UNIT-1 SOLIDS

QUESTIONS CARRYING <u>ONE</u> MARK:

1. Which type of solid is anisotropic in nature?

Ans: Crystalline solids are anisotropic in nature

2. Which type of solids is called as super cooled liquids or pseudo solids?

Ans:Amorphous solids are called super cooled liquids

3. A solid has a sharp melting point, and then to which type of solids does it belong?

Ans: Crystalline solids

4. Which type of solids has long range orderly arrangement of constituent particles?

Ans: Crystalline solids

5. Sodium chloride and quartz belong to which type of solid?

Ans: Crystalline solids

6. A solid shows different values for refractive index when measured in different directions. - Identify the type of solid

Ans: Crystalline solids

7. When a solid is cut with a sharp edged tool, they cut into two pieces and the newly generated surfaces are plain and smooth. – Identify the type of solid.

Ans: Crystalline solids

8. Which type of force of attractions is present between the molecules in polar molecular solids?

Ans: Dipole –dipole interactions

9. Which type of force of attractions is present between the molecules in non-polarmolecular solids?

Ans: London forces or Dispersion forces

10. Which type of force of attractions is present between the particlesin ionic solids?

Ans: Electrostatic force of attraction or coulombic force of attraction

11.Solid SO_2 and solid NH_3belong to which type of molecular solids?

Ans: Polar molecular solids

12. What is crystal lattice?

Ans: The regular three dimensional array of lattice points in space is called crystal lattice

13. What is a unit cell?

Ans: It is the smallest repeating unit which when arranged in three dimension gives the crystal lattice.

14. How many types of primitive unit cells are present?

Ans: Three types

15. What is a primitive cubic unit cell?

Ans: The cubic unit cell in which the particles/atoms are present only at the eightcorner of the cube is called primitive cubic unit cell.

16. Define the co-ordination number of a particle in solids.

Ans:It is the total number of nearest neighboring particles to a given particle.

17. What is the number of octahedral voids generated, if the number of close packed spheres is N?

Ans: N

18. What is the number of tetrahedral voids generated, if the number of close packed spheres is N?

Ans: 2N

19. What is the co-ordination number of a particle in a tetrahedral void?

Ans:Four

20. Among Schottky and Frenkel defect, which type of defect decreases the density of the crystal?

Ans: Schottky defect

21. What are point defects?

Ans: Deviations from the ideal arrangement around a particular point or an atomin a crystalline solid

22. What are F-centers?

Ans: The anionic sites occupied by the unpaired electrons are called F- centre.

23. To which colour potassium chloride crystal turns, when excess potassium ionis present?

Ans: Violet

24. Name the type of non-Stoichiometric defect observed when white ZnO turns yellow on heating.

Ans: Metal excess defect

25. Name the non-Stoichiometric defect responsible for the composition of ferrous oxide to be $Fe_{0.95}O_1$.

Ans:Metal deficiency defect

26. Which type of point defect is observed when NaCl containing little $SrCl_2$ is crystallized?

Ans:Impurity defect

27. Which defect is also called as dislocation defect?

Ans:Frenkel defect

28. What is doping?

Ans: The process of increasing the conductivity of an intrinsic semiconductors by adding asuitable impurity is called doping

29. What type of semiconductors are obtained when silicon doped with boron impurity?

Ans: p-type semiconductor

30. Name the unit used to measure magnetic moment.

Ans: Am^2(1Bohr magneton= 9.27x10-24 Am^2)

31. What are diamagnetic substances?

Ans: These are the substances which are repelled by the magnetic field

32. What are ferromagnetic substances?

Ans: These are the substances which are strongly attracted by the magnet

33. How body diagonal and radius of a sphere(r) are related in bcc unit cell?

Ans:$4r = \sqrt{2}a$

34. Give an example for Ferromagnetic substance.

Ans: Fe Co Ni Gd CrO_2

35. Give an example for Diamagnetic substance.

Ans: H_2O, NaCl, and C_6H_6

QUESTIONS CARRYING TWO MARKS:

