Q1. 'Crystalline Solids are anisotropic in nature'. What does this Statement mean?

A 1. The statement means that some of the physical properties like electrical resistance or refractive index of Crystalline Solids show different values when measured along different directions in the same crystal.

Q 2. Why does the presence of excess of lithium make LiCl crystals pink?

A 2. The presence of excess of lithium makes LiCl crystals pink due to e^{-s}trapped in anionic vacancies (F centers). These electrons absorb some energy of the white light giving pink colour to LiCl crystal.

Q3. What is meant by anti-ferromagnetism? What type of substances exhibit anti ferromagnetism?

A3. Substance like MnO, MnO_2 in which magnetic domains are oppositely oriented and cancel out each other's magnetic moment exhibit anti ferromagnetism. Magnetic. Alignment of magnetic moments in antiferromagnetic substance:-

$$\downarrow\uparrow\downarrow\ \uparrow\ \downarrow\uparrow$$

OR

Q3 What type of substance would make better magnets, ferromagnetic or ferromagnetic?

A3. Ferromagnetic substance would make better magnets because when ferromagnetic substance is placed in magnetic field all the domains get oriented in the directionof the magnetic field and a strong magnetic effect is produced eg : Co, Ni

Q4. In a compound nitrogen atoms (N) make ccp and metal atoms (M) occupy one third of the tetrahedral voids present. Determine the formula of the compound formed by M & N?

A4. Let the no of nitrogen atoms (N) be x

No of tetrahedral voids = 2x

No of metal atoms = 2/3 x.

Ratio of M:N = 2/3x : x

Therefore the formula of the compound is $M_2 N_3$

Q 5. Classify each of the following as being either a p type or n type semi conductor?

(i) Ge doped with In.
(ii) B doped with Si.

A 5. (i) P type semiconductor because when group 14 element is doped with group 13 element, an electron deficit hole is created.

(ii) n type semiconductor because when group 13 element is doped wih group 14 element , free electrons will become available.

Q 6. Analysis shows that nickel oxide has the formula $Ni_{0.98}$ $0_{1.00}$. What fractions of nickel exist as Ni^{2+} and Ni^{3+} ions?

A6. The formula of the oxide is $Ni_{0.98}$ $0_{1.00}$
Let the number of O^{2-} ions be 100.
Then number of nickel ions = 98
Let the number of Ni^{2+} be x
Then number of Ni^{3+} = 98 - x

Since total charge on cations = total charge on anions.

X x (2) + (98-x) x (3) = 100 x 2
2x + 294 – 3x = 200
x = 94

% of Ni^{2+} = $\frac{94}{98}$ x 100 = 96%

% of Ni^{3+} = 100 -96 = 4%

Q 7. A compound forms hcp structure. What is the total number of voids in 0.5 mol of it? How many of these are tetrahedral voids?

A7. No of atoms = 0.5 mol = 0.5 x 6.022 x 10^{23}
= 3.011 x 10^{23}

No of octahedral voids = no of atoms in hcp structure
= 3.011 x 10^{23}

No of tetrahedral voids = 2 x no of atoms in hcp structure
= 2 x 3.011 x 10^{23}
= 6.022 x 10^{23}

Total no of voids = 6.022 x 10^{23} + 3.011 x 10^{23}
= 9.033 x 10^{23}

Q 8. If NaCl crystals are doped with 2 x 10^{-3} mol percent of $SrCl_2$,calculate the cation vacancies per mole?

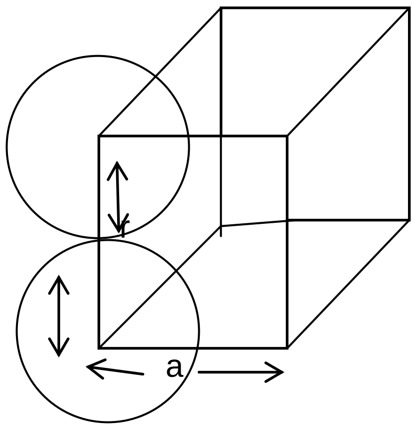
A 8. Doping of NaCl with 2 x 10 $^{-3}$mol percent of $SrCl_2$ means 100 moles of NaCl is doped with 2 x 10 $^{-3}$ mole of $SrCl_2$ or 1 mole of NaCl is doped with 2 x 10^{-5} mole of $SrCl_2$

Each Sr^{2+} will occupy the place of Na^+ and displace one Na^+ from crystal lattice to create cation vacancies.

Cation vacancies = Number of Sr^{2+} ion added.
= 2 x 10^{-5} mol = 2 x 10^{-5} x 6.022 x 10^{23}. = 12.046 x 10^{18} mol $^{-1}$

Q 9. Calculate the packing efficiency of a metal crystal for a simple cubic lattice?

