

Chemistry-Std-XII-Science

Chapter: The Solid State

Crystalline and amorphous solids

Question 1

'Crystalline solids are anisotropic in nature'. What does this statement mean?

Ans.

This statement means that some of the physical properties of crystalline solids such as electrical resistance or refractive index show different values when measured along different directions in the same crystals.

Question 2

Write a feature which will distinguish a metallic solid from an ionic solid.

Ans.

Metallic solids	Ionic solids
Metallic solids are conductors of electricity in solid state as well as in molten state.	Ionic solids are insulators in solid state but conductors in molten state and in aqueous solutions.

Question 3

Explain and illustrate binding force in metallic crystal.

Ans.

Metals too are crystalline. They are bonded by the strong bond called the metallic bond which is a compact packing of positive charge in a pool of delocalized electrons. As a result are hard and conduct electricity.

Question 4

What is isotropy.

Ans.

In amorphous solids there is short range order value of all properties remain same along any direction and are **isotropic** in nature. An amorphous substance, such as window glass, tends to be isotropic

Question 5

With example explain difference between crystalline and amorphous solids.

Ans.

Amorphous	Crystalline
A solid substance with its atoms held apart at equilibrium spacing, but with no long-range periodicity in atom location in its structure is an amorphous solid. Examples of amorphous solids are glass and some	In crystalline solids you can see there is long range order. Arrangement of particles in crystalline solids is different along different directions so the value of properties like

Chemistry-Std-XII-Science

types of plastic. In amorphous solids there is short range order value of all properties remain same along any direction and are isotropic in nature.

refractive index or electrical resistance vary in different direction and such solids are.

Crystals will melt at a fixed temperature called melting pt.

Arrangement of particles in crystalline solids is different along different directions so the value of properties like refractive index or electrical resistance vary in different direction and such solids are Anisotropic.

Question 6

Give the basis of classification of crystalline solids and deciding factor of there properties.

Ans.

The classification of crystals depend on the constituting particle and the binding force. If the properties of each type of crystal is compared it is observed the properties are related to the binding force.

Question 7

Under what conditions will sodium chloride conduct electricity.

Ans.

Sodium chloride is ionic solids made of sodium and chloride ions bonded to each other by ionic bond. In solid state the high binding energy keeps the ion in fixed sites permitting only rotational and vibrational movement. In molten state the movement of ions is not restricted so in electrical field the ions move towards the opposite field.

Question 8

With an example explain glass is a super cooled liquid or a pseudo solid.

Ans.

An amorphous substance, such as glass, tends to be isotropic. This difference may make it possible to distinguish between a glass and a crystal. Amorphous materials, like window glass, have no long-range order at all, so they have no translational symmetry. The structure of an amorphous solid (and indeed a liquid) is not truly random - the distances between atoms in the structure are well defined and similar to those in the crystal. This is why liquids and crystals have similar densities - both have short-range order that fixes the distances between atoms, but only crystals have long-range order. Amorphous materials like glass have no 'distinct' crystal directions, so anisotropic properties are generally not observed. For example Glass panes fixed to old building are thicker at the bottom than the top because amorphous solids do not melt at a sharp

Chemistry-Std-XII-Science

melting point. They soften over a range of temperature and can be molded and blown. Like liquids amorphous solids have a tendency to flow very slowly and the movement is not noticeable. Therefore they are called super cooled liquids or pseudo solids.

Question 9

Name the binding force in each of the following. (a) Molecular (b) Ionic (c) Covalent (d) Metallic.

Ans.

Type of crystal.	Molecular	Metallic	Covalent	Ionic
Bonding force	Dispersion Dipole-dipole H-bonding	Positive kernel and delocalized electrons	Covalent bond between atoms	Electrostatic bond or ionic bond between constituting ions.

Question 10

Which type of solids will show least melting point. Give reason.

Ans.

Molecular crystals are made of molecules and are held by weak dispersion force or dipole-dipole interaction so are soft and melt easily. As the Binding energy holding the molecule is weakest they have least melting point. . Like ice & sugar.

Question 11

How is crystalline solid converted to amorphous.

Ans.

When the crystalline solids are melted and the liquid is cooled rapidly enough to avoid crystallization, an amorphous solid is formed. For example the two forms of quartz sand converted to glass.

Question 12

Give reasons why are ionic crystals hard and brittle.

Ans.

Binding energy in ionic crystal ranges between 400 to 4000 kJ/mol and its melting point is upto 1500K. Ionic crystal is made of ions bonded to each other by ionic bond which is non directional so they are hard and brittle .

Chemistry-Std-XII-Science

Question 13

Classify solids and give basis of their classification.

Ans.

Solids are classified as **crystalline** and **amorphous**. Crystalline solids have ions, atom or molecules arranged in an orderly array and the elementary particles have a fixed site/place. The fundamental difference between single crystal and amorphous solids is the length scale over which the atoms are related to one another by translational symmetry ('periodicity' or 'long-range order'). Crystals have infinite periodicity and amorphous solids (and liquids) have no long-range order.

Question 14

Name the binding forces that exist in molecular crystals.

Ans.

Molecular crystals show Dispersion force called London force also, Dipole-dipole and H-bonding.

Question 15

Give two examples each of (a) Molecular (b) Ionic (c) Covalent (d) Metallic.

Ans.

Types of solids	Molecular e.g. ice, sugar	Metallic e.g. Silver, gold	Covalent e.g. sand, diamond)	Ionic e.g. Common salt NaCl and potassium chloride.
-----------------	------------------------------	----------------------------------	------------------------------------	---

Question 16

Give difference between ionic and molecular crystals.

Ans.

Molecular Molecular crystals are made of molecules and are held by weak dispersion force or dipole-dipole interaction so are soft and melt easily. They are soft and insulators as there are no charged particles to conduct electricity. As the binding energy holding the molecule is weak they have low melting point. Like ice & sugar.	ionic The most common type of crystal is ionic made of ions bonded to each other by ionic bond. All salts that you see and analyze are ionic with high binding energy and melting point. Like NaCl, KBr and KI.
---	---

Chemistry-Std-XII-Science

Question 17

Describe crystalline solids.

