UNIT 1 THE SOLID STATE
VERY SHORT ANSWER TYPE QUESTIONS (1 MARKS)

Q-1. How many spheres are in contact with each other in a single plane of a close packed structure?
A-1. Six(6).

Q-2.Name the two closest packed arrangements of identical spheres.
A-2. a) Hexagonal close- packed arrangement
b) Cubic closest packed arrangement.

Q-3. What is the coordination number of a sphere in a
a) Hexagonal close –packed structure
b) Cubic close packed structure
c) body –centered cubic close -packed structure
d) face – centered cubic close- packed structure.
A-3.a) 12 b)12 c) 8 d)12

Q-4. W hat is the non- stoichiometry defect in the crystals ?
A-4.These defects occur when the ratio of the cations and anions in the resulting compound is different from that as indicated by the laws of the chemical combinations.

Q-5. How many atoms are there in a
a) simple or primitive unit cell
b) body centered cubic unit cell
c) face centered cubic unit cell
A-5.a) one b) two c) four

Q-6.W hat other elements may be added to silicon to make electrons available for the conduction of an electric current?
A-6. Phosphorous or Gallium.

Q-7. How many octahedral sites per sphere are there in a cubic closest – packed (face centered cubic) structure.?
A-7. One.

Q-8. How many Tetrahedral sites per sphere are there in a cubic closest – packed (face centered cubic) structure.?
A-8. Two.

Q-9. I f the formula of an ionic compound is AB, can the cation A occupy all the
a) tetrahedral voids b) octahedral voids
A-9. a)No, the cation A can occupy only ½ of the tetrahedral voids.
b) Yes , the cation A can occupy all the octahedral voids.

Q-10. What is the coordination no. of an octahedral void ?
A-10. Six(6).

Q-11. What is the coordination no. of a tetrahedral void?
A-11. Four (4).

Q-12. What is the maximum radius of a sphere that can be fitted in a tetra hedral void of cubic close packing of the spheres of radius R without disturbing the arrangement ?
A-12. 0.414 R.

Q-13. What is the arrangement of the layers in a hexagonal close – packing of atoms?
A-13. ABABABAB…….

Q-14. What is the arrangement of the layers in a Cubic close – packing of the spheres?
A-14. ABCABCABCABC…….

Q-15. Why is Fe_3O_4 ferrimagnetic at room temperature but becomes paramagnetic at 850 k?
A-15. This is due to the randomization of the spins at 850 K.

Q-16 W hich of the two will show the Schottky defect when added to the AgCl crystal
NaCl or $CdCl_2$.
A-16. $CdCl_2$. This is because divalent Cd^{2+} ions occupy the Ag^+ sites and thus produce cationic vacancies in the crystal.

Q-17 What typ[e of compounds show the Schottky defect?
A-17. Ionic compounds which have cations and anions of nearly the same size.

Q-18. What is an intrinsic semi-conductor?
A-18. An insulator which conducts the electricity at high temperature or on irradiation by electromagnetic radiations.

Q-19. What are 12-16 and 13-15 compounds?
A-19. These are solid substances which are prepared by combining elements of groups
12 and 16 or 13 and 15 respectively.

Q-20.How do electrical resitivity of the following class of the materials vary with temperature : semiconductor, metallic conductor and insulators?
A-20 T he electrical resistivity of a semi-conductor decreases with the rise in the temperature but increase in case of metallic conductors and superconductors.

Q-21 What are interstitials in the crystals?
A-21 The ions occupying the vacant sites are called as interstitials.

Q-22.W hy is Frenkel defect not found in pure alkali metal halides?
A-22.Because of the small size of the anions.

Q-23Which point defect lowers the density of the crystals?
A-23 Shottky defect.

Q-24.Why AgCl show the Frenkel defect?
A-24 Frenkel defect is found in the ionic compounds which have lower coordination no. and larger difference in the size of the cations and anions.

Q-25.H ow is ferromagnetism is different from the paramagnetism?
A-25. The ferromagnetism arises due to the spontaneous alignment of the magnetic moment of ions or atoms in the same direction. Paramagnetism is due to the randomization of the spins.

Q-26.What is the difference between ferromagnetic and ferromagnetic substances?
A-26. Ferromagnetic substances are strongly attracted by the magnetic field while ferrimagnetic substances are attracted weakly.

Q-27.Name the compound in which both Scottky and Frenkel defects are found together?
A-27 AgBr.

Q-28.Why does ZnO appears yellow on heating?
A-28 ZnO when heated, loses oxygen reversibly the excess metal is accommodated in interstitial sites, with electron trapped in the neighbourhood . the yellow colour and the electrical conductivity of non – stoiciometric ZnO is due to these trapped electrons.

