Important Question for Class 12

Chemistry

Chapter 1 – The Solid State

Very Short Answer Questions **1 Mark**

1. What are anisotropic substances?
Ans: The chemical and physical properties of crystals are different in different directions. This phenomenon is known as anisotropy, and these substances are anisotropic.

2. Why are amorphous solids isotropic in nature?
Ans: Amorphous solids have an uneven particle arrangement in all directions; therefore every physical property's value is the same in any direction. As a result, they are isotropic.

3. Why glass is regarded as an amorphous solid?
Ans: In the case of glass, there is no regular, repeating molecular structure and the solid is considered to be amorphous.

4. Define the term 'crystal lattice'.
Ans: Lattice is a three-dimensional orderly arrangement of atoms, ions, and molecules. A crystal lattice is sometimes referred to as a space lattice or a lattice in its most common form.

5. Define the term voids.
Ans: Void, in its literal sense, refers to the spaces between the component particles of a substance. Unoccupied or empty space in a unit cell is what we refer to as the void.

6. What type of stochiometric defect is shown by
(i) ZnS
Ans: There is a large difference in the size of Zn^{2+} ion and S^{2-} ion, therefore, there will be a Frenkel defect.

(ii) CsCl

Ans: The size of K^+ ion and Cl^- ion are similar, therefore, there will be a Schottky defect.

7. If the formula of a compound is A_2B, which sites would be occupied by A ions?

Ans: There are twice as many A ions as B ions, therefore the A ions will fill the tetrahedral gaps or tetrahedral voids in the molecule.

8. What is the coordination number for

(a) An octahedral void

Ans: The coordination number for an octahedral void will be 6.

(b) A tetrahedral void

Ans: The coordination number for a tetrahedral void will be 4.

9. How many octahedral voids are there in 1 mole of a compound having cubic closed packed structure?

Ans: In a unit cell, four octahedral voids are essentially present. Each element has four atoms in a cell.

Number of unit cells = $\dfrac{1 \text{ x } 6.023 \text{ x } 10^{23}}{4}$

Number of octahedral voids = $\dfrac{6.023 \text{ x } 10^{23}}{4}$ x 4 = $6.023 \text{ x } 10^{23}$

10. Arrange simple cubic, bcc and fcc lattice in decreasing order of the fraction of the unoccupied space.

Ans: Unoccupied space of simple cubic is 47.6%, bcc is 32%, and fcc is 26%.

The order will be Simple cubic > bcc > fcc

11. How much space is empty in a hexagonal closed packed solid?

Ans: There is 26 percent vacant space in a hexagonal closed packed solid.

12. An element crystallizes separately both in hcp and ccp structure. Will the two structures have the same density? Justify your answer.

Ans: The densities of both buildings are equal. Because both constructions have the same percentage of occupied space, this is the case.

13. In NaCl crystal, Cl^- ions form the cubic close packing. What sites are occupied by Na^+ ions?

Ans: The chloride ion in the NaCl pack has a cubic closed packed shape, which results in octahedral voids. These octahedral gaps are filled by sodium ions.

14. In corundum, O^{2-} ions form hcp and Al^{3+} occupy two third of octahedral voids. Determine the formula of corundum.

Ans: Only $\frac{2}{3}$ of the octahedral gaps are filled in corundum.

It indicates that for every oxide, there are two-thirds of aluminium ions.

Corundum has a 3:2 ratio of oxide to aluminium ions.

Therefore, corudum's formula is Al_2O_3.

15. Why is Frenkel defect not found in pure alkali metal halides?

Ans: In pure alkali metal halides, the Frenkel defect is not present. Larger cations of alkali metals can't fit into interstitial sites because of their size.

16. Which point defect is observed in a crystal when a vacancy is created by an atom missing from a lattice site?

Ans: Vacancy and Schottky defect.

17. Define the term 'doping'.

Ans: Doping is the deliberate introduction of impurities into a semiconductor to modify its electrical and structural characteristics.

