Exercise-1

✍ **Marked questions are recommended for Revision.**

PART - I : SUBJECTIVE QUESTIONS

Section (A) : Basics of solid state

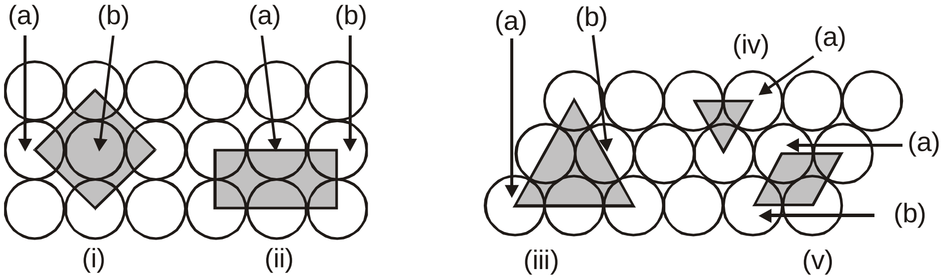
Commit to memory :

Contribution of a particle = $\frac{\text{angle}}{360^o}$ (for 2D unit cell).

A-1.✍ Classify each of the following solids.

(a) Tetra phosphorus decoxide (P_4O_{10})	(b) Graphite
(c) Brass	(d) Ammonium phosphate $[(NH_4)_3 PO_4]$
(e) SiC	(f) Rb
(g) I_2	(h) LiBr
(i) P_4	(j) Si
(k) Plastic.	

A-2. Given below are two dimension lattices with nicely shaded regions.You just have to find the contributions (in fractions) of particles marked to the shaded regions and the total number of particles in the regions.



Figure

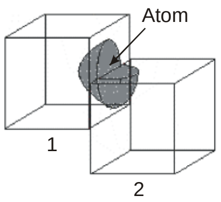
A-3.✍ What are the crystallographic parameter of hexagonal, monoclinic and triclinic unit cell respectively.

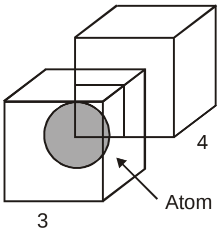
Section (B) : Simple Cubic Structure & BCC

Commit to memory :

Density = $\frac{Z \times M}{N_A \times a^3}$

B-1. Following diagrams show identical cubes such that edge of cube2 lies exactly in the middle of one of the faces of Cube1 and Cube 4 has a corner at the body center of the Cube3. Find the contributions(in fraction) of the spheres shown to each of the cubes.





B-2. The inter metallic compound Li Ag crystallizes in a cubic lattice in which both lithium and silver atoms have coordination no. of 8. To what crystal class does the unit cell belong?

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

Section (C) : HCP & CCP structures

Commit to memory :

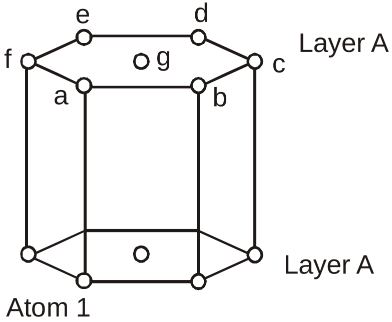
For CCP : a = b = c = $2\sqrt{2}$ R, Z = 4, Coordination number = 12

For HCP : a = 2R, b = 2R, c = 2h and h = $\sqrt{\frac{8}{3}}$ R, Z = 6, Coordination number = 12

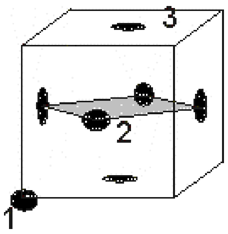
C-1. In which type of 3D arrangement have Ist and IV layer's of sphere are identical.

C-2. Metallic magensium has a hexagoanl close-packed structure and a density of 1.74 g/cm^3. Assume magnesium atoms to be spheres of radius r. 74.1% of the space is occupied by atoms. Calculate the volume of each atom and the atomic radius r. (Mg = 24.31)

C-3. Consider a corner atom of Ist layer of an HCP unit cell showing alternate AA layers. Find
(i) Find identical atoms (III layer) with respect to the distances from the atom 1.
(ii) Arrange the distances in ascending order.



C-4. Following figure shows an FCC unit cell with atoms of radius r marked 1(corner), 2(face center), 3(face center). A quadrilateral is also shown by joining the centers of 4 face centered atoms.
Find : (i) The distances between atoms 1 & 2, 2 & 3 and 1 & 3.
(ii) The shape and dimensions of the quadrilateral.



Figure

C-5. Aluminium metal (atomic weight = 27 g) crystallises in the cubic system with edge length 4.0Å. The density of metal is 27/16 amu/ Å^3. Determine the unit cell type and calculate the radius of the Aluminium metal.

C-6. "Tom" cat arranges the glass balls, in a particular 3D array; that two (I and II) continuous layer are not identical, but all (I and III) alternative layers are identical, this type of arrangement is known as :

Section (D) : Voids

Commit to memory :

Radius ratio = 0.155, 0.225, 0.414, 0.732 for triangular, tetrahedral, octahedral, cubic void respectively.

D-1. A student wants to arrange 4 identical spheres (of radius R) on a two dimensional floor as close as possible.Finally he could arrange them.Identify the type and dimensions of the figure obtained by joining their centers. Could he occupy the whole available space, if not, then what type of voids were generated.Calculate their number and radius of small ball that can be fitted in them.

D-2. Illustrate an octahedral void in the close packing of spheres. Why is it so called ?

D-3. The number of tetrahedral and octahedral voids in hexagonal primitive unit cell are _______ and _______.

D-4. What is the number and closest distance between two octahedral voids and two tetrahedral voids in fcc unit cell ?

Section (E) : Radius ratio rule and Type of ionic structures

Commit to memory :

Radius ratio = 0.155, 0.225, 0.414, 0.732 for triangular, tetrahedral, octahedral, cubic void respectively.

E-1.✍ Suggest the probable structues of the unit cells of following each compound with the help of given data

		Cationic radius	**Anionic radius**
(a)	RbBr	1.48 Å	1.95 Å
(b)	MeTe	0.65 Å	2.21 Å
(c)	MgO	0.65 Å	1.40 Å
(d)	BaO	1.35 Å	1.40 Å

E-2. Why does ZnS not crystallize in the NaCl structure?

E-3. Try to answer the following:

(i) In Zinc Blende structure there is one Zn^{+2} ion per S^{2-} ion.But the radius ratio lies in the range of Tetrahedral void and there are two tetrahedral voids available per S^{2-}.Can you give the idea about the arrangement of the lattice.

(ii) What is the striking difference between the Fluorite and the Anti-fluorite structures.

E-4.✍ KBr crystallizes in NaCl type of unit cell. K^+ radius = 1.33Å, Br^- radius = 1.95 Å

(a) How many K^+ ions and how many Br^- ions are in each unit cell?

(b) Assuming the additivity of ionic radii, what is a ?

(c) Calculate the density of a perfect KBr crystal.

(d) What minimum value of r_+/r_- is needed to prevent anion-anion contact in this structure.

Section (F) : Crystal defects and Properties of solids

Commit to memory :

Stoichiometric - The formula of compound remains same even after presence of these defects.

Non-stoichiometric - The formula of compound will get modified because of the presence of these defects.

$$\% \text{ missing units} = \left(\frac{\rho_{th} - \rho_{exp}}{\rho_{th}}\right) \times 100\% \text{ (Schottky Defects)}$$

Locations of electrons in metal excess defect are also known as color centres (F-centres).

F-1. What do you understand by imperfections in ionic crystals ? Name the types of imperfections which generally occur in ionic crystals.

F-2.✍ How would you explain that (i) non-stoichiometric NaCl is yellow ; (ii) non-stoichiometric ZnO is yellow ?

F-3.✍ Account the following: Silicon is an insulator but silicon doped with phosphorus acts as a semiconductor.

F-4.✍ How does the conductivity of a semiconductor change if its temperature is raised?

PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : Basics of solid state

A-1. Which of the following is/are pseudo solids ?

I. KCl II. Barium chloride dihydrate

III. Rubber IV. Solid cake left after distillation of coal tar

(A) I,III (B) II, III (C) III, IV (D) only III

A-2. The smallest repeating pattern which when repeated in three dimensions results in the crystal of the substance is called

(A) Space lattice (B) Crystal lattice (C) Unit cell (D) coordination number

A-3. The crystal system for which $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90^0$ is said to be :

(A) triclinic (B) tetragonal (C) cubic (D) orthorhombic

A-4.✍ Which of the following are the correct axial distance and axial angles for rhombohedral system?
(A) $a = b = c, \alpha = \beta = \gamma \neq 90^0$ (B) $a = b \neq c, \alpha = \beta = \gamma = 90^0$
(C) $a \neq b \neq c, \alpha = \beta = \gamma = 90^0$ (D) $a \neq b \neq c, \alpha \neq \beta \neq \gamma \neq 90^0$

A-5. Choose the correct statements
(A) equivalent points in unit cells of a periodic lattice lie on a Bravais lattice
(B) equivalent points in unit cells of a periodic lattice do not lie on a Bravais lattice
(C) There are four Bravais lattices in two dimensions
(D) There are five Bravais lattices in three dimensions

A-6.✍ The crystal system of a compound with unit cell dimensions, a = 0.387 and b = 0.387 and c = 0.504nm and $\alpha = \beta = 90^o$ and $\gamma = 120^o$ is :
(A) Cubic (B) Hexagonal (C) Orthorhombic (D) Rhombohedral

Section (B) : Simple Cubic Structure & BCC

B-1. Body centred cubic lattice has co–ordination number of :
(A) 8 (B) 12 (C) 6 (D) 4

B-2. Iron has body centred cubic lattice structure. The edge length of the unit cell is found to be 286 pm. What is the radius of an iron atom?
(A) r = 124 pm (B) r = 128 pm (C) r = 124 Å (D) r = 128 Å

B-3. A metal crystallizes in a body centered cubic lattice (bcc) with the edge of the unit cell 5.2Å. The distance between the two nearest neighbour is
(A) 10.4 Å (B) 4.5 Å (C) 5.2Å (D) 9.0Å

B-4.✍ At room temperature, Polonium cryatsllises in Cubic primitive cell. If edge length is 3.0 Å, calculate the theoretical density of Po. (Atomic wt of Po = 207g)
(A) 25/3 amu/ $Å^3$ (B) 23/3 amu/ $Å^3$ (C) 21/3 amu/ $Å^3$ (D) 27/3 amu/ $Å^3$

B-5. Lithium crystallizes in a body centered cubic lattice. How many next–nearest neighbors does each Li have?
(A) 6 (B) 8 (C) 12 (D) 4

B-6.✍ Consider a Body Centered Cubic(bcc) arrangement, let d_e, d_{fd}, d_{bd} be the distances between successive atoms located along the edge, the face-diagonal, the body diagonal respectively in a unit cell.Their order is given by:
(A) $d_e < d_{fd} < d_{bd}$ (B) $d_{fd} > d_{bd} > d_e$ (C) $d_{fd} > d_e > d_{bd}$ (D) $d_{bd} > d_e > d_{fd}$,

Section (C) : HCP & CCP structures

C-1. How many number of atoms are completely inside the HCP unit cell ?
(A) Exactly 6 (B) > 6 (C) < 6 (D) 12

C-2.✍ The shortest distance between Ist and Vth layer of HCP arrangement is :
(A) $8\sqrt{\frac{2}{3}}\,r$ (B) $4\sqrt{\frac{3}{2}}\,r$ (C) $16\frac{\sqrt{2}}{3}\,r$ (D) $8\sqrt{\frac{3}{2}}\,r$

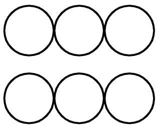
C-3.✍ Volume of HCP unit cell is :
(A) $24\sqrt{2}\,r^3$ (B) $8\sqrt{2}\,r^3$ (C) $16\sqrt{2}\,r^3$ (D) $24\sqrt{3}\,r^3$

C-4. Fraction of empty space in ABAB type arrangement in 3D :
(A) 0.74 (B) 0.26 (C) 0.68 (D) 0.32

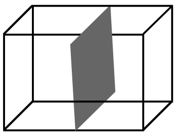
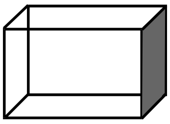
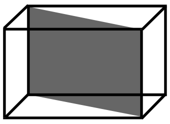
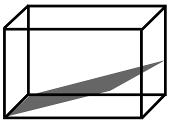
C-5.✍ What is the hight of an HCP unit cell ?
(A) $\frac{\sqrt{3}}{2}\,a$ (B) $\sqrt{\frac{3}{2}}\,a$ (C) $\sqrt{\frac{2}{3}} \times 2a$ (D) $\frac{\sqrt{2}}{3}\,a$

C-6. What is the number of atoms in a unit cell of face-centred cubic crystal?
(A) 4 (B) 6 (C) 2 (D) 1

C-7. Which of the following shaded plane in fcc lattice contains arrangement of atoms as shown by circles :



Figure

(A) 
(B) 
(C) 
(D) 

C-8. Copper crystallises in a structure of face centerd cubic unit cell. The atomic radius of copper is 1.28 Å. What is axial length on an edge of copper?

(A) 2.16 Å (B) 3.62 Å (C) 3.94 Å (D) 4.15 Å

C-9. The maximum percentage of available volume that can be filled in a face centred cubic system by atoms is-

(A) 74% (B) 68% (C) 34% (D) 26%

C-10. In a face centred cubic lattice the number of nearest neighbours for a given lattice point are :

(A) 6 (B) 8 (C) 12 (D) 14

C-11. Which one of the following schemes of ordering closed packed sheets of equal sized spheres does not generate close packed lattice.

(A) ABCABC (B) ABACABAC (C) ABBAABBA (D) ABCBCABCBC

Section (D) : Voids

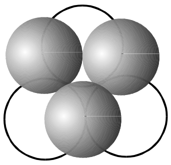
D-1. If the anions (A) form hexagonal closest packing and cations (C) occupy only 2/3 octahedral voids in it, then the general formula of the compound is

(A) CA (B) CA_2 (C) C_2A_3 (D) C_3A_2

D-2. You are given 4 identical balls. What is the maximum number of square voids and triangular voids (in separate arrangements) that can be created ?

(A) 1, 2 (B) 2, 1 (C) 3, 1 (D) 1, 3

D-3. The empty space between the shaded balls and hollow balls as shown in the diagram is called

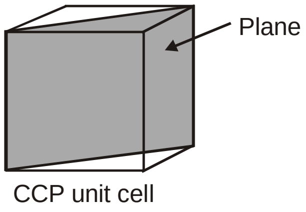


(A) hexagonal void
(B) octahedral void
(C) tetrahedral void
(D) double triangular void

D-4. In the close packed structure of AB type solid have cation radius of 75 pm, what would be the maximum and minimum sizes of the anions which formed voids in unit cell ?

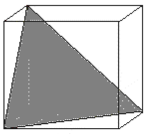
(A) $r^{-}_{\text{minmum}} = 101.45$, $r^{-}_{\text{maximum}} = 303.3$ pm (B) $r^{-}_{\text{minmum}} = 105.45$, $r^{-}_{\text{maximum}} = 300.3$ pm
(C) $r^{-}_{\text{minmum}} = 102.45$, $r^{-}_{\text{maximum}} = 333.3$ pm (D) $r^{-}_{\text{minmum}} = 98.4$, $r^{-}_{\text{maximum}} = 333.3$ pm

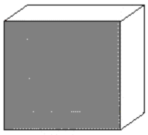
D-5. In a hypothetical solid C atoms form CCP lattice with A atoms occupying all the Tetrahedral Voids and B atoms occupying all the octahedral voids.A and B atoms are of the appropriate size such that there is no distortion in the CCP lattice.Now if a plane is cut (as shown) then type of voids and their numbers whic are present at the cross section would be.

