# One Two academy | Solid State

**Maximum Mark: 25** **Chemistry** **Time: 50 minutes**

**Choose the correct answer:** **3 x 1 = 3**

1. The yellow colour in NaCl crystal is due to
   a) excitation of electrons in F centers
   b) reflection of light from Cl- ion on the surface
   c) refraction of light from Na+ ion d) all of the above
2. Packing efficiency if Body Centered Cube (BCC):
   a) 52.31% b) 68% c) 86 % d) 52.13%
3. The number of close packed spheres is 'n'. The number of tetrahedral voids generated is equal to _____.
   a) n b) 2n c) $2n^2$ d) 3n

**Answer Any four of the following:** **4 x 2 = 8**

4. Define unit cell.
5. Write a note on Frenkel defect.
6. Define covalent solids.
7. What is meant by the term "coordination number"? What is the coordination number of atoms in a bcc structure?
8. Write a note on isotropy and anisotropy.

**Answer any three of the following:** **3 x 3 = 9**

9. What are the limitations of VB theory?
10. In an octahedral crystal field, draw the figure to show splitting of d orbitals
11. Write a note on stability constant.
12. Explain Optical Isomerism in coordination compounds with an example.

**Answer the following:** **1 x 5 = 5**

13. a) Calculate the percentage efficiency of packing in case of body centered cubic crystal.

**(Or)**

b) Explain AAAA and ABABA and ABCABC type of three-dimensional packing with the help of neat diagram.

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All the Best

# Answer Key attached in the next page !!!

This page is to prevent seeing answer key

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## Answer Key

**Choose the Correct answer:**

1. - a)  2. - b)  3. - b)

**Answer any four of the following:**

4. **Unit Cell:** A basic repeating structural unit of a crystalline solid is called a unit cell. Unit cell is the smallest fundamental repeating portion of a crystal lattice
5. **Frenkel defect:** Frenkel defect arises due to the dislocation of ions from its crystal lattice. The ion which is missing from the lattice point occupies an interstitial position. This defect is shown by ionic solids in which cation and anion differ in size. Unlike Schottky defect, this defect does not affect the density of the crystal.
6. **Covalent solids:** the constituents (atoms) are bound together in a three-dimensional network entirely by covalent bonds. Examples: Diamond, silicon carbide etc.
7. **Coordination number:** The number of near or neighbours of a particle is called co-ordination number. In a body centered cubic unit cell, each corner is occupied by an identical particle and in addition to that one atom occupies the body centre. Hence, each atom is surrounded by eight nearest neighbours and co-ordination number in bcc structure is 8.
8. **Isotropy:** Isotropy means uniformity in all directions. In solid state isotropy means having identical values of physical properties such as refractive index, electrical conductance etc.., in all directions.
   **Anisotropy:** anisotropy is the property which depends on the direction of measurement. Crystalline solids are anisotropic and they show different values of physical properties when measured along different directions.

**Answer any three of the following:**

9.

| S.No | Crystalline solids | Amorphous solids |
|---|---|---|
| 1 | Long range orderly arrangement of constituents. | Short range, random arrangement of constituents. |
| 2 | Definite shape | Irregular shape |
| 3 | Generally crystalline solids are anisotropic in nature | They are isotropic* like liquids |
| 4 | They are true solids | They are considered as pseudo solids (or) super cooled liquids |
| 5 | Definite heat of fusion | Heat of fusion is not definite |
| 6 | They have sharp melting points. | Gradually soften over a range of temperature and so can be moulded. |
| 7 | Examples: NaCl , diamond etc., | Examples: Rubber , plastics, glass etc |

10. **Ans:** $0.1 \times 10^{24}$

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11. **Calculation of density:**

Using the edge length of a unit cell, we can calculate the density (ρ) of the crystal by considering a cubic unit cell as follows.