18. Why does conductivity of silicon increase with the rise in temperature?

Ans: When the gap between the valance band and the conduction band is filled with energy, electrons can flow from one to the other. As a result, semiconductors like silicon become more conductive as their temperatures rise.

19. Name the crystal defect which lowers the density of an ionic crystal.

Ans: Schottky defect.

20. What makes the crystal of KCl sometimes appear violet?

Ans: A result of the F-center is that electrons become excited and emit energy in the visible area, resulting in the crystal's color.

21. Which point defect in ionic crystal does not alter the density of the relevant solid?
Ans: Due to the fact that the cation is present in the interstitial location, the Frenkel defect is named as such. As a result, the density does not change.

22. Name one solid in which both Frenkel and Schottky defects occur.
Ans: AgBr

23. Which types of defects are known as thermodynamic defects?
Ans: Stoichiometric defects.

24. In a p-type semiconductor the current is said to move through holes. Explain.
Ans: When electrons travel through a substance, they create an electric current. The electron must be able to enter into a 'hole' in the substance in order to do so. More electrons than holes are found in p-type semiconductors. There is just one direction in which a current can travel along the material.

25. Solid A is very hard, electrical insulator in solid as well as in molten state and melts at extremely high temperature. What type of solid is it?
Ans: The characteristics listed above are those of a covalent or network solid, respectively. Covalent or network solids are the result. Diamond and quartz are examples of solids that fit this description.

Short Answer Questions **2 Marks**

1. List four distinctions between crystalline and amorphous solids with one example of each.
Ans: This is tabulated below:

Crystalline solids	Amorphous solids
They have symmetric arrangement.	They have unsymmetric arrangement.
Melting points of these are sharp	Wide range of melting point is observed
They are anisotropic	They are isotropic
They go through a clean cleavage procedure.	They do not go through a clean cleavage procedure.
Example- Quartz	Example- Glass

2. Give suitable reason for the following–
(a) Ionic solids are hard and brittle.

Ans: Ions are the particles that make up ionic crystals. The electrostatic force of attraction holds these ions together in three-dimensional configurations. The charged ions are kept in place by the electrostatic force of attraction, which is quite powerful. Ionic crystals are hard and brittle for this reason.

(b) Copper is malleable and ductile.
Ans: All metallic solids, including copper, are ductile and malleable.

3. Define F–centre. Mention its one consequence.
Ans: One or more unpaired electrons occupy an anionic vacancy in a crystal in a crystallographic defect known as an F-center, FARBE center, or color center (from the German Farbzentrum). Vacancies like these tend to absorb visible spectrum light, turning normally clear materials into colorful ones. As a result, it is used to detect a wide variety of chemicals, including zinc oxide.

4. What is packing efficiency? Calculate the packing efficiency in body-centered cubic crystal.
Ans: As the name suggests, packing efficiency is the proportion of the crystal (or unit cell) that is actually taken up by the atoms themselves.
Packing efficiency is calculated by:

$$\text{Packing efficiency} = \frac{\text{Volume occupied by the atoms in the unit cell}}{\text{Total volume of the unit cell}} \times 100$$

For BCC (Body centered cubic cell), volume occupied by the atoms in the unit cell is:

$$\frac{8}{3}\pi r^3$$

Total volume of the BCC unit cell is:

$$\frac{64r^3}{3\sqrt{3}}$$

Now, putting the values:

$$\text{Packing efficiency} = \frac{\frac{8}{3}\pi r^3}{\frac{64r^3}{3\sqrt{3}}} \times 100 = 68\%$$

5. Explain:
(a) List two differences between metallic and ionic crystals.

Ans: This is tabulated below:

Ionic solids	Metallic solids
They have coulombic or electrostatic forces between the constituent particles.	They have metallic bond between the constituent particles.
In solid form they are insulators but in the molten form, they are conductors.	They are conductors in both solid as well as molten form.

(b) Sodium chloride is hard but sodium metal is soft.
Ans: Due to the fact that sodium has only one valence electron, there is a weak metallic link. As a result, sodium metal is a brittle substance. Because the chlorine atom has received an electron from the sodium atom, sodium chloride exists in crystal form.

