ANSWERS OF SOLID STATE

1.   (a) Both gases and liquids possess fluidity and hence viscosity molecules in the solid state do not have translational motion.
2   **A**
3.   (c) Piezoelectric crystals are used in record player.
4.   **C**
5   (b) $NaCl$ is a ionic solid in which constituent particles are positive (Na^+) and negative (Cl^-) ions.

6   (d) Amorphous solids have short range order but no sharp in melting point.
7   (d) Solids have definite shape, size and rigidity.
8   (a) In crystalline solid there is perfect arrangement of the constituent particles only at $0K$. As the temperature increases the chance that a lattice site may be unoccupied by an ion increases. As the number of defects increases with temperature solid change in liquid.
9   (c) Diamond is a covalent solid in which constituent particles are atoms.
10. (c) Solid $NaCl$ is a bad conductor of electricity because ions are not free to move.
11. (a) The existence of a substance in more than one crystalline form is known as polymorphism.
12   (a)   Solids are also non-crystalline in nature
13. (b) Ionic solids have highest melting point due to strong electrostatic forces of attraction.
14. (d) For *n*-type, impurity added to silicon should have more than 4 valence electrons.

15. (d) Glass is an amorphous solid.
16. (a) Crystalline solids have regular arrangement of constituent particles, sharp melting points and are anisotropic.
17. (d) Sugar is a crystalline solid while glass, rubber and plastic are amorphous solids.
18   (a)
19. (a) MnO_2 is antiferromagnetic.
20. (d) Graphite is sp^2 hybridised and a covalent crystal.
21. (d) Ionic crystals exhibit non-directional properties of the bond.
22. (d) Ice is a molecular crystal in which the constituent units are molecules and the interparticle forces are hydrogen bonds.
23. (a) Quartz is a covalent crystal having a framework of silicates or silica, *i.e.* a three dimensional network when all the four oxygen atoms of each of SiO_4 tetrahedron are shared.
24. (c) Metallic crystals are good conductor of heat and current due to free electrons in them.
25. (a) Silicon is a covalent crystal in which constituent particles are atoms.
26. (b) LiF is an example of ionic crystal solid, in which constituent particles are positive (Li^+) and negative (F^-) ions.
27. (a) Amorphous solids neither have ordered arrangement (*i.e.* no definite shape) nor have sharp melting point like crystals, but when heated, they become pliable until they assume the properties usually related to liquids. It is therefore they are regarded as super-cooled liquids.
28.   (a)   Silicon is a semiconductor because it is a thermal active and its conductivity increased with increasing temperature
29. (b) Amorphous solids are isotropic, because of these substances show same properties in all directions.
30. (c) Polymorphism is a ability of a substances which show two or more crystalline structure
31   (ac) Amorphous solids neither have ordered arrangement (*i.e.* no definite shape) nor have sharp melting point like crystals, but when heated, they become pliable until they assume the properties usually related to liquids. It is therefore they are regarded as super-cooled liquids.

Crystallography and Lattice

1.   (c) Rhombohedral crystal system

   $a = b = c$, $\alpha = \beta = \gamma \neq 90^o$

       ex $-$ $NaNO_3$, $CaSO_4$, calcite $CaCO_3$,

2   (b) Tetragonal system has the unit cell dimension $a = b \neq c, \alpha = \beta = \gamma = 90°$.

3.   **d**

4.   (a) Space lattice of CaF_2 is face centred cubic.

5. (a) For body centred cubic arrangement co-ordination number is 8 and radius ratio (r_+ / r_-) is

6. (b) There are 14 Bravais lattices (space lattices).

7. (d) Monoclinic sulphur is an example of Monoclinic crystal system.

8   d

9. (b) $r = 0.414 \, r$.

10 (c) Each unit cell of $NaCl$ contains $4 \, NaCl$ units.

11 (c) Definition of unit cell.

12. (c) For tetrahedral arrangement co-ordination number is 4 and radius ratio (r_+ / r_-) is $0.225 - 0.414$.

13. (a) For body centred cubic arrangement co-ordination number is 8 and radius ratio (r_+ / r_-) is $0.732 - 1.000$.