Ans.

In crystalline solids you can see there is long range order. Arrangement of particles in crystalline solids is different along different directions so the value of properties like refractive index or electrical resistance vary in different direction such solids are anisotropic. Crystals will melt at a fixed temperature called melting point. Crystalline solids when melted and cooled rapidly form amorphous solid.

Question 18

Which type of crystals show anisotropy. Describe anisotropy.

Ans.

In crystalline solids you can see there is long range order. Arrangement of particles in crystalline solids is different along different directions so the value of properties like refractive index or electrical resistance vary in different direction such solids are anisotropic. Crystals will melt at a fixed temperature called melting point. Crystalline solids when melted and cooled rapidly form amorphous solid.

Three dimensional packing

Question 1

What types of voids are formed in close packing.

Ans.

There are two types of voids in the second layer. The triangular void of the first and second layer called tetrahedral void. Second is a combination of triangular void of first layer & triangular void of second layer called octahedral void.

Question 2

Illustrate the formation of first layer A.

Ans.

In the first layer arrange spheres as close as possible in x- axis . Place spheres in between the space of the spheres of the x-axis to occupy maximum space. This forms the first layer i.e. hexagonal arrangements called A.

This is first layer (A) the basic repeating unit is hexagonal.

Question 3

Formula of oxide of copper is CuO. If oxide forms the close packing what will be the ratio of octahedral void occupied by copper.

Ans.

If oxide forms the close packing the ratio of octahedral void occupied by copper be 1:1.

For Cu: O to be 1: 1 all the octahedral void should be occupied

Chemistry-Std-XII-Science

Question 4

If formula of the compound is A_2B_3 A forms the close packing how many octahedral voids are occupied.

Ans.

In this compound A forms the close packing and B occupies the $\frac{2}{3}$ the octahedral void. Ratio will be n A: $\frac{2}{3}$ n B.

Question 5

In which packing the first and third layer are same.

Ans.

In hexagonal packing the first and third layer are same represented as AB-AB packing.

Question 6

Chloride ion forms the close packing and calcium ion occupies $\frac{1}{2}$ the octahedral voids. What is the formula.

Ans.

Imagine x oxide ions form the close packing number of octahedral voids formed will be x and $\frac{1}{2}$ voids are occupied by calcium ratio of calcium : oxide is $\frac{1}{2}$ x: x so the formula the formula will be $CaCl_2$.

Question 7

If atom A forms the close packing B occupies $\frac{1}{4}$ the octahedral void and C occupies the $\frac{1}{4}$ the tetrahedral void, find the formula of the compound.

Ans.

Step 1--- If n number of A forms the close packing 2n tetrahedral voids will be formed and n octahedral void will be formed.

Step 2---- If $\frac{1}{4}$ the Tetrahedral voids and $\frac{1}{4}$ the octahedral voids are occupied then the ratio will be nA : n x $\frac{1}{4}$ B : 2n x $\frac{1}{4}$ C = A : $\frac{1}{4}$ B : $\frac{1}{2}$ C, formulas are whole number so multiply by 4

Step 3--- The formula of the compound is A_4BC_2

Question 8

In iron oxide, oxide ion forms the close packing and iron occupies all the octahedral void. Give the formula of the iron oxide.

Ans.

Step1.--- n oxide : n iron

Step2-----1oxide : 1 iron

Step3---- 1oxide(O) : 1 iron(Fe) ☐ formula is FeO

Chemistry-Std-XII-Science

Question 9

If 300 atoms form close packing how many tetrahedral void and octahedral void will be formed

Ans.

If n number of atoms form close packing then $2n$ tetrahedral voids & n Octahedral voids are formed. For 300 atoms forming close packing 600 tetrahedral void and 300 octahedral void will be formed.

Question 10

Define coordination number in hexagonal close packing.

Ans.

In hcp each sphere has 6 spheres as immediate neighbor in the same plane & 3 in the plane above & 3 in the plane below i.e. one sphere is surrounded by 12 spheres. Number of nearest neighbor is called coordination number.

Question 11

Give coordination number of octahedral void.

Ans.

Coordination number is 6. The space unoccupied between 4 spheres in one plane & 2 spheres in the axis and space occupied is 74%.

Question 12

Why do solids show close packing.

Ans.

Crystal is a regular, repeating arrangement of atoms or molecules. The majority of solids, including all metals, adopt a crystalline arrangement because the amount of stabilization achieved by anchoring interactions between neighboring particles is at its greatest when the particles adopt regular (rather than random) arrangements. In the crystalline arrangement, the particles pack efficiently together to minimize the total intermolecular energy.

Question 13

Compare the two types of voids formed in cubic close packing.

Ans.

Number of spheres in octahedral void is six—4 in one plane & 2 in the axis and Coordination number is 6 the space occupied is 74%.

In tetrahedral void number of spheres is Four—3 in one plane and 1 in the axis and Coordination number is 4 in this also 74% space is occupied.

Chemistry-Std-XII-Science

Question 14

How will you distinguish Hexagonal close packing and cubic close packing?

Ans.

First layer & second layer are same in both referred as A & B respectively. In the third layer if the sphere is placed on the tetrahedral void the third layer will be identical to the first layer (A) it is called hexagonal close packing (hcp) & arrangement will be AB-AB-AB e.g. Mg & Zn. If the sphere is placed on octahedral void a new layer the third layer (C) will be formed this arrangement its called cubic close packing (ccp) & arrangement will be ABC-ABC-ABC e.g. Cu, Ag & Au.

Question 15

Explain the cubic close packing.

Ans.

If the sphere is placed on octahedral void of the second layer the third layer (C) will be formed and this arrangement is called cubic close packing (ccp) & arrangement will be ABC-ABC-ABC e.g. Cu, Ag & Au.