6. Account for the following:
(a) Glass objects from ancient civilizations are found to become milky in appearance.
Ans: A long period of heating and chilling turns glass into a crystalline solid, causing it to seem milky.

(b) Window glass panes of old buildings are thicker at the bottom than at the top.
Ans: Glass is a supercooled liquid since it flows. Bottom glass panes are thicker than top glass panes.

7. Why is graphite soft lubricant and good conductor of electricity?
Ans: A soft lubricant, graphite is an excellent conductor of electricity because its electrons are delocalized and free to flow about in the crystal structure. In addition to being an excellent conductor of electricity, graphite has a large number of free electrons.
Carbon is the only element in it.

8. What do you understand by the following types of stacking sequences:
What kind of lattices do these sequences lead to?
(a) AB AB …..
Ans: This indicates that the arrangement of spheres in every third layer is the same as that in the first. As a result, a hexagonal tight packing is obtained.

(b) ABC ABC
Ans: This indicates that the arrangement of spheres in every fourth layer is the same as the arrangement of spheres in every first layer, and so on. Ultimately, this results in

a tightly packed cubical structure.

9. Derive the formula for the density of a crystal whose length of the edge of the unit cell is known?

Ans: Let the edge of the unit cell = a pm

Number of atoms present per unit cell = Z

The atomic mass of the element is represented as = M

So, the volume of the unit cell = $(a\ pm)^3 = a^3 \times 10^{-30} cm^3$

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

Mass of unit cell can be calculated as = Z x m

Where m is the mass of each atom = $\frac{\text{Atomic mass}}{\text{Avogadro's number}} = \frac{M}{N_0}$

Now, putting all the values, we can write:

$$\text{Density} = \frac{Z \times M}{a^3 \times N_0 \times 10^{-30}} \text{ g/cm}^3$$

10. Explain how much portion of an atom is located at

(a) corner and

Ans: In the corner of a cubic unit cell, eight neighboring unit cells share the same atom. One unit cell therefore shares 1/8th of the atom.

(b) body centre

Ans: Each unit cell in a cubic unit cell has its own atom in the body centre, which is not shared with its neighbor unit cell. Due to its presence in a single unit cell, an atom's contribution to the unit cell is one.

(c) face-centre

Ans: On the face of a cubic unit cell, six neighboring unit cells share the same atom. One unit cell therefore shares 1/2th of the atom.

(d) edge centre of a cubic unit cell.

Ans: A cubic unit cell's edge is always shared by four unit cells at a time. Each unit cell will get 1/4th of an atom located at the edge centre.

11. In a fcc arrangement of A and B atoms A are present at the corners of the unit cell and B are present at the face centers. If one atom of A is missing from its position at the corner, what is the formula of the compound?

Ans: We know that there are eight corners in the unit cell and each contributes 1/8th. One atom (A) from the corner is missing, which means there are 7 A atoms whose contribution will be = $\frac{7}{8}$

There are six face centers and 'B' atoms are present there. Each has a contribution = $\frac{1}{2}$

So, the total contribution will be = $6 \times \frac{1}{2} = 3$

Ratio will be = A : B = $\frac{7}{8}$: 3 = 7 : 24

The formula will be = A_7B_{24}

12. A compound made up of elements 'A' and 'B' crystallizes in a cubic close packed structure. Atoms A are present on the corners as well as face centers, whereas atoms B are present on the edge-centers as well as body centre. What is the formula of the compound?

Ans: The total contribution of A atom is calculated as:

$A = \frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 4$

The total contribution of B atom is calculates as:

$B = \frac{1}{12} \times 4 + 1 = 4$

The ratio will be = A : B = 4 : 4 or 1 : 1

The formula will be AB.

13. Explain the terms:

(a) Intrinsic semiconductor

Ans: A semiconductor that is intrinsic is one that is not doped. Hole vacancies generated by thermally excited electrons in the conduction band are different from doped semiconductors in which holes or electrons are supplied by an impurity.