14   7 seven

15 (b) In $NaCl$ (rock salt) : Number of Na^+ ions $= 12$ (at edge centers) $\times \dfrac{1}{4} + 1$ (at body centre) $\times 1 = 4$. Number of

Cl^- ions $= 8$ (at corners) $\times \dfrac{1}{8} + 6$ (at face centre) $\times \dfrac{1}{2} = 4$. Thus 4 formula units per unit cell.

16 (b) Lowest potential energy level provides stable arrangement.

17 (b) The seven basic crystal lattice arrangements are :- Cubic, Tetragonal, Orthorhombic, Monoclinic, Hexagonal, Rhombohedral and Triclinic.

18. (a) The conditions for monoclinic crystal system.

19 (14)

20 **GM** (b)Zinc blende (ZnS) has fcc structure and is an ionic crystal having 4 : 4 co-ordination number.

21 **b**

22 (d) $\dfrac{1}{8} \times 8$ (at corners) $= 1$

$\dfrac{1}{2} \times 6$ (at face centre) $= 3$

$Z = 1 + 3 = 4$ (total no. of atoms)

Crystal packing

1. (b) Number of tetrahedral voids in the unit cell

$= 2 \times$ number of atoms = 2Z.

2. (b) The system $ABC \, ABC \ldots \ldots$ is also referred to as face-centred cubic or fcc.

3. (d) It represents ccp arrangement.

4. (a) BCC has a coordination number of 8.

5. (b) In rock salt structure the co-ordination number of $Na^+ : Cl^-$ is $6 : 6$.

6. (d) The bcc cell consists of 8 atoms at the corners and one atom at centre.

$\therefore \; n = \left(8 \times \dfrac{1}{8} \right) + 1 = 2$.

The fcc cell consists of 8 atoms at the eight corners and one atom at each of the six faces. This atom at the face is shared by two unit cells.

$\therefore \; n = 8 \times \dfrac{1}{8} + \left(6 \times \dfrac{1}{2} \right) = 4$.

7. (c) AB_2 type of structure is present in CaF_2

$\therefore \; AB_2 \rightleftharpoons A^{2+} + 2B^- ; \quad CaF_2 \rightleftharpoons Ca^{2+} + 2F^-$

8. (b) Potassium (K) has bcc lattice.

9. (b) Number of atoms per unit cell in bcc system = 2.

10. (b) In body centred cubic, each atom/ion has a coordination number of 8.

11. (d) Number of octahedral sites = Number of sphere in the packing.

$\therefore$ Number of octahedral sites per sphere $= 1$.(4/4)

12. (c) $ABAB \ldots \ldots$ is hexagonal close packing

13. (b) SrF_2 has fluorite (CaF_2) type structure.(see notes table5.5)

14. (c) CaF_2 (fluorite) has fcc structure with 8 : 4 coordination number. (see notes table5.5)

15. (b) Every constituent has two tetrahedral voids. In ccp lattice atoms

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

∴ Tetrahedral void $= 4 \times 2 = 8$,

Thus ratio $= 4 : 8 :: 1 : 2$.

16. (c) Tetrahedral sites one double comparable to octahedral sites then ratio of X and Z respectively 2 : 1 since formula of the compound X_2Z .

17. (c) A atoms are at eight corners of the cube. Therefore, the no. of A atoms in the unit cell $= \frac{8}{8} = 1$. B atoms are at the face centre of six faces. Therefore, its share in the unit cell $= \frac{6}{2} = 3$. The formula is AB_3 .

18. (a) In bcc structure 68% of the available volume is occupied by spheres. Thus vacant space is 32%.

19. (c) Number of atoms in the cubic close packed structure = 8.

        Number of octahedral voids

20. (a) Co-ordination number in *HCP* and *CCP* arrangement is 12 while in *bcc* arrangement is 8.

Mathematical analysis of cubic system

1. (b) Density of unit cell $= \dfrac{N \times \text{mol.wt.}(M)}{V(= a^3) \times \text{avogadro no.}(N_o)} \, g \, cm^{-3}$

2. (a) There are two atoms in a *bcc* unit cell.

So, number of atoms in 12.08×10^{23} unit cells $= 2 \times 12.08 \times 10^{23} = 24.16 \times 10^{23} \, atom$.