1. How crystalline solids differ from amorphous solids in their melting point?

Ans:Crystalline solids have sharp melting point whereas amorphous solid do not have a sharp melting point

2. Write any two differences between crystalline solids and amorphous solids?

Crystalline solid	Amorphous solid
3-D long range orderly arrangement of particles	No orderly arrangement of constituent particles
Sharp Melting point	Do not have sharp M P (Softening temperature)
True solids having definite shape	Pseudo solids having irregular shapes
They have a well-defined cleavage planes	Do not have cleavage planes
Anisotropic in nature	Isotropic in nature

3. What is meant by anisotropy? What type of solids show this nature?

Ans: The physical properties like refractive index, coefficient of thermal expansion, when measured in different directions gives different value for a crystalline solid hence it is anisotropic in nature.
Crystalline solids

4. What are the nature of particles and the force of attractions between the particles in non-polar molecular solids?

Ans: In a non-polar molecular solids, the constituent particles are non-polar moleculeslike H_2, Cl_2, I_2 and even atoms like Ar, Ne, Xe etc.
The nature of force of attraction is weak dispersion force or London force.

5. What are the nature of particles and the force of attractions between the particles in polar molecular solids?

Ans: In a polar molecular solids, the constituent particles are formed by polar covalent bond like HCl, SO_2.
The nature of force of attraction is dipole-dipole attractions

6. What are the nature of particles and the force of attractions between the particles in hydrogen bonded molecular solids?

Ans: In a hydrogen bonded molecular solids, the constituent particles are polar molecules capable of forming hydrogen bond like water.
The nature of force of attraction is hydrogen bonding

7. What are point defects? Mention the types

Ans: Point defects are the irregularities in the arrangement of constituent particlesaround a point or a lattice site in a crystalline substance.
These are of three types.

1. Stoichiometric defects.
2. Non-stoichiometric defect
3. Impurity defect.

8. What are the differences between Schottky and Frenkel defect?

Schottky defect	**Frenkel defect**
a. Shown by ionic solidscontaining similar-sized cationsand anions (having high coordination number)	a. Shown by ionic solids containing largedifferences in the sizes of ions, (having less coordination number)
b. An equal number of cations and anions are missing to maintain electrical neutrality	b. Created when the smaller ion (usually cation) is dislocated from its normal site to an interstitial site
c. Decreases the density of the substance	c. No change in density of the crystal. creates a vacancy defect as well as an interstitial defect .Also known as dislocation defect
d. Example, NaCl, KCl , CsCl, and AgBr	d. Example: AgCl, AgBr, AgI and ZnS

9. What are the nature of particles and the force of attractions between the particles in ionic solids?

Ans: The nature of the particles is ions (both cation and anion). The nature of the force of attraction is electrostatic force or coulombic force

10. What are the nature of particles and type of bonding in network solids?

Ans: The nature of the particles is atoms. The bonding is covalent bond.

11. Classify the following into polar and non-polar molecular solids:
Ar, HCl, I_2 and SO_2

Ans: Non-polar molecular solids: Ar, I_2
Polar molecular solids:HCl, SO_2

12. Calculate the number of particles present per unit cell in an FCC unit cell.

Ans:Contribution of corner particle = 8 x 1/8 = 01
Contribution of a particle at the centreof face = 6 x ½ = 03
Total number particle /unit cell = 04

13. Calculate the number of particles present per unit cell in a BCC unit cell.

Ans:Contribution of corner particle = 8 x 1/8 = 01
Contribution of a particleat the centre = 1 x 1 = 01
Total number particle /unit cell = 02

14. Calculate the number of particles present per unit cell in a simple cubic unit cell.

Ans:Contribution of corner particle = 8 x 1/8 =01
Total number particle /unit cell = 01

15. Mention the two characteristics of a unit cell.

Ans: Two characteristics of unit cells are
a. Edge length
b. Axial angles

16. What is the relation between edge length (a) and radius of the sphere (r) infcc unit cell? What is itspacking efficiency?