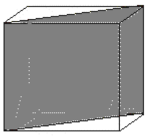


(A) O.V = 3, T.V. = 4 (B) O.V. = 2, T.V. = 4
(C) O.V. = 1, T.V. = 2 (D) O.V. = 0, T.V. = 4

D-6. Following three planes (P_1, P_2, P_3) in an FCC unit cell are shown:


P1


P2

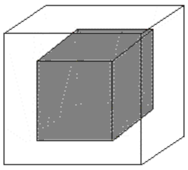

P3

Consider the following statements and choose the correct option that follow:

(i) P_1 contains no voids of three dimensions.
(ii) P_2 contains only octahedral voids.

(iii) P_3 contains both octahedral and tetrahedral voids.
(A) All are true (B) Only (i) & (ii) are true
(C) (i) & (iii) are true (D) Only (iii) is true.

D-7. In an FCC unit cell a cube is formed by joining the centers of all the tetrahedral voids to generate a new cube.Then the new cube would contain voids as :
(A) 1 full tetrahedral void, 1 full octahedral void
(B) 1 full tetrahedral void only
(C) 8 full tetrahedral voids and 1 full octahedral void
(D) 1 full Octahedral void only



Section (E) : Radius ratio rule and Type of ionic structures

E-1. The radius of Ag^+ ion is 126 pm and that of I^- ion is 216 pm. The co-ordination number of Ag^+ ion is.
(A) 2 (B) 4 (C) 6 (D) 8

E-2. The tetrahedral voids formed by ccp arrangement of Cl^- ions in rock salt structure are
(A) Occupied by Na^+ ions (B) Occupied by Cl^- ions
(C) Occupied by either Na^+ or Cl^- ions (D) Vacant

E-3. Antifluorite structure is derived from fluorite structure by :
(A) heating fluorite crystal lattice
(B) subjecting fluorite structure to high pressure
(C) Inter changing the positions of positive and negative ions in the lattice
(D) none of these

E-4. In zinc blende structure the coordination number of Zn^{2+} ion is
(A) 2 (B) 4 (C) 6 (D) 8

E-5. Strontium chloride has a fluorite structure, which of the following statement is true for the structure of strontium chloride ?
(A) the strontium ions are in a body–centered cubic arrangement
(B) the strontium ions are in a face–centered cubic arrangement
(C) each chloride ion is at the center of a cube of 8 strontium ions
(D) each strontium ion is at the center of a tetrahedron of 4 chloride ions

E-6. The spinal structure (AB_2O_4) consists of an fcc array of O^{2-} ions in which the :
(A) A cation occupies one-eighth of the tetrahedral holes and B cation occupies one-half of octahedral holes
(B) A cation occupies one-fourth of the tetrahedral holes and the B cations the octahedral holes
(C) A cation occupies one-eighth of the octahedral hole and the B cation the tetrahedral holes
(D) A cation occupies one-fourth of the octahedral holes and the B cations the tetrahedral holes

E-7. In the crystal lattice of diamond, carbon atoms adopt :
(A) fcc arrangement along with occupancy of 50% tetrahedral holes
(B) fcc arrangement along with occupancy of 25% tetrahedral holes
(C) fcc arrangement along with occupancy of 25% octahedral hole
(D) bcc arrangement

E-8. Cesium chloride on heating to 760 K changes into
(A) CsCl(g) (B) NaCl structure
(C) antifluorite structure (D) ZnS structure

Section (F) : Crystal defects and Properties of solids

F-1. In a solid lattice the cation has left a lattice site and is located at an interstitial position, the lattice defect is
(A) Interstitial defect (B) Valency defect (C) Frenkel defect (D) Schottky defect

F-2. Which of the following statements are correct in context of point defects in a crystal ?
(A) AgCl has anion Frenkel defect and CaF_2 has Schottky defects
(B) AgCl has cation Frenkel defects and CaF_2 has anion Frenkel defects
(C) AgCl as well as CaF_2 have anion Frenkel defects
(D) AgCl as well as CaF_2 has Schottky defects

F-3.✍ F-centers are
(A) the electrons trapped in anionic vacancies
(B) the electrons trapped in cation vacancies
(C) non-equivalent sites of stoichiometric compound
(D) all of the above

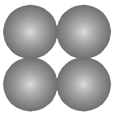
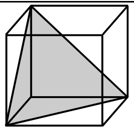
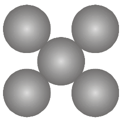
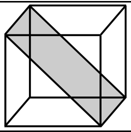
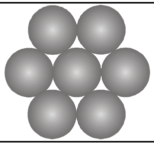
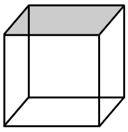
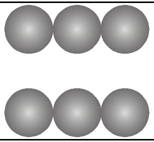
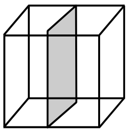
F-4.✍ Which of the following is true about the charge acquired by p-type semiconductors?
(A) positive (B) neutral
(C) negative (D) depends on concentration of p impurity

PART - III : MATCH THE COLUMN

1.✍ We are good at matching things let us try our hand on the following columns:

Solid	**Constituent particle**	**Binding force**
(a) Diamond	(e) Ion	(i) Metallic
(b) Sodium Chloride	(f) Atom	(j) Dipole dipole
(c) HCl	(g) Kernel	(k) Ionic
(d) Aluminium	(h) Molecule	(l) Covalent

2. **Match the column :**

	Column I (Arrangement of the atoms/ions)		**Column II (Planes in fcc lattice)**
(A)		(p)	
(B)		(q)	
(C)		(r)	
(D)		(s)	

3.✍ **Match the column :**

	Column-I		**Column-II**
(A)	ZnS crystal	(p)	fcc
(B)	CaF_2 crystal	(q)	hcp
(C)	NaCl crystal	(r)	Distance between closest particles is $\frac{\sqrt{3}}{4}$ a.
(D)	Diamond crystal	(s)	Only one type of voids are occupied

Exercise-2

✍ **Marked questions are recommended for Revision.**

PART - I : ONLY ONE OPTION CORRECT TYPE

1. Which of the following solids are not correctly matched with the bonds found between the constituent particles:
(A) Solid CO_2 : Vanderwaal's (B) Graphite : Covalent and Vanderwaal
(C) Grey Cast Iron : Ionic (D) Metal alloys : Ions-delocalised electrons

2. Which of the following is not correct for ionic crystals :
(A) They possess high melting point and boiling point
(B) All are electrolyte
(C) Exhibit the property of isomorphism
(D) Exhibit directional properties of the bond

3.✍ An element (atomic mass = 100 g/mole) having bcc structure has unit cell edge 400 pm. The density of the element is (no. of atoms in bcc(Z) = 2).
(A) 2.144 g/cm^3 (B) 5.2 g/cm^3 (C) 7.289 g/cm^3 (D) 10.376 g/cm^3

4. What is the nearest distance between two different layers in ABAB arrangement (a = 2 × radius of the particle).
(A) $\sqrt{\frac{8}{3}}\,a$ (B) $\sqrt{\frac{4}{3}}\,a$ (C) $\frac{1}{\sqrt{6}}\,a$ (D) $\sqrt{\frac{2}{3}}\,a$

5.✍ In a CCP lattice of X and Y, X atoms are present at the corners while Y atoms are at face centers.Then the formula of the compound would be if one of the X atoms from a corner is replaced by Z atoms (also monovalent)?
(A) $X_7Y_{24}Z_2$ (B) $X_7Y_{24}Z$ (C) $X_{24}Y_7Z$ (D) $XY_{24}Z$

6. You are given 6 identical balls.What is the maximum number of square voids and triangular voids (in separate arrangements) that can be created?
(A) 2, 4 (B) 4, 2 (C) 4, 3 (D) 3, 4

7. In a simple cubic lattice of anions, the side length of the unit cell is 2.88 Å. The diameter of the void in the body centre is
(A) 1.934 Å (B) 0.461 Å (C) 2.108 Å (D) 4.988 Å