3. (b) *bcc* structure has one atom shared by 1 unit cell.

4. (b) The structural arrangement of co-ordination number '6' is octahedral and its radius ratio is $0.414 - 0.732$. The example of octahedral is *KCl* and *NaCl* . (notes table 5.4)

5. (a) The number of spheres in one body centred cubic and in one face centred cubic unit cell is 2 and 4 respectively.(page 4)

6. (b) Closest approach in *bcc* lattice

$$= \frac{1}{2} \text{ of body diagonal } = \frac{1}{2} \times \sqrt{3}a = \frac{\sqrt{3}}{2} \times 4.3 = 3.72 \text{Å} .$$

7. c

8 (a) $M = \dfrac{\rho \times a^3 \times N_0 \times 10^{-30}}{z}$

$$= \frac{10 \times (100)^3 \times (6.02 \times 10^{23}) \times 10^{-30}}{4} = 15.05$$

No. of atoms in $100 \, g = \dfrac{6.02 \times 10^{23}}{15.05} \times 100$

(notes page 4 formula)

9. (c) $58.5 \, g \, NaCl = 1 \, mole = 6.02 \times 10^{23} \, Na^+Cl^- \, units$.

One unit cell contains $4 \, Na^+Cl^-$ units. Hence number of unit cell present

$$= \frac{6.02 \times 10^{23}}{4} = 1.5 \times 10^{23} .$$

10. (a) $\dfrac{1}{58.5} \times 6.023 \times 10^{23} = 1.029 \times 10^{22}$

A unit cell contains $4 \, Na^+$ ion and $4 \, Cl^-$ ions

$$\therefore \text{Unit cell} = \frac{1.029 \times 10^{22}}{4} = 2.57 \times 10^{21} \text{ unit cell.}$$

11. (b) Bragg's equation is $n\lambda = 2d \sin\theta$

where n is an integer *i.e.* 1, 2, 3, 4 etc.

12. (d) Face centred cubic structure contribute of 1/8 by each atom present on the corner and 1/2 by each atom present on the face.

13. (c) As *CsCl* is body-centred, $d = \sqrt{3}a/2$.(table page 4)

14. (a) Radius of *Na* (if *bcc* lattice) $= \dfrac{\sqrt{3}a}{4} = \dfrac{\sqrt{3} \times 4.29}{4}$

$$= 1.8574 \text{Å} = 1.8574 \times 10^{-8} \, cm$$

15. (b) The crystals in which radius ratio value is found between $0.225 - 0.414$ shows tetrahedral crystal structure.(table 5.4)

16. (d) For $bcc, d = \dfrac{\sqrt{3}}{2} a$ or $a = \dfrac{2d}{\sqrt{3}} = \dfrac{2 \times 4.52}{1.732} = 5.219 \text{Å} = 522\,pm$

$$\rho = \dfrac{Z \times M}{a^3 \times N_0 \times 10^{-30}} = \dfrac{2 \times 39}{(522)^3 \times (6.023 \times 10^{23}) \times 10^{-30}}$$
$$= 0.91\,g/cm^3 = 910\,kg\,m^{-3}$$

17. (c) The value of ionic radius ratio is 0.52 which is between $0.414 - 0.732$, then the geometrical arrangement of ions in crystal is octahedral.

18. (c) The number of atoms present in *sc, fcc* and *bcc* unit cell are 1, 4, 2 respectively.

19. (b) The number of atoms present in *sc, fcc* and *bcc* unit cell are 1, 4, 2 respectively.

20. (a) $r = \dfrac{a}{2\sqrt{2}}$; $r = \dfrac{620}{2\sqrt{2}} = 219.25\,Pm$

21. (b) Volume of unit cell $= a^3$
$$= (3.04 \times 10^{-8}\,cm)^3 = 2.81 \times 10^{-23}\,cm^3$$

22. (b) In *FCC*
$$4r = \sqrt{2}a$$
$$a = \dfrac{4r}{\sqrt{2}}$$

Crystal structure and Coordination number

1. (b) In a unit cell, W atoms at the corner $= \dfrac{1}{8} \times 8 = 1$

O atoms at the centre of edges $= \dfrac{1}{4} \times 12 = 3$

Na atoms at the centre of the cube $= 1$
$$W : O : Na = 1 : 3 : 1, \text{ hence formula} = NaWO_3$$

2. (d) For *bcc* lattice, co-ordination number is 8.

