TRIUMPH

CHEMISTRY

BASED ON STD. XII CURRICULUM (MAHARASHTRA BOARD)

MULTIPLE CHOICE QUESTIONS

FOR ALL MEDICAL & ENGINEERING ENTRANCE EXAMINATIONS

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STD. XII Sci.

Triumph Chemistry

Based on Maharashtra Board Syllabus

Fourth Edition: May 2015

Salient Features

- Exhaustive subtopic wise coverage of MCQs
- Quick review and/or important formulae provided for all the chapters
- Hints included for relevant questions
- Various competitive exams questions updated till the latest year
- Includes solved MCQs from JEE (Main), AIPMT, MH CET 2015
- Evaluation test provided at the end of each chapter

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Printed at: **Repro India Ltd.,** Mumbai

P.O. No. 1072

TEID : 915

Preface

"Std. XII: Sci. Triumph Chemistry" is a complete and thorough guide to prepare students for competitive level examinations. This book not only assists students with MCQs of Std. XII but also helps them to prepare for JEE, AIPMT, AIIMS, AFMC, CET and various other competitive examinations.

The content of this book is based on the Maharashtra State Board Syllabus. **Quick Review** which summarizes the important concepts of the entire chapter is provided for all the chapters. **Formulae** that form a vital part of MCQ solving are provided for relevant chapters. **Shortcuts** provide easy and less tedious solving methods.

MCQs in each chapter are divided into three sections:

Classical Thinking: consists of straight forward questions including knowledge based questions.

Critical Thinking: consists of questions that require understanding of the concept and the applications of the same.

Competitive Thinking: consists of questions from various competitive examinations like JEE, AIPMT, AIIMS, AFMC, CET, CPMT, etc.

Hints (i.e., complete solutions broken down to the simplest form possible) have been provided to the MCQs.

An **Evaluation Test** has been provided at the end of each chapter to assess the level of preparation of the student on a competitive level.

In order to understand how chemistry plays an important role in our day to day life, we have made an attempt to illustrate the same in the form of images/visuals in the related chapters.

The journey to create a complete book is strewn with triumphs, failures and near misses. If you think we've nearly missed something or want to applaud us for our triumphs, we'd love to hear from you.
Please write to us on : mail@targetpublications.org

Best of luck to all the aspirants!

Yours faithfully
Authors

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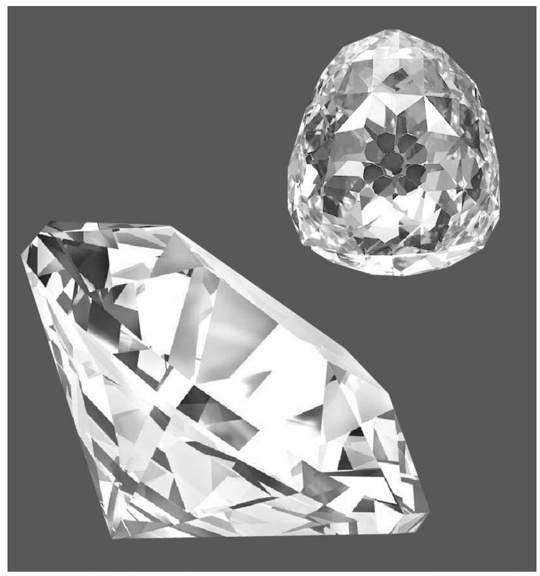
01 Solid State

Syllabus

Valuable defective materials !!!!



Do all defective materials turn up discarded? Well …. think again. They might be present in your jewelleries studded with precious and semi-precious stones. These stones with eye-catching colour and shine are due to their crystalline structure with presence of trace quantities of mostly transition elements which are generally called as impurities. One such example is corrundum (Al_2O_3) an important mineral of aluminium. The gemstone varieties of this mineral are ruby, sapphire, etc.
Ruby (Red) contains Al_2O_3 and Cr_2O_3
Sapphire (blue) contains Al_2O_3, Fe_2O_3 and TiO_2.

Quick Review

➢ **Classification of solids on the basis of the presence or absence of orderly arrangement of the constituent particles:**

Solids

Crystalline
A homogeneous solid in which the constituent particles are arranged in a definite geometric pattern.

Amorphous
Substances that appear like solids but do not have well developed perfectly ordered crystalline structure.
eg. Tar, glass, plastic, rubber, butter, etc.

(Crystalline →)

Isomorphous Form
Two or more substance having same crystal structure.
eg. i. NaF and MgO
ii. K_2SO_4 and K_2SeO_4
iii. $NaNO_3$ and $CaCO_3$
iv. Cr_2O_3 and Fe_2O_3

Polymorphous Form (Allotropes)
A single substance crystallising in two or more forms under different conditions.
eg. i. Graphite and diamond
ii. Rhombic sulphur and Monoclinic sulphur
iii. Polymorphic forms of calcium carbonate and silicon dioxide

➢ **Classification of crystalline solids based on different binding forces:**

Crystalline Solids

Molecular solids
Constituent particles are molecules of the same compound.

Ionic solids
Constituent particles are ionic molecules.
eg. NaCl, ZnS, CuCl

Metallic solids
Formed by atoms of the same metallic elements.
eg. Copper, gold

Covalent solids
Formed by chemical (covalent) bonds between the neighbouring constituent atoms of non-metallic solids.
eg. diamond, graphite and fullerene

(Molecular solids →)

Polar molecular solids
Constituent particles are covalently bonded molecules.
eg. HCl, SO_2 at low temperature and high pressure

Non-polar molecular solids
Constituent particles are non-polar molecules and weakly polar molecules.
eg. CO_2, H_2, Cl_2, CH_4 at very low temperatures

Hydrogen bonded molecular solids
Molecules are held together by hydrogen bonds.
eg. Solid ice

➢ **Three types of cubic lattices:**

Cubic lattice

Simple
Lattice points at eight corners of unit cell.
(1 particle per unit cell)
(52.4% occupied space)
eg. Polonium

Body centered
Lattice points at eight corners and one at body center of unit cell.
(2 particles per unit cell)
(68% occupied space)
eg. Fe, Na

Face centered
Lattice points at eight corners and six face centers of unit cell.
(4 particles per unit cell)
(74 % occupied space)
eg. Cu, Al

➢ **Classification of solids based on response to magnetic field:**

Substance	Characteristics	Magnetic alignment	Example	Application
Diamagnetic materials	• Repelled weakly in magnetic field. • All electrons are paired.	⇅ ⇅ ⇅ ⇅	Benzene, NaCl, TiO_2	Insulators
Paramagnetic materials	• Weakly attracted in magnetic field. • Unpaired electrons are present. • Permanent magnetisation is not possible.	↖↙→↑↘↗	O_2, CuO, TiO	Electronic devices
Ferromagnetic materials	• Strongly attracted in magnetic field. • Unpaired electrons are present. • Permanent magnetisation is possible.	↑ ↑ ↑ ↑ ↑	Fe, Ni, Co, CrO_2	CrO_2 is used in audio,video tapes.

Formulae

1. **Density of unit cell:**

$$d = \frac{z.M}{a^3.N_0}$$

where, a is edge of unit cell
N_0 = Avogadro number (6.023×10^{23})
M = Molar mass
z = number of atoms per unit cell
For fcc, z = 4
for bcc, z = 2
for simple cubic, z = 1

2. **Packing efficiency** $= \frac{\text{Volume occupied by spheres in unit cell}}{\text{Volume of unit cell}} \times 100$

3. **Radius rule and coordination number for ionic crystals:**
In simple ionic crystals, the cations commonly occupy the voids or holes. The voids are empty spaces left between anionic spheres.

i. **Radius Ratio** $\left(\frac{r^+}{r^-}\right)$**:**

The critical radius ratio of the void (cation) and sphere (anion), is calculated by solid geometry.