Density of the unit cell ρ = $\frac{\text{mass of the unit cell}}{\text{volume of the unit cell}}$ ….(1)

mass of the unit cell=

{total number of atoms belongs to that unit cell}x{mass of one atom} …..(2)

mass of one atom = $\frac{molar\ mass\ (gmol{-}1)}{Avagadro\ number\ (mol{-}1)}$

m = $\frac{M}{NA}$ .....(3)

Substitute (3) in (2)

mass of the unit cel l= n x $\frac{M}{NA}$ …..(4)

For a cubic unit cell, all the edge lengths are equal i.e., a=b=c

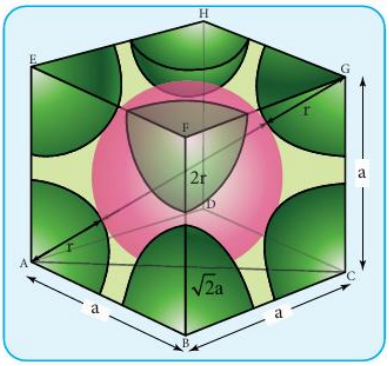
volume of the unit cell = a x a x a = $a^3$ …..(5)

∴ Density of the unit cell ρ = $\frac{n\,M}{a\text{^}3\ NA}$ …..(6)

12. The structural units of an ionic crystal are cations and anions. They are bound together by strong electrostatic attractive forces. To maximize the attractive force, cations are surrounded by as many anions as possible and vice versa. Ionic crystals possess definite crystal structure.

**Answer the following:**

13. a) **Packing efficiency:** Here, the spheres are touching along the leading diagonal of the cube




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In $\Delta ABC$

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

$AC = \sqrt{AB^2 + BC^2}$

$AC = \sqrt{a^2 + a^2} = \sqrt{2a^2} = \sqrt{2}\ a$

In $\Delta ACG$

$AG^2 = AC^2 + CG^2$

$AG = \sqrt{AC^2 + CG^2}$

$AG = \sqrt{\left(\sqrt{2}a\right)^2 + a^2}$

$AG = \sqrt{2a^2 + a^2} = \sqrt{3a^2}$

$AG = \sqrt{3}\ a$

i.e., $\sqrt{3}a = 4r$

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

∴ Volume of the sphere with radius 'r'

$$= \frac{4}{3}\pi r^3$$

$$= \frac{4}{3}\pi\left(\frac{\sqrt{3}}{4}a\right)^3$$

$$= \frac{\sqrt{3}}{16}\pi a^3 \quad \ldots(1)$$

Number of spheres belong to a unit cell in bcc arrangement is equal to two and hence the total volume of all spheres

$$= 2 \times \left(\frac{\sqrt{3}\ \pi\ a^3}{16}\right) = \frac{\sqrt{3}\ \pi\ a^3}{8}$$

Dividing (2) by (3)

$$\text{Packing fraction} = \frac{\left(\frac{\sqrt{3}\ \pi\ a^3}{8}\right)}{\left(a^3\right)} \times 100$$

$$= \frac{\sqrt{3}\ \pi}{8} \times 100$$

$$= \sqrt{3}\ \pi \times 12.5$$

$$= 1.732 \times 3.14 \times 12.5$$

$$= 68\ \%$$

i.e., 68 % of the available volume is occupied. The available space is used more efficiently than in simple cubic packing.

**(Or)**

b) **i) AAAA three-dimensional packing:**

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- This type of three-dimensional packing arrangements can be obtained by repeating the AAAA type two dimensional arrangements in three dimensions.
- spheres in one layer sitting directly on the top of those in the previous layer so that all layers are identical.
- All spheres of different layers of crystal are perfectly aligned horizontally and also vertically.
- In simple cubic packing, each sphere is in contact with 6 neighbouring spheres - Four in its own layer, one above and one below and hence the coordination number of the sphere in simple cubic arrangement is 6.

**ii) ABABA three dimensional packing:**

- In this type, the second row spheres are arranged in such a way that they fit in the depression of the first row.
- The second row is denoted as B type. The third row is arranged similar to the first row A, and the fourth one is arranged similar to second one.
- the pattern is repeated as ABAB….In this arrangement each sphere is in contact with 6 of its neighbouring spheres.

**iii) ABCABC three dimensional packing:**

- the first layer (a) is formed by arranging the spheres as in the case of two dimensional ABAB arrangements.
- The second layer (b) is formed by placing the spheres on the depression of the first layer.
- A tetrahedral void (x) and octahedral void (y) are formed in the first layer.
- The third layer is placed over the second layer in such a way that all the spheres of the third layer fit in octahedral voids.
- This arrangement of the third layer is different from other layers (a) and (b). Hence, the third layer is designated (c).
- If the stacking of layers is continued in abcabc… pattern, then the arrangement is called cubic close packed (ccp) structure.
- In ccp arrangements, the coordination number of each sphere is 12- six neighbouring spheres in its own layer, three spheres in the layer above and three spheres in the layer below.

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