanium ?

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6. Calculate the approximate number of unit cells present in 1 g of ideal NaCl crystals.

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7. Two ions $A^{\oplus}$ and $B^{\ominus}$ have radii 88 and 200 pm, respectively. In the close-packed crystal of compound AB, predict coodination number of $A^{\oplus}$.

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8. Br^{-} ions form a close packed structure. If the radius of Br^{-} ions is 195 pm, calculate the radius of the cation that just fits into the

tetrahedral hole. Can a cation A^+ having a radius of 82 pm be shipped into be octahedral hole of the crystal A^+Br^- ?

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9. Xenon crystallizes in the face-centred cubic lattice and the edge of the unit cell is 620 pm. What is the nearest neighbour distance and what is the redius of xenon atom?

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10. $CsCl$ has bcc arrangement and its unit cell edge length is 400 pm. Calculate the interionic distance in $CsCl$.

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11. Sodium metal crystallises in body centred cubic lattic with the cell edge, 4.29 Å . What is the radius of radius of sodium atom ? What is the length of the body dioganl of the unit cell ?

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12. In face - centred cubic (fcc) crystal lattice, edge length is 400 pm. Find the diameter of the greatest sphere which can be fitted into the interstital void without distortion of the lattice.

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13. Silver froms ccp lattice and X-ray studies of its crystals show that the edge length of its

unit cell is 408.6 pm. Calculate the density of silver (atomic mass $= 107.9u$).

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14. Sodium has a bcc structure with nearest neighbour distance of 365.9 pm. Calculate its density. (Atomic mass of sodium $= 23$)

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15. Gold (atomic mass = 197 u) has atomic radius = 0.144 nm. It crystallises in face centred unit cell. Calculate the density of gold. (No = $6.022 \times 10^{23} mol^{-1}$)

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16. Gold has a close-packed structure which can be viewed as-spheres occupying 0.74 of the total volume. If the density of gold is 19.3

g/cc, calculate the apparent radius of a gold ion in the solid

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17. $CsCl$ has cubic structure. Its density is $3.99gcm^{-3}$. What is the distance between $Cs^{\oplus}$ and Cl^{Θ} ions?

(Atomic mass of $Cs = 133$)

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18. The density of aluminium is $2700 kgm^{-3}$, Aluminium crytallises in face - centred cubic lattic. Calculate the radius of aluminium atom in meters (Atomic mass of Al = 27)

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19. The edge length of unit cell of a metal having molecular weight 75 g/mol is 5Å which crystallises in cubic lattice. If the density is 2

g/c.c., then the radius of the metal atom in pm is

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20. Calculate the value of Avogadro's number from the following data:

Density of $NaCl = 2.165 gcm^{-3}$

Distance between $Na^{\oplus}$ and Cl^{Θ} in $NaCl = 281$ pm

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21. The density of KCl is $1.9893 gcm^{-3}$ and the length of a side unit cell is $6.29082 Å$ as determined by $X-$ ray diffraction. Calculation the value of Avogadro's number.

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22. X-rays diffraction studies show that copper crystallizes in an fcc unit cell with cell edge of $3.608 \times 10^{-8} cm$. In a separte experiment, copper is determined to have a

density of $8.92 g cm^3$. Calculate the atomic mass of copper.

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23. An element crystallizes into a structure which may be describes by a cubic type of unit cell having one atom on each corner of the cube and two atoms on one of its diagonals. If the volume of this unit cell is $24 \times 10^{-24} cm^3$ and density of element is $7.2 g cm^{-3}$. Calculate

the number of atoms present in $200g$ of element.

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24. Density of Li is $0.53\mathrm{g\,cm^{-3}}$. The edge length of Li is 3.5Å. Find the number of Li atoms in a unit cell $\left(N_0 = 06.023 \times 10^{23}, M = 6.94\right)$.

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25. The density of KBr is $2.75gcm^{-3}$, The length of edge of the unit cell is 654 pm. Predict, the type of cubic lattice to which unit cell of KBr belongs $\left(N_0 = 6.023 \times 10^{23} \text{ mol}^{-1}\right.$, At mass : K = 29 , Br = 80)

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26. The density of copper metal is $8.95 \text{ g } cm^{-3}$. If the redius of copper atom

be 127.8 pm, is the copper unit cell simple cubic, body - centred or face- centred cubic ?

(Given : atomic mass of Cu = 63. 5 g/mol)

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27. If NaCl is doped with 10^{-3} mol percent of $SrCI_2$, what is the concentration of cation vacancy?

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28. If Al^{3+} replaces Na^{+} at the edge centre of $NaCl$ lattice ,then the cation vacancies in 1 mole of $NaCl$ will be

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

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Curiosity Question

1. Why is glass of window panes of very old buildings found to be thicker at the bottom than as the top and why is it milky ?

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2. What ar optical fibers ? What are their advatages over ordinary glass like that of window panes ?

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Problem For Pactice

1. A compound formed by elements X and Y crysstallixzes in the cubic struture where Y atoms are at the corners of the cube and X atoms are at the alterante faces. What is the formula of the compound. ?

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2. Calculate the number of atoms in a cubic based unit cell having one atome on each corner and two atoms on each body diagonal.

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3. A compound made up of elements A and B crystallizes in the cubic structures. Atoms A are present on the corners as well as face centres whereas atoms B are present on the edge centres centres as well as body centre.