(b) Extrinsic semiconductor.

Ans: In optoelectronic applications (diodes, transistors, etc.), extrinsic semiconductors are semiconductors doped with a particular impurity that can profoundly alter their electrical characteristics (light emitters and detectors).

14. Explain how vacancies are introduced in a solid NaCl crystal when divalent cations are added to it.

Ans: A higher-valence cation is introduced as an impurity in an ionic solid. Less than 2 higher-valance ions replace two or more lower-valance cations or ions. Few locations are left empty in order to ensure electrical neutrality. As an example, when Sr^{2+} is introduced to NaCl, two Na^+ ions are replaced by each Sr^{2+} ion In other words, Sr^{2+} has the same charge as two ions of Na^+, therefore, only one of those ions leaves.

15. What is meant by non-stoichiometric defect? Ionic solids which have anionic vacancies due to metal excess defect develop color. Explain with the help of suitable example.

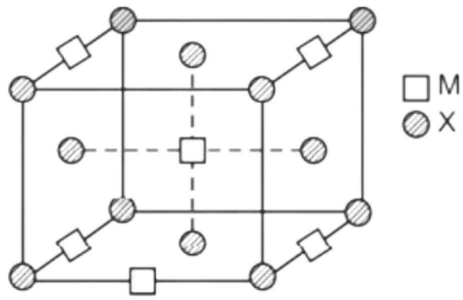
Ans: Non-stoichiometric flaws are those imperfections that do not affect the crystalline substance's stoichiometry. The anionic sites contain electrons, which cause the color to develop. As a result of absorbing energy from visible light, these electrons get excited. Crystals of NaCl, for example, produce NaCl when they are heated in an environment of sodium vapours. It is during this phase that the Na atoms on the surface lose their electrons and form Na^+ ions, while the liberated electrons diffuse inside the crystal to fill the unoccupied anionic sites. They are stimulated when they absorb energy from visible light and give the crystals a yellow color.

16. Define the term 'point defects'? Mention the main difference between stoichiometric and non-stoichiometric point defects.

Ans: Point defect - As the name implies, point faults occur exclusively at or around a single lattice point. They are not spatially expanded in any way.

Stoichiometric defect do not affect the stoichiometric composition of a compound whereas the non-stoichiometric defect affect the stoichiometric composition of a compound.

17. A compound M_pX_q has cubic close packing (ccp) arrangement of X. Its unit cell structure is show below:



Determine the empirical formula of the compound.

Ans: From the given figure:

Total contribution of M atoms will be:

$$M=1+4\times\frac{1}{4}=2$$

Total contribution of X atom will be:

$$X=\frac{1}{8}\times 8+6\times\frac{1}{2}=4$$

So, the formula will be MX_2

18. The concentration of cation vacancies in NaCl crystal doped with $CdCl_2$ is found to be $6.02 \times 10^{16} mol^{-1}$. What is the concentration of $CdCl_2$ added to it?

Ans: 1 mole = 6.023×10^{23} $CdCl_2$ creates = 1 mole of vacancy.

So, 1 $CdCl_2$ creates = $\frac{1}{6.022\times 10^{23}}$ vacancy

Now, 6.022×10^{16} creates = x vacancy.

So, the percentage of $CdCl_2$ added will be:

$$\frac{6.022\times 10^{23}\times x}{100}=6.022\times 10^{16}$$

$x=10^{-5}\%$ mol of $CdCl_2$

19. Iron changes its crystal structure from body contred to cubic close backed structure when heated to $916^{o}C$. Calculate the ratio of the density of the BCC crystal to that of CCP crystal. Assume that the metallic radius of the atom does not change.