Packing Efficiency

Question 1

In chromium (III) chloride, CrCl_3 , the chloride ions have CCP (cubic close packing) arrangement and Cr (III) ions are present in octahedral holes. What fraction of the octahedral holes is occupied? What fraction of the total number of holes is occupied?

Ans.

In CCP arrangement each chloride ion would have one octahedral void and two tetrahedral void associated with it.

Number of octahedral voids with 3 chloride ions = 3

Number of tetrahedral voids with 3 chloride ions = $3 \times 2 = 6$

Total number of voids with 3 chloride ions = 9

Number of octahedral voids occupied by Cr (III) = 1

Fraction of octahedral voids occupied = $\frac{1}{3}$

Fraction of total number of voids occupied = $\frac{1}{9}$.

Question 2

A FCC lattice cube is formed by atoms A and B .if atom A is present at the corner of the cube and the atom B at the faces of the cube. Find out the formula of the compound?

Ans.

www.vijaynazare.weebly.com

Chemistry-Std-XII-Science

Contribution of atom A at eight corners of the cube = $\frac{1}{8} \times 8 = 1 \text{ atom}$

Contribution of atom at each face = $\frac{1}{2}$ atom

Contribution of atom B at six faces of the cube = $\frac{1}{2} \times 6 = 3 \text{ atoms}$

Formula of the compound = AB_3

Question 3

A cubic solid is made of two elements P and Q. Atoms P are at the corners of the cube and Q at the edge centre and the body centre. What is the formula of the compound?

Ans.

The atom at corner makes $\frac{1}{8}$ contribution while atom at body center makes 1 contribution to the unit cell.

Number of atoms of P per unit cell = $8 \text{ (at corners)} \times \frac{1}{8} = 1$

Number of atoms of Q per unit cell = $\frac{1}{4} \times 12 + 1 \times 1 = 4$

Therefore formula of the compound is PQ_4 .

Question 4

In corundum oxide, ions are arranged in HCP array and the aluminum ions occupy two-thirds of octahedral voids. What is the formula of corundum?

Ans.

In a close packing (hcp) or (ccp) there is one octahedral void corresponding to each atom constituting the close packing.

In corundum only two thirds of octahedral voids are occupied. It means that corresponding to each oxide ion there are $\frac{2}{3}$ aluminium ions. The whole number ratio of oxide and aluminium ion in corundum is, therefore 3:2.

Hence, formula of corundum is Al_2O_3 .

Question 5

In a solid, oxide ions are arranged in CCP, cation A occupy one-sixth of the tetrahedral voids and cations B occupy one third of the octahedral voids. What is the formula of the compound?

Ans.

Chemistry-Std-XII-Science

In CCP, there would be 2 tetrahedral voids and 1 octahedral void. One-third octahedral voids are occupied by B while one-sixth tetrahedral voids are occupied by A. Thus, formula of the compound may be derived as



Question 6

In AB_2O_4 , the oxide ions are placed in cubic close packed lattice, cation A is present in tetrahedral voids and cations B are present in octahedral voids .what is the percentage of tetrahedral and octahedral voids occupied by A and B respectively?

Ans.

In CCP lattice of oxide ions, there would be two tetrahedral voids and one octahedral void for each oxide ion. Therefore for four oxide ions, there would be 8 tetrahedral and 4 octahedral voids. Out of 8 tetrahedral voids, 1 is occupied by A and out of 4 octahedral voids 2 are occupied by B

$$\% \text{ of tetrahedral voids occupied by A} = \frac{1}{8} \times 100 = 12.5\%$$

$$\% \text{ of octahedral voids occupied by B} = \frac{2}{4} \times 100 = 50\%$$

Question 7

An element exists as hexagonal close packed structure as well as cubic close packed structure. In which case the element would have higher density?

Ans.

The density of the element will be same in both the cases as the two structures will have the same coordination number and hence the same packing fraction.

Question 8

What is the co-ordination number of atoms in BCC, HCP, CCP and simple lattices?

Ans.

The co-ordination number of atoms in BCC lattice is 8, in HCP lattice 12, in CCP lattice 12 and in simple lattice it is 6.

Question 9

What is co-ordination number?

Ans.

The number of nearest neighbours in a packing is called co-ordination number.

Question 10

What is the percentage of space occupied by the spheres in hexagonal close packing in two dimensions?

Ans.

In hexagonal close packing in two dimension 52.4% of the total space is occupied by spheres.

Chemistry-Std-XII-Science

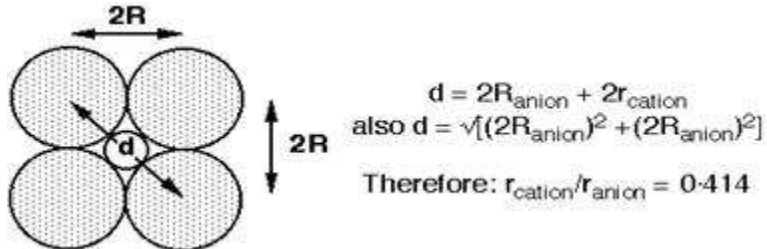
Crystal lattice

Question 1

If the radius of the cation is r present in octahedral void and radius of the anion in close- packing is R , derive relation between r and R .

Ans.

Relation between r and R .

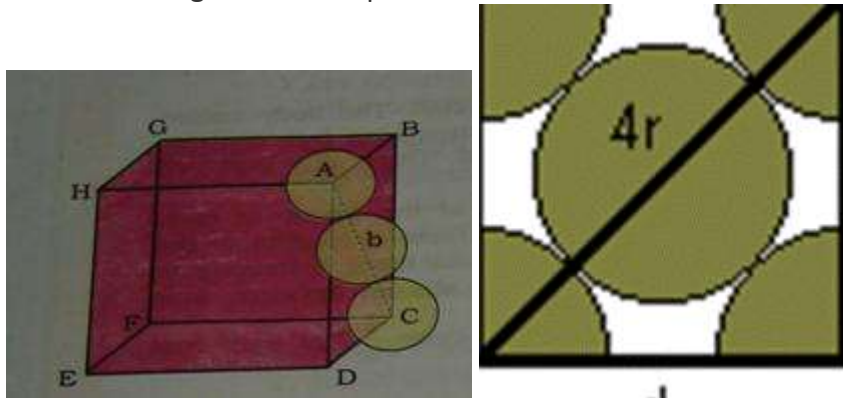


Question 2

Show that 74% space is occupied in case of face centered cube.