8. In a multi layered close-packed structure
(A) there are twice as many tetrahedral holes as many close-packed atoms
(B) there are as many tetrahedral holes as many closed packed atoms
(C) there are twice as many octahedral holes as many close-packed atoms
(D) there are as many tetrahedral holes as many octahedral holes

9.✍ In a compound, oxide ions are arranged in cubic close packing arrangement. Cations A occupy one-sixth of the tetrahedral voids and cations B occupy one-third of the octahedral voids. The formula of the compound is
(A) A_2BO_3 (B) AB_2O_3 (C) $A_2B_2O_2$ (D) ABO_3

10. Platinum crystallizes in a face-centered cubic crystal with a unit cell length 'a'. The distance between nearest neighbors is :
(A) a (B) $a\,\frac{\sqrt{3}}{2}$ (C) $a\,\frac{\sqrt{2}}{2}$ (D) $a\,\frac{\sqrt{2}}{4}$

11. Platinum crystallises in a face centered cube crystal with a unit cell length of 3.9231 Å. The density and atomic radius of platinum are respectively. [Atomic mass of Pt = 195]
(A) 45.25 g. cm^{-3}, 2.516 Å (B) 21.86 g. cm^{-3}, 1.387 Å
(C) 29.46 g. cm^{-3}, 1.48 Å (D) None of these

12. Metallic gold crystallises in face centered cubic. Lattice with edge-length 4.070 Å. Closest distance between gold atoms is :
(A) 2.035 Å (B) 8.140 Å (C) 2.878 Å (D) 1.357 Å

13.✍ Which of the following statements is correct in the rock-salt structure of ionic compounds?
(A) Co-ordination number of cation is four whereas that of anion is six.
(B) Co-ordination number of cation is six whereas that of anion is four.
(C) Co-ordination number of each cation and anion is four.
(D) Co-ordination number of each cation and anion is six.

14. The compound AB crystallizes in a cubic lattice in which both A and B atoms have coordination numbers of 8. To what crystal class does the unit cell belong ?
(A) CsCl structure (B) NaCl structure (C) ZnS structure (D) Al_2O_3 structure

15.✍ BaO has a rock-salt type structure. When subjected to high pressure, the ratio of the coordination number of Ba^{+2} ion to O^{-2} changes to
(A) 4 : 8 (B) 8 : 4 (C) 8 : 8 (D) 4 : 4

16. A crystal of NaCl, which has sodium ions and chloride ions missing from the lattice point, is said to exhibit
(A) Surface defect (B) Lattice defect (C) Frenkel defect (D) Schottky defect

17.✍ In the Schootky defect :
(A) cations are missing from the lattice sites and occupy the interstitial sites
(B) equal number of cations and anions are missing
(C) anion are missing and electrons are present in their place
(D) equal number of extra cations and electrons are present in the interstitial sites

18. NaCl shows Schottky defects and AgCl Frenkel defects. Their electrical conductivity is due to:
(A) motion of ions and not the motion of electrons
(B) motion of electrons and not the motion of ions
(C) lower co-ordination number of NaCl
(D) higher co-ordination number of AgCl

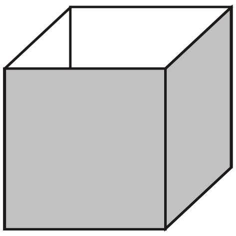
19. Zinc Oxide, white in colour at room temperature, acquires yellow colour on heating due to:
(A) Zn being a transition element.
(B) paramagnetic nature of the compound.
(C) trapping of electrons at the site vacated by Oxide ions.
(D) Both (A) & (B).

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1.✍ How many of the following are Covalent network solids?
S_8, Bronze, SiO_2, Diamond, $ZnSO_4$, Si, AlN, SiC, CO_2.

2. How many number of atom effectively present in a cubic unit formed by arrangement of eight B.C.C unit cell.

3. How many spherical balls of radii 2 cm can be placed completely inside a cubical box of edge = 8 cm ?



4. What is the co-ordination number of an atom in its own layer in ABAB type arrangement.

5.✍ In ABAB .... arrangement if an atom is placed in A layer then calculate the number of atoms touching in its adjacent B layers ?

6. How many number octahedral voids are effectively inside an HCP unit cell.

7.✍ In a compound, oxide ions are arranged in cubic close packing arrangement. Cations A occupy one-sixth of the tetrahedral voids and cations B occupy one-third of the octahedral voids. The formula of the compound is $A_xB_yO_z$, then find the value of x + y + z.

8.✍ The coordination number of cation and anion in Fluorite CaF_2 and Zinc blende ZnS are respectively x : y and a : b. Find (x + y + a + b).

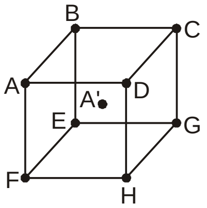
9. In a crystalline solid having molecular formula A_2B anion (B) are arranged in cubic close packed lattice and cations (A) are equally distributed between octahedral and tetrahedral voids.
(i) What percentage of octahedral voids is occupied?
(ii) What percentage of tetrahedral voids is occupied?
Report your answer ((i) – (ii)).

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. Which of the following statements is/are false.
(A) It is the isotropic nature of amorphous solids that all the bonds are of equal strength.
(B) Entropy of a crystalline solid is higher than that of an amorphous solid.
(C) Amorphous solids have definite volume but not definite shape.
(D) Amorphous solids can become crystalline on slow heating (annealing).

2. Amorphous solid can also be called ________.
(A) pseudo solids (B) true solids
(C) super cooled liquids (D) super cooled solids

3.✍ In body-centred cubic lattice given below, the three distance AB, AC and AA’ are :



(A) AB = a (B) AC = $\sqrt{2}a$ (C) AA' = $\frac{\sqrt{3}a}{2}$ (D) AA' = $\sqrt{3}a$

4. A metal crystallises in bcc. Find the % fraction of edge length not covered and also % fraction of edge length covered by atom is :
(A) 10.4% (B) 13.4% (C) 86.6% (D) 11.4%

5. Select the correct statements about three dimensional HCP system.
(A) Number of atoms in HCP unit cell is six. (B) The volume of HCP unit cell is $24\sqrt{2}\,r^3$.
(C) The empty space in HCP unit cell is 26%. (D) The base area of HCP unit cell is $6\sqrt{3}\,r^2$.

6.✍ Which statements is/are true about HCP and CCP lattice
(A) Number of tetrahedral voids are twice of octahedral holes
(B) 12 tetrahedral and 6 octahedral voids are present in one HCP unit cell
(C) C.N. of HCP unit cell is 12
(D) If atom of tetrahedral voids displace into octahedral voids then it is Schootky defect.

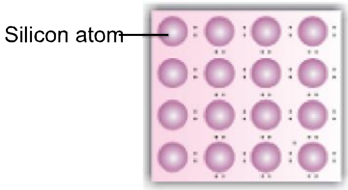
7.✍ In which of the following arrangements octahedral voids are formed?
(A) hcp (B) bcc (C) simple cubic (D) fcc

8.✍ The number of tetrahedral voids per unit cell in NaCl crystal is ________.
(A) 4
(B) 8
(C) twice the number of octahedral voids.
(D) four times the number of octahedral voids.

9. Which of the following statements are correct :
(A) The coordination number of each type of ion in CsCl crystal is 8.
(B) A metal that crystallises in bcc structure has a coordination number of 12.
(C) A unit cell of ionic crystal shares some of its ion with other unit cells.
(D) The length of the unit cell in NaCl is 552 pm. (γ_{Na^+} = 95 pm, γ_{Cl^-} = 181 pm)

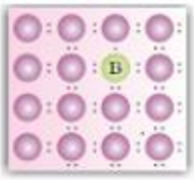
10. Which of the following is/are correct ?
(A) Schottky defect lowers the density
(B) Frenkel defect increases the dielectric constant of the crystals
(C) Stoichiometric defects make the crystals electrical conductors
(D) In the Schoottky defect, equal number of extra cations and electrons are present in the interstitial sites

11. A perfect crystal of silicon (Fig) is doped with some elements as given in the options. Which of these options show n-type semiconductors?



