CHAPTER 01

SOLID STATE

1. All the metallic elements like iron, copper; non-metallic elements like sulphur, iodine and compounds like NaCl, ZnS form

(a) amorphous solids *(b)* crystalline solids
(c) polycrystalline solis *(d)* Both (b) and (c)

2. Some of the physical properties of crystalline solids like refractive index show different values on measuring along different directions in the same crystals. This property is called

(a) isotropy *(b)* cleavage property
(c) anisotropy *(d)* None of these

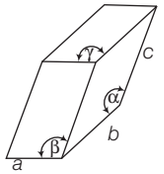
3. The lattice points of a crystal of hydrogen iodide are occupied by

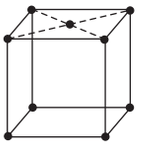
(a) HI molecules
(b) H atoms and I atoms
(c) H^+ cations and I^- anions
(d) H_2 molecules and I_2 molecules

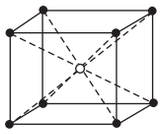
4. Identify the type of crystal system of the following
(A) KNO_3; (B) $CaCO_3$; (C) $CaSO_4$;
(D) $CuSO_4 \cdot 5H_2O$

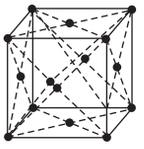
(a) *A*-Cubic; *B*-Triclinic; *C*-Hexagonal; *D*-Rhombohedral
(b) *A*-Tetragonal; *B*-Monoclinic; *C*-Triclinic; *D*-Hexagonal
(c) *A*-Orthorhombic; *B*-Trigonal; *C*-Tetragonal; *D*-Triclinic
(d) *A*-Rhombohedral; *B*-Hexagonal; *C*-Trigonal; *D*-Orthorhombic

5. In which of the following structure unit cell shows the triclinic structure?

(a) 

(b) 

(c) 

(d) 

6. Which primitive unit cell has unequal edge lengths ($a \neq b \neq c$) and all axial angles different from 90°?

(a) Hexagonal *(b)* Monoclinic
(c) Tetragonal *(d)* Triclinic

7. In a face centred cubic lattice, atom *A* occupies the corner positions and atom *B* occupies the face centre positions. If one atom of *B* is missing from one of the face centred points, the formula of the compound is

(a) A_2B *(b)* AB_2
(c) A_2B_2 *(d)* A_2B_5

8. The number of octahedral void(s) per atom present at a cubic close packed structure is

(a) 1 *(b)* 3 *(c)* 2 *(d)* 4

9. A compound is formed by cation *C* and anion *A*. The anions form hexagonal close packed (hcp) lattice and the cations occupy 75% of octahedral voids. The formula of the compound is

(a) C_3A_2 *(b)* C_3A_4
(c) C_4A_3 *(d)* C_2A_3

10. In a crystalline solid, having formula XY_2O_4, oxide ions are arranged in cubic close packed lattice, while cations *X* are present in tetrahedral voids and cations *Y* are present in octahedral voids. The percentage of tetrahedral voids occupied by *X* is

(a) 12.5% *(b)* 25% *(c)* 50% *(d)* 75%

11. Element '*B*' forms ccp structure and '*A*' occupies half of the octahedral voids, while oxygen atoms occupy all the tetrahedral voids. The structure of bimetallic oxide is

(a) A_2BO_4 *(b)* AB_2O_4
(c) A_2B_2O *(d)* A_4B_2O

12. Sodium metal crystallises in a body centred cubic lattice with a unit cell edge of 4.29 Å. The radius of sodium atom is approximately

(a) 1.86 Å *(b)* 3.22 Å
(c) 5.72 Å *(d)* 0.93 Å

13. Which of the following is correct order of packing efficiency?

(a) hcp = fcc > bcc > sc *(b)* sc > bcc > hcp = fcc
(c) bcc > sc > hcp < fcc *(d)* fcc = hcp > sc > bcc

14. Which of the following is the ratio of packing density of fcc, bcc and simple cubic structures ?

(a) 0.92 : 0.70 : 1 *(b)* 0.70 : 0.92 : 1
(c) 1 : 0.92 : 0.70 *(d)* 1 : 0.70 : 0.92

15. A metal has bcc structure and the edge length of its unit cell is 3.04 Å. The volume of the unit cell in cm^3 will be