∴ Radius ratio $= \frac{r^+}{r^-} = \frac{\text{Cation radius}}{\text{Anion radius}}$

ii. **Coordination Number (CN) :**
The number of spheres (atoms, molecules or ions) directly surrounding a single sphere in a crystal, is called coordination number.

4. **Crystal structures of some elements and their coordination number's (CN):**

Crystal structure	Example	Coordination No.
bcc	Li, Na, K, Rb, Cs, Ba	8
fcc or ccp	Al, Ni, Cu, Ag, Au, Pt	12

5. **Relation between radius ratio, coordination number and geometry :**

Radius ratio $\left(\frac{r^+}{r^-}\right)$	Coordination number	Geometry	Examples
0.155 to 0.225	3	Planar triangular	B_2O_3
0.225 to 0.414	4	Tetrahedral	ZnS
0.414 to 0.732	6	Octahedral	NaCl
0.732 to 1.0	8	Cubic	CsCl

Classical Thinking

1.0 Introduction

1. The physical state of matter is the result of interplay of intermolecular forces such as _______.
   (A) dipole-dipole interactions
   (B) London forces
   (C) hydrogen bonding
   (D) all of these

2. Which among the following solids is NOT soft?
   (A) Sodium (B) Potassium
   (C) Copper (D) Phosphorus

1.1 Classification of solids

3. A crystalline solid has _______.
   (A) long range order
   (B) short range order
   (C) disordered arrangement
   (D) none of these

4. A solid having irregular shape is called _______ solid.
   (A) amorphous
   (B) crystalline
   (C) anisotropic
   (D) isomorphous

5. Amorphous substances have _______.
   (i) definite heat of fusion
   (ii) only short range order
   (iii) only long range order
   (iv) indefinite heat of fusion

   (A) (i) and (iii) are correct
   (B) (ii) and (iii) are correct
   (C) (iii) and (iv) are correct
   (D) (ii) and (iv) are correct

6. Amorphous solids _______.
   (A) possess sharp melting points
   (B) exhibit anisotropy
   (C) do not undergo clean cleavage when cut with knife
   (D) possess orderly arrangement over long distances

7. Glass is a _______.
   (A) supercooled liquid
   (B) crystalline solid
   (C) non-crystalline solid
   (D) liquid crystal

1.2 Classification of crystalline solids

8. The molecules of polar molecular solids are held together by _______.
   (A) dipole-dipole interactions
   (B) London dispersion forces
   (C) hydrogen bonds
   (D) covalent bonds

9. Which of the following is a hydrogen bonded molecular crystal?
   (A) HCl (B) H_2
   (C) CH_4 (D) Ice

10. Ice has three dimensional crystal structure in which _________ of total volume is unoccupied.
   (A) one half (B) one third
   (C) one fourth (D) one fifth

11. ZnS is a / an _______ crystal.
   (A) ionic (B) covalent
   (C) metallic (D) molecular

12. Crystals which are good conductor of electricity and heat are known as _______ crystals.
   (A) ionic (B) covalent
   (C) metallic (D) molecular

13. Which of the following is an example of metallic crystal solid?
   (A) C (B) Si
   (C) W (D) AgCl

14. _______ solids are also called giant solids or network solids.
   (A) Covalent (B) Molecular
   (C) Ionic (D) Metallic

15. In graphite, carbon atoms form interlinked _______ membered rings.
   (A) four (B) five
   (C) six (D) seven

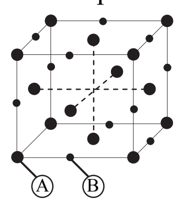
16. In fullerene, carbon atoms are _______ hybridized.
   (A) sp (B) sp^2
   (C) sp^3 (D) sp^3d

17. Fullerene reacts with potassium to form _______.
   (A) $K_{39}C_{57}$ (B) $K_{37}C_{63}$
   (C) $K_{40}C_{62}$ (D) $K_{35}C_{60}$

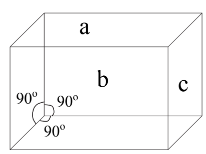
1.3 Unit cell, two and three dimensional lattices and number of atoms per unit cell

18. The three dimensional graph of lattice points which sets the pattern for the whole lattice is called _______.
    (A) space lattice (B) simple lattice
    (C) unit cell (D) crystal lattice

19. For a solid with the structure as shown in the figure, the coordination number of the point B is _______.
    (A) 3
    (B) 4
    (C) 5
    (D) 6



20. The unit cell with the following structure refers to _______ crystal system.
    (A) cubic
    (B) orthorhombic
    (C) tetragonal
    (D) trigonal



21. Which of the following are the CORRECT axial distances and axial angles for rhombohedral system?
    (A) $a = b = c, \alpha = \beta = \gamma \neq 90°$
    (B) $a = b \neq c, \alpha = \beta = \gamma = 90°$
    (C) $a \neq b \neq c, \alpha = \beta = \gamma = 90°$
    (D) $a \neq b \neq c, \alpha \neq \beta \neq \gamma \neq 90°$

22. The number of atoms or molecules contained in one primitive cubic unit cell is _______.
    (A) 1 (B) 2
    (C) 4 (D) 6

23. If the number of atoms per unit in a crystal is 2, the structure of crystal is _______.
    (A) octahedral
    (B) body centered cubic
    (C) face centered cubic
    (D) simple cubic

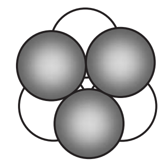
1.4 Packing in solids

24. The interstitial hole is called tetrahedral because _______.
    (A) it is formed by six spheres
    (B) it is tetrahedral in shape
    (C) it is formed by four spheres and the centres form a regular tetrahedron
    (D) it is formed by three spheres

25. In a close pack array of N spheres, the number of tetrahedral holes are _______.
    (A) 4N (B) N/2
    (C) 2N (D) N

26. The number of tetrahedral voids in a unit cell of cubical closest packed structure is _______.
    (A) 1 (B) 2
    (C) 4 (D) 8

27. The empty space between the shared balls and hollow balls as shown in the diagram is called _______.
    (A) hexagonal void
    (B) octahedral void
    (C) tetrahedral void
    (D) triangular void



28. In octahedral voids, _______.
    (A) a simple triangular void is surrounded by four spheres
    (B) a bi-triangular void is surrounded by four spheres .
    (C) a bi-triangular void is surrounded by six spheres
    (D) a bi-triangular void is surrounded by eight spheres

29. Which of the following crystallises in bcc structure?
    (A) Al (B) Cu
    (C) Mg (D) W

30. The arrangement ABCABC ……. is referred to as _______ close packing.
    (A) octahedral
    (B) hexagonal
    (C) tetrahedral
    (D) cubic

31. In hcp arrangement, the number of nearest neighbours are _______.
    (A) 10 (B) 7
    (C) 2 (D) 12

1.5 Density of unit cell

32. The packing efficiency in simple cubic unit cell is _______.
    (A) 52.4% (B) 68%
    (C) 74% (D) 80%

33. The space occupied by b.c.c. arrangement is approximately _______.
    (A) 50% (B) 68%
    (C) 74% (D) 56%

34. The maximum percentage of available volume that can be filled in a face centered cubic system by an atom is _______.
(A) 74% (B) 68%
(C) 34% (D) 26%