Ans.

In the face diagonal three spheres touch each other.



In ΔABC Using the Pythagorean Theorem...

$$AC^2 = b^2 = BC^2 + AB^2$$

$$= a^2 + a^2 = 2a^2 \text{ or}$$

$$b = \sqrt{2}a$$

If r is the radius of the sphere,

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

$$\text{or } a = 4r/\sqrt{2} = 2\sqrt{2}r$$

volume of the cube is a^3 or $(2\sqrt{2}r)^3$.

Packing efficiency = Volume occupied by four spheres in the unit cell $\times 100$ / Total

volume of the unit cell. %

$$= 4 \times \left(\frac{4}{3}\right) \pi r^3 \times 100 / (2\sqrt{2}r)^3 \%$$

$$= (16/3) \pi r^3 \times 100 / 16\sqrt{2}r^3 \%$$

$$= 74\%.$$

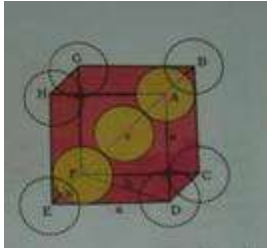
Chemistry-Std-XII-Science

Question 3

Show in case of body centered cube only 68% the space is occupied and rest is unoccupied.

Ans.

Atom in the body diagonal will be in touch with other two atoms diagonally.



In ΔEFD ,

$$b^2 = a^2 + a^2 = 2a^2,$$

$$b = \sqrt{2}a$$

Now in ΔAFD

$$c^2 = a^2 + b^2 = a^2 + 2a^2 = 3a^2$$

$$c = \sqrt{3}a$$

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

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

Volume of the cube = a^3 will be equal to $a^3 = \left[\frac{4}{\sqrt{3}} \times r\right]^3$.

Packing efficiency = volume occupied by two spheres in the unit cell $\times 100$ / total volume of the unit cell %

$$= 2 \times \left(\frac{4}{3}\right) \pi r^3 \times 100 / \left[\left(\frac{4}{\sqrt{3}}\right)r\right]^3 \%$$

$$= \left(\frac{8}{3}\right) \pi r^3 \times 100 / 64 / (3\sqrt{3})r^3 \% = 68\%.$$

Question 4

How many octahedral voids and tetrahedral voids are formed in one cube.

Ans.

Octahedral voids are formed by 6 spheres and so there will be 4 octahedral voids in a cube and tetrahedral voids are formed by 4 spheres so there are 8 tetrahedral voids in a cube.

Question 5

Compare the space available in the two types of voids formed in the solids.

Ans.

The stacking of two close packed anion layers produces 2 types of voids or holes. One set of holes are octahedrally coordinated by 6 anions, the second set are tetrahedrally coordinated by 4 anions. Six particles form the octahedral void 4 in one plane and one above and one below. If the radius of the bigger ion which is generally the anion is R and of the smaller ion r then the radius ratio = .414. Similarly for a perfect fit of a cation into the tetrahedral sites it can be shown that $r_{\text{cation}}/r_{\text{anion}} = 0.225$.

Chemistry-Std-XII-Science

Question 6

In ionic compounds what is the criteria which ion will form the close packing.

Ans.

In case of ionic compounds bigger ion forms the close packing and smaller ion occupies the void space.

Question 7

Compare the most preferred packing of solids to the least preferred packing of solids.

Ans.

The most preferred packing is face centered cubic by solids and the least preferred packing is simple cube. The packing efficiency is maximum in face centered cube so it is very stable. If we compare the values obtained for the two unit cells, we see that "packing efficiency" increases in the face-centered cubic 74% > simple cubic 52%.

Question 8

Define packing efficiency.

Ans.

The packing efficiency is the fraction of the crystal or unit cell actually occupied by the atoms. It is impossible to pack spheres without having some empty space between them.

Packing efficiency = area of the spheres in the unit cell / total area of unit cell

Question 9

Which is the least preferred type of close packing in crystals?

Ans.

Least space occupied is in simple cube 52% and this is the least preferred type of close packing in crystals.

Question 10

What is the volume occupied in body centered cube.

Ans.

The number of atoms in body centered cube is 2. One in the corners and 1 in the body diagonal. Volume of two spheres = $2 \times \left(\frac{4}{3}\right) \pi r^3$ so you can see the actual volume occupied.

Chemistry-Std-XII-Science

Dimensions of Unit cells

Question 1

Silver crystallizes in face-centred cubic unit cell. Each side of this unit cell has a length of 400 pm. Calculate the radius of the silver atom. (Assume the atoms just touch each other on the diagonal across the face of the unit cell. That is each face atom is touching the four corner atoms.)

Ans.

Given, silver crystallizes in fcc unit cell

$$\text{So, } r = \frac{a}{2\sqrt{2}}$$

Where r is the radius of the silver atom and a is the edge length

$$\text{Now, edge length} = 400 \text{ pm} = 400 \times 10^{-10} \text{ cm}$$

Thus,

$$\begin{aligned} r &= \frac{400 \times 10^{-10} \text{ cm}}{2 \times 1.414} \\ &= 141.44 \times 10^{-10} \text{ cm} \\ &= 141.4 \text{ pm} \end{aligned}$$

Thus, the radius of the silver atom was found to be 141.4 pm

Question 2

The well known mineral fluorite is chemically calcium fluoride. It is known that in one unit cell of this mineral there are 4 Ca^{2+} ions and 8 F^- ions and that Ca^{2+} ions are arranged in an fcc lattice. The F^- ions fill all the tetrahedral holes in the face centred cubic lattice of Ca^{2+} ions. The edge of the unit cell is 5.46×10^{-8} cm in length. The density of the solid is 3.18 g cm^{-3} . Use this information to calculate Avogadro's number (Molar mass of $\text{CaF}_2 = 78.08 \text{ g mol}^{-1}$)

Ans.