Pure crystal

(A)


(B)


(C)


(D)

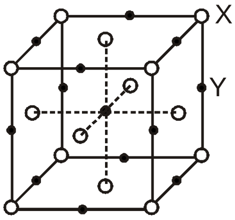

12. Which of the following statements are true about semiconductors?
(A) Silicon doped with electron rich impurity is a p-type semiconductor.
(B) Silicon doped with an electron rich impurity is an n-type semiconductor.
(C) Delocalised electrons increase the conductivity of doped silicon.
(D) An electron vacancy increases the conductivity of n-type semiconductor.

PART - IV : COMPREHENSION

Read the following comprehension carefully and answer the questions.

Comprehension # 1

Consider the figure given for solid XY. Answer the following questions



Figure

1. The site Y represents
(A) tetrahedral void (B) Octahedral void (C) triangular void (D) cubical void.

2. The number of XY units per unit cell is
(A) 4 (B) 3 (C) 3 (D) 8

3. Co-ordination number of Y is
(A) 3 (B) 4 (C) 6 (D) 8

Comprehension # 2

When an atom or an ion is missing from its normal lattice site, a lattice vacancy (Schottky defect) is created. In stoichiometric ionic crystals, a vacancy of one ion has to be accompanied by the vacancy of the oppositely charged ion in order to maintain electrical neutrality.

In a Frenkel defect an ion leaves its position in the lattice and occupies an interstitial void. This is the Frenkel defect commonly found along with the Schottky defects and interstitials. In pure alkali halides, Frenkel defects are not found since the ions cannot get into the interstitial sites. Frenkel defects are found in silver halides because of the small size of the Ag^+ ion. Unlike Schottky defects, Frenkel defects do not change the density of the solids. In certain ionic solids (e.g. AgBr) both Schottky and Frenkel defects occur.

The defects discussed above do not disturb the stoichiometry of the crystalline material. There is large variety of non-stoichiomertic inorganic solids which contain an excess or deficiency of one of the elements. Such solids showing deviations from the ideal stoichiometric composition form an important group of solids. For example in the vanadium oxide, VO_x, x can be anywhere between 0.6 and 1.3. There are solids which are difficult to prepare in the stoichiometric composition. Thus, the ideal composition in compounds such as FeO is difficult to obtain (normally we get a composition of $Fe_{0.95}$ O but it may range from $Fe_{0.93}$ O to $Fe_{0.96}O$). Non-stoichiometric behaviour is most commonly found for transition metal compounds though is also known for some lanthanoids and actinoids.

Zinc oxide loses oxygen reversibly at high temperatures and turns yellow in colour. The excess metal is accommodated interstitially, giving rise to electrons trapped in the neighbourhood. The enhanced electrical conductivity of the non-stoichiometric ZnO arises from these electrons.

Anion vacancies in alkali halides are produced by heating the alkali halide crystals in an atmosphere of the alkali metal vapour. When the metal atoms deposit on the surface they diffuse into the crystal and after ionisation the alkali metal ion occupies cationic vacancy whereas electron occupies anionic vacancy. Electrons trapped in anion vacancies are referred to as F-centers (from Farbe the German word for colour) that gives rise to interesting colour in alkali halides. Thus, the excess of potassium in KCl makes the crystal appear violet and the excess of lithium in LiCl makes it pink.

4. When LiCl is heated into the vapour of lithium, the crystal acquires pink colour. This is due to
(A) Schottkty defects (B) Frenkel defects
(C) Metal excess defect leading to F-centers (D) Electronic defect

5.✍ Strongly heated ZnO crystal can conduct electricity. This is due to
(A) Movement of extra Zn^{2+} ions present in the interstitial sites
(B) Movement of electrons in the anion vacancies
(C) Movement of both Zn^{2+} ions and electrons
(D) None of these

6.✍ AgCl is crystallized from molten AgCl containing a little $CdCl_2$. The solid obtained will have
(A) cationic vacancies equal to number of Cd^{2+} ions incorporated
(B) cationic vacancies equal to double the number of Cd^{2+} ions
(C) anionic vacancies
(D) neither cationic nor anionic vacancies

7. Which of the following is most appropriate crystal to show Frenkel defect.
(A) CsCl (B) NaCl (C) AgBr (D) $CaCl_2$

Comprehension # 3

Answer Question no. 8, 9 and 10 by appropriately matching the information given in the three columns of the following table. (Z = effective number of atoms)

Column 1	**Column 2**	**Column 3**
(I) Square 2D packing	(i) Z = 1 in smallest unit cell	(P) edge length = 2R in smallest unit cell
(II) Hexagonal 2D packing of circles	(ii) $Z \geq 3$ in smallest unit cell	(Q) close packing
(III) CCP	(iii) Coordination Number = 6	(R) packing efficiency > 50%
(IV) Simple cubic	(iv) Primitive unit cell possible	(S) can be made by 2D hexagonal layers of spheres

8.^ Identify the true combination:
(A) (I) (i) P (B) (II) (i) Q (C) (III) (iii) R (D) (IV) (ii) S

9.^ For packing with minimum void space the true combination is:
(Consider 2D & 3D arrangements separately)
(A) (I) (i) P (B) (II) (i) P (C) (III) (iv) S (D) (IV) (iii) R

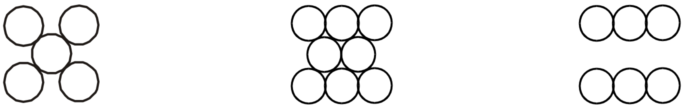
10.^ For the arrangement classified as ABAB type the correct combination is:
(A) (I) (ii) P (B) (III) (i) Q (C) (II) (iii) R (D) (IV) (iv) S

Exercise-3

*** Marked Questions may have more than one correct option.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. In the figures given below show the location of atoms in three crystallographic planes in a fcc lattice. Draw the unit cell of the corresponding structure and identify these planes in your diagram. **[JEE-2000, 3/100]**



Figure

2. In a solid 'AB' having the NaCl structure, 'A' atoms occupy the corners of the cubic unit cell. If all the face centered atoms along one of the axes are removed, then the resultant stoichiometry of the solid is: **[JEE-2001, 1/35]**

(A) AB_2 (B) A_2B (C) A_4B_3 (D) A_3B_4

3. A substance $A_x B_y$ crystallizes in a face centered cubic lattice in which atoms 'A' occupy each corner of the cube and atoms 'B' occupy the centers of each face of the cube. Identify the correct composition of the substance $A_x B_y$. **[JEE-2002, 3/90]**

(A) AB_3 (B) $A_4 B_3$

(C) $A_3 B$ (D) composition cannot be specified

4. Marbles of diameter 10 mm each are to be arranged on a flat surface so that their centers lie within the area enclosed by four lines of length each 40 mm. Sketch the arrangement that will give the maximum number of marbles per unit area, that can be enclosed in this manner and deduce the expression to calculate it. **[JEE-2003, 2/60]**

5. A binary salt AB (formula weight = 6.023 Y amu, where Y is an arbitrary number) has rock salt structure with 1 : 1 ratio of A to B. The shortest A—B distance in the unit cell is $Y^{1/3}$ nm. **[JEE-2004, 4/60]**

(a) Calculate the density of the salt in kg m^{-3}.

(b) Given that the measured density of the salt is 20 kg m^{-3}, specify the type of point defect present in the crystal.