Ans: Edge length of the BCC crystal can be calculated as:

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

Edge length of the CCP crystal can be calculated as:

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

We know that density is calculated as:

$$d = \frac{Z \times M}{N_0 \times a^3}$$

Z = 2 for BCC

Z = 4 for CCP

The ratio of density of BCC to CCP is:

$$d = \frac{\dfrac{2 \times M}{N_0 \times \left(\dfrac{4}{\sqrt{3}}\right)^3}}{\dfrac{4 \times M}{N_0 \times \left(2\sqrt{2}\right)^3}}$$

$$d = \frac{\left(2\sqrt{2}\right)^3}{\left(\dfrac{4}{\sqrt{3}}\right)^3}$$

d = 0.918 = 1

Short Answer Questions **3 Marks**

1. Write the relationship between atomic radius (r) and edge length (a) of cubic unit cell for:

(a) Simple cubic unit cell

Ans: For simple cubic unit cell, the relation between (r) and (a) is:

$$r = \frac{a}{2}$$

(b) Body-centered cubic unit cell

Ans: For Body-centered cubic unit cell, the relation between (r) and (a) is:

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

(c) Face-centered cubic unit cell

Ans: For Face-centered cubic unit cell, the relation between (r) and (a) is:

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

2. Define a semiconductor? Describe the two main types of semiconductors when it is doped with

Ans: Semiconductors are materials whose conductivity is between that of metals (conductors) and insulators.

Both n-type and p-type semiconductors are common.

(a) group 13 element,

Ans: A semiconductor of the n-type Only four of the five valance electrons of each impurity atom participate in the formation of covalent bonds when a silicon crystal is doped with group-15 elements, such as P, As, Sb, or Bi. The fifth electron is almost free to conduct electricity. n-type semiconductor is silicon that has been doped with group-15 elements.

(b) group 15 element.

Ans: B, Al, Ga, or In impurities in silicon crystals establish just three covalent connections with the host atoms. The hole created by the absence of the fourth electron, t, causes the crystal's conductivity to rise. P-type semiconductor is silicon that has been doped with a group-13 element.

3. Explain the following terms with one example each:

(a) Ferrimagnetism

Ans: Ferrimagnetism: Ferrimagnetic substances contain magnetic moments aligned in parallel and anti-parallel orientations, in unequal quantities. Ferrites such as MgF_2O_4 and $ZnFe_2O_4$ are examples of this. Magnesium is attracted to ferrimagnetic materials more strongly than to ferromagnetic materials. These compounds become paramagnetic when heated.

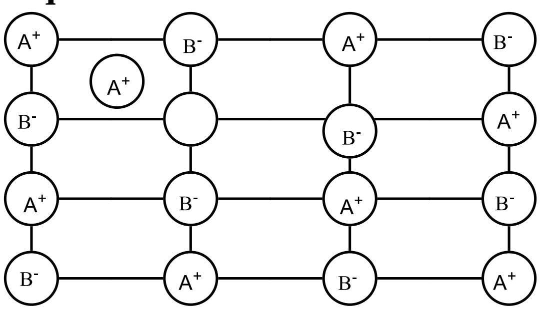
(b) Antiferromagnetism

Ans: As a result of their opposite orientation, antiferromagnetic compounds exhibit comparable domain structures to ferromagnetic substances. The magnetic moments of the domains that are in opposition to each other are cancelled out.

(c) 13-15 compounds

Ans: Compounds of the 13-15 group are produced by combining components of the 13-15 group. Ge or Si has a four-valence average, and these chemicals are produced to promote that. Group 13-15 chemicals include indium (III) antimonide (IrSb), aluminium phosphide (AlP), and gallium arsenide (GaAS). As a result of its rapid reaction time, GaAs semiconductors have changed the design of electronic devices.

4. Examine the defective crystal lattice given below and answer the following questions:



(a) Name the crystal defect present in ionic solid.

Ans: Frenkel defect

(b) Out of AgCl and NaCl, which is most likely to show this type of defect and why?

Ans: However, the Frenkel defect is not present in AgCl. Cations and anions with a substantial variation in size are said to have Frenkel defects. Since Ag^{+} ions have a tiny size, they display the Frenkel defect, whereas NaCl does not because alkali metal ions cannot enter into interstitial spaces.