1.6 Packing in voids of ionic solids

35. If the radius ratio of cation to anion is in the range of 0.225 – 0.414, then the coordination number of cation will be _______.
(A) 2 (B) 4
(C) 6 (D) 8

36. If the type of the hole occupied is tetrahedral, the radius ratio (r_+/r_-) should be _______.
(A) 0.414 – 0.732
(B) > 0.732
(C) 0.155 – 0.225
(D) 0.225 – 0.414

37. For cubic coordination, the value of radius ratio is _______.
(A) 0.732 – 1.000 (B) 0.225 – 0.414
(C) 0.000 – 0.225 (D) 0.414 – 0.732

38. In NaCl lattice, the radius ratio is $\frac{r_{Na^+}}{r_{Cl^-}}$ = _______.
(A) 0.225 (B) 0.115
(C) 0.5248 (D) 0.471

39. For some crystals, the radius ratio for cation and anion is 0.525. Its coordination number will be _______.
(A) 2 (B) 4
(C) 6 (D) 8

40. TiCl has structure similar to CsCl, the coordination number of Ti^+ is _______.
(A) 4 (B) 6
(C) 10 (D) 8

41. For an ionic crystal of the type AB, the value of (limiting) radius ratio is 0.40. The value suggests that the crystal structure should be _______.
(A) octahedral
(B) tetrahedral
(C) square planar
(D) planar triangular

42. Which of the following ions has the largest radius?
(A) Na^+ (B) Mg^{2+}
(C) Al^{3+} (D) Si^{4+}

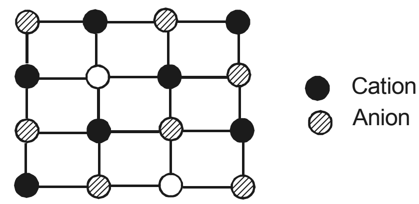
43. In the unit cell of NaCl lattice, there are _______.
(A) 3 Na^+ ions (B) 6 Na^+ ions
(C) 6 Cl^- ions (D) 4 NaCl units

1.7 Defects in crystal structure

44. Schottky defect is shown by _______.
(A) strongly ionic compounds
(B) compounds having high coordination number
(C) compounds containing cations and anions of almost similar size
(D) all of these

45. Schottky defect is noticed in _______.
(A) NaCl (B) KCl
(C) CsCl (D) All of these

46. The given structure represents _______.



(A) Schottky defect
(B) Frenkel defect
(C) Metal excess defect
(D) Metal deficiency defect

47. Which of the following defect, if present, lowers the density of the crystal?
(A) Frenkel
(B) Schottky
(C) Substitution impurity defect
(D) Interstitial impurity defect

48. Both Schottky and Frenkel defects are present in _______.
(A) AgCl (B) AgBr
(C) AgI (D) ZnS

1.8 Electrical properties

49. The variation property of ability to conduct electricity of metals, non-metals and semiconductors is explained by _______.
(A) energy gain enthalpy
(B) band theory
(C) bond theory
(D) hydride gap

50. Silicon is a _______.
(A) conductor (B) semiconductor
(C) non-conductor (D) metal complex

51. Germanium is an example of _______.
(A) an intrinsic semiconductor
(B) a n-type semiconductor
(C) a p-type semiconductor
(D) insulator

52. A silicon solar battery makes use of _______.
(A) n-type semiconductor
(B) p-type semiconductor
(C) combination of Si doped with As and B
(D) p-n junction

1.9 Magnetic properties

53. Which among the following is NOT a diamagnetic substance?
(A) water (B) sodium chloride
(C) oxygen (D) benzene

Miscellaneous

54. Which among the following is called a pseudo solid?
(A) CaF_2 (B) Glass
(C) NaCl (D) All of these

55. A solid X melts slightly above 273 K and is a poor conductor of heat and electricity. To which of the following categories does it belong?
(A) Ionic solid
(B) Covalent solid
(C) Metallic
(D) Molecular

56. Value of heat of fusion of NaCl is _______.
(A) very low (B) very high
(C) moderate (D) zero

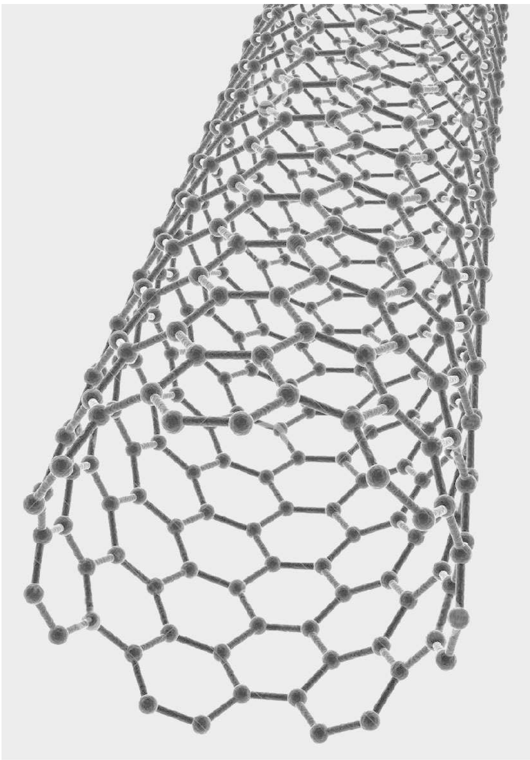
57. Amorphous solids are _______.
(A) solid substances
(B) liquids
(C) super cooled liquids
(D) substances with definite melting point

58. The most malleable metals (Cu, Ag, Au) have close - packing of the type _______.
(A) AAAA
(B) ABCABC
(C) ABAB
(D) ABCCBA

59. Each unit cell of NaCl consists of 4 chloride ions and _______.
(A) 13 Na atoms (B) 4 Na^+ ions
(C) 6 Na atoms (D) 8 Na atoms

60. If the value of ionic radius ratio $\left(\frac{r_c}{r_a}\right)$ is 0.52 in an ionic compound, the geometrical arrangement of ions in crystal is _______.
(A) tetrahedral
(B) planar triangular
(C) octahedral
(D) cubic

Carbon nanotubes (CNTs)



Carbon nanotubes (CNTs) are allotropes of carbon and are the members of the fullerene structural family. CNTs have long, hollow and cylindrical nanostructure with the walls formed by graphene (one-atom-thick sheets of carbon). These sheets are rolled at specific and discrete angles, and the combination of the rolling angle and radius decides the nanotube properties. The unique strength of CNTs is due to sp^2 bonding present in them. CNTs find applications in nanotechnology, electronics, optics and other fields of materials science and technology. These are not necessarily products of high-tech laboratories but have been found in soot from air, flames produced by burning methane, ethylene and benzene, etc.

Critical Thinking

1.0 Introduction

1. The characteristic features of solids are _______.
(A) definite shape (B) definite size
(C) definite rigidity (D) all of these

2. For the various types of interactions, the CORRECT order of increasing strength is:
(A) covalent < hydrogen bonding < van der Waal's < dipole-dipole
(B) van der Waal's < hydrogen bonding < dipole-dipole < covalent
(C) van der Waal's < dipole-dipole < hydrogen bonding < covalent
(D) dipole-dipole < van der Waal's < hydrogen bonding < covalent

3. Which of the following statement is TRUE?
(A) Solid changes into liquid on heating to its melting point.
(B) Liquid changes into gas, on cooling to its freezing point.
(C) Liquid changes into solid, on heating to its boiling point.
(D) Solid changes into gas, on heating to its melting point.