Chemistry-Std-XII-Science

Given:

Edge of unit cell = 5.46×10^{-8} cm

Density of solid, $d = 3.18 \text{ g cm}^{-3}$

Molar mass of CaF_2 , $M = 78.08 \text{ g mol}^{-1}$

Since lattice is fcc type, $z = 4$

Density of unit cell, $d = \frac{z \cdot M}{a^3 \cdot N_A}$

$$\begin{aligned}\therefore N_A &= \frac{z \cdot M}{a^3 \cdot d} \\ &= \frac{4 \times 78.08 \text{ g mol}^{-1}}{(5.46 \times 10^{-8} \text{ cm})^3 \times 3.18 \text{ g cm}^{-3}} \\ &= 6.03 \times 10^{23}\end{aligned}$$

Question 3

Tungsten crystallizes in body centred cubic unit cell. If the edge of the unit cell is 316.5 pm, what is the radius of tungsten atom?

OR

Iron has a body centred cubic unit cell with a cell dimension of 286.65 pm. The density of iron is 7.874 g cm^{-3} . Use this information to calculate Avogadro's number. (At. Mass of Fe = 55.845 u)

Ans.

For a body centred cubic cell, the radius of atom is:

$$\begin{aligned}r &= \frac{\sqrt{3}}{4} \cdot a \\ a &= 316.5 \text{ pm} \\ \therefore r &= \frac{1.732 \times 316.5}{4} = 137.044 \text{ pm}\end{aligned}$$

Or

Cell dimension, $a = 286.65 \text{ pm}$

Since it is bcc arrangement, number of atoms in the unit cell, $Z = 2$

Atomic mass of iron = 55.84 g/mol

Density of iron = 7.874 g cm^{-3}

Now, Density = $\frac{Z \times M}{a^3 \times N_0}$

$$\begin{aligned}\therefore N_0 &= \frac{Z \times M}{a^3 \times \text{Density}} \\ &= \frac{2 \times 55.84 \text{ g mol}^{-1}}{(286.65 \times 10^{-10})^3 \times 7.874 \text{ g cm}^{-3}} \\ &= 6.09 \times 10^{23} \text{ mol}^{-1}\end{aligned}$$

Question 4

www.vijaynazare.weebly.com

Chemistry-Std-XII-Science

The densities of the various forms of carbon are shown in the table below. Explain the drastic change in density between the various forms of carbon.

Form of Carbon	Density (grams/cubic centimeter)
Amorphous carbon	1.8 - 2.1
Buckminsterfullerene C ₆₀	1.69
Graphite	1.9 - 2.3
Diamond	3.50 - 3.53

Ans.

The density is a property that measures how efficiently a substance is spatially packed. The relationship between the mass, volume, and density of a substance is:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

This drastic change in density between the various forms of carbon is a consequence of the crystalline structure that each substance adopted. The macroscopically measured density is usually slightly different than that measured using X-ray diffraction because of defects and/or impurities within the sample.

Question 5

Calculate the density for nickel if the unit cell edge length for nickel given is 0.3524 nm and atomic mass is 58.69 g/mol. It crystallizes as a simple cube.

Ans.

The volume (V) of the unit cell is equal to the cell-edge length (a) cubed.

$$a = 0.3524 \text{ nm} = 0.352 \times 10^{-7} \text{ cm}$$

$$V = a^3 = (0.3524 \times 10^{-7} \text{ cm})^3 = 4.376 \times 10^{-23} \text{ cm}^3$$

The mass of a nickel atom can be calculated from the atomic weight of this metal and Avogadro's number. $58.69 \text{ g/mol} / 6.022 \times 10^{23}$

$$= 9.746 \times 10^{-23} \text{ g/atom}$$

The density of nickel, $= 9.746 \times 10^{-23} / 4.376 \times 10^{-23} = 2.23 \text{ g/cm}^3$

Chemistry-Std-XII-Science

Question 6

How is the ideal density of a substance calculated from unit cell data?

Ans.

The density of a substance is defined as the ratio of its mass to its volume.

Density = mass/ volume the density of the metal, we can calculate the mass of the atoms in the unit cell. The determination of the mass of a single atom gives an accurate method of determination of Avogadro constant. Suppose, edge length of a unit cell of a cubic crystal determined by X-ray diffraction is a , d the density of the solid substance and M the molar mass/ atomic mass and z is the number of atoms present in the unit cell. Volume of a unit cell = a^3 and Mass of the unit cell now connect the volume and mass of a substance to calculate density.

$$d = zM / a^3 N_A.$$

Therefore, density of the unit cell = mass of unit cell / volume of unit cell.

Remember the density of the unit cell is the same as the density of the substance.

Question 7

Calculate the density for if the diamond. Cell volume = $45.385 \times 10^{-24} \text{ cm}^3$ and Atoms/unit cell = 8 (atomic mass of carbon is 12u).

Ans.

Density = Mass/Volume = Mass per unit cell/Volume per unit cell g/cm^3

Mass of unit cell = $(12\text{g/mol})(1\text{mol}/6.022 \times 10^{23} \text{ atoms})(8 \text{ atoms/unit cell}) = 15.941 \times 10^{-23} \text{ g/unit cell}$

$$\text{density} = 3.5155 \text{ g/cm}^3$$

Question 8

An element A has a ccp arrangement of atoms. The radius of A is equal to 143.2pm. Calculate the lattice parameter of the unit cell and the density of solid Al if its atomic weight = 30u.

Ans.

