

**NCERT SOLUTIONS**  
**CLASS-XII CHEMISTRY**  
**CHAPTER-1**  
**THE SOLID STATE**

**Q1. What do you understand by amorphous solids ? Give examples.**

**Ans:**

Amorphous solids are solids without a regular/ definitive arrangement of its constituent particles (ions, atoms or molecules) and they possess something called the short range order i.e , a regular and periodically repeating arrangement is seen only over short distances, e.g., rubber, glass.

**Q2. What differentiates glass from quartz? How can we convert quartz to glass?**

**Ans:**

The arrangement of the constituent particles differentiates glass from quartz. The constituent particles in glass have a short range order, but the constituent particles of quartz possess both short range and long range orders.

**Quartz is converted into glass by heating it and then rapidly cooling it.**

**Q3. Categorize the give solids as metallic, molecular, ionic, amorphous or network (covalent).**

(a) Tetra phosphorus decoxide ( $P_4O_{10}$ )

(b) Ammonium phosphate

(c) SiC

(d)  $I_2$

(e)  $P_4$

(f) Graphite ( $NH_4$ )<sub>3</sub>PO<sub>4</sub>

(g) Brass

(h) Rb

(i) LiBr

(j) Si

(k) Plastic

**Ans:**

Metallic : ( g ) Brass, ( h ) Rb

Molecular : (a) Tetra phosphorus decoxide ( $P_4O_{10}$ ), (d)  $I_2$ , (e)  $P_4$ .

Ionic : ( b ) Ammonium phosphate ( $NH_4$ )<sub>3</sub>PO<sub>4</sub>, ( i ) LiBr

Amorphous : ( k ) Plastic

Covalent : ( c ) SiC, ( f ) Graphite, ( j ) Si

**Q4. (a) Define coordination number. (b) Give the coordination number of atoms in : (1). a body-centred cubic structure (2). a cubic close-packed structure**

**Ans:**

(a) Coordination number is the number of nearest neighbors of a particle

(b) 1 – coordination number =12, 2 – coordination number = 8

**Q5. How can the atomic mass of a mystery metal be determined if dimension and density of its unit cell is given?**

**Ans:**

Given,

We know the dimension and density of its unit cell.

Let,

The edge length of a unit cell = a

Volume of the cell =  $a^3$

Density = d

Atomic mass = M

Mass of unit cell = No. of atoms in unit cell x Mass of each atom =  $Z \times m$

Mass of an atom present in the unit cell,  $m = M/ N_a$

where  $N_a$  is the Avogadro's number.

We know,

$d = \text{Mass of unit cell} / \text{Volume of unit cell} = Zm/a^3 = Z.M / a^3N_a$

**Therefore, Atomic mass,  $M = (da^3 N_a) / Z$**

**Q6. 'Stability of a crystal is reflected in the magnitude of its melting point'. State your thoughts on this.**

**Give the melting points of methane, diethyl ether, solid water, and ethyl alcohol.**

**Comment on the intermolecular forces between the molecules of these elements?**

**Ans:**

A substance with a high melting point is more stable than a substance with a low melting point, this is because higher the melting point, stronger the intermolecular forces of attraction in that substance/ crystal. Thus, implying greater stability.

The melting points of above substances are:

Methane → 89.34 K

Diethyl ether → 156.85 K

Solid water → 273 K

Ethyl alcohol → 158.8 K

Observing the data we can say that solid water has the strongest intermolecular force and methane has the weakest.

**Q7. Differentiate between:**

(a) Cubic close-packing and hexagonal close-packing.

(b) Unit cell and crystal lattice.

(c) Octahedral void and Tetrahedral void.

**Ans:**

(a) **Cubic close packing:** When a third layer is placed over the second layer in a manner that the octahedral voids are covered by the spheres, a layer different from the first (A) and second (B) is obtained. If we continue packing in this manner we get the cubic close packing.