(c) Why this defect is also known as dislocation defect?

Ans: It is called dislocation defect because a cation is generally displaced from its position in this defect.

5. Tungsten crystallizes in body centered cubic unit cell. If the edge of the unit cell is 316.5 pm, calculate the radius of tungsten atom.

Ans: We are given that the crystal is Body-centered cubic unit cell. So, the relation between the radius of atom (r) and edge length of the unit cell (a) is given as:

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

Given the value of edge length of the unit cell is 316.5 pm.

Putting the value in the formula, we get:

$$r = \frac{\sqrt{3}}{4} \times 316.5 = 137.04 \text{ pm}$$

So, the radius of the tungsten atom is 137.04 pm.

6. Iron has a body centered 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 = 55.845u).

Ans: We are given the edge length as 286.65 pm. This can be written as:

$$a = 286.65 \times 10^{-10} \text{cm}$$

Given the density is $= 7.874 \text{ g/ cm}^{-3}$

Atomic mass of the iron is given as 55.845 u

We are given that the unit cell is BCC, and for BCC the number of atoms is 2 (Z = 2).

We know the formula of density is:

$$d = \frac{Z \times M}{a^3 \times N_0}$$

Putting the values in the formula, we get:

$$7.874 = \frac{2 \times 55.845}{(286.65 \times 10^{-10} \text{cm})^3 \times N_0}$$

$$N_0 = 6.022 \times 10^{23} \text{ mol}^{-1}$$

NUMERICALS

1. Sodium crystallises in a bcc unit cell. What is the approximate number of unit cells in 4.6 g of sodium? Given that the atomic mass of sodium is 23 g/ mol.

Ans: We are given that the sodium crystallizes into BCC unit cell and for BCC unit cell the number of atoms per unit cell will be 2 (Z = 2).

The amount of sodium given is 4.6 g, so the number of atoms in sodium in 4.6g will be:

$$N = nN_A$$

$$n = \frac{m}{M} = \frac{4.6}{23}$$

Putting the values, we get:

$$N = \frac{4.6}{23} \times 6.022 \times 10^{23}$$

$N = 1.2046 \times 10^{23}$

Number of unit cell will be = $\frac{N}{Z}$

$= \frac{1.2046 \times 10^{23}}{2} = 6.023 \times 10^{22}$

Number of unit cell will be = 6.023×10^{22}

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

Ans: Let us assume that the number of atoms of element C = 4 (because CCP is present)

'A' occupy the 50% of tetrahedral void, so the number of A atoms in the element will be = $2 \times \frac{50}{100} \times 4 = 4$

'B' occupy the 50% of octahedral voids, so the number of B atoms in the element will be = $\frac{50}{100} \times 4 = 2$

So, the ratio will be = A : B : C = 4 : 2 : 4 = 2 : 1 : 2

Therefore, the formula will be A_2BC_2

3. Magnetite, a magnetic oxide of iron used on recording tapes, crystallizes with iron atoms occupying $\frac{1}{8}$ of the tetrahedral holes and $\frac{1}{2}$ of the octahedral holes in a closed packed array of oxides ions. What is the formula of magnetite?

Ans: Let us assume that the number of oxide = N

From the question, number of iron atoms will be = 1/8 of tetrahedral voids + ½ of octahedral void.

$= \frac{1}{8} \times 2N + \frac{1}{2} \times N$

$= \frac{N}{4} + \frac{N}{2}$

$= \frac{3N}{4}$

Now, taking the ratio, we get:

$$\text{Iron : Oxide} = \frac{3N}{4} : N$$

Fe_3O_4 will be the formula of Magnetite.

4. A metal crystalises into two cubic lattices fcc and bcc, whose edge length are 3.5Å and 3.0Å respectively. Calculate the ratio of the densities of fcc and bcc lattices.