Because A is ccp we have an fcc unit cell. Cell contents: 4 atoms/cell [8 at corners (each 1/8), 6 in faces (each 1/2)]

Lattice parameter: atoms in contact along face diagonal, therefore $4r_{\text{Al}} = a(2)^{1/2}$

$$a = 4(1.432\text{\AA})/(2)^{1/2} = 4.050\text{\AA}.$$

Density = Mass/Volume = Mass per unit cell/Volume per unit cell g/cm^3

Mass of unit cell = mass 4 Al atoms = $(30\text{g/mol})(1\text{mol}/6.022 \times 10^{23} \text{ atoms})(4 \text{ atoms/unit cell}) = 1.792 \times 10^{-22} \text{ g/unit cell}$

Volume unit cell = $a^3 = (4.05 \times 10^{-8} \text{ cm})^3 = 66.43 \times 10^{-24} \text{ cm}^3/\text{unit cell}$

$$\text{Density} = \{1.792 \times 10^{-22} \text{ g/unit cell}\} / \{66.43 \times 10^{-24} \text{ cm}^3/\text{unit cell}\} = 2.698 \text{ g/cm}^3$$

Chemistry-Std-XII-Science

Question 9

What is meant by a Buckminster Fullerene?

Ans.

A Fullerene is an allotrope of carbon in a spherical shape with 60, 70 or 80 carbon atoms.

Question 10

Element A, B and C crystallize as body centered, simple cube and face centered cubic unit cells respectively. Which one will have least number of atoms and why.

Ans.

To know the number represented by Z we need to know about sharing of atoms as per its position in the unit cell. In body center cube number of atoms is 2 atoms calculated as corners $8 \times 1/8 = 1$ and body center = 1×1 therefore total 2 atoms per unit cell. In face centered cube there are total 4 atoms as Corners - $8 \times 1/8 = 1$, face- $6 \times 1/2 = 3$ and in simple cube atoms are present only in the corners $8 \times 1/8 = 1$ atom per cube. Simple cube has least number of atoms.

Question 11

Give the volume of a simple cube, face centered cube and body centered cube in terms of radius of the sphere forming the close packing.

Ans.

1. Simple cube $a = 2r$ therefore $a^3 = (2r)^3$
2. Face centered cube $a = 2\sqrt{2}r$ so $a^3 = (2\sqrt{2}r)^3$
3. Body centered cube $a = 4r/\sqrt{3}$ so $a^3 = (4r/\sqrt{3})^3$

Question 12

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

Ans.

Identify given: in fcc, $z = 4$, $a = 4.05 \times 10^{-8} \text{ cm}$, $d = 10.5 \text{ g cm}^3$, $N_A = 6.022 \times 10^{23} \text{ atoms}$

$M = ?$ $d = zM / a^3 N_A$

$$10.5 \text{ g cm}^3 = 4 \times M / (4.05 \times 10^{-8} \text{ cm})^3 \times 6.022 \times 10^{23} \text{ atoms} = 107.8 \text{ u}$$

Question 13

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

Ans.

Chemistry-Std-XII-Science

$$\text{Volume} = 288\text{pm} = (288 \times 10^{-10} \text{ cm})^3 = 2.39 \times 10^{-23} \text{ cm}^3$$

Volume of 208g of the element

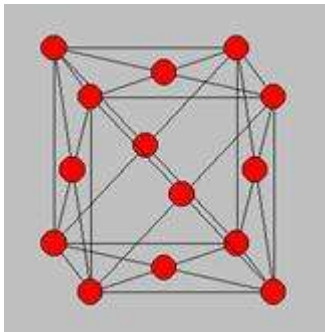
$$= \text{mass/density} = 208\text{g} / 7.2\text{g cm}^{-3} = 28.88\text{cm}^3$$

$$\text{Number of unit cells in this volume} = 28.88\text{cm}^3 / 2.39 \times 10^{-23} \text{ cm}^3 / \text{unit cell} = 12.08 \times 10^{23} \text{ unit cells.}$$

Since each bcc cubic unit cell contains 2 atoms, therefore, the total number of atoms in 208g = 2 atoms /unit cell \times 12.08×10^{23} unit cells = 24.16×10^{23} atoms

Question 14

Identify the type of unit cell and describe it.

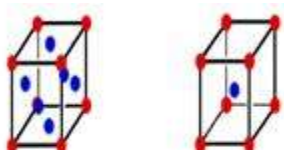


Ans.

This is a face centered cubic unit cell. The face centered cubic structure has atoms located at each of the corners and the centers of all the cubic faces. Each of the corner atoms is the corner of another cube so the corner atoms are shared among eight unit cells. Additionally, each of its six face centered atoms is shared with an adjacent unit cell. The fcc unit cell consists of a net total of four atoms.

Question 15

Recognize and name the following centered unit cells.



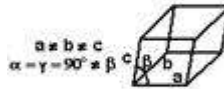
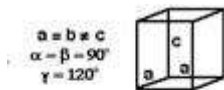
Ans.

Face Centered Cubic (FCC) unit cell and Body-Centered Cubic (BCC) unit cell.

Chemistry-Std-XII-Science

Question 16

Recognize and name the following primitive cells.



Ans.

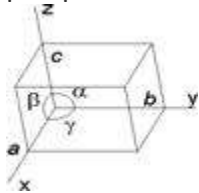
First is hexagonal, second is monoclinic and third is triclinic.

Question 17

Name and illustrate the parameter that characterise a unit cell in a crystal?

Ans.

Characteristics of Unit cells based on distance between particles in the x- axis, y- axis & z- axis depicted by a, b & c and the angle between the edges in the three axis given by α , β & γ as shown in the figure below.



Question 18

Describe primitive cells in which all 3 sides are equal.

Ans.

In cubic unit cell all 3 sides are equal & angles are equal to 90° represented as $a = b = c$; $\alpha = \beta = \gamma = 90^\circ$. In rhombohedral all 3 sides are equal & angles are not equal to 90° represented as $a = b = c$; $\alpha = \beta = \gamma \neq 90^\circ$. Cubic and rhombohedral have all 3 sides are equal.

Question 19

Gold crystallizes as BCC and iron as FCC which element will more number of atoms.

Ans.

The body-centered cubic unit cell has atoms at each of the eight corners of a cube plus one atom in the center of the cube. Corners will always be $1/8$ and 1 in the center. (show graphics of bcc & fcc and show counting of each component)

Corners $8 \times 1/8 = 1$

Body center $1 \times 1 = 1$

therefore total 2 atoms per unit cell.