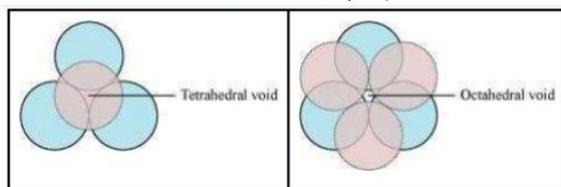
Hexagonal close packing: When the third layer is placed over the second layer in a way that the tetrahedral voids are covered by the spheres, a 3D close packing is produced where spheres in each third or alternate layers are vertically aligned. If we continue packing in this order we get hexagonal close packing.

(b) **Unit cell :** It is the smallest 3D dimensional portion of a complete space lattice, which when repeated over and over again in different directions from the crystal lattice.

Crystal lattice – it is a regular orientation of particles of a crystal in a 3D space.

(c) **Octahedral void** – it is a void surrounded by 6 spheres.

**Tetrahedral void** – it is a void surrounded by 4 spheres.



**Q8. Find the packing efficiency of a metal crystal for :**

(a) simple cubic

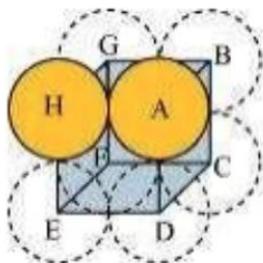
(b) body-centred cubic

(c) face-centred cubic (with the assumptions that atoms are touching each other).

**Ans:**

(a) **Simple cubic:**

In a simple cubic lattice, particles are present only at the corners and they touch each other along the edge.



Let, the edge length = a

Radius of each particle = r.

Thus, a = 2r

Volume of spheres =  $\pi r^3(4/3)$

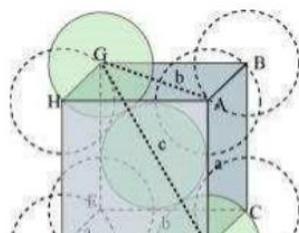
Volume of a cubic unit cell =  $a^3 = (2r)^3 = 8r^3$

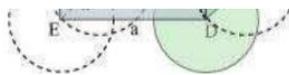
We know that the number of particles per unit cell is 1.

Therefore,

Packing efficiency = Volume of one particle/Volume of cubic unit cell =  $[\pi r^3(4/3)] / 8r^3 = 0.524$  or 52.4 %

(b) **Body-centred cubic:**





From  $\triangle FED$ , we have:

$$b^2 = 2a^2$$

$$b = (2a)^{1/2}$$

Again, from  $\triangle AFD$ , we have :

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

$$\Rightarrow c^2 = a^2 + 2a^2$$

$$c^2 = 3a^2$$

$$\Rightarrow c = (3a)^{1/2}$$

Let the radius of the atom = r.

Length of the body diagonal,  $c = 4r$

$$\Rightarrow (3a)^{1/2} = 4r$$

$$\Rightarrow a = 4r / (3)^{1/2}$$

$$\text{or, } r = [a (3)^{1/2}] / 4$$

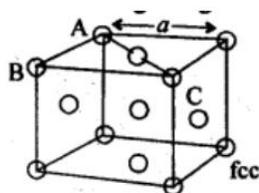
$$\text{Volume of the cube, } a^3 = [4r / (3)^{1/2}]^3$$

**A BCC lattice has 2 atoms.**

So, volume of the occupied cubic lattice =  $2\pi r^3(4/3) = \pi r^3(8/3)$

Therefore, packing efficiency =  $[\pi r^3(8/3)] / [4r / (3)^{1/2}]^3 = 0.68$  or 68%

(iii) Face-centred cubic:



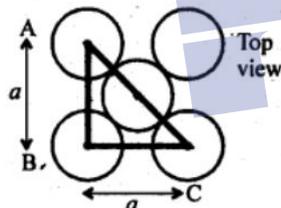
Let the edge length of the unit cell = a

let the radius of each sphere = r

Thus,  $AC = 4r$

From the right angled triangle ABC, we have :

$$AC = (a^2 + a^2)^{1/2} = a(2)^{1/2}$$



Therefore,  $4r = a(2)^{1/2}$

$$\Rightarrow a = 4r / (2)^{1/2}$$

Thus, Volume of unit cell =  $a^3 = [4r / (2)^{1/2}]^3$

$$a^3 = 64r^3 / 2(2)^{1/2} = 32r^3 / (2)^{1/2}$$

No. of unit cell in FCC = 4

Volume of four spheres =  $4 \times \pi r^3(4/3)$

Thus, packing efficiency =  $[\pi r^3(16/3)] / [32r^3 / (2)^{1/2}] = 0.74$  or 74 %