6. In which of the following compounds the cations are present in alternate tetrahedral voids: **[JEE-2005, 3/84]**

(A) NaCl (B) ZnS (C) CaF_2 (D) Na_2O

7. In a FCC lattice of a metal edge length is 400 pm. Find the maximum diameter of an atom which can be accommodated in an interstitial gap in this lattice without causing any distortion. **[JEE-2005, 2/60]**

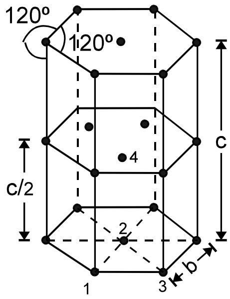
8. For a unit cell edge length = 5Å, the element is of atomic mass 75, has density of 2gm/cc. Calculate atomic radius of the element. **[JEE-2006, 6/184]**

9. Match the crystal system/unit cells mentioned in **Column I** with their characteristic features mentioned in **Column II**. **[JEE-2007, 6/162]**

	Column I		**Column II**
(A)	simple cubic and face-centerd cubic	(p)	have these cell parameters a=b=c and $\alpha=\beta=\gamma$
(B)	cubic and rhombohedral	(q)	are two crystal systems
(C)	cubic and tetragonal	(r)	have only two crystallographic angles of 90º
(D)	hexagonal and monoclinic	(s)	belong to same crystal system

Comprehension :

In hexagonal systems of crystals, a frequently encountered arrangement of atoms is described as a hexagonal prism. Here, the top and bottom of the cell are regular hexagons and three atoms are sandwiched in between them. A space-filling model of this structure, called hexagonal close-packed (HCP), is constituted of a sphere on a flat surface surrounded in the same plane by six identical spheres as closely as possible. There spheres are then placed over the first layer so that they touch each other and represent the second layer. Each one of these three spheres touches three spheres of the bottom layer. Finally, the second layer is covered with third layer that is identical to the bottom layer in relative position. Assume radius of every sphere to be 'r'.



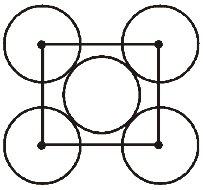
10. The number of atoms in the HCP unit cell is **[JEE-2008, 4/163]**
(A) 4 (B) 6 (C) 12 (D) 17

11. The volume of this HCP unit cell is **[JEE-2008, 4/163]**
(A) $24\sqrt{2}\ r^3$ (B) $16\sqrt{2}\ r^3$ (C) $12\sqrt{2}\ r^3$ (D) $\frac{64}{3\sqrt{3}} r^3$

12. The empty space in this HCP unit cell is **[JEE-2008, 4/163]**
(A) 74% (B) 47.6% (C) 32% (D) 26%

13.* The correct statement(s) regarding defects in solids is(are) : **[JEE-2009, 4/160]**
(A) Frenkel defect is usually favoured by a very small difference in the sizes of cation and anion.
(B) Frenkel defect is a dislocation defect.
(C) Trapping of an electron in the lattice leads to the formation of F-center.
(D) Schottky defects have no effect on the physical properties of solids.

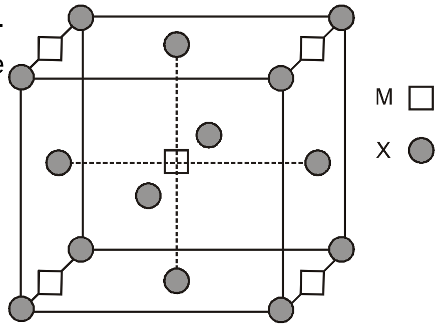
14. The packing efficiency of the two dimensional square unit cell shown below is : **[JEE-2010, 5/163]**



(A) 39.27%
(B) 68.02%
(C) 74.05%
(D) 78.54%

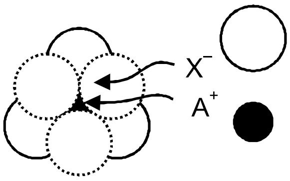
15. The number of hexagonal faces that are present in a truncated octahedron is **[JEE-2011, 3/160]**

16. A compound $M_P X_q$ has cubic close packing (ccp) arrangement of X. Its unit cell structure is shown below. The empirical formula of the compound is : **[IIT-JEE-2012, 3/136]**



(A) MX
(B) MX_2
(C) M_2X
(D) M_5X_{14}

17. The arrangement of X^- ions around A^+ ion in solid AX is given in the figure (not drawn to scale). If the radius of X^- is 250 pm, the radius of A^+ is : **[JEE(Advanced) 2013, 2/120]**



(A) 104 pm (B) 125 pm (C) 183 pm (D) 57 pm

18. If the unit cell of a mineral has cubic close packed (ccp) array of oxygen atoms with m fraction of octahedral holes occupied by aluminium ions and n fraction of tetrahedral holes occupied by magnesium ions, m and n, respectively, are **[JEE(Advanced) 2015, 4/168]**

(A) $\frac{1}{2},\frac{1}{8}$ (B) 1, $\frac{1}{4}$ (C) $\frac{1}{2},\frac{1}{2}$ (D) $\frac{1}{4},\frac{1}{8}$

19.* The **CORRECT** statement(s) for cubic close packed (ccp) three dimensional structure is(are) **[JEE(Advanced) 2016, 4/124]**

(A) The number of the neighbours of an atom present in the topmost layer is 12
(B) The efficiency of atom packing is 74%
(C) The number of octahedral and tetrahedral voids per atom are 1 and 2, respectively
(D) The unit cell edge length is $2\sqrt{2}$ times the radius of the atom

20. A crystalline solid of a pure substance has a face-centred cubic structure with a cell edge of 400 pm. If the density of the substance in the crystal is 8 g cm^{-3}, then the number of atoms present in 256 g of the crystal is $N\times10^{24}$. The value of N is **[JEE(Advanced) 2017, 2/122]**

21. Consider an ionic solid **MX** with NaCl structure. Construct a new structure (**Z**) whose unit cell is constructed from the unit cell of **MX** following the sequential instructions given below. Neglect the charge balance.

(i) Remove all the anions (**X**) except the central one
(ii) Replace all the face centered cations (**M**) by anions (**X**)
(iii) Remove all the corner cations (M)
(iv) Replace the central anion (**X**) with cation (**M**)

The value of $\left(\frac{\text{number of anions}}{\text{number of catons}}\right)$ in Z is ______. **[JEE(Advanced) 2018, 3/120]**

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. Na and Mg crystallize in BCC and FCC type crystals respectively, then the number of atoms of Na and Mg present in the unit cell of their respective crystal is **[AIEEE-2002, 3/225]**

(1) 4 and 2 (2) 9 and 14 (3) 14 and 9 (4) 2 and 4

2. How many unit cells are present in a cube-shaped ideal crystal of NaCl of mass 1.00g?
[Atomic masses : Na = 23, Cl = 35.5] **[AIEEE-2003, 3/225]**

(1) 2.57×10^{21} (2) 5.14×10^{21} (3) 1.28×10^{21} (4) 1.71×10^{21}.

3. What type of crystal defect is indicated in the diagram below? **[AIEEE-2004, 3/225]**

Na^+ Cl^- Na^+ Cl^- Na^+ Cl^-
Cl^- □ Cl^- Na^+ □ Na^+
Na^+ Cl^- □ Cl^- Na^+ Cl^-
Cl^- Na^+ Cl^- Na^+ □ Na^+

(1) Frenkel defect (2) Schottky defect
(3) interstitial defect (4) Frenkel and Schottky defects

4. An ionic compound has a unit cell consisting of A ions at the corners of a cube and B ions on the centers of the faces of the cube. The empirical formula for this compound would be **[AIEEE-2005, 1½/225]**

(1) AB (2) A_2B (3) AB_3 (4) A_3B

5. Total volume of atoms present in a face-center cubic unit cell of a metals (r is atomic radius). **[AIEEE-2006, 3/165]**

(1) $\frac{20}{3}\pi r^3$ (2) $\frac{24}{3}\pi r^3$ (3) $\frac{12}{3}\pi r^3$ (4) $\frac{16}{3}\pi r^3$

6. In a compound, atoms of element Y form ccp lattice and those of element X occupy 2/3rd of tetrahedral voids. The formula of the compound will be **[AIEEE - 2008, 3/105]**

(1) X_2Y_3 (2) X_2Y (3) X_3Y_4 (4) X_4Y_3

7. Copper crystallises in fcc with a unit cell length of 361 pm. What is the radius of copper atom ? **[AIEEE - 2009, 8/144]**