Ans: We know that the density of the crystal is calculated by the formula:

$$d = \frac{Z \times M}{a^3 \times N_0}$$

FCC means face centered cubic unit cell and the number of atoms in fcc unit cell is 4 (Z). The edge length of the unit cell is = 3.5×10^{-8}cm

Putting this in the formula, we get:

$$d = \frac{4 \times M}{(3.5 \times 10^{-8}\text{cm})^3 \times N_0}$$

BCC means body centered cubic unit cell and the number of atoms in bcc unit cell is 2 (Z). The edge length of the unit cell is = 3.0×10^{-8}cm

Putting this in the formula, we get:

$$d' = \frac{2 \times M}{(3.0 \times 10^{-8}\text{cm})^3 \times N_0}$$

Now, taking the ratio, we get:

$$\frac{d}{d'} = \frac{4 \times 3^3}{(3.5)^3 \times 2} = 1.26$$

The ratio is 1.26

5. An element of atomic mass 98.5 g/ mol occurs in fcc structure. If its unit cell edge length is 500 pm and its density is $5.22\ g/cm^3$. Calculate the value of Avogadro constant.

Ans: We are given the edge length as 500 pm. This can be written as:

$a = 500 \times 10^{-8}$cm

Given the density is = $5.22\ g/cm^{-3}$

Atomic mass given is 98.5 g/mol

We are given that the unit cell is FCC, and for FCC the number of atoms is 4 (Z = 4).

We know the formula of density is:

$$d = \frac{Z \times M}{a^3 \times N_0}$$

Putting the values in the formula, we get:

$$5.22 = \frac{4 \times 98.5}{(500 \times 10^{-8}cm)^3 \times N_0}$$

$N_0 = 6.03 \times 10^{23}\ mol^{-1}$

6. An element crystallises in a cubic close packed structure having a fcc unit cell of an edge 200 pm. Calculate the density if 200 g of this element contain 24×10^{23} atoms.

Ans: We know the formula of density is:

$$d = \frac{Z \times M}{a^3 \times N_0}$$

We are given that the unit cell is FCC, and for FCC the number of atoms is 4 (Z = 4).
We are given the edge length as 200 pm. This can be written as:

$a = 200 \times 10^{-8}cm$

$N_0 = 24 \times 10^{23}$

M = 200g

Putting the values, we get:

$$d = \frac{4 \times 200}{8 \times 10^{-24} \times 24 \times 10^{23}}$$

$d = 41.67\ g/cm^3$

7. Analysis shows that a metal oxide has a empirical formula $M_{0.96}O$. Calculate the percentage of M^{2+} and M^{3+} ions in this crystal.

Ans: We know that the ratio of M^{2+} and O^{2-} ion in the pure metal oxide sample has a ratio = 1:1

Let us assume that x ions of M^{2+} are replaced with M^{3+} ions.

Number of M^{2+} ions present will be = (0.96 – x)

As we know that oxides are neutral in nature, the total charge on M atoms will be equal to charge on oxygen atoms.

This can be written as:

$2(0.96 - x) + 3x = 2$

$x = 0.08$

So, the percentage of M^{3+} ions will be = $\frac{0.08}{0.96} \times 100 = 8.3\%$

Now the percentage of M^{2+} ions will be = 100 – 8.3 = 91.7%

8. AgCl is doped with 10^{-2} mol % of $CdCl_2$, find the concentration of cation vacancies.

Ans: Given in the question is AgCl is doped with 10^{-2} mol % of $CdCl_2$.

From this we can say that 100 moles of AgCl are doped with 0.01 moles of $CdCl_2$.

So, we can say that 1 mole of AgCl will be doped with = $\frac{0.01}{100} = 10^{-4}$ moles of $CdCl_2$

Therefore, 10^{-4} moles of cation vacancies will be formed.

9. A metallic element has a body centered cubic lattice. Edge length of unit cell is 2.88×10^{-8}cm. The density of the metal is $7.20\ g/cm^3$. Calculate

(a) The volume of unit cell.

Ans: From the edge length we can find the volume of unit cell.

$V = (a)^3$

Given the edge length is = 2.88×10^{-8} cm.