Q-29. What is the difference between phosphorous doped and gallium doped semicondutors?
A-29 Doping with phosphorous gives rise to electronic conduction(n-type) whereas doping with gallium gives rise to positive holes conduction(p-type)

Q-30 Arrange simple cubic, body centered cubic , face centered cubic and hexagonal close packing in the increasing order of packing efficiency.
A-30 Simple cubic< body centered cubic <face centered cubic = hexagonal close packing.

Q-31 Name the i) most symmetrical and ii)most unsymmetrical crystal system.
A-31 i) cubic ii) triclinic

Q-32 How are unit cell and space lattice related?
A-32 Space lattice is obtained by repeating the unit cell in three dimensions.

Q-33. Although pure silicon is an insulator, then how does it behave as a semi-conductor on heating?

A-33. As the conductivity of semiconductors increases on heating.

Q-34. For tetrahedral co-ordination, what should be the range of radius ratio r^+/r^- value?

A-34. For a tetrahedral void r^+/r^- = 0.225-0.414.

Q-35. When atoms are placed at the corners of all 12 edges of a cube, how many atoms are present per unit cell ?

A-35. Atoms are present at corners .No of atoms = $8 \times \frac{1}{8} = 1$

PANKAJ SHARMA PGT CHEMISTRY KV CHAMERA -2

UNIT 1 THE SOLID STATE
SHORT ANSWER TYPE QUESTIONS (2 MARKS)

Q-1.What are F- centers ? why are the solids containing the F- centers are paramagnetic?
A-1.The free electrons trapped in the anion vacancies are termed as the F-centers..The solids containing the F-centres are paramagnetic because the electrons occupying the vacant sites are unpaired.
Q-2 A unit cell consists of a cube in which there are anions at each corner and one at the center of the unit cell. The cations are the center of the each face . how many A) cations and B)anions make up the unit cell? C)What is the simplest formula of the compound?
A-2. A)The cation at the center of each face is shared by two unit cells.
Hence no. of cations= 6 X ½ = 3
B) The anion at each corner is shared by 8 unit cells . the anion at the center is not shared by any other unit cell.
Hence no. of anions= 8 X 1/8 + 1 = 2
C) Since there are 3 cations and 2 anions the simplest formula of the compond is A_3B_2.
Q-3.Exess of potassium in the KCl makes the crystal appears violet. Explain why?
A-3.When KCl is heated in an atmosphere of K metal vapour , the metal K deposits on the surface of the KCl crystal . the chloride ions diffuse into the surface and combine with K atoms. The electrons produced by the ionization of the K Atoms then diffuse into the crystals and are then trapped in the anion vacancies called F- centers . the excess of the K in KCl makes the crystal appear violet.
Q-4. The two ions A^+ and B^- have radii 88 and 200 pm respectively. In the close packed crystal of compound AB, predict the coordination number of A.

A- 4. I n the close-packed arrangement, A^+ will be in the intersites of the close – packed arrangement of B^-
Radius of cation = 88 pm
Radius of anion =200 pm

Radius ratio = r^+/r^- = 88pm/200pm = 0.44
Since the radius ratio lies between 0.414—0.732, the ion A^+ MUST OCCUPY THE OCTAHEDRAL SITE. Hence the coordination no. of A^+ is 6.
Q-5. A solid AB has NaCl structure . if the radius of the cation A+ is 140 pm calculate the maximum possible values of the radius of anion B-.
A-5. Radius ratio = r^+/r^- = 0.414
OR 140/ rB- = O.414
SO r B- = 140/0.414
= 338 pm

Q-6. Copper crystallises in face-centred cubic lattice and has a density of 8.930 g mol^{-3} at 293 K. Calculate the edge length of unit cell. [At. mass of Cu = 63.5 a.m.u, Avogadro's constant $N_A = 6.02 \times 10^{23}$].

Ans6. Density = Mass of unit cell/Volume of unit cell
$8.93 = (4 \times 63.5)/(a^3 \times 6.02 \times 10^{23})$.
$a^3 = 47.24 \times 10^{-24}$
$a = 3.6 \times 10^{-8}$ cm. = 360 pm.

Q7. The edge length of NaCl unit cell is 500 pm. What is the density of NaCl in g/cm^3?
[$N_A = 6.02 \times 10^{23}$, Na = 23.0, Cl = 35.5 a.m.u.]

Ans7. $d = (4 \times 58.5)/[6.02 \times 10^{23} \times (500 \times 10^{-10})^3]$
= 3.12 g/cm^3.

Q.-8 Addition of $CdCl_2$ to the crystal of AgCl will produce schottky defect, but the same is not produced when NaCl crystal are added, Why ?

Ans. The replacement of one Ag+ ion with Cd+ ion necessitates the removal of other Ag+ ion from the lattice to maintain the electrical neutrality of the crystal. But in case of NaCl, Na+ and Ag+ both are monovalent.