(1) 127 pm (2) 157 pm (3) 181 pm (4) 108 pm

8. The edge length of a face centred cubic cell of an ionic substance is 508 pm. If the radius of the cation is 110 pm, the radius of the anion is **[AIEEE - 2010, 4/144]**

(1) 288 pm
(2) 398 pm
(3) 618 pm
(4) 144 pm

9. Percentages of free space in cubic close packed structure and in body centered packed structure are respectively. **[AIEEE - 2010, 4/144]**

(1) 30% and 26%
(2) 26% and 32%
(3) 32% and 48%
(4) 48% and 26%

10. 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: **[AIEEE-2011, 4/120]**

(1) A_2B
(2) AB_2
(3) A_2B_3
(4) A_2B_5

11. Copper crystallises in fcc lattice with a unit cell edge of 361 pm. The radius of copper atom is: **[AIEEE-2011, 4/120]**

(1) 108 pm
(2) 128 pm
(3) 157 pm
(4) 181 pm

12. Lithium forms body centred cubic structure. The length of the side of its unit cell is 351 pm. Atomic radius of the lithium will be : **[AIEEE-2012, 4/120]**

(1) 75 pm
(2) 300 pm
(3) 240 pm
(4) 152 pm

13. Experimentally it was found that a metal oxide has formula $M_{0.98}O$. Metal M, present as M^{2+} and M^{3+} in its oxide. Fraction of the metal which exists as M^{3+} would be : **[JEE(Main) 2013, 3/120]**

(1) 7.01%
(2) 4.08%
(3) 6.05%
(4) 5.08%

14. CsCl crystallises in body centred cubic lattice. If 'a' its edge length then which of the following expressions is correct ? **[JEE(Main) 2014, 4/120]**

(1) $r_{Cs^+} + r_{Cl^-} = 3a$
(2) $r_{Cs^+} + r_{Cl^-} = \frac{3a}{2}$
(3) $r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$
(4) $r_{Cs^+} + r_{Cl^-} = \sqrt{3}a$

15. Sodium metal crystallizes in a body centred cubic lattice with a unit cell edge of 4.29Å. The radius of sodium atom is approximately: **[JEE(Main) 2015, 4/120]**

(1) 1.86Å
(2) 3.22Å
(3) 5.72Å
(4) 0.93Å

16. Which of the following compounds is metallic and ferromagnetic ? **[JEE(Main) 2016, 4/120]**

(1) CrO_2
(2) VO_2
(3) MnO_2
(4) TiO_2

17. A metal crystallises in a face centred cubic structure. If the edge length of its unit cell is 'a', the closest approach between two atoms in metallic crystal will be : **[JEE(Main) 2017, 4/120]**

(1) $2\sqrt{2}\,a$
(2) $\sqrt{2}\,a$
(3) $\frac{a}{\sqrt{2}}$
(4) 2^a

18. Which type of 'defect' has the presence of cations in the interstitial sites ? **[JEE(Main)-2018, 4/120]**

(1) Frenkel defect
(2) Metal deficiency defect
(3) Schottky defect
(4) Vacancy defect

ONLINE JEE-MAIN

1. In a face centered cubic lattice atoms A are at the corner points and atoms B at the face centered points. If atom B is missing from one of the face centered points, the formula of the ionic compound is : **[JEE(Main) 2014 Online (09-04-14), 4/120]**

(1) AB_2
(2) A_5B_2
(3) A_2B_3
(4) A_2B_5

2. The appearance of colour in solid alkali metal halides is generally due to : **[JEE(Main) 2014 Online (11-04-14), 4/120]**

(1) Schottky defect
(2) Frenkel defect
(3) Interstitial position
(4) F-centres

3. In a monoclinic unit cell the relation of sides and angles are respectively : **[JEE(Main) 2014 Online (12-04-14), 4/120]**

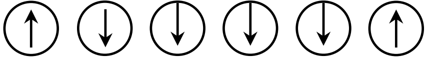
(1) $a = b \neq c$ and $\alpha = \beta = \gamma = 90^o$
(2) $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90^o$
(3) $a \neq b \neq c$ and $\alpha = \gamma = 90^o \neq \beta$
(4) $a \neq b \neq c$ and $\alpha \neq \beta \neq \gamma \neq 90^o$

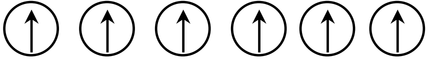
4. The total number of octahedral void (s) per atom present in a cubic close packed structure is :

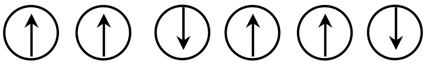
[JEE(Main) 2014 Online (19-04-14), 4/120]

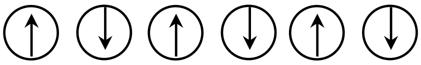
(1) 2 (2) 4 (3) 1 (4) 3

5. Which of the following arrangements shows the schematic alignment of magnetic moments of antiferromagnetic substance ? **[JEE(Main) 2018 Online (15-04-18), 4/120]**

(1) 

(2) 

(3) 

(4) 

6. All of the following share the same crystal structure except :

[JEE(Main) 2018 Online (15-04-18), 4/120]

(1) LiCl (2) NaCl (3) RbCl (4) CsCl

7. The one that is extensively used as a piezoelectric material is :

[JEE(Main) 2019 Online (09-01-19), 4/120]

(1) tridymite (2) amorphous silica

(3) quartz (4) mica

8. At 100ºC, copper (Cu) has FCC unit cell structure with cell edge length of x Å. What is the approximate density of Cu (in g cm^{-3}) at this temperature? [Atomic mass of Cu = 63.55 u]

[JEE(Main) 2019 Online (09-01-19), 4/120]

(1) $\frac{205}{x^3}$ (2) $\frac{105}{x^3}$ (3) $\frac{422}{x^3}$ (4) $\frac{211}{x^3}$

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

[JEE(Main) 2019 Online (10-01-19), 4/120]

(1) Monoclinic (2) Triclinic (3) Hexagonal (4) Tetragonal

10. A compounds of formula A_2B_3 has the hcp lattice. Which atom forms the hcp lattice and what fraction of tetrahedral voids is occupied by the other atoms;

[JEE(Main) 2019 Online (10-01-19), 4/120]

(1) hcp lattice –A, $\frac{2}{3}$ Tetrahedral voids-B (2) hcp lattice –B, $\frac{1}{3}$ Tetrahedral voids-A

(3) hcp lattice –B, $\frac{2}{3}$ Tetrahedral voids-A (4) hcp lattice –A, $\frac{1}{3}$ Tetrahedral voids-B

11. A solid having density of 9×10^3 kg m^{-3} forms face centred cubic crystals of edge length $200\sqrt{2}$ pm. What is the molar mass of the solid? [Avogadro constant $\cong 6 \times 10^{23}$ mol^{-1}, $\pi \cong 3$]

[JEE(Main) 2019 Online (11-01-19), 4/120]

(1) 0.0432 kg mol^{-1} (2) 0.0305 kg mol^{-1} (3) 0.4320 kg mol^{-1} (4) 0.0216 kg mol^{-1}

12. The radius of the largest sphere which fits properly at the centre of the edge of a body centred cubic unit cell is : (Edge length is represented by 'a')

[JEE(Main) 2019 Online (11-01-19), 4/120]

(1) 0.047 a (2) 0.027 a (3) 0.134 a (4) 0.067 a

Answers

EXERCISE - 1

PART - I

A-1. Ionic – LiBr, $(NH_4)_3PO_4$; Metallic – Brass, Rb ; Molecular – P_4O_{10} , I_2 , P_4
Network – SiC, Graphite, Si, Amorphous – Plastic

A-2.

Ques.	(a)	(b)	Total particles
(i)	1/4	1	2
(ii)	1/2	1/4	2
(iii)	1/6	1/2	2
(iv)	1/6	–	1/2
(v)	1/3	1/6	1

A-3.