1.1 Classification of solids

4. Which of the following is a crystalline solid?
(A) Tar (B) Butter
(C) Glass (D) Common salt

5. Which of the following pair of compounds is NOT isomorphous?
(A) NaF and MgO
(B) K_2SO_4 and K_2SeO_4
(C) $NaNO_3$ and $CaCO_3$
(D) NaCl and KCl

6. Graphite, diamond and fullerene are the polymorphic forms of _______.
(A) sulphur
(B) carbon
(C) calcium carbonate
(D) silicon dioxide

7. The ability of crystalline solids to change values of physical properties when measured in different directions is called _______.
(A) polymorphism (B) isomorphism
(C) anisotropy (D) isotropy

8. Which among the following will show anisotropy?
(A) Glass (B) Barium chloride
(C) Wood (D) Paper

9. Which of the following statements is TRUE?
(A) Both crystalline and amorphous solids are isotropic.
(B) Both crystalline and amorphous solids are anisotropic.
(C) Crystalline solids are always isotropic and amorphous solids are anisotropic.
(D) Crystalline solids are anisotropic and amorphous solids are isotropic.

10. Pyrex glass is obtained by fusing together _______.
(A) 60 to 80% Al_2O_3, 10 to 25% SiO_2 and remaining amount of B_2O_3
(B) 60 to 80% B_2O_3, 10 to 25% Al_2O_3 and remaining amount of SiO_2
(C) 60 to 80% SiO_2, 10 to 25% B_2O_3 and remaining amount of Al_2O_3
(D) 60 to 80% SiO_2, 10 to 25% Al_2O_3 and remaining amount of B_2O_3

11. Soda lime glass is produced by fusing SiO_2 with _______.
(A) CaO and B_2O_3 (B) Na_2O and CoO
(C) B_2O_3 and Fe_2O_3 (D) Na_2O and CaO

12. Red glass contains trace amount of _______.
(A) boron oxide
(B) Al_2O_3 and Fe_2O_3
(C) gold and copper
(D) zinc and aluminium

13. Yellow glass contains _______.
(A) CuO (B) UO_2
(C) CoO (D) Fe_2O_3

1.2 Classification of crystalline solids

14. Iodine crystals are _______ solid.
(A) metallic (B) ionic
(C) molecular (D) covalent

15. Among the following, which crystal will be soft and has low melting point?
(A) Covalent (B) Ionic
(C) Metallic (D) Molecular

16. Solid CO_2 is an example of _______ crystal.
(A) non-polar molecular
(B) polar molecular
(C) covalent
(D) metallic

17. The interparticle forces in solid hydrogen are _______.
(A) hydrogen bonds
(B) covalent bonds
(C) coordinate bonds
(D) van der Waal's forces

18. In ionic solids, the arrangement of ions depends on _______.
(A) sizes of cations and anions
(B) the charges on the ions
(C) polarisability of anion
(D) all of these

19. LiF is a/an _______ crystal.
(A) ionic (B) metallic
(C) covalent (D) molecular

20. A sea of electrons is present in _______ solids.
(A) ionic
(B) metallic
(C) non-polar molecular
(D) polar molecular

21. The lustre of a metal is due to _______.
(A) its high density
(B) its high polishing
(C) its chemical inertness
(D) presence of free electrons

22. Crystals of covalent compounds always have _______.
(A) atoms as their structural units
(B) molecules as structural units
(C) ions held together by electrostatic forces
(D) high melting points

23. In which of the following substances, the carbon atom is arranged in a regular tetrahedral structure?
(A) Diamond (B) Benzene
(C) Graphite (D) Carbon black

24. The major binding force of diamond, silicon and quartz is _______.
(A) electrostatic force
(B) electrical attraction
(C) covalent bond force
(D) van der Waal's force

25. In C_{60}, carbon atoms form _______.
(A) hexagons and octagons
(B) pentagons and triangles
(C) hexagons and pentagons
(D) squares and quadrilaterals

26. $K_{35}C_{60}$ is a compound of potassium and fullerene. It is _______ at 18 K.
(A) a super conductor of electricity
(B) a conductor of electricity
(C) a semi-conductor
(D) an insulator

1.3 Unit cell, two and three dimensional lattices and number of atoms per unit cell

27. Crystals can be classified into _______ basic crystal units.
(A) 3 (B) 7
(C) 14 (D) 4

28. Bravais lattices are of _______ types.
(A) 8 (B) 12
(C) 14 (D) 9

29. Monoclinic crystal has dimensions _______.
(A) $a \neq b \neq c, \alpha = \beta = 90°, \gamma \neq 90°$
(B) $a = b = c, \alpha = \beta = \gamma = 90°$
(C) $a = b \neq c, \alpha = \beta = \gamma = 90°$
(D) $a \neq b \neq c, \alpha \neq \beta \neq \gamma \neq 90°$

30. If the coordination number of Ca^{2+} in CaF_2 is 8, then the coordination number of F^- ion would be _______.
(A) 3 (B) 4
(C) 6 (D) 8

31. The number of equidistant oppositely charged ions in a sodium chloride crystal is _______.
(A) 8 (B) 6
(C) 4 (D) 2

32. In CsCl lattice, the coordination number of Cs^+ ion is _______.
(A) 2 (B) 4
(C) 8 (D) 12

33. Potassium fluoride has NaCl type structure. What is the distance between K^+ and F^- ions if cell edge is 'a' cm?
(A) 2a cm (B) a / 2 cm
(C) 4a cm (D) a / 4 cm

1.4 Packing in solids

34. The vacant space in b.c.c. unit cell is _______.
(A) 32 % (B) 10 %
(C) 23 % (D) 46 %

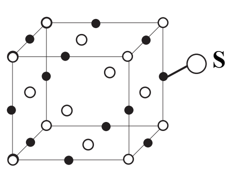
35. Hexagonal close packed arrangement of ions is described as _______.
(A) ABCABA.... (B) ABCABC....
(C) ABABA.... (D) ABBAB....

36. The decreasing order of the size of void is _______.
(A) Cubic > Octahedral > Tetrahedral > Trigonal
(B) Trigonal > Tetrahedral > Octahedral > Cubic
(C) Trigonal > Octahedral > Tetrahedral > Cubic
(D) Cubic > Tetrahedral > Octahedral > Trigonal

37. The fraction of total volume occupied by the atoms in a simple cube is _______.
(A) $\frac{\pi}{4}$ (B) $\sqrt{2}\frac{\pi}{8}$
(C) $\sqrt{2}\frac{\pi}{6}$ (D) $\frac{\pi}{6}$

38. Which among the following statements is CORRECT for ccp?
(A) Each octahedral void is surrounded by 6 spheres and each sphere is surrounded by 3 octahedral voids.
(B) Each octahedral void is surrounded by 6 spheres and each sphere is surrounded by 6 octahedral voids.
(C) Each octahedral void is surrounded by 6 spheres and each sphere is surrounded by 8 octahedral voids.
(D) Each octahedral void is surrounded by 6 spheres and each sphere is surrounded by 12 octahedral voids.