3. (b) Body centered cubic lattice has a co-ordination number 8.

4. (a) A atoms are at eight corners of the cube. Therefore, the number of *A* atoms in the unit cell $= \dfrac{8}{8} = 1$, atoms *B* per unit cell = 1. Hence the formula is *AB*.

5. (d) *X* atoms are at eight corners of the cube. Therefore, the number of *X* atoms in the unit cell $= \dfrac{8}{8} = 1$.

Y atoms are at the face centre of six faces. Therefore, its share in the unit cell $= \dfrac{6}{2} = 3$. The formula is XY_3.

6. (b) Cl^- ions in $CsCl$ adopt *BCC* type of packing.

7. (a) In Cs^+Cl^- crystal co-ordination number of each ion is 8.

8. (b) $r_+ / r_- = \dfrac{180}{187} = 0.962$ which lies in the range of $0.732 - 1.000$, hence co-ordination number = 8 *i.e.* the structure is $CsCl$ type.

9. (a) In diamond, C-atoms are arranged in a regular tetrahedral structure.

10. (b) In *hcp*, co-ordination no. is 12.

11. (d) In $NaCl$ crystal every Na^+ ion is surrounded by $6\,Cl^-$ ion and every chloride ion is surrounded by $6\,Na^+$ ion.

12. (a) In sodium chloride, each Na^+ ion is surrounded by six Cl^- ions and each Cl^- ion is surrounded by six Na^+ ions. Thus, both the ions have coordination number six.

13. (b) Fe_3O_4 is a non-stoichiometric compound because in it the ratio of the cations to the anions becomes different from that indicated by the chemical formula.

14. (d) The radius ratio for co-ordination number 4, 6 and 8 lies in between the ranges $[0.225 - 0.414]$, $[0.414 - 0.732]$ and $[0.732 - 1]$ respectively.

15. (c) The radius ratio for co-ordination number 4, 6 and 8 lies in between the ranges $[0.225 - 0.414]$, $[0.414 - 0.732]$ and $[0.732 - 1]$ respectively.

16. (b) When radius ratio between $0.732 - 1$, then co-ordination number is 8 and structural arrangement is body-centred cubic.

17. (c) Each Cs^+ is surrounded by eight Cl^- ions in $CsCl$ crystal lattice because its co-ordination number is $8 : 8$.

18. (a) $NaCl$ has *fcc* arrangement of ions.

19. (c) Each Na^+ is surrounded by six Cl^- ions in $NaCl$ crystal lattice because its co-ordination number is $6 : 6$.

20 easy

21. (d) In a simple cubic structure

$z = \dfrac{1}{8} \times 8$ (atoms one at a corners)

$z = 1$

31. (a) Co-ordination number in hcp structure is 12.

Defects in crystal

1. (c) When polar crystal is subjected to a mechanical stress, electricity is produced – a case of piezoelectricity. Reversely, if electric field is applied, mechanical stress is developed. Piezoelectric crystal acts as a mechanical electrical transductor.

2. (b) More is the Schottky defect in crystal more is the decrease in density.

3. (d) All the given statements are correct about F-centres.

4. b

5. (c) Yellow colour on heating $NaCl$ in presence of Na is due to presence of electrons in anion vacancies (F-centres).

6. (d) Frenkel's defect is due to shift of an ion from the normal lattice site (Creating a vacancy) and occupy interstitial spaces.

7. (d) Schottky defect is due to missing of equal number of cations and anions.

8. (c) Since no ions are missing from the crystal as a whole, there is no effect on density.

9. (b) On adding non-metal in metal the metal becomes less tensile.

10. (c) Both are stoichiometric crystalline defects.

11. (d) In metal excess defect when holes created by missing of anions are occupied by electrons, there sites are called F-centres and are responsible for colour in the crystal.

12. (c) When cation shifts from lattice to interstitial site, the defect is called Frenkel defect.

13. (d) F-centres are the sites where anions are missing and instead electrons are present. they are responsible for colour.