Chemistry-Std-XII-Science

The face centered cubic structure has atoms located at each of the corners and the centers of all the cubic face Eight eighths from corners atoms and six halves of the face atoms.

Corner $8 \times \frac{1}{8} = 1$

Face $6 \times \frac{1}{2} = 3$ therefore total 4. As iron crystallizes as FCC it will have 4 atoms and gold crystallizes as BCC it will have 2 atoms. Number of atoms are more in iron than gold.

Question 20

If an element crystallizes in a unit cell with 1 atom in each of its body diagonal how many atoms will be there in the unit cell?

Ans.

The unit cell has atoms at each of the eight corners of a cube

8 Corners $\times \frac{1}{8} = 1$. Cube has 4 body diagonal and not shared so 4 atoms in the body.

The unit cell will have 1 in the corner and 4 in the body diagonal so total is 5 atoms.

Question 21

Aluminium crystallizes as FCC. Calculate number of atoms that will be present in the unit cell.

Ans.

The face centered cubic structure has atoms located at each of the corners and the centers of all the cubic face Eight eighths from corners atoms and six halves of the face atoms. 8 Corners $\times \frac{1}{8} = 1$ and 6 Faces $\times \frac{1}{2} = 3$ therefore total 4 atoms.

Question 22

Element crystallizes as BCC. How many atom will be present in the unit cell of the element.

Ans.

The body-centered cubic unit cell has atoms at each of the eight corners of a cube plus one atom in the center of the cube. Corners will always be $\frac{1}{8}$ and 1 in the center.

8 corners $\times \frac{1}{8} = 1$ and Body center = 1×1 therefore total 2 atoms per unit cell.

So the unit cell of the element will have 2 atoms.

Question 23

Name all the primitive unit cell in which all 3 sides are different.

Ans.

Triclinic - $a \neq b \neq c; \alpha \neq \beta \neq \gamma$
Monoclinic- $a \neq b \neq c; \alpha = \gamma = 90^\circ, \beta \neq 90^\circ$
Orthorhombic- $a \neq b \neq c; \alpha = \beta = \gamma = 90^\circ$

Chemistry-Std-XII-Science

Question 24

Distinguish between Triclinic and monoclinic unit cell.

Ans.

Triclinic	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	$a \neq b \neq c; \alpha \neq \beta \neq \gamma$ 3sides & angles are different
Monoclinic	Monoclinic Sulphur	$a \neq b \neq c; \alpha = \gamma = 90^\circ, \beta \neq 90^\circ$ means 3sides are different & 1angle greater or equal to 90°

Question 25

How do we identify primitive and centered cell.

Ans.

Unit cells are classified as Primitive unit cells if particles are present only in the corners & Centered unit cells if particles are present at positions other than corners. There are 7 types of primitive unit cells and 3 types of cubic centered unit cells.

Question 26

Ferric oxide crystalises as hexagonal close packing array of oxide ion two out of every three octahedral holes is occupied by ferric ions. derive the formula of ferric oxide

Ans.

n oxide ions form close packing, & n octahedral void are formed & $\frac{2}{3}n$ octahedral voids are occupied so the ratio is $\frac{2}{3}n$ Fe: n O-- so the formula is Fe_2O_3 (multiply by 3 to get whole number formula)

Question 27

Calculate formulas if atom A forms ccp B occupies $\frac{1}{2}$ tetrahedral void & atom C occupies all octahedral void.

Ans.

n atoms of A form close packing, 2n tetrahedral void are formed & n octahedral void are formed. $\frac{1}{2} \cdot 2n$ tetrahedral void are occupied all n octahedral void are occupied. So the ratio is A:B:C so the formula is ABC

Chemistry-Std-XII-Science

Question 28

Show that edge centered cube and body centered cube has 2 atoms.

Ans.

Show that edge centered cube and body centered cube has 2 atoms.

Ans- The body-centered cubic unit cell has atoms at each of the eight corners of a cube plus one atom in the center of the cube. Corners will always be $1/8$ and 1 in the center.

8 corners $\times 1/8 = 1$

Body center = 1×1 therefore total 2 atoms per unit cell.

The edge centered cubic structure has atoms located at each of the corners and the centers of two opposite cubic face. $1/8$ from corners atoms and 2 halves of the face atoms.

Corner ----- $8 \times 1/8 = 1$

Face----- $2 \times 1/2 = 1$ therefore total 2 atoms per unit cell.

Imperfections in Crystals

Question 1

What is mean by 'doping' in a semiconductor?

Ans.

Doping refers to the process of introducing impurity atoms into a semiconductor in a controllable manner in order to define the electrical properties of this region.

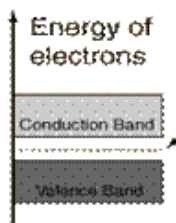
Question 2

Define semiconductors.

Ans.

Semi Conductors have conductivity range of 10^{-6} To 10^4 ohm/m and gap between the bands is small and jump of electron to conduction band increases with temperature and are called intrinsic semiconductors like silicon and germanium.

This conductivity is increased by adding impurity the conductivity is increased by extra electrons or by creating a hole. (Band Diagram can be shown with small gap between valence band & conduction band electron movement more than semiconductor less than conductor)



b. Semiconductor

Chemistry-Std-XII-Science

Question 3

Why is LiCl in excess of Li pink in color.

Ans.

LiCl in vapor of Li an electron occupies anionic site called F-center and the crystal imparts pink color. F centers is the anionic site occupied by the electron (e^- becomes part of the lattice) These electrons are color centers, often referred to as F-centers (from the German word *farben* meaning color).

Question 4

What is the difference between Schottky and Frenkel defects.

Ans.

A Frenkel defect is form of interstitial defect when an atom or ion leaves its place in the lattice (leaving a vacancy), and lodges nearby in the crystal (becoming an interstitial). The number of interstitials formed will equal the number of vacancies formed and the density remains the same.