39. For the given structure, the site marked as 'S' is a _______ void.



(A) tetrahedral (B) cubic
(C) octahedral (D) triangular

1.5 Density of unit cell

40. The formula for determination of density of unit cell is _______.
(A) $\frac{a^3 \times N_0}{z \times M}$ g cm^{-3} (B) $\frac{z \times M}{a^3 \times N_0}$ g cm^{-3}
(C) $\frac{a^3 \times M}{z \times N_0}$ g cm^{-3} (D) $\frac{M \times N_0}{a^3 \times z}$ g cm^{-3}

41. The density of KBr is 2.75 gm cm^{-3}. Length of the unit cell is 654 pm. K = 39, Br = 80. Then what is TRUE about the predicted nature of the solid?
(A) Solid has face centered cubic system with z = 4.
(B) Solid has simple cubic system with z = 4.
(C) Solid has face centered cubic system with z = 1.
(D) Solid has body centered cubic system with z = 2.

42. Xenon crystallizes in face centre cubic lattice and the edge of the unit cell is 620 pm, then the radius of Xenon atom is _______.
(A) 219.20 pm (B) 438.5 pm
(C) 265.5 pm (D) 536.94 pm

43. A metallic element crystallizes in simple cubic lattice. Each edge length of the unit cell is 3 Å. The density of the element is 8 g / cc. Number of unit cells in 108 g of the metal is _______. (Molar mass of the metal = 108 g/mol.)
(A) 1.33×10^{20} (B) 2.7×10^{22}
(C) 5×10^{23} (D) 2×10^{24}

44. If the density of NaCl = 2.165 g cm^{-3} and the distance between Na^+ and Cl^- = 281 pm, Avogadro's number is equal to _______.
(A) 7×10^{23} mol^{-1} (B) 8×10^{23} mol^{-1}
(C) 6×10^{23} mol^{-1} (D) 4×10^{23} mol^{-1}

45. A solid has a bcc structure. If the distance of closest approach between the two atoms is 1.73 Å. The edge length of the cell is _______.
(A) 200 pm (B) $\frac{\sqrt{3}}{\sqrt{2}}$ pm
(C) 142.2 pm (D) $\sqrt{2}$ pm

46. A compound CuCl has face centered cubic structure. Its density is 3.4 g cm^{-3}. The length of unit cell is _______. (Atomic mass of Cu = 63.54 and Cl = 35.45)
(A) 5.783 Å (B) 6.783 Å
(C) 7.783 Å (D) 8.783 Å

47. At room temperature, sodium crystallizes in a body centered cubic lattice with a = 4.24 Å. The theoretical density of sodium (At. mass of Na = 23) is _______.
(A) 1.002 g cm^{-3} (B) 2.002 g cm^{-3}
(C) 3.002 g cm^{-3} (D) 4.002 g cm^{-3}

1.6 Packing in voids of ionic solids

48. The coordination number of a cation occupying a tetrahedral hole is _______.
(A) 6 (B) 8
(C) 12 (D) 4

49. The structure of MgO is similar to NaCl. What would be the coordination number of magnesium?
(A) 2 (B) 4
(C) 6 (D) 8

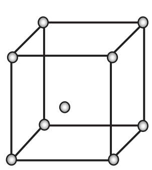
50. Coordination number for Cu is _______.
(A) 1 (B) 6
(C) 8 (D) 12

51. Which of the following adopts normal spinal structure?
(A) CsCl (B) $MgAl_2O_4$
(C) FeO (D) CaF_2

52. In the crystal of CsCl, the nearest neighbours of each Cs ion are _______.
(A) six chloride ions
(B) eight chloride ions
(C) six caesium ions
(D) eight caesium ions

53. In a face centered cubic arrangement of A and B atoms, if A atoms are at the corner of the unit cell and B atoms at the face centres, and one of the A atom is missing from one corner in unit cell. Then the simplest formula of compound is _______.
(A) A_7B_3 (B) AB_3
(C) A_7B_{24} (D) $A_{7/8}B_3$

54. A solid A^+B^- has the B^- ions arranged as below. If the A^+ ions occupy half of the octahedral sites in the structure. The formula of solid is _______.
(A) AB
(B) AB_2
(C) A_2B
(D) A_3B_4



55. An alloy of Cu, Ag and Au is found to have copper constituting the ccp lattice. If silver atoms occupy the edge centre and gold is present at body centre, the alloy has a formula _______.
(A) Cu_4Ag_2Au (B) Cu_4Ag_4Au
(C) Cu_4Ag_3Au (D) CuAgAu

56. The maximum radius of sphere that can be fitted in the octahedral hole of cubical closed packing of sphere of radius r is _______.
(A) 0.732 r (B) 0.414 r
(C) 0.225 r (D) 0.155 r

57. The ratio of cations to anion in a closed pack tetrahedral is _______.
(A) 0.155 (B) 0.225
(C) 0.02 (D) 0.732

58. The unit cell cube length for LiCl (just like NaCl structure) is 5.14 Å. Assuming anion-anion contact, the ionic radius for chloride ion is _______.
(A) 1.815 Å (B) 2.8 Å
(C) 3.8 Å (D) 4.815 Å

59. The CORRECT statement for rock salt structure is _______.
(A) the tetrahedral voids are larger than octahedral voids
(B) the tetrahedral voids are unoccupied while octahedral voids are occupied by cations
(C) the radius ratio is 0.732
(D) the radius ratio is 0.99

60. For an ionic crystal of the general formula AX and coordination number 6, the value of radius ratio will be _______.
(A) greater than 0.73
(B) in between 0.73 and 0.41
(C) in between 0.41 and 0.22
(D) less than 0.22

61. The edge length of the unit cell of NaCl crystal lattice is 552 pm. If ionic radius of sodium ion is 95 pm, what is the ionic radius of chloride ion?
(A) 190pm (B) 368pm
(C) 181pm (D) 276pm

62. A binary solid (A^+B^-) has a rock salt structure. If the edge length is 400 pm and radius of cation is 75 pm, the radius of anion is _______.
(A) 100 pm (B) 125 pm
(C) 250 pm (D) 325 pm

63. The radius of the Na^+ is 95 pm and that of Cl^- ion is 181 pm. Predict the coordination number of Na^+.
(A) 4 (B) 6
(C) 8 (D) Unpredictable

64. A solid AB has rock salt structure. If the edge length is 520 pm and radius of A^+ is 80 pm, the radius of anion B^- would be _______.
(A) 440 pm (B) 220 pm
(C) 360 pm (D) 180 pm

65. A certain metal crystallises in a simple cubic structure. At a certain temperature, it arranges to give a body centered structure. In this transition, the density of the metal _______.
(A) decreases
(B) increases
(C) remains unchanged
(D) changes without a definite pattern

66. The mass of a unit cell of CsCl corresponds to _______.
(A) $8Cs^+$ and $1Cl^-$ (B) $1Cs^+$ and $6Cl^-$
(C) $1Cs^+$ and $1Cl^-$ (D) $4Cs^+$ and $4Cl^-$

67. A mineral having the formula AB_2 crystallize in cubic close packed lattice with the A atoms occupying the lattice points. The coordination number of atoms of A, atoms of B and the fraction of the tetrahedral sites occupied by B are respectively _______.
(A) 2, 6, 75% (B) 8, 4, 100%
(C) 3, 1, 25% (D) 6, 6, 50%

68. In Corundum, oxide ions are arranged in hcp arrangement and aluminium ions occupy two third of the octahedral holes. Its formula is _______.
(A) Al_2O_3 (B) Al_2O_4
(C) Al_2O_2 (D) AlO_2

69. NH_4Cl crystallizes in bcc lattice with edge length of unit cell equal to 387 pm. If radius of Cl^- is 181 pm, the radius of NH_4^+ will be _______.
(A) 174 pm (B) 154 pm
(C) 116 pm (D) 206 pm