**Q9.** Silver is crystallized to a face-centered cubic lattice. Given that the cell has an edge length of  $4.07 \times 10^{-8}$  cm and density is  $10.5 \text{ g cm}^{-3}$ . Find its atomic mass.

Ans:

Given:

Edge length,  $a = 4.077 \times 10^{-8}$  cm

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

The given lattice is of fcc type,

Thus the number of atoms per unit cell,  $z = 4$

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

let M be the atomic mass of silver.

We know,  $d = zM/a^3N_A$

$$\Rightarrow M = da^3N_A / z$$

$$= 10.5 \times 4.077 \times 10^{-8} \times 6.022 \times 10^{23} / 4 = 107.13 \text{ g/mol}$$

**Q10. A cubic solid is constituted by two elements X and Y. Atoms of Y occupy the corners of the cube and X is at the center. Give the compound's formula. Also, provide the coordination numbers of X and Y.**

**Ans:**

Given:

Atoms of Y occupy the corners of the cube.

=> Number of Y atoms in a unit cell =  $8 \times \frac{1}{8} = 1$

Atom of X occupies the body center.

=> Number of X atoms in a unit cell = 1

Therefore, the ratio of the number of X atoms to the number of Y atoms;

X : Y = 1 : 1

**Thus the formula of the compound is XY**

**And the coordination number of both the elements is 8.**

**Q11. Studies demonstrate that the formula of nickel oxide is  $\text{Ni}_{0.98}\text{O}_{1.00}$ . Find the fractions of nickel that exist as  $\text{Ni}^{2+}$  and  $\text{Ni}^{3+}$  ions.**

**Ans:**

The given formula of nickel oxide is  $\text{Ni}_{0.98}\text{O}_{1.00}$ .

Thus, the ratio of the number of Ni atoms to the number of O atoms is,

Ni : O = 0.98 : 1.00 = 98 : 100

Now,

Total charge on 100  $\text{O}^{2-}$  ions =  $100 \times (-2) = -200$

Let the number of  $\text{Ni}^{2+}$  ions = x.

So, the number of  $\text{Ni}^{3+}$  ions is  $98 - x$ .

Now,

Total charge on  $\text{Ni}^{2+}$  ions =  $x(+2) = +2x$

Similarly, total charge on  $\text{Ni}^{3+}$  ions =  $(98 - x)(+3) = 294 - 3x$

As, the compound is neutral, we can write:

$2x + (294 - 3x) + (-200) = 0$

$\Rightarrow -x + 94 = 0$

$\Rightarrow x = 94$

Therefore, number of  $\text{Ni}^{2+}$  ions = 94

And, number of  $\text{Ni}^{3+}$  ions =  $98 - 94 = 4$

**Thus, the fraction of nickel that exists as  $\text{Ni}^{2+} = \frac{94}{98} = 0.0959$**

**And, the fraction of nickel that exists as  $\text{Ni}^{3+} = \frac{4}{98} = 0.041$**

**Q12. Write notes on the following, providing suitable examples:**

- Ferromagnetism**
- Paramagnetism**
- Ferrimagnetism**
- Antiferromagnetism**
- 12-16 and 13-16 group compounds.**

**Ans:**

**(a) Ferromagnetic:**

These substances ( ferromagnetic substances ) are strongly attracted by magnetic fields. They could be permanently magnetized even when a magnetic field is absent. Few examples of ferromagnetic substances include cobalt, iron, nickel,  $\text{CrO}_2$  and gadolinium.

In a solid state, their metal ions come together to form small regions termed domains and each domain behaves like a tiny magnet.