Q.9 Ferromagnetic and Ferrimagnetic substances become para magnetic upon heating . Why ?

Ans. The temperature at which they are changed into paramagnetic is called curie temperature. This is because the realignment of electrons spin or their magnetic moments which are now oriented in one particular direction.

Q.10 Explain the term 'dislocations' in relation to the crystal.

Ans. The defects which result from improper orientation of planes with respect to one-another in the crystal are called dislocations.

Q.11 Sodium metal is quite soft whereas NaCl crystals are quite hard. Why?

Ans. In sodium metal, atoms are held together by weak metallic bond but in NaCl crystal Na+ and Cl ions are held together by strong ionic bonds.

Q.12 Diamond and solid rhombic sulphur both are covalent solids but latter has very low. M.P. Why ?

Ans. Diamond is three dimensional net work covalent solid with strong inter atomic forces where as sulphur consists of packered ring structure (S_8) in which atoms are held together by weak vander waal forces.

Q13. An element of atomic mass 98.5 g mol^{-1} occurs n FCC structure. If its unit cell edge length is 500 pm and its density is 5.22 g cm^{-3}, what will be the value of Avogadro's constant?

Ans13. $N = (4 \times 98.5)/[5.22 \times (500 \times 10^{-10})^3]$
$= 6.023 \times 10^{23}$.

Q14. Cr has mono atomic body-centred cubic structure. Its cell edge is 400 pm. What is its density? [Atomic mass of Cr = 52 g mol^{-1}, $N_A = 6.023 \times 10^{23}$]

Ans14. $d = (2 \times 52)/[6.023 \times 10^{23} (400 \times 10^{-10})^3]$
$= (2 \times 52 \times 10)/(6.023 \times 64) = 2.697$ g cm^{-3}.

Q15. The edge length of the unit cell is 408 pm. Its density is 10.6 g cm^{-3} predict whether the metal X is body-centred or face centred or simple cubic. [Molar mass of metal X = 107.9 g, $N_A = 6.023 \times 10^{23}$]

Ans16. $Z = (d \times N \times a^3)/M$
$= [10.6 \times 6.023 \times 10^{23} \times (408 \times 10^{-10})^3]/107.9 = 4$
Therefore it is a f.c.c. crystal.

Q17. The unit cell of an element of atomic mass 96 and density 10.3 g cm^{-3} is a cube with edge length of 314 pm. Find the structure of the crystal lattice. (Simple cubic, FCC or BCC). [$N_A = 6.023 \times 10^{23}$]

Ans17. $Z = (d \times N \times a^3)/M$
$= [10.3 \times 6.023 \times 10^{23} \times (314 \times 10^{-10})^3]/96 = 2$
Therefore it is a BCC crystal

PANKAJ SHARMA PGT CHEMISTRY KV CHAMERA -2

UNIT 1 SOLID STATE
SHORT ANSWER QUESTIONS (3MARKS)

Q1. What is the difference between Schottky and Frankel defect?

Ans1.

Serial no.	***Schottky defect***	***Frankel defect***
1.	It decreases the density of the crystal.	It does not decrease the density of the crystal.
2.	It occurs in compounds with high Co-ordination number.	It occurs in compounds with low number.
3.	It occurs in compounds in which cations and anions are of similar size. Examples: NaCl, KCl, KBr, CsCl.	It occurs in compounds in which cations and anions differ in their size to a large extent. Examples: ZnS, AgCl, AgBr, AgI.

Q.-2 A metal crystallises into two cubic phases, fcc and bcc, whose unit lengths are 3.5 and 3.0A^o respectively. Calculate the ratio of the densities of fcc and bcc.

A-2 $d\alpha \frac{Z}{a^3}$

for fcc, Z = 4 for bcc , Z = 2 then

$$\frac{dfcc}{dbcc} = \frac{Zfcc}{a^3 fcc} \times \frac{a^3 bcc}{Zbcc} = \frac{4}{2}\left(\frac{3}{3.5}\right)^3 = 1.26$$

Q.3 In corundum, oxide ions are arranged in hcp arrangement and the aluminium ions occupy 2/3 of the octahedral voids. What is the formula of corundum.

A-3 Number of oxide Ions = 8 x 1/8 = 1 per unit cell

Number of Al ions = 2/3

formula $Al_{2/3}O$ or Al_2O_3

OR

Rank of hcp = 6 = No. of octahedral voids.

No. of Al ions = $6 \times \frac{2}{3} = 4$

Formula Al_4O_6 or Al_2O_3.

Q4. Explain why?
(*i*) Conductivity of metals decreases with increase in temperature.
(*ii*) Conductivity of semiconductors increases with increase in temperature.