70. Arrangement of Cl^- in CsCl is _______.
(A) hcp (B) simple cubic
(C) fcc (D) bcc

71. A compound alloy of gold and copper crystallizes in a cube lattice in which the gold atoms occupy the lattice points at the corners of cube and copper atoms occupy the centres of each of the cube faces. The formula of this compound is _______.
(A) AuCu (B) $AuCu_2$
(C) $AuCu_3$ (D) Au_2Cu

72. What is the simplest formula of a solid whose cubic unit cell has the atom A at each corner, the atom B at each face centre and C atom at the body centre?
(A) AB_2C (B) A_2BC
(C) AB_3C (D) ABC_3

73. KCl crystallises in the same type of lattice as NaCl. Calculate the ratio of the side of the unit cell for KCl to that for NaCl.
(given $r_{Na^+} / r_{Cl^-} = 0.55$ and $r_{Na^+} / r_{K^+} = 0.74$)
(A) 1.122 (B) 1.224
(C) 1.414 (D) 0.732

74. Which of the following crystals show 4 : 2 coordination?
(A) CaF_2 (B) SiO_2
(C) PbO_2 (D) $SiCl_4$

75. Zinc sulphide exists in two different forms zinc blende and wurtzite. Both occur as 4 : 4 coordination compounds. Choose the CORRECT option from among the following:
(A) Zinc blende has a bcc structure and wurtzite a fcc structure.
(B) Zinc blende has a fcc structure and wurtzite a hcp structure.
(C) Zinc blende as well as wurtzite have a hcp structure.
(D) Zinc blende as well as wurtzite have a ccp structure.

76. How many atoms are there in a unit cell of Mg which forms hexagonal crystals, there being a face- centered atom in each end of the unit cell and 3 completely enclosed atoms within the unit cell?
(A) 4 (B) 6
(C) 12 (D) 8

77. The ionic radii of Rb^+ and I^- are 1.46 and 2.16 Å. The most probable type of structure exhibited by it is _______ type.
(A) CsCl (B) NaCl
(C) ZnS (D) CaF_2

78. In A^+B^- ionic compound, radii of A^+ and B^- ions are 180 pm and 187 pm respectively. The crystal structure of this compound will be _______.
(A) NaCl type (B) CsCl type
(C) ZnS type (D) B_2O_3 type

79. Which of the following will NOT adopt CsCl structure?
(A) CsF (B) CsBr
(C) CsS (D) CsCN

80. A solid is made of two elements X and Z. The atoms Z are in ccp arrangement while atoms X occupy all the tetrahedral sites. What is the formula of the compound?
(A) XZ (B) XZ_2
(C) X_2Z (D) Unpredictable

81. In a solid, oxide ions are arranged in ccp. 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) ABO_3 (B) AB_2O_3
(C) A_2BO_3 (D) $A_2B_2O_3$

82. A binary solid (A^+B^-) has a zinc blende structure with B^- ions constituting the lattice and A^+ ions occupying 25% tetrahedral holes. The formula of solid is _______.
(A) AB (B) A_2B
(C) AB_2 (D) AB_4

1.7 Defects in crystal structure

83. If a non-metal is added to the interstitial sites of a metal then the metal becomes _______.
(A) softer (B) less tensile
(C) less malleable (D) more ductile

84. Frenkel defect is caused due to _______.
(A) an ion missing from the normal lattice site creating a vacancy
(B) an extra positive ion occupying an interstitial position in the lattice
(C) an extra negative ion occupying an interstitial position in the lattice
(D) the shift of a positive ion from its normal lattice site to an interstitial site

85. Due to Frenkel defect, the density of ionic solids _______.
(A) increases (B) decreases
(C) does not change (D) changes

86. 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 coordination number of NaCl
(D) higher coordination number of AgCl

87. Pink colour in non-stoichiometric LiCl is due to _______.
(A) Cl^- ions in lattice (B) Li^+ ions in lattice
(C) e^- in lattice (D) dissociation

1.8 Electrical properties

88. Band theory of metals is based on _______.
(A) valence bond theory
(B) molecular orbital theory
(C) crystal field theory
(D) ligand field theory

89. The space between the outermost filled energy band and the next empty band is called _______.
(A) valence band (B) conduction band
(C) forbidden zone (D) none of these

90. Which of the following statements is TRUE?
(A) In metals, the forbidden zone is very small and in insulators, the forbidden zone is very large.
(B) Forbidden zone is very large in metals and insulators.
(C) Forbidden zone is very small in metals and insulators.
(D) In metals, the forbidden zone is very large and in insulators, the forbidden zone is very small.

91. With increase in temperature, the electrical conductivity of semiconductors _______.
(A) decreases (B) remains same
(C) increases (D) none of these

92. When suitable impurity is added to pure intrinsic semiconductor, the electrical conductivity _______.
(A) is enhanced
(B) remains same
(C) decreases to a large extent
(D) decreases slightly

93. Silicon doped with arsenic is an example of which type of semiconductor?
(A) p - type (B) n - type
(C) n,p - type (D) Intrinsic type

1.9 Magnetic properties

94. Each electron has permanent _______.
(A) spin magnetic moment
(B) orbital magnetic moment
(C) both (A) and (B)
(D) none of these

95. The materials which are weakly repelled by the magnetic field are known as _______.
(A) diamagnetic materials
(B) paramagnetic materials
(C) ferromagnetic materials
(D) ferrimagnetic materials

96. Which of the following statements is TRUE?
(A) Paramagnetic substances are attracted by the magnetic field.
(B) Paramagnetic substances are strongly repelled by the magnetic field.
(C) Paramagnetic substances are neither attracted nor repelled by the magnetic field.
(D) Paramagnetic substances are either attracted or repelled by the magnetic field.

97. Which of the following represents ferromagnetism?
(A) $\uparrow\uparrow\uparrow\uparrow\uparrow$ (B) $\uparrow\downarrow\uparrow\downarrow$
(C) $\uparrow\uparrow\uparrow\downarrow\downarrow$ (D) $\uparrow\uparrow\uparrow\downarrow$

98. Which of the following is ferromagnetic in nature?
(A) Ni (B) Co
(C) CrO_2 (D) All of these

99. Maximum ferromagnetism is found in _______.
(A) Fe (B) Ni
(C) Co (D) All of these

Miscellaneous

100. Which of the following is a crystalline solid?
(A) Glass (B) Rubber
(C) Plastic (D) Sugar

101. Which of the following is an example of ionic crystal solid?
(A) Diamond (B) LiF
(C) Li (D) Silicon

102. If NaCl is doped with 10^{-3} mol% $SrCl_2$, then the concentration of cation vacancies will be _______.
(A) 6.023×10^{18} mol^{-1}
(B) 6.023×10^{17} mol^{-1}
(C) 6.023×10^{14} mol^{-1}
(D) 6.023×10^{16} mol^{-1}

103. $LiBH_4$ crystallizes in orthorhombic system with 4 molecules per unit cell. The unit cell dimensions are a = 6.8 Å, b = 4.4 Å and c = 7.2 Å. If the molar mass is 21.76, the density is _______.
(A) 0.6708 g/cm^3 (B) 16708 g/cm^3
(C) 2.6708 g/cm^3 (D) 16.708 g/cm^3

104. Point defects are present in _______.
(A) ionic solids
(B) molecular solids
(C) amorphous solids
(D) liquids

105. Which among the following is an example of ferroelectric compound?
(A) Quartz (B) Lead chromate
(C) Barium titanate (D) Tourmaline