(a) 1.6×10^{-21} cm^3 *(b)* 2.81×10^{-23} cm^3
(c) 6.02×10^{-23} cm^3 *(d)* 6.6×10^{-24} cm^3

16. An atom forms face centred cubic crystal with density $d = 8.92$ g / mL and edge length $a = 3.6 \times 10^{-8}$ cm. The molecular mass of atom in amu is

(a) 98 amu *(b)* 63 amu
(c) 32 amu *(d)* 93 amu

17. Iron exhibits bcc structure at room temperature. Above 900°C , it transforms to fcc structure. The ratio of density of iron at room temperature to that at 900°C (assuming molar mass and atomic radii of iron remains constant with temperature) is

(a) $\frac{3\sqrt{3}}{4\sqrt{2}}$ *(b)* $\frac{4\sqrt{3}}{3\sqrt{2}}$ *(c)* $\frac{\sqrt{3}}{\sqrt{2}}$ *(d)* $\frac{1}{2}$

18. The cubic unit cell of Al (molar mass 27 g mol^{-1}) has an edge length of 405 pm. Its density is 2.7 g cm^{-3}.

The cubic unit cell is

(a) face centred *(b)* body centred
(c) primitive *(d)* edge centred

19. Volume occupied by single CsCl ion pair in a crystal is 7.014×10^{-23} cm^3. The smallest Cs — Cs

Cs — Cs internuclear distance is equal to length of the side of the cube corresponding to volume of one CsCl ion pair. The smallest Cs to Cs internuclear distance is nearly

(a) 4.4 Å *(b)* 4.3 Å *(c)* 4 Å *(d)* 4.5 Å

20. Which kind of defect is shown by the given crystal?

K^+ Cl^- K^+ Cl^- K^+ Cl^-
Cl^- □ Cl^- K^+ □ K^+
K^+ Cl^- □ Cl^- K^+ Cl^-
Cl^- K^+ Cl^- K^+ □ K^+

(a) Schottky defect
(b) Frenkel defect
(c) Both Schottky and Frenkel defects
(d) Substitution disorder

21. Which of the following compounds is likely to show both Frenkel and Schottky defects in its crystalline form?

(a) AgBr *(b)* CsCl *(c)* KBr *(d)* ZnS

22. Electrical conductivity of semiconductors increases with increase in

(a) temperature *(b)* pressure
(c) volume *(d)* None of these

23. Which of the following has the highest value of energy gap?

(a) Aluminium *(b)* Silver
(c) Germanium *(d)* Diamond

24. Which type of magnetic behaviour is exhibited by $MgFe_2O_4$ is ?

(a) Diamagnetic *(b)* Paramagnetic
(c) Ferromagnetic *(d)* Ferrimagnetic

25. Which one is not a ferroelectric compound?

(a) KH_2PO_4 *(b)* $K_4[Fe(CN)_6]$
(c) Rochelle salt *(d)* $BaTiO_3$

ANSWERS

1. (b)	**2.** (c)	**3.** (a)	**4.** (c)	**5.** (a)	**6.** (d)	**7.** (d)	**8.** (a)	**9.** (b)	**10.** (a)
11. (b)	**12.** (a)	**13.** (a)	**14.** (c)	**15.** (b)	**16.** (b)	**17.** (a)	**18.** (a)	**19.** (c)	**20.** (a)
21. (a)	**22.** (a)	**23.** (d)	**24.** (d)	**25.** (b)					

HINTS AND SOLUTION

1. (*b*) Most of the solid substances are crystalline in nature. For example, all the metallic elements like iron, copper and silver, non-metallic elements like sulphur, phosphorus and iodine and compounds like sodium chloride, zinc sulphide and naphthalene form crystalline solids.

3. (*a*) Since, HI is a covalent molecule, so HI molecules are present at the lattice points of the crystal.

4. *(c)* (A) KNO_3 — Orthorhombic
(B) $CaCO_3$ — Trigonal
(C) $CaSO_4$ — Tetragonal
(D) $CuSO_4 \cdot 5H_2O$ — Triclinic

5. (*a*) Fig. (a) represents structure of triclinic crystal system as, $a \neq b \neq c$ and $\alpha \neq \beta \neq \gamma \neq 90°$.
Whereas, the structures in option (b), (c) and (d) represents end-centred body centred and face-centred cubic.