A 9. Packing efficiency in simple cubic lattice



$$\frac{\text{Volume of one atom x 100}}{\text{Volume of cubic unit cell } (a^3)}$$

Since a= 2r for simple cubic

Vol of one atom $=4/3\pi r^3$

$$= \frac{4/3 \, \pi \, r^3 \times 100}{(2\,r)^3}$$

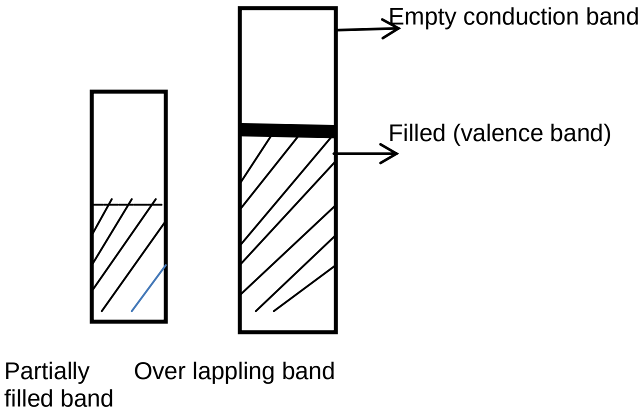
$$= \frac{4 \times 3.14 \times r^3 \times 100}{3 \times 8 \times r^3}$$

$= 52.36\% \approx 52.4\%$

Q10. In terms of band theory.What is the difference?

(a) between a conductor and an insulator.

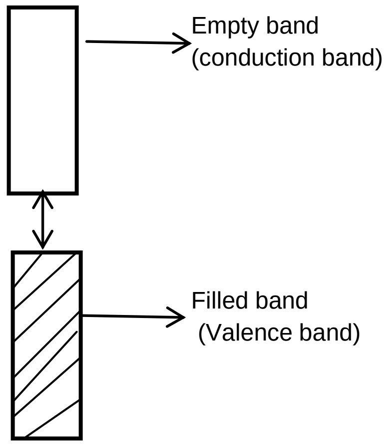
(b) between a conductor and a semi conductor.



<u>**Conductors**</u>

A 10 (a) In conductors, energy band is partially filled or it overlaps with a higher energy unoccupied conduction band. Due to this electrons can flow easily under an applied electric field and show conductivity

In insulators, the gap between filled valence band and the next higher unoccupied band is large, hence electrons cannot jump to it and substance has very small conductivity and behaves as an insulator.



(b) In semiconductors the gap between valence band and conduction band is small. Therefore some electrons may jump from valence band to conduction band and show some conductivity eg 'Si' and 'Ge'

Q11.) Aluminum crystallizes in a cubic close packed structure. Its metallic radius is 125 pm.

(a) What is the length of the side of the unit cell?

(b) How many unit cells are there in 1 cm^3 of aluminum?

A11. (a) In a cubic close packed structure :-

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

Given $r = 125 \times 10^{-12}$ m

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

$a = 125 \times 10^{-12} \times 2 \times 1.414$ m = 354 pm.

(c) $a^3 = (354)^3 \times (10^{-12})^3$
$= 44.21 \times 10^{-30}\ m^3$

No of unit cells in 1 cm^3 $= \frac{\text{Total Volume}}{\text{Vol of one unit cell}} = \frac{10^{-6}}{44.21 \times 10^{-30}}$

$= 2.261 \times 10^{22}$ unit cells.

Q12 Account for the following :-

(i) Table salt, NaCl sometimes appears yellow in colour.

(ii) FeO(s) is not formed in stoichiometric composition.

(iii) Some of the very old glass objects appear slightly milky instead of being transparent.

A12. (i) Yellow colour in NaCl is due to metal excess defect due to which unpaired electrons occupy anionic vacancies. These sites are called F centers. These electrons absorb energy from the visible region and transmits yellow colour.

(ii) In the crystal of FeO, some of the Fe^{2+} cations are replaced by Fe^{3+} ions. Three Fe^{2+} ions are replaced by two Fe^{3+} ions to make up for the loss of positive charge. Thus there would be less amount of metal as compared to stoichiometric properties.

(iii) Very old glass objects become slightly milky, because of heating during the day & cooling at nights i.e annealing. Over a number of years, glass acquires some crystalline character.

Q13. The density of copper is 8.95 gcm^{-3}. It has a face centered cubic structure. What is the radius of copper atom? (Atomic mass Cu = 63.5 g mol^{-1} . $N_A = 6.022 \times 10^{23}\ mol^{-1}$) ?

A13. Mass per unit cell $= \frac{\text{Atomic mass of Cu} \times 4}{N_A}$

$= \frac{63.5 \times 4}{6.022 \times 10^{23}}$

$= 4.22 \times 10^{-22}$ g

Volume of unit cell $= \frac{\text{Mass}}{\text{Density}}$

$= \frac{4.22 \times 10^{-22}}{8.95}$

$= 4.7 \times 10^{-23}\ cm^3$

Edge $= (\text{Volume})^{1/3}$

$= (4.7 \times 10^{-23})^{1/3}$

$= 3.61 \times 10^{-8}$ cm or 361pm

For fcc, r $= \frac{a}{2\sqrt{2}}$

r $= \frac{361}{2 \times 1.41}$

r = 128 pm

14.Why are solids rigid?

A 14.The intermolecular forces of attraction that are present in solids are very strong. The constituent particles of solids cannot move from their positions i.e., they have fixed positions. However, they can oscillate about their mean positions. This is the reason solids are rigid.