106. At the limiting value of radius ratio $\frac{r^+}{r^-}$, the _______.
(A) forces of attraction are larger than the forces of repulsion
(B) forces of attraction are smaller than the forces of repulsion
(C) forces of attraction and repulsion are just equal
(D) forces are not equal

107. At low temperature and high pressure, SO_2 freezes to form crystalline solid. Which term best describes the solid?
(A) Ionic crystal
(B) Covalent crystal
(C) Metallic crystal
(D) Molecular crystal

108. Quartz is a crystalline variety of _______.
(A) silica (B) sodium silicate
(C) silicon carbide (D) silicon

109. The structure of sodium chloride crystal is _______.
(A) body centered cubic lattice
(B) face centered cubic lattice
(C) octahedral
(D) square planar

110. Close packing is maximum in the ______ crystal.
(A) simple cubic (B) face centered
(C) body centered (D) hexagonal

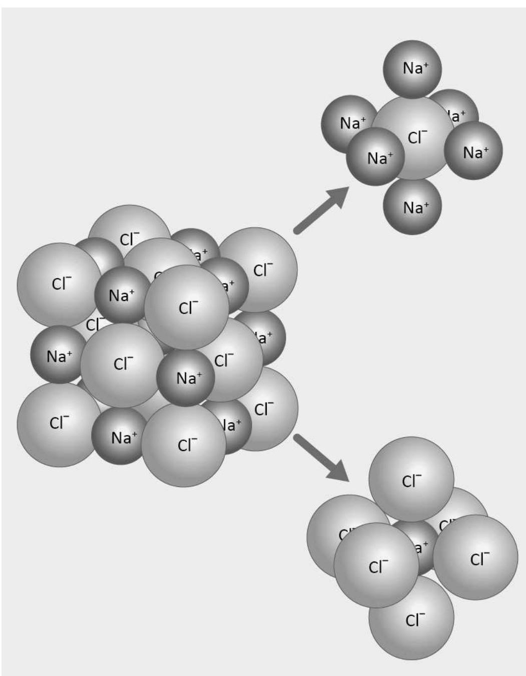
111. Transition metals, when form interstitial compounds, the non-metals (H, B, C, N) are accomodated in _______.
(A) voids or holes in cubic-packed structure
(B) tetrahedral voids
(C) octahedral voids
(D) all of these

112. NH_4Cl crystallizes in body centred cubic lattice, with a unit cell distance of 267 pm. Calculate the distance between the oppositely charged ions in the lattice.
(A) 256.2 pm (B) 231.2 pm
(C) 323.1 pm (D) 156.2 pm

113. The unit cell of a binary compound of A and B metals has a ccp structure with A atoms occupying the corners and B atoms occupying the centres of each faces of the cubic unit cell. If during the crystallisation of this alloy, in the unit cell two A atoms are missed, the overall composition per unit cell is _______.
(A) AB_6 (B) AB_4
(C) AB_8 (D) A_6B_{24}

114. In CsCl structure, the coordination number of Cs^+ is _______.
(A) equal to that of Cl^-, i.e., 6
(B) equal to that of Cl^-, i.e., 8
(C) not equal to that of Cl^-, i.e., 6
(D) not equal to that of Cl^-, i.e., 8

Rock – salt crystal structure (NaCl)



In the crystal of sodium chloride, each ion has a coordination number of 6 i.e., each ion is surrounded by six ions of the opposite charge located at the vertices of a regular octahedron. The larger chloride ions are arranged in a cubic array whereas the smaller sodium ions fill all the octahedral voids between them. It can be represented as two interpenetrating face centered cubic lattices.

Competitive Thinking

1.0 Introduction

1. In the Bragg's equation for diffraction of X-rays, n represents _______. **[MP PMT 2000]**
(A) quantum number
(B) an integer
(C) avogadro's numbers
(D) moles

2. Which of the following is NOT a property of solids? **[MP PET 1995]**
(A) Solids are always crystalline in nature.
(B) Solids have high density and low compressibility.
(C) The diffusion of solids is very slow.
(D) Solids have definite volume.

1.1 Classification of solids

3. A crystalline solid _______. **[Kerala CET (Med.) 2003]**
(A) changes abruptly from solid to liquid when heated
(B) has no definite melting point
(C) undergoes deformation of its geometry easily
(D) has an irregular 3-dimensional arrangements

4. The existence of a substance in more than one solid modifications is known as _______. **[MP PMT 1993; MP PET 1999]**
(A) polymorphism
(B) isomorphism
(C) anisotropy
(D) enantiomorphism

1.2 Classification of crystalline solids

5. Among solids, the highest melting point is established by _______ solids. **[Kerala CET (Med.) 2002]**
(A) covalent (B) ionic
(C) pseudo (D) molecular

6. Which of the following is NOT CORRECT for ionic crystals? **[Orissa JEE 2002]**
(A) They possess high melting point and boiling point.
(B) All are electrolytes.
(C) Exhibit the property of isomorphism.
(D) Exhibit directional properties of the bond.

7. Diamond is an example of _______.
[MP PET/PMT 1998; CET Pune 1998]
(A) solid with hydrogen bonding
(B) electrovalent solid
(C) covalent solid
(D) glass

8. Which of the following is TRUE for diamond? **[AFMC 1997]**
(A) Diamond is a good conductor of electricity.
(B) Diamond is soft.
(C) Diamond is a bad conductor of heat.
(D) Diamond is made up of C, H and O.

9. In graphite, carbon atoms are joined together due to _______. **[AFMC 2002]**
(A) ionic bonding
(B) van der Waal's forces
(C) metallic bonding
(D) covalent bonding

10. Silicon is found in nature in the forms of _______.
[MH CET 2002]
(A) body centered cubic structure
(B) hexagonal close packed structure
(C) network solid
(D) face centered cubic structure

11. Mostly crystals show good cleavage because their atoms, ions or molecules are _______.
[CBSE 1991]
(A) weakly bonded together
(B) strongly bonded together
(C) spherically symmetrical
(D) arranged in planes

1.3 Unit cell, two and three dimensional lattices and number of atoms per unit cell

12. How many space lattices are obtainable from the different crystal systems?
[MP PMT 1996; MP PET/PMT 1998]
(A) 7 (B) 14
(C) 32 (D) 230

13. Tetragonal crystal system has the following unit cell dimensions: **[MP PMT 1993]**
(A) $a = b = c$ and $\alpha = \beta = \gamma = 90°$
(B) $a = b \neq c$ and $\alpha = \beta = \gamma = 90°$
(C) $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90°$
(D) $a = b \neq c$ and $\alpha = \beta = 90°, \gamma = 120°$

14. The crystal system of a compound with unit cell dimensions $a = 0.387$, $b = 0.387$ and $c = 0.504$ nm and $\alpha = \beta = 90°$ and $\gamma = 120°$ is _______. **[AIIMS 2004]**
(A) cubic (B) hexagonal
(C) orthorhombic (D) rhombohedral

15. An example of a body centred cube is _______. **[AIIMS 1996]**
(A) sodium (B) aluminium
(C) nickel (D) copper

16. Body centered cubic lattice has a coordination number of _______.
[AIIMS 1996; MP PMT 2002]
(A) 4 (B) 8
(C) 12 (D) 6

17. The number of atoms or molecules contained in one face centered cubic unit cell of a monoatomic substance is _______.
[CPMT 1989, 94; CBSE 1989, 96; NCERT 1990; MP PET 1993; KCET 1999]
(A) 1 (B) 2
(C) 4 (D) 6