6. (*d*) Triclinic primitive unit cell has dimensions as, $a \neq b \neq c$ and $\alpha \neq \beta \neq \gamma \neq 90°$.
Among the seven basic or primitive crystalline systems, the triclinic system is most unsymmetrical. In other cases, edge length and axial angles are given as follows :
Hexagonal : $a = b \neq c$ and $\alpha = \beta = 90°, \gamma = 120°$
Monoclinic : $a \neq b \neq c$ and $\alpha = \gamma = 90°, \beta \neq 90°$
Tetragonal : $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90°$

7. (*d*) Number of effective A atoms
$= 8$ corners $\times$ 1/8 per corner atom share
$= 1$ atoms/unit cell
Number of atoms on faces of a cube = 6 atoms
If one B atom is missing from one face,
number of B atoms left = 5
$\therefore$ Number of effective B atoms
$= 5$ faces $\times$ 1/2 per face atom share $= \frac{5}{2}$ per unit cell
The formula of the compound is A_2B_5.

8. (*a*) Number of octahedral voids = Number of atoms in the close packed structure
Since, number of atom = 1; Therefore, number of octahedral void = 1

9. (*b*) Anions (A) form hexagonal close packed (hcp) lattice, so
Number of anions (A) = 6
Number of octahedral voids
= Number of atoms in the close packed structure = 6.
Cations (C) occupy 75% of octahedral voids,
so number of cations $(C) = 6 \times \frac{75}{100} = 6 \times 3/4 = 9/2$
$\therefore$ The formula of compound $= C_{9/2}A_6 = C_9A_{12} = C_3A_4$

10. (*a*) In a cubic close packed lattice of oxide ions, there would be two tetrahedral and one octahedral void per oxide ion.
Since, the formula shows the presence of 4 oxide ions, the number of tetrahedral voids is eight and that of octahedral voids is four. Out of the eight tetrahedral voids, one is occupied by X.
$\therefore$ Percentage of tetrahedral voids occupied
$$= \frac{1}{8} \times 100 = 12.5\%$$

11. (*b*) The number of element 'B' in the crystal structure = $4N$
Number of tetrahedral voids = $2N$
Number of octahedral voids = N
$\therefore$ Number of 'A' in the crystal $= \frac{N}{2} = \frac{4}{2} = 2$
Number of oxygen (O) atoms = $2N = 2 \times 4 = 8$
$\therefore$ The structure of bimetallic oxide = $A_2\ B_4\ O_8$
$= AB_2O_4$

12. (*a*) Given, Na metal crystallises in bcc unit cell with unit cell edge, $a = 4.29$ Å
We have the formula for radius, $r = \frac{\sqrt{3}}{4} \times a$
$$= \frac{\sqrt{3}}{4} \times 4.29 \text{ Å} = 1.86 \text{ Å}$$

13. (*a*) Packing efficiency for :
Hexagonal close packing (hcp) = 74%
Face-centered cubic close packing (fcc) = 74%
Body centered cubic close packing (bcc) = 68%
and simple cubic (sc) = 52%
Thus, correct order of packing efficiency is :
hcp = fcc > bcc > sc
Hence, option (a) is the correct.

14. (*c*) Packing fraction in fcc, bcc and sc are 0.74, 0.68, and 0.52 respectively.
$$\text{Ratio} = \frac{0.74}{0.74} : \frac{0.68}{0.74} : \frac{0.52}{0.74} = 1 : 0.92 : 0.70$$

15. (*b*) Edge length, $a = 3.04$ Å $= 3.04 \times 10^{-8}$ cm
Volume of bcc unit cell $= a^3$
$$= (3.04 \times 10^{-8})^3 = 2.81 \times 10^{-23} \text{ cm}^3$$

16. (*b*) Given,
Density (d) = 8.92 g/mL
Edge length (a) = 3.6×10^{-8} cm $\Rightarrow$ $Z = 4$ (fcc)
The molecular mass of atom in a lattice can be calculated by using the formula,
$$d = \frac{Z \times M}{N_0 a^3}$$
$\therefore$ $$M = \frac{dN_0 a^3}{Z}$$