Ans: The relationship between edge length and radius of the sphere are $a=2\sqrt{2}\,r$
Packing efficiency is 74%

17. What is the relation between edge length (a) and radius of the sphere (r) in bcc unit cell? What is its packing efficiency?

Ans: The relationship between edge length and radius of the sphere are $a=\frac{4r}{\sqrt{3}}$

Packing efficiency is 68 %

18. How many tetrahedral and octahedral voids is present, if the number of sphere is N?

Ans: The number of tetrahedral void is 2N
The number of octahedral void is N

19. Explain Schottky defect. Give an example.

Ans: The defect which arises due to missing of equal number of cations and anions from the crystal lattice is called Schottky defect. Ex. NaCl, KCl ,CsCl, AgBr

20. Explain Frenkel defect. Give an example.

Ans: The defect in which an ion (generally cation) leaves the original site and occupies the interstitialsite is called Frenkel defect. E. AgCl, AgBr, AgI

21. How Schottky defect and Frenkel defect affect the density of the crystal?

Ans: In Schottky defect density of the crystal decreases.
In Frenkel defect the density of the crystal remains same.

22. Mention the two types of Non-stoichiometric defects in solids?

Ans: Metal excess defect and metal deficiency defect.

23. What is F- center? What colour is imparted to the NaCl crystal, due to the presence of excess sodium?

Ans: The anionic sites occupied by the unpaired electrons are called F- Centre
The colour of NaCl crystal is Yellow

24. Write the formula to calculate the density of the unit cell and explain the terms.

Ans:
z = number of particles present per unit cell

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

M = Molecular mass , d = density N_A = Avogadro's number
a = Edge length.

25. What are n-type and p-type semiconductors?

Ans:
n-type semiconductor is obtained by doping of the crystal of a group 14 element such as Si or Ge, with a group 15 element such as P or As(pentavalent).
Conductivity increases due to negatively charged electrons.

p-type semiconductor is obtained by doping of the crystal of a group 14 element such as Si or Ge, with a group 13 element such as B, Al or Ga(trivalent).
Conductivity increases as a result of electron hole

26. An ionic compound is formed by two elements A and B. The cat ions A are in ccp arrangement and those of anions B occupy all the tetrahedral voids. What is the simplest formula of the compound?

Ans:
Since cations are in ccp arrangement, the total number cat ions A = 4
The number of tetrahedral voids is double the number of particles = 8
All the tetrahedral voids are occupied by anions B.
The number of elements of B = 8
Hence the formula of the ionic compound is A_4B_8 or AB_2

27. A compound is formed by two elements X and Y. The element X forms ccp and atoms of Y occupy 1/3 rd of tetrahedral voids. What is the formula of the compound?

Ans:

Since element X are in ccp arrangement, the number of X per unit cell = 4

The number of tetrahedral void = 8

But only 1/3 rd is occupied by Y, therefore 8 x1/3 = 8/3

Hence the formula of the compound is $X_4Y_{8/3} = X_{12}Y_8$ or X_3Y_2

28. Gold(atomic radius=0.144nm)crystallizesin a face centered unit cell. What is the length of the side of the cell?

Ans:

For FCC the edge length and radius of sphere arerelated by the equation,

r = 0.144nm $a = 2\sqrt{2}\,r$

a = ? $= 2\sqrt{2}$ x 0.144 nm

= 2x1.414 x 0.144

= 0.40723nm.

29. Silver forms ccp lattice and X- ray studies of its crystals show that the edge lengthof its unit cell is 408.6pm. Calculate the density of silver (atomic mass = 107.9 u)

Ans:

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

d= 4 x 107.9/$(4.08)^3$ x10^{-24} x 6.022 x10^{23}

d = 431.6/40.899

d = 10.5528g/cm^3

30. X- ray diffraction studies show that copper crystallizes in an fcc unit cell with cell edge of 3.6 x10^{-8}cm. In a separate experiment, copperis determined to have a density of 8.92g/cm^3,calculate the atomic mass of copper.