A-4. (*i*) The conductivity of metals is due to the migration of free mobile electrons under the influence of applied potential difference. This migration of electrons is hindered to some extent by the lattice vibrations. At low temperature, lattice vibrations are quite insignificant, and as such metals are excellent electric conductors at low temperature. But with the rise of temperature lattice vibrations increases due to thermal energy and as such migration of electrons is hindered. Therefore, electrical conductivity of metals decreases with rise in temperature. (*ii*) Electrons and holes produced by the ionisation or defects contribute to the electronic conduction of semiconductors. Unlike metals, the conductivity of semiconductors increases with increase in temperature. This can be explained as follows. In semiconductors electrons are bound rather tightly to local centres at room temperature. When temperature is raised these electrons are freed and are now able to move through the crystal. The higher the temperature, the greater the number of electrons freed. Due to greater number of free electrons the conductivity increases even though lattice vibrations offer more resistance at the higher temperature.

Q-5 Given that for Fe, a=286 pm ;d=7.86g/cm^3. Find the type of the cubic lattice to which the crystal of iron belongs to. Also calculate the radius of Fe atom.

A-5. $d = Z \times M / a^3 N_0$

$Z = d / a^3 N_0 M$

$$= \frac{(7.86\ gcm^{-3}) \times (286 \times 10^{-10}\ cm)^3 \times (6.02 \times 10^{23})\ mol^{-1}}{55.85\ gmol^{-1}}$$

$= 2$

Since the no. of the atoms in the unit cell is 2 , it is therefore body - centered cubic structure.

For the body centered cubic structure , the radius of the atom

$$r = \frac{\sqrt{3}}{4} a = \frac{\sqrt{3}}{4} \times 286\ pm = 123.80\ pm$$

Q-6. Chromium metal crystallizes with a body- centered cubic lattice . the length of the unit cell edge is found to be 287 pm . calculate the atomic radius. What would be the density of chromium in g/cm^3?

A-6. For the body centered cubic structure , the radius of the atom

$$r = \frac{\sqrt{3}}{4} a = \frac{\sqrt{3}}{4} \times 287 \text{ pm} = 124.27 \text{ pm}$$

THUS, THE ATOMIC RADIUS OF CHROMIUM=124.27 pm

Mass of an atom of chromium = atomic mass of Cr/Avogadro`s no.

$= 51.99 \text{ g} / 6.02 \times 10^{23}$.

No. of atoms in one unit cell = 2

Volume of the unit cell $= (287 \text{ pm})^3 = (287 \times 10^{-10} \text{cm})^3$

Density of Cr = mass of unit cell/ volume of the unit c

$= 2 \times 51.99 / (287 \times 10^{-10} \text{ cm})^3 \times 6.02 \times 10^{23} = 7.32 \text{ g/cm}^3$

Q. 7. In the mineral spinal; having the formula $MgAl_2O_4$. The oxide ions are arranged in CCP, Mg^{2+} ions occupy the tetrahedral voids. While Al^{3+} ions occupy the octahedral voids.

(i) What percentage of tetrahedral voids is occupied by Mg^{2+} ions ?

(ii) What percentage of octahedral voids is occupied by Al^{3+} ions ?

Ans. According to the formula, $MgAl_2O_4$. If there are 4 oxide ions, there will be 1 Mg^{2+} ions and 2 Al^{3+}. But if the 4 O^{2-} ions are ccp in arrangement, there will be 4 octahedral and 8 tetrahedral voids.

(i) Percentage of tetrahedral voids occupied by $Mg^{2+} = (1 / 8) \times 100$

$= 12.5\%$

(ii) Percentage of octahedral voids occupied by $Al^{3+} = (2 / 4) \times 100$

$= 50\%$

Q. 8. Analysis shows that nickel oxide has the formula $NiO_{.98}O_{1.00}$. What fractions of nickel exist as Ni^{2+} and Ni^{3+} ions ?

Ans. $NiO_{.98}O_{1.00}$

Let Ni^{2+} be x and Ni^{3+} be $0.98 - x$

Total charge on compd. is equal to zero.

$[2 (Ni^{2+}) + 3 (Ni^{3+}) - 2 (O^{2-})] = 0$

$2x + 3 (0.98 - x) - 2 = 0$

$x = 0.94$

Therefore Ni^{2+} % $= \frac{0.94}{0.98} \times 100 = 96\%$

$Ni^{3+} = 4\%$

Q. 9. How many unit cells are present in a cube shaped ideal crystal of NaCl of mass 1 gm ?

Ans. Mass of 1 unit cell = volume × density

$= a^3 \times d$

$= \frac{a^3 \times M \times Z}{N^0 a^3}$

$= \frac{58.5 \times 4}{6.023 \times 10^{23}}$

No. of unit cells in 1 gm = 1/M

$= 6.023 \times 10^{23} / 58.5 \times 4$

$= 2.57 \times 10^{21}$