Schottky defects: is a vacancy defect , it decreases the density and equal numbers of cations and anions are missing from the lattice.

Question 5

Compare line defect and dislocation.

Ans.

Line defects: -When planes of atoms are not perfectly fitted into the lattice in a linear manner along a axis it results in a line defect.

Dislocations Linear defects occur when a crystal structure contains misaligned planes of atoms and atoms are 'dislocated' from their position in the lattice.

Question 6

Explain Non-stoichiometric Defects in solids.

Ans.

These defects disturb the stoichiometry of the compound and are of two types Metal excess defect due to anionic vacancy or extra cations & Metal deficiency defect.

Metal excess defect Some non-stoichiometric solids On the other hand, ZnO is white and lose oxygen on heating, and the excess Zn metal atoms in the sample are ready to give electrons. Electrons in defect region only absorb light and it becomes yellow.

Replacement of Al^{3+} for Si^{4+} in quartz gives rise to the color of smoky quartz.

Metal deficiency defect. Sometimes the crystal is not formed as per the stoichiometric proportions e.g. FeO is more typically is found as Fe_xO where $x \sim 0.95-0.99$ Charge neutrality must be maintained so some (Fe^{2+}) are missing and the loss is made up by (Fe^{3+}) in FeO crystal.

Chemistry-Std-XII-Science

Question 7

Explain vacancy defect in solids.

Ans.

Vacancy Defect: Constituent particles are not present in the lattice site its called vacancy defect and the density decreases due to missing particles. Schottky defects: is a vacancy defect , it decreases the density and equal numbers of cations and anions are missing from the lattice. This effect is shown by ionic substances where there is less difference in ionic size e.g. NaCl, KCl, CsCl.

Question 8

Why do solids show magnetic property? Classify these properties.

Ans.

In solids the spin of the electron in the orbital around the nucleus & around its own axis, behaving like a tiny magnet .Magnetic moment created is small measured as bohr magnetron μ_B . Depending on the alignment of spinning electrons.

The magnetic behavior of materials can be classified into the following five major groups:

1. Diamagnetism
2. Paramagnetism
3. Ferromagnetism
4. Ferrimagnetism
5. Antiferromagnetism

Question 9

Compare p-type and n-type conductor.

Ans.

In doped semiconductors, extra energy levels are added by adding impurity which is electron rich or electron deficient as compared to intrinsic semiconductors like silicon and germanium.

Crystals doped with P and As electron rich to form n- type semiconductors these impurities atom that has five valence electrons is added because only four are needed for bonding it creates an electron that is free to move.

Crystals doped with electron deficient elements B, Al etc to form p-type semiconductors. The impurity atom that has only three valence electrons is added, thus creating a hole in p-type (positive) to the semiconductor. Diode is a combination of n-type and p-type conductor used in rectifiers. npn & pnp are used in amplifying audio signals. Solar cell is photo-diode.

Chemistry-Std-XII-Science

Question 10

In term of band theory what is the difference between conductor and insulator.

Ans.

In term of band theory what is the difference between conductor and insulator.

Ans5.As per the band theory in the conductor there is as an overlap of the valence band and the conduction band so that a fraction of the valence electrons can move through the material and in insulator in terms of the band theory of solids this implies that there is a large forbidden gap between the energies of the valence electrons and the energy at which the electrons cannot move freely through the material .(Draw diagram of two bands in conductor overlapping and in insulator there gap is more and label the band as valence & conduction band.

Question 11

Explain the following with suitable examples.(a)12-16 and 13-15 group compounds, (b) Ferromagnetic.

Ans.

(a)Compounds of 12-16 & 13-15 compounds prepared to acquire a characteristic valence of four and form four bonds as in germanium and silicon. e.g. Of 12-16 compounds are ZnS, CdS, CdSe & HgTe e.g. of 13-15 compounds are InSb, AlP and GaAs.

(b) Ferromagnetic materials exhibit parallel alignment of moments i.e.all unpaired electrons are spinning in parallel direction resulting in large net magnetization even in the absence of a magnetic field. The elements Fe, Ni, and Co and many of their alloys are typical ferromagnetic .

Question 12

With example explain F-center.

Ans.

F-centers is the anionic site occupied by the electron (e⁻ becomes part of the lattice) These electrons are color centers, often referred to as F-centers (from the German word farben meaning color). e.g. NaCl in vapor of Na electron occupies anionic site called F-center and the crystal imparts yellow color.

$\text{NaCl} + \text{Na} \rightarrow \text{Na}^{1+} (\text{Cl})(\text{e}^-)$

Chemistry-Std-XII-Science

Question 13

Name two point defects and explain them.

Ans.

Schottky and Frenkel defects. Schottky defects is a vacancy defect, it decreases the density and equal numbers of cations and anions are missing from the lattice. This effect is shown by ionic substances where there is less difference in ionic size e.g. NaCl, KCl, CsCl. A Frenkel defect is form of interstitial defect when an atom or ion leaves its place in the lattice (leaving a vacancy), and lodges nearby in the crystal (becoming an interstitial). The number of interstitials formed will equal the number of vacancies formed and the density remains the same. This effect is shown by ionic substances where there is a large difference in ionic size e.g. ZnS, AgCl, AgBr, AgI.

Question 14

Explain dislocation.

Ans.

Dislocations means linear defects which occur when a crystal structure contains misaligned planes of atoms, atoms are 'dislocated' from their position in the lattice.

Question 15

Magnetite is ferrimagnetic on heating what changes are expected.

Ans.

(a) magnetic power increases (b) becomes paramagnetic* (c) becomes diamagnetic (on heating alignment of electron spin changes)

Question 16

Which of the following Frenkel defects or Schottky defects decreases the density of the solid.

Ans.

Schottky defects as it is a vacancy defect in which equal numbers of cations and anions are missing from the lattice.

Question 17

What are crystal defects.

Ans.

Some unit cells may have one or more atoms less whereas others may have one or more atoms more than the ideal unit cell. This imperfection of crystals is called crystal defects.

@@