Ans:

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

M = d a^3 N_A/Z

= 8.92 x$(3.6)^3$x10^{-24} x 6,022 x10^{23}/4

= 250.61/4

M = 62.6525 u

31. The edge of fcc unit cell of platinum is 392 pm and density is 21.5 g/cm^3, calculate the Avogadro number.

Ans:

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

N_A = Z x M/ d a^3

= 4 x 195.08/21.5 x $(3.92)^3$x 10^{-24}

= 780.32/1295.08 x10^{-24}

N_A= 6.025 x10^{23}

32. A unit cell of sodium chloride has four formula units. The edge length of the unit cell is 0.564 nm. What is the density of sodium chloride?

Ans:

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

d = 4 x 58.5/(5.64)^3 x10^{-24} x 6.022 x10^{23}

d = 234/108.038

d = 2.165 g/cm^3

33. A body centered cubic element having density 10.3 g/cm^3, has a edge length of 314pm. Calculate the atomic mass of the element

(Avogadro's number= 6.023x10^{23}/mol)

Ans:

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

M = d x a^3 xN_A/Z

= 10.3 x (3.14)^{3}x 10-^{24} x 6.022 x10^{23}/2

M = 96.01u

34. Calcium metal crystallizes in a face centered cubic lattice with edge length of 0.556nm. Calculate the density of the metal.

(Atomic mass of calcium = 40g/mol and Avogadro number= 6.022 x10^{23}mol^{-1})

Ans:

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

d = 4 x 40/(5.56)^3 x10^{-24} x 6.022 x10^{23}

d = 160/103.50

d = 1.54 g/cm^3

35. Copper crystallizes into afcc lattice with edge length 3.61 x10^{-8}cm.

Calculate the density of the of the crystal

(Atomic mass of copper =63.5g/mol and Avogadro number= 6.022 x10^{23}mol^{-1})

Ans:

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

d = 4 x 63.5/(3.61)^3 x10^{-24} x 6.022 x10^{23}

d = 254/28.33

d = 8.9 g/cm^3

36. Silver crystallizes in a face centered cubic structure. If the edge length is 4.077 x10^{-8}cm and density is 10.5 g/cm^3, calculate the atomic mass of silver.

Ans:

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

M = d a^3 N$_A$/Z

= 10.5 x (4.077)^{3}x10^{-24} x 6,022 x10^{23}/4

= 103.57/4

The atomic mass of silver M = 107.09 u

37. The density of Li atoms is 0.53g/cm^3.The edge length of Li is 3.5 A^0. Find out the number of Li atoms in a unit cell (N$_0$= 6.022 x10^{23}/mol& M= 6.94)

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

$$Z = d \times a^3 N_A / M$$

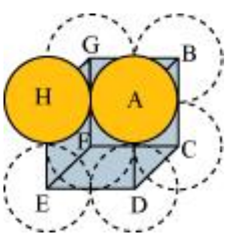
= 0.53 x (3.5)^3 x10^{-24}x 6.022 x10^{23}/6.94

= 2

The number of lithium atoms in unit cell is 2

Questions carrying <u>THREE</u> marks

1. Calculate the packing efficiency in simple cubic unit cell

<table>
<tr>
<td></td>
<td>Edge length of the cube = $a = 2r$
Volume of the cubic unit cell= $a^3 = (2r)^3 = 8r^3$
volume of one particle(sphere) $= \frac{4}{3}\pi r^3$
The number of particles per unit cell $=1$
Total volume occupied by one sphere $=\frac{4}{3}\pi r^3$