What is the formula of the compound? Draw the structure of its unit cell.

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4. If three elements X, Y and Z crystallize in a cubic solid with X atoms at the corners, Y atoms at the cube centres and Z atoms at the face of the cube, then write the formula of the compound.

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5. Sodium crystallizes in a bcc unit cell. Calcuate the approximate number of unit cells in 9.2 g of sodium (Atomic mass of Na=23)

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6. Calculate the approximate number of unit cells present in 1 g of gold. Given that gold cyrstallises in a face centred cubic lathce (Given atomic mass of gold = 197 u).

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Advanced Problems

1. A bcc lattic is made up of hollow spheres of X. spheres of soldid 'Y,' are present in hollow spheres of X. The radius of 'Y' is half of the radius of 'X' . Calculate the ratio of the total volume of spherees of 'X' unoccupied by Y in a unit cell and volume of the unit cell ?

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2. A metal crystallizes into two cubic phases, face-centred cubic and body-centred cubic, which have unit cell lengths 3.5 and $3.0A$, respectively. Calculate the ration of densities of fcc and bcc.

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3. The density of solid argon is $1.65g/mL$ at $-233^{\circ}C$. If the argon atom is assumed to be sphere of radius $1.54 \times 10^{-8}cm$, what

percentage of solid argon is apparentaly empty space ? $(At.\ Wt.\ of Ar = 40)$

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4. In the cubic crystal of $CsCl\left(d = 3.97 gcm^{-3}\right)$, the eight corners are occupied by Cl^{Θ} with a $Cs^{\oplus}$ at the centre and vice versa. Calculate the distance between the neighbouring $Cs^{\oplus}$ and Cl^{Θ} ions. What is the radius of the two ions? (Aw of $Cs = 132.91$ and $Cl = 35.45$)

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5. An ionic compound AB has a rock salt structure with A :B = 1:1. the formula mass of AB is 6.023 y amu and the closest A-B distance is $y^{1/3}$ nm.

(a) Calculate the density of the attice.

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

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6. An element crystallises in $f.c.c.$ lattice having edge length $400pm$. Calculate the maximum diameter, which can be placed in interstitial sites without disturbing the structure.

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7. In diamond lattice, all attice point and alternate tetrahedral voids are occupied by carbon atoms.

if diamond crystallizes in fcc form with edge

length 'a' find out .

(b) distance between the next nearest neighbours.

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8. A metallic crystal cystallizes into a lattice containing a sequence of layers $ABABAB\ldots$. Any packing of spheres leaves out voids in the lattice. What percentage by volume of this lattice is empty spece?

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9. Calculate the distance between (111) planes in a crystal of calcium. Repeat the calculation for (222) planes. Which palnes are closer ? (a = 0.556 nm)

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10. Determine the miller indices of the shaded plane. Coordinates of the corner of the plane

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11. The coordinate of the three corners of a shaded face on a cubic unit cell are $\left(\frac{1}{2}, \frac{1}{2}, 1\right), \left(0, 1, \frac{1}{2}\right)$ and $\left(1, 1, \frac{1}{2}\right)$ as shown in the figure. Determine the Miller indices of the plane.

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12. The density of sodium chloride at $25^{\circ} C \text{is} 2.163 \times 10^{3} \ \mathrm{kg\,m^{-3}}$ When X -rays rom a palladium target having waveleth of 58.1

pm are used, the (200) reflection of sodium chloride occurs at an angle of 5.90° . How many Na^+ and Cl^- ions are present in the unit cell ? (Molar mass of NaCl = 58.5 $\text{mol}^{-1} \sin 5.9^\circ = 0.1028$)

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13. What fraction (n/N) of the lattice sites are vacant at 298 K for a crystal in which the energy required to make a defect is 1 eV. $(1eV = 1.602 \times 10^{-19} J)$

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14. Metallic magnesium has a hexagonal close packed structure and a density of $1.74g/cm^3$. Assuming magnesium atoms to be spherical, calculate the volume of each atom and atomic radius of Mg atom (Atomic mass of Mg =24)

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15. Calculate the packing fraction and density of diamond if a = 3.57Å . Diamond crystallizes

in fcc lattice with some more carbon atoms in alternate tetrahedral voids.

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16. Calculate the packing effeciency of a fcc crystal in which all the tetrahedral and octahedral voids are occupied by the largest spheres without disturibing the lattice.

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17. Using X -rays of wavelength 154.1 pm and staring from the glancing angle, the reflection fro sliver crystal was found to occur at $\theta = 22.20^{\circ}$. Calculate the spacing between the planes of Ag atoms that gave rise to the above reflection. $(\sin 22.20^{\circ} = 0.3778)$

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18. A reflaction from (111) planes of a cubic crystal was observed ad at a glancing angle of

11.2° when X -rays of wavelength 154 pm were used. What is the length of the side of the unit cell ? $(\sin 11.2^{\circ} = 0.1944)$

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19. When an electron in an excited state of Mo atom falls L to K -shell, an X -ray is emitted. These X -rays are diffranted at angle of 7.75° by planes with a sepration of 2.64Å . What is the difference in energy between K-shelll and L

-shell in Mo, assuming a first order diffraction

? ` (sin 7.75^(@) = 0.1349)

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