In a magnetized piece of a ferromagnetic substance, these domains are randomly arranged thus, their net magnetic moment becomes zero. However, when it is kept in a magnetic field, the domains orient themselves in the direction of the field. This results in a powerful magnetic effect being produced. This orientation of domains persists even after the field is removed. Hence, the ferromagnetic substance is transformed into a permanent magnet.

Schematic alignment of magnetic moments in ferromagnetic substances:



**(b) Para magnetism :**

These substances ( paramagnetic substances ) are attracted by a magnetic field but after the removal of the field, they lose their magnetism. Examples of paramagnetic substances include  $\text{Cr}_3\text{t}$ ,  $\text{O}_2$ ,  $\text{Cu}_2\text{t}$ , and  $\text{Fe}_3\text{t}$ . To undergo paramagnetism, a substance must possess one or more unpaired electrons. These unpaired electrons are pulled by the magnetic field, thus causing paramagnetism.

**(c) Antiferromagnetism :**

An antiferromagnetic substance has domain structures similar to that of ferromagnetic substances, but in opposite orientation. These oppositely-oriented domains null out each other's magnetic moments.

Schematic alignment of magnetic moments in antiferromagnetic substances

**(d) Ferrimagnetism:**

In these substances, the magnetic moments of the domains are oriented in parallel and anti-parallel directions and in unequal numbers. Few examples of ferromagnetic substances include ferrites like  $\text{MgFe}_2\text{O}_4$  and  $\text{ZnFe}_2\text{O}_4$ ,  $\text{Fe}_3\text{O}_4$  (magnetite), etc.

As compared to ferromagnetic substances these substances are weakly attracted by magnetic fields. **Upon heating, they become paramagnetic.**

**(e) 12-16 and 13-15 group compounds:**

The group 12-16 compounds are obtained by combining together group 16 and group 12 elements. Group 13-15 compounds are obtained by combining group 15 and group 13 elements. These compounds are prepared to stimulate average valence of four as in Si or Ge. Indium (III) antimonide ( $\text{IrSb}$ ), gallium arsenide ( $\text{GaAs}$ ), and aluminum phosphide ( $\text{AlP}$ ) are some typical compounds of groups 13-15.

GaAs semiconductors provide a very minute response time and they have totally changed the designing of semiconductor devices. Few examples of group 12-16 compounds are zinc sulphide ( $\text{ZnS}$ ), mercury (II) telluride ( $\text{HgTe}$ ), cadmium sulphide ( $\text{CdS}$ ) and cadmium selenide ( $\text{CdSe}$ ). The bonds these compounds have are not perfect covalent. **Their bond's ionic character depends upon the electronegativity of the two specie/elements.**

**Q13. What is the reason for solids being rigid?**

**Ans:**

Intermolecular forces of attraction in a solid is really strong, because of this the molecules of solids have fixed positions. None the less, they still can oscillate about their mean positions. **This is the reason for solids being rigid.**

**Q14. Explain why solids have a definite volume.**

**Ans:**

Intermolecular forces of attraction in a solid is really strong, because of this the molecules of solids have fixed positions. **This makes them very rigid, thus giving them definite volumes.**

Q15. Identify the amorphous and crystalline solids from the following:

**Fiberglass, polyurethane, naphthalene, teflon, benzoic acid, potassium nitrate, polyvinyl chloride, copper, cellophane.**

**Ans:**

**Crystalline solids:**

Naphthalene, potassium nitrate, benzoic acid, and copper

**Amorphous solids:**

Polyurethane, cellophane, teflon, fibreglass and polyvinyl chloride.