Packing efficiency$= \frac{Total\ Volume\ occutied\ by\ one\ sphere}{Volume\ of\ cubic\ unit\ cell} \times 100$
$= \frac{\frac{4}{3}\pi r^3 \times 1}{8\ r^3} \times 100$
= 52.4%</td>
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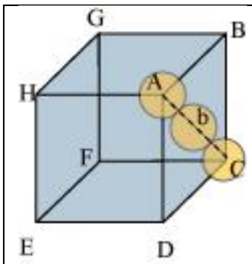
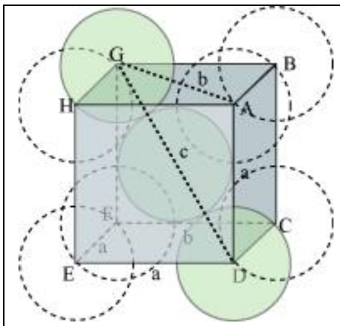
2. Calculate the packing efficiency in face centered cubic unit cell

 edge length of the cube be '*a*' In □ABC $AC^2 = BC^2 + AB^2$ $b^2 = a^2 + a^2$ $b^2 = 2a^2$ $b = \sqrt{2}\ a$ Let the radius of the atom = *r* Length of the diagonal of □ABC, b= 4r $\sqrt{2}\,a = 4r$ $a = 2\sqrt{2}\,r$	Edge length of the cube $= a = 2\sqrt{2}\,r$ Volume of the cubic unit cell$= a^3 = \left(2\sqrt{2}\,r\right)^3$ volume of one particle(sphere) $= \frac{4}{3}\pi r^3$ The number of particles per unit cell =4 Total volume occupied by four spheres = $4 \times \frac{4}{3}\pi r^3$ packing efficiency$= \frac{Total\ Volume\ occutied\ by\ four\ spheres}{Volume\ of\ cubic\ unit\ cell} \times 100$ $= \frac{\frac{4}{3}\pi r^3 \times 4}{\left(2\sqrt{2}r\right)^3} \times 100$ $= \frac{\frac{16}{3}\pi r^3}{16\sqrt{2}r^3} \times 100 =$ **74 %**

3. Calculate the packing efficiency in body centered cubic unit cell

 In □ABG, $b^2 = a^2 + a^2 \Rightarrow b^2 = 2\,a^2$ In, □AGD, $C^2 = a^2 + b^2$ $C^2 = a^2 + 2a^2$ $C^2 = 3a^2 \Rightarrow C = \sqrt{3a}$ Radius of the atom = *r.* Length of the body diagonal, C=4r $\sqrt{3a} = 4r$ $a = \frac{4r}{\sqrt{3}}$	Edge length of the cube $= a = \frac{4r}{\sqrt{3}}$ Volume of the cubic unit cell$= a^3 = \left(\frac{4r}{\sqrt{3}}\right)^3$ volume of one particle(sphere) $= \frac{4}{3}\pi r^3$ The number of particles per unit cell =2 Total volume occupied by two spheres = $2 \times \frac{4}{3}\pi r^3$ packing efficiency$= \frac{Total\ Volume\ occutied\ by\ two\ spheres}{Volume\ of\ cubic\ unit\ cell} \times 100$ $= \frac{\frac{4}{3}\pi r^3 \times 2}{\left(\frac{4}{\sqrt{3}}r\right)^3} \times 100$ $= \frac{\frac{8}{3}\pi r^3}{\frac{64}{3\sqrt{3}}r^3} \times 100$ **= 68%**

4.Based on band theory explain conduction in metals, insulators and semiconductors

Conduction of electricity in metals: In metals, the valence shell is partially filled, so this valence band overlaps with a higher energy unoccupied conduction band so that electrons can flow easily under an applied electric field.
Conduction of electricity in insulators: In insulators, the valence shell is empty, so the gap between the valence band and conduction band is very large. so that electrons cannot flow under an applied electric field.
Conduction of Electricity in Semiconductors In semiconductors, the gap between the valence band and conduction band is so small that some electrons may jump to the conduction band. Electrical conductivity of semiconductors increases with increase in temperature. Substances like Si, Ge show this type of behaviour, and are called intrinsic semiconductors.