15.Why do solids have a definite volume?

A15. The intermolecular forces of attraction that are present in solids are very strong. The constituent particles of solids have fixed positions i.e., they are rigid. Hence, solids have a definite volume.

16. Why is glass considered a super cooled liquid?

A 16. Similar to liquids, glass has a tendency to flow, though very slowly. Therefore, glass is considered as a super cooled liquid. This is the reason that glass windows and doors are slightly thicker at the bottom than at the top.

17. Refractive index of a solid is observed to have the same value along all directions. Comment on the nature of this solid. Would it show cleavage property?

A17. An isotropic solid has the same value of physical properties when measured along different directions. Therefore, the given solid, having the same value of refractive index along all directions, is isotropic in nature. Hence, the solid is an amorphous solid.

When an amorphous solid is cut with a sharp edged tool, it cuts into two pieces with irregular surfaces.

18. Explain how vacancies are introduced in an ionic solid when a cation of higher valence is added as an impurity in it.

A18. When a cation of higher valence is added to an ionic solid as an impurity to it, the cation of higher valence replaces more than one cation of lower valence so as to keep the crystal electrically neutral. As a result, some sites become vacant. For example, when Sr^{2+} is added to NaCl, each Sr^{2+} ion replaces two Na^+ ions. However, one Sr^{2+} ion occupies the site of one Na^+ ion and the other site remains vacant. Hence, vacancies are introduced.

19. Ionic solids, which have anionic vacancies due to metal excess defect, develop colour. Explain with the help of a suitable example.

A19. The colour develops because of the presence of electrons in the anionic sites. These electrons absorb energy from the visible part of radiation and get excited.

For example, when crystals of NaCl are heated in an atmosphere of sodium vapours, the sodium atoms get deposited on the surface of the crystal and the chloride ions from the crystal diffuse to the surface to form NaCl with the deposited Na atoms. During this process, the Na atoms on the surface lose electrons to form Na^+ ions and the released electrons diffuse into the crystal to occupy the vacant anionic sites. These electrons get excited by absorbing energy from the visible light and impart yellow colour to the crystals.

20. Silver crystallises in fcc lattice. If edge length of the cell is 4.07×10^{-8} cm and density is 10.5 g cm^{-3}, calculate the atomic mass of silver.

It is given that the edge length, $a = 4.077 \times 10^{-8}$ cm

Density, $d = 10.5$ g cm^{-3}

As the lattice is fcc type, the number of atoms per unit cell, $z = 4$

We also know that, $N_A = 6.022 \times 10^{23}\ mol^{-1}$

Using the relation:

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

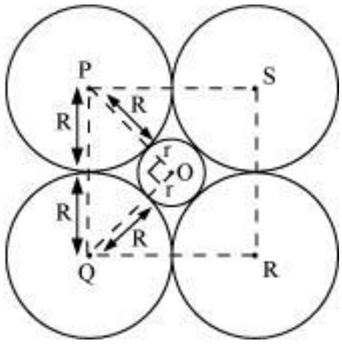
$$\Rightarrow M = \frac{d\,a^3\,N_A}{z}$$

$$= \frac{10.5\ gcm^{-3} \times \left(4.077 \times 10^{-8}\ cm\right)^3 \times 6.022 \times 10^{23}\ mol^{-1}}{4}$$

= 107.13 $gmol^{-1}$

Therefore, atomic mass of silver = 107.13 u

21. If the radius of the octachedral void is r and radius of the atoms in close packing is R, derive relation between r and R.



A sphere with centre O, is fitted into the octahedral void as shown in the above figure. It can be observed from the figure that ΔPOQ is right-angled

$\angle POQ = 90^0$

Now, applying Pythagoras theorem, we can write:

$$PQ^2 = PO^2 + OQ^2$$
$$\Rightarrow (2R)^2 = (R + r)^2 + (R + r)^2$$
$$\Rightarrow (2R)^2 = 2(R + r)^2$$
$$\Rightarrow 2R^2 = (R + r)^2$$
$$\Rightarrow \sqrt{2}R = R + r$$
$$\Rightarrow r = \sqrt{2}R - R$$
$$\Rightarrow r = (\sqrt{2} - 1)R$$
$$\Rightarrow r = 0.414 R$$

22. Copper crystallises into afcc lattice with edge length 3.61×10^{-8} cm. Show that the calculated density is in agreement with its measured value of 8.92 g cm^{-3}

Edge length, $a = 3.61 \times 10^{-8}$ cm

As the lattice is fcc type, the number of atoms per unit cell, $z = 4$

Atomic mass, M = 63.5 g mol^{-1}

We also know that, $N_A = 6.022 \times 10^{23}$ mol^{-1}

Applying the relation:

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

$$= \frac{4 \times 63.5 \text{ g mol}^{-1}}{\left(3.61 \times 10^{-8} \text{ cm}\right)^3 \times 6.022 \times 10^{23} \text{mol}^{-1}}$$

= 8.97 g cm^{-3}

The measured value of density is given as 8.92 g cm^{-3}. Hence, the calculated density 8.97 g cm^{-3} is in agreement with its measured value.