**Q16. For what reason is glass also considered a supercooled liquid?**

**Ans:**

Just like a liquid, glass also flows from top to bottom but very slowly. **For this reason, glass is also considered a supercooled liquid.**

**Q17. Why do some solids have the same value of the refractive index in every direction? Do they also exhibit cleavage property?**

**Ans:**

**These solids are isotropic in nature** i.e., they have the same value of physical properties in all directions. Thus, they also have the same value of refractive index along with all directions. As the solid is amorphous it will not exhibit cleavage property i.e., **it will break into pieces with undefined surfaces when cut.**

**Q18. Categorize the given solids into different categories depending on the nature of intermolecular forces working in them.**

**Potassium sulfate, benzene, tin, urea, water, ammonia, zinc sulfide, rubidium, graphite, silicon carbide, argon.**

**Ans:**

**Potassium sulphate** → Ionic solid

**Benzene** → Molecular (non-polar) solid

**Tin** → Metallic solid

**Urea** → Polar molecular solid

**Water** → Hydrogen bonded molecular solid

**Ammonia** → Polar molecular solid

**Zinc sulphide** → Ionic solid

**Rubidium** → Metallic solid

**Graphite** → Covalent or network solid

Graphite → Covalent or network solid  
Silicon carbide → Covalent or network solid  
Argon → Non-polar molecular solid

Q19. Solid X is a really hard electrical insulator in solid and in a liquid state and it has an extremely high melting point. Identify the type of solid it is?

Ans:

The above qualities are qualities of a covalent or network solid, thus it is a covalent or network solid. **The solid could be a diamond (C).**

Q20. Ionic solids do not conduct electricity in the solid state but only in the molten state. Why ?

Ans:

The ions of ionic solids are responsible for conducting electricity. In the solid state, however, these ions are not free to move around inside the solid because of the strong electrostatic forces. Hence, ionic solids do not conduct electricity in solid state. Whereas, **in a molten state, the ions are free to move and thus they can conduct electricity.**

Q21. What kind of solids are malleable, ductile and electrical conductors?

Ans:

**Metallic solids are malleable, ductile and electrical conductors.**

Q22. What is the importance of 'lattice point'?

Ans:

The importance of the lattice point is that every lattice point represents a fundamental particle of a solid which could be an ion, an atom or a molecule.

Q23. What are the parameters that make up a unit cell ?

Ans:

A unit cell is made up of the following parameters:  
(i) The three dimensions of a unit cell. ( the three edges)  
(ii) the angles between the edges.

Q24. Differentiate between:

- (i) End-centred and face- centered unit cells.
- (ii) Monoclinic and hexagonal unit cells.

Ans:

(i)

End centered unit cell	Face centered unit cell
They contain particles at the corners and one in the center of any two opposite faces.	They contain particles at the corners and one in the center of each face.
Total number of particles = 2	Total number of particles = 4

(ii)

Monoclinic unit cell	Hexagonal unit cell
$a = b \neq c$	$a \neq b \neq c$
$\alpha = \beta = 90^\circ$	$\alpha = \gamma = 90^\circ$
$\gamma = 120^\circ$	$B \neq 90^\circ$

Q25. A cubic unit cell has atoms at its (i) body center, and (ii) corner, find the amount of atom each unit cell gets after share with its neighboring unit cells.

Remove Watermark Now

Ans:

- (i) An atom in the body center is not shared between unit cells, thus the atom in the body center only belongs to the unit cell it is in.  
(ii) An atom in the corner is shared between 8 adjacent cells. Thus each cell gets  $1/8^{\text{th}}$  of the atom.

Q26. A molecule is in the square close-packed layer, find its two-dimensional coordination number.

Ans:

A molecule in square close-packed layer touches four of its neighbors. Thus, its two-dimensional coordination number is 4.

Q27. Find the number of voids in 0.2 moles of a compound forming hexagonal close-packed structure. What number of these are tetrahedral voids?

Ans:

Given:

$$\text{No. of close-packed particles} = 0.2 \times 6.022 \times 10^{23} = 1.2044 \times 10^{23}$$

$$\text{Thus, no. of octahedral voids} = 1.2044 \times 10^{23}$$

$$\text{And, no. of tetrahedral voids} = 2 \times 1.2044 \times 10^{23} = 2.4088 \times 10^{23}$$

$$\text{Thus, total number of voids} = 1.2044 \times 10^{23} + 2.4088 \times 10^{23} = 3.6132 \times 10^{23}$$

Q28. A compound is made up off two elements A and B. The atoms of element B form ccp and element A's atoms take up  $1/3^{\text{rd}}$  of the tetrahedral voids. Find the formula of this compound.