5. How are solids classified on the basis of the force of attraction?
Ans:

a. Molecular solids: Particles are held by
a. London forces (in non-polar solids) ex : Benzene, Argon, P_4O_{10}, I_2, P_4
b. Dipole - dipole interaction (in polar solids) ex: Urea, Ammonia
c. Hydrogen bonding (in hydrogen bonded solids) ex: ice

b. Ionic solids

a. Particles are held by ionic bond
b. Conduct electric current in aqueous solution or molten state
c. Examples: NaCl, MgO, ZnS
d. In solid state, ions are held together by strong electrostatic forces and are not free to move about within the solid. Hence, ionic solids do not conduct electricity in solid state. However, in molten state or in solution form, the ions are free to move and can conduct electricity.

c. Covalent or network solids:

a. Particles are held by covalent bonding. Examples SiO_2 (quartz), diamond,

d. Metallic solids:

a. Particles are held by metallic bond.
b. These are electrical conductors, malleable, and ductile. Examples: Fe, Cu,

6. What are point defects? Explain the types.

Ans: Point defects are the irregularities in the arrangement of constituent particles around a point or an atom in a crystalline substance. These are of three types.

1. Stoichiometric defects: Do not disturb stoichiometry of the solid.
These are also called intrinsic or thermodynamic defects
Ex : Frenkel defect, Schottky defect

2. Non-stoichiometric defects: This defect alters the stoichiometric ratio of the constituent elements

i) Metal excess defect
a. Metal excess defect due to anionic vacancies:
b. Metal excess defect due to the presence of extra cations at interstitial sites:

ii) Metal deficiency defect
a. By cation vacancy

3. Impurity defect.

7. What are diamagnetic, paramagnetic and ferromagnetic substances?

1. Paramagnetic substance: The substance which are attracted by the magnet. The magnetic character is temporary and is present as long as the external magnetic field is present. Ex; O_2, Cu^{2+}, Fe^{3+}, Cr^{3+} NO.
2. Diamagnetic substance: The substance which are weakly repelled by the magnetic field TiO_2, H_2O,NaCl.This property is shown by those substance which contain fully –filled orbitals (no unpaired electrons)
3. Ferro magnetic substance: The substance which are strongly attracted by the magnet. They show permanent magnetism even in the absence of magnetic field.
Ex : Fe Co Ni Gd& CrO_2

8. An element with molar mass 2.7 x 10^{-2} kg/mol forms a cubic unit cell with edge length 405pm. If its density is 2.7 x 10^3 kg/m^3, what is the nature of the cubic unit cell
Ans:

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

$$Z = d \times a^3 N_A/M$$

$= 2.7 \times 10^3 \times (405)^3 \times 10^{-27} \times 6.022 \times 10^{23}/2.7 \times 10^{-2}$

$= 4$

Since there are 4 atoms of the element present per unit cell. Hence, the cubic unit cell must be face centered or cubic close packed structure (ccp)

9. Niobium crystallises in body-centered cubic structure. If density is 8.55g/cm^3, calculate atomic radius of niobium, given that its atomic mass is 93 u.

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

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

$= 2 \times 93/8.55 \times 6.022 \times 10^{23}$

$= 36.1 \times 10^6$

$a = (36.1)^{1/3} \times 10^2$

$=330$ pm

For BCC $r = \frac{\sqrt{3}}{4} a$

$r = \frac{\sqrt{3}}{4} \times 330$

$r = 143$pm

10. An element has a body-centered cubic (bcc) structure with cell edge of 288pm. The density of the element is 7.2 g/cm^3. How many atoms are present in 208g of the element?

Ans:

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

M = d a^3 N_A/Z

= 7.2 x $(2.88)^3$x10^{-24} x 6,022 x10^{23}/2

= 103.57/2

M = 51.78 u

51.78 g (1mole) contains 6.022 x10^{23} atoms

Therefore 208g contains 4.01 x 6.022 x10^{23} = 24.187 x10^{23} atoms.