Volume will be:

$V = (2.88 \times 10^{-8} cm)^3 = 2.39 \times 10^{-23}\ cm^3$

(b) Mass of unit cell.

Ans: The mass of the unit cell can be calculated by:

Mass = Density $\times$ Volume

Given the density is $7.20\ g/cm^3$

Mass = $7.20 \times 2.39 \times 10^{-23} = 1.72 \times 10^{-22}$g

(c) Number of atoms in 100 g of metal.

Ans: Number of unit cell in 100 g of metal can be calculated by dividing the mass of the unit cell from 100. It is given below:

$$= \frac{100}{1.72 \times 10^{-22}} = 5.82 \times 10^{23}$$

So, there will be 5.82×10^{23} atom in 100g.

10. Molybednum has atomic mass 96 g/mol with density $10.3\ g/cm^3$. The edge length of unit cell is 314 pm. Determine lattice structure whether simple cubic, bcc or fcc. (Given = $N_A = 6.023 \times 10^{23}$).

Ans: To determine the structure of the lattice we have to find the number of atoms present in it.

Density of the cell is given as d = 10.3 g/cm^3

Edge length is given (a) = 314 pm = 314×10^{-8}cm

Avogadro's number $N_A = 6.023 \times 10^{23}$

We know the formula of density is:

$$d = \frac{Z \times M}{a^3 \times N_0}$$

This will be written as:

$$Z = \frac{d \times N_a \times a^3}{M} = \frac{10.3 \times 6.023 \times 10^{23} \times (314 \times 10^{-8})^3}{96} = 2$$

So, there are 2 atoms in the unit cell, which means that lattice is body-centered cubic unit cell.

11. The density of copper metal is $8.95\ g/cm^3$. If the radius of copper atom is 127 pm, is the copper unit cell a simple cubic, a body-centred cubic or a face centred cubic structure? (Given at. mass of Cu = 63.54 g/mol and $N_A = 6.023 \times 10^{23}$]

Ans: We know the formula of calculating the density of the unit cell.

$$d = \frac{Z \times M}{a^3 \times N_0}$$

Now, we are not given the edge length, so we have to find the density in each case of the crystal lattice.

For, simple cubic, a = 2r and Z = 1,

Putting the values, we get:

$$d = \frac{1 \times 63.54}{(2 \times 127.8 \times 10^{-10})^3 \times 6.02 \times 10^{23}} = 6.31\ g/cm^3$$

For BCC, Z = 2 and $a = \frac{4}{\sqrt{3}}r$

$$d = \frac{2 \times 63.54}{(\frac{4}{\sqrt{3}} \times 127.8 \times 10^{-10})^3 \times 6.02 \times 10^{23}} = 8.2 \text{ g/cm}^3$$

For FCC, Z = 4 and $a = \frac{4}{\sqrt{2}} r$

$$d = \frac{4 \times 63.54}{(\frac{4}{\sqrt{2}} \times 127.8 \times 10^{-10})^3 \times 6.02 \times 10^{23}} = 8.92 \text{ g/cm}^3$$

In the question the density given is 8.95 g/ cm^3 and it is nearest to the density of fcc. So, the structure of the crystal is fcc.

12. 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 Cd^{2+} ions are arranged in a fcc lattice. The F^- ions fill all the tetrahedral holes in the fcc lattice of Cd^{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 CaF_2 = 78.08 g/mol]

Ans: We know the formula of density is:

$$d = \frac{Z \times M}{a^3 \times N_0}$$

We are given the edge length of the unit cell (a) = 5.46×10^{-8}cm

We are given the density of the solid (d) = 3.18 g/ cm^3

Given the molar mass of CaF_2 (M) = 78.08 g/mol

For FCC, the numbers of atoms in the unit cell are 4 (Z).

Now, putting all these values in the formula, we get:

$$3.18 = \frac{4 \times 78.08}{(5.46 \times 10^{-8})^3 \times N_0}$$

$N_0 = 6.023 \times 10^{23}$ = Avogadro's number