Ans:

Given:

Atoms of element B form ccp, thus no. of atoms = n

No. of oct voids = n

$$\text{No. of td voids} = 2n = 2 \times n(1/3) = 2n/3$$

Therefore :

Formula of the compound is A : B

$$2n/3 : n$$

$$2:3 = \mathbf{A_2B_3}$$

Q29. Identify the lattice with the highest packing efficiency (i) hexagonal close-packed (ii) simple cubic or (iii) body-centered lattice.

Ans:

The lattice with the greatest packing efficiency is the hexagonal close packed lattice with a packing efficiency of 74 %.

Q30. An element with a density of  $2.7 \times 10^3 \text{ kg m}^{-3}$  has a molar mass of  $2.7 \times 10^{-2} \text{ kg / mol}$  and it makes a cubic unit cell with an edge length of 405 pm. What kind of cubic unit cell does it have ?

Ans:

Given,

$$\text{Density, } d = 2.7 \times 10^3 \text{ kg m}^{-3}$$

$$\text{Molar mass, } M = 2.7 \times 10^{-2} \text{ kg /mol}$$

$$\text{Edge length, } a = 405 \text{ pm} = 405 \times 10^{-12} \text{ m} = 4.05 \times 10^{-10} \text{ m}$$

We know,

$$\text{Avogadro's number, } N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$\text{We also know that } d = (Z \times M)/(a^3 \times N_A)$$

$$\Rightarrow Z = (d \times N_A \times a^3)/M = 3.99 \sim 4$$

This means that the cell is a face centered cubic.

Q31. When solids are heated what kind of defects can arise in it ? Find physical property affected by it and the way it is affected.

Ans:

Heating solids produce vacancy defects in the crystal. This means that when heat is applied to the solid, some ions or atoms leave their lattice site totally, making those sites empty. **Thereby, decreasing the solid's density.**

Q32. Identify the type of stoichiometric defect present in :

(i) AgBr

(ii) ZnS

Ans:

(i) Frenkel and Schottky defects are present in AgBr.

(ii) ZnS contains Frenkel defect.

Q33. When a cation of higher valency is put in an ionic solid as an impurity, vacancies are created in the ionic solid. Explain how this happens.

Ans:

When a cation of higher valence is put in an ionic solid, it starts replacing cations of lower valency such that the crystal remains electrically neutral. Thereby, creating some vacant sites. For instance, if  $\text{Sr}^{2+}$  is put in NaCl, each  $\text{Sr}^{2+}$  ion replaces two  $\text{Na}^+$  ions. **Thereby creating one vacant for every  $\text{Sr}^+$  ion introduced.**

Q34. Explain using an appropriate example how ionic solids, with anionic vacancies caused due of the metal excess defect, start developing a color.

Ans:

Let us take an example of NaCl to explain this when NaCl crystals are heated in a sodium vapor atmosphere, sodium atoms are deposited on the crystal's surface. This causes the  $\text{Cl}^-$  ions to leave their lattice sites to form NaCl with the deposited sodium atoms. In this process, the sodium atoms on the surface lose their electrons to form  $\text{Na}^+$  ions and the released electrons move into the crystal to fill in the vacant anionic sites. **These electrons absorb energy from the incoming visible light and get excited to a higher energy level. Thereby, imparting a yellow color to the crystals.**

Q35. To convert a group 14 element into an n-type semiconductor a suitable impurity is doped into it. To which group does this impurity belong?

Ans:

This impurity should belong to group 15.

Q36. Which substance would be a better choice to make a permanent magnet, ferromagnetic or ferro-magnetic. Explain your answer.

Ans:

Ferromagnetic substances have their ions grouped into small regions called domains, and each domain behaves like a small magnet. So, when placed in a magnetic field these domains get oriented in the direction of the field, producing a strong magnetic field. And this orientation of the domains remain even when the field is removed. **Thus, ferromagnetic substances become a better permanent magnet.**