Crystal System	Features	Unit cell found	Examples
Monoclinic	$a \neq b \neq c$ $\alpha = \gamma = 90°$; $\beta \neq 120°, \neq 90°, \neq 60°$	S, EC	Monoclinic sulphur, $PbCrO_4$, $Na_2SO_4.10H_2O$, $Na_2B_4O_7.10H_2O$.
Hexagonal	$a = b \neq c$ $\alpha = \beta = 90°, \gamma = 120°$	S	Graphite, ZnO, CdS, Mg, PbI_2, SiC.
Triclinic	$a \neq b \neq c$ $\alpha \neq \beta \neq \gamma \neq 90°$	S	$K_2Cr_2O_7$, $CuSO_4.5H_2O$, H_3BO_3.

B-1. Cube1 - 1/2 ; Cube2 - 1/4 ; Cube3 - 1 ; Cube4 - 1/8

B-2. BCC

B-3. 124.27 pm, density = 7.30 g cm^{-3}

C-1. ABC-ABC-Arrangement (CCP unit cell).

C-2. 1.72×10^{-23} cm^3, 1.60 Å

C-3. (i) b, f, g are identical; c, e are identical. (ii) $d_a < [d_b = d_f = d_g] < [d_c = d_e] < d_d$

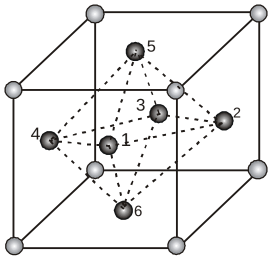
C-4. (i) 2r, 2r, $2\sqrt{3}r$; (ii) Square, side = 2r.

C-5. FCC, $\sqrt{2}$ Å

C-6. ABAB............type arrangement (unit cell = HCP).

D-1. No, Rhombous: 2R, 60º, 120º ; Triangular voids; 2 voids, 0.155 R.

D-2. Octahedral void is present at the body center, which is formed by six face centered atoms and it consist at triangle faces.



D-3. 12 and 6

D-4. 4, 8, $\frac{a}{\sqrt{2}}$, $\frac{a}{2}$

E-1. (a) CsCl type (b) ZnS type (c) NaCl type (d) CsCl type

E-2. In case of ZnS radius ratio is $\frac{r_{Zn^{2+}}}{r_{S^{2-}}} = 0.402$.

That's why Zn^{2+} ion is present in tetrahedral void. If Zn^{2+} ion is present in octahedral void [For NaCl type structure] then anion-anion contact is there and compound become unstable. That's why. ZnS not crystallize in the NaCl structure.

E-3. (i) Zn^{2+} ions occupy alternate Tetrahedral holes ; (ii) Anti-Flourite: Anions in FCC and Cations in Tetrahedral holes, Fluorite: Cations in FCC and Anions in Tetrahedral holes

E-4. (a) K^+ ion = 4 & Br^- ion = 4 (b) 6.56 Å (c) 2.80 g/cm^3 (d) 0.414

F-1. **Imperfections in solids :** *Any deviation from the perfectly ordered arrangement constitutes a defect or imperfection.* These defect are sometimes called thermodynamic defects because the number of these defects depends on the temperature.
(i) Stoichiometric point defects : Schottky Defects, Interstitial Defects, Frenkel Defects.
(ii) Non-Stoichiometric defects : Metal excess defects, Metal deficiency defects.

F-2. The reason of both is the presence of electron in anionic vacancies which is known as F– center.

F-3. Silicon doped with phosphorus forms n - type of semiconductor. Phosphorus contains one extra electron than silicon which can move easily through the crystal and is responsible for semiconductor properties.

F-4. In semiconductor fairly small band gap is present between valence band (filled with electrons) and conduction band (lowest unoccupied energy band). Increase in temperature gives thermal energy to some of the electrons and they move to conduction band and change the conductivity of semiconductor (Increase).

PART - II

A-1.	(C)	**A-2.**	(C)	**A-3.**	(D)	**A-4.**	(A)	**A-5.**	(A)
A-6.	(B)	**B-1.**	(A)	**B-2.**	(A)	**B-3.**	(B)	**B-4.**	(B)
B-5.	(A)	**B-6.**	(C)	**C-1.**	(C)	**C-2.**	(A)	**C-3.**	(A)
C-4.	(B)	**C-5.**	(C)	**C-6.**	(A)	**C-7.**	(C)	**C-8.**	(B)
C-9.	(A)	**C-10.**	(C)	**C-11.**	(C)	**D-1.**	(C)	**D-2.**	(A)
D-3.	(B)	**D-4.**	(C)	**D-5.**	(A)	**D-6.**	(A)	**D-7.**	(A)
E-1.	(C)	**E-2.**	(D)	**E-3.**	(C)	**E-4.**	(B)	**E-5.**	(B)
E-6.	(A)	**E-7.**	(A)	**E-8.**	(B)	**F-1.**	(C)	**F-2.**	(B)
F-3.	(A)	**F-4.**	(A)						

PART - III

1.✍ (a - f,l); (b - e,k); (c - h,j); (d - g,i) **2.** (A - r,s); (B - r,s); (C - p); (D - q)

3. (A - p,q,r,s); (B - p,r,s); (C - p,s); (D - p,r,s)

EXERCISE - 2

PART - I

1.	(C)	**2.**	(D)	**3.**	(B)	**4.**	(D)	**5.**	(B)
6.	(A)	**7.**	(C)	**8.**	(A)	**9.**	(D)	**10.**	(C)
11.	(B)	**12.**	(C)	**13.**	(D)	**14.**	(A)	**15.**	(C)
16.	(D)	**17.**	(B)	**18.**	(A)	**19.**	(C)		

PART - II

1.	5	**2.**	16	**3.**	8	**4.**	6	**5.**	6
6.	6	**7.**	5 = (1 + 1 + 3)	**8.**	20=(8+4+4+4)	**9.**	50 = (100 – 50)		

PART - III

1.	(ABC)	**2.**	(AC)	**3.**	(ABC)	**4.**	(BC)	**5.**	(ABCD)

6.	(ABC)	**7.**	(AD)	**8.**	(BC)	**9.**	(ACD)	**10.**	(ABC)
11.	(AC)	**12.**	(BC)						

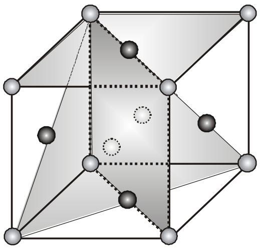
PART - IV

1.	(B)	**2.**	(A)	**3.**	(C)	**4.**	(C)	**5.**	(B)
6.	(A)	**7.**	(C)	**8.**	(A)	**9.**	(B)	**10.**	(C)

EXERCISE - 3

PART - I

1.



2.	(D)	**3.**	(A)						
4.	25, 1.804 marbles/cm^2	**5.**	(a) 5 kg m^{-3}, (b) Cancelled (Full marks given in part a)						
6.	(B)	**7.**	117.08 pm	**8.**	216.5 pm.	**9.**	(A - p,s); (B - q, p); (C - q); (D - q, r)		
10.	(B)	**11.**	(A)	**12.**	(D)	**13.***	(BC)	**14.**	(D)
15.	8	**16.**	(B)	**17.**	(A)	**18.**	(A)	**19.***	(BCD)
20.	2	**21.**	3						

PART - II

OFFLINE JEE-MAIN

1.	(4)	**2.**	(1)	**3.**	(2)	**4.**	(3)	**5.**	(4)
6.	(4)	**7.**	(1)	**8.**	(4)	**9.**	(2)	**10.**	(4)
11.	(2)	**12.**	(4)	**13.**	(2)	**14.**	(3)	**15.**	(1)
16.	(1)	**17.**	(3)	**18.**	(1)				

ONLINE JEE-MAIN

1.	(4)	**2.**	(4)	**3.**	(3)	**4.**	(3)	**5.**	(4)
6.	(4)	**7.**	(3)	**8.**	(3)	**9.**	(2)	**10.**	(2)
11.	(2)	**12.**	(4)						