18. In a face centered cubic cell, an atom at the face contributes to the unit cell _______.
[Karnataka (Engg./Med.) 2000; AFMC 2001]
(A) 1/4 part (B) 1/8 part
(C) 1 part (D) 1/2 part

19. 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]
(A) 4 and 2 (B) 9 and 14
(C) 14 and 9 (D) 2 and 4

20. Potassium crystallizes in a bcc lattice, hence the coordination number of potassium in potassium metal is _______.
[KCET 1993]
(A) 0 (B) 4
(C) 6 (D) 8

21. What is the coordination number of sodium in Na_2O? **[AIIMS 2003]**
(A) 6 (B) 4
(C) 8 (D) 2

22. The intermetallic compound LiAg crystallizes in cubic lattice in which both lithium and silver have coordination number of eight. The crystal class is _______. **[CBSE PMT 1997]**
(A) simple cube
(B) body centered cube
(C) face centered cube
(D) none of these

23. The number of carbon atoms per unit cell of diamond unit cell is _______. **[NEET 2013]**
(A) 4 (B) 8
(C) 6 (D) 1

24. An element occurring in the bcc structure has 12.08×10^{23} unit cells. The total number of atoms of the element in these cells will be _______. **[MP PET 1994]**
(A) 24.16×10^{23} (B) 36.18×10^{23}
(C) 6.04×10^{23} (D) 12.08×10^{23}

25. The number of unit cells in 58.5 g of NaCl is nearly _______. **[MP PMT 2000, 01]**
(A) 6×10^{20} (B) 3×10^{22}
(C) 1.5×10^{23} (D) 0.5×10^{24}

1.4 Packing in solids

26. The number of octahedral sites per sphere in a fcc structure is _______. **[MP PMT 2000, 01]**
(A) 8 (B) 4
(C) 2 (D) 1

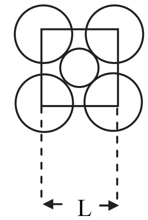
27. The ratio of close-packed atoms to tetrahedral holes in cubic close packing is _______. **[Pb. PMT 1998]**
(A) 1 : 1 (B) 1 : 2
(C) 1 : 3 (D) 2 : 1

28. The number of close neighbour in a body centered cubic lattice of identical sphere is _______. **[MP PET 2001]**
(A) 8 (B) 6
(C) 4 (D) 2

1.5 Density of unit cell

29. The interionic distance for caesium chloride crystal will be _______. **[MP PET 2002]**
(A) a (B) $\frac{a}{2}$
(C) $\frac{\sqrt{3}a}{2}$ (D) $\frac{2a}{\sqrt{3}}$

30. The packing efficiency of the two–dimensional square unit cell shown below is _______. **[IIT 2010]**



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

31. In face centred cubic unit cell, the edge length is _______. **[DPMT 2005]**
(A) $\frac{4}{\sqrt{3}}r$ (B) $\frac{4}{\sqrt{2}}r$
(C) 2r (D) $\frac{\sqrt{3}}{2}r$

32. The edge of unit cell of fcc Xe crystal is 620 pm. The radius of Xe atom is _______. **[MP PET 2004]**
(A) 219.20 pm (B) 235.16 pm
(C) 189.37 pm (D) 209.87 pm

33. Total volume of atoms present in a face centred cubic unit cell of a metal is _______. (r is atomic radius) **[AIEEE 2006]**
(A) $\frac{8}{3}\pi r^3$ (B) $8\pi r^3$
(C) $\frac{16}{3}\pi r^3$ (D) $\frac{4}{3}\pi r^3$

34. If 'a' stands for the edge length of the cubic systems: simple cubic, body centered cubic and face centered cubic, then the ratio of radii of the spheres in these systems will be _______ respectively. **[CBSE (PMT) 2008; J & K CET 2010]**
(A) $\frac{1}{2}a : \frac{\sqrt{3}}{2}a : \frac{\sqrt{3}}{\sqrt{2}}a$
(B) $1a : \sqrt{3}a : \sqrt{2}a$
(C) $\frac{1}{2}a : \frac{\sqrt{3}}{4}a : \frac{1}{2\sqrt{2}}a$
(D) $\frac{1}{2}a : \sqrt{3}a : \frac{1}{\sqrt{2}}a$

35. Sodium metal crystallizes in a body centred cubic lattice with a unit cell edge of 4.29 Å. The radius of sodium atom is approximately _______. **[JEE (Main) 2015]**
(A) 1.86 Å (B) 3.22 Å
(C) 5.72 Å (D) 0.93 Å

36. The number of atoms in 100 g of a fcc crystal with density d = 10 g / cm^3 and cell edge equal to 100 pm, is equal to _______.
[CBSE 1994; KCET 2002]
(A) 4×10^{25} (B) 3×10^{25}
(C) 2×10^{25} (D) 1×10^{25}

37. An element (atomic mass 100 g / mol) having bcc structure has unit cell edge 400 pm. Then density of the element is _______.
[CBSE PMT 1996; AIIMS 2002]
(A) 10.376 g / cm^3 (B) 5.188 g / cm^3
(C) 7.289 g / cm^3 (D) 2.144 g / cm^3

38. A given metal crystallizes out with a cubic structure having edge length of 361 pm. If there are four metal atoms in one unit cell, what is the radius of one atom?
[AIPMT 2015]
(A) 40 pm (B) 127 pm
(C) 80 pm (D) 108 pm

39. In orthorhombic, the value of a, b and c are respectively 4.2 Å, 8.6 Å and 8.3 Å. The molecular mass of the solute is 155 gm mol^{-1} and density is 3.3 g/cc, the number of formula units per unit cell is _______.
[Orrisa JEE 2005]
(A) 2 (B) 3 (C) 4 (D) 6

40. Ferrous oxide has a cubic structure and each edge of the unit cell is 5.0 Å. Assuming density of the oxide as 4.09 g cm^{-3}, then the number of Fe^{2+} and O^{2-} ions present in each unit cell will be _______. **[MP PET 2000]**
(A) four Fe^{2+} and four O^{2-}
(B) two Fe^{2+} and four O^{2-}
(C) four Fe^{2+} and two O^{2-}
(D) three Fe^{2+} and three O^{2-}

41. The 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 _______.
[PET (Kerala) 2007]
(A) face- centered (B) body- centered
(C) edge- centered (D) simple

42. How many unit cells are present in a cube-shaped ideal crystal of NaCl of mass 1.00 g? [Atomic masses: Na = 23, Cl = 35.5]
[AIEEE 2003]
(A) 1.28×10^{21} unit cells
(B) 1.71×10^{21} unit cells
(C) 2.57×10^{21} unit cells
(D) 5.14×10^{21} unit cells

43. AB crystallizes in a body centered cubic lattice with edge length 'a' equal to 387 pm. The distance between two oppositely charged ions in the lattice is _______. **[CBSE (PMT) 2010]**
(A) 335 pm (B) 250 pm
(C) 200 pm (D) 300 pm

44. CsBr crystal has bcc structure. It has an edge length of 4.3 Å. The shortest interionic distance between Cs^+ and Br^- ions is _______.
[IIT 1995]
(A) 1.86 Å (B) 3.72 Å
(C) 4.3 Å (D) 7.44 Å

45. The edge length of face centered unit cubic cell is 508 pm. If the radius of the cation is 110 pm, the radius of the anion is _______.
[CBSE 1998]
(A) 285 pm (B) 398 pm
(C) 144 pm (D) 618 pm

46. A metal has a fcc lattice. The edge length of the unit cell is 404 pm. The density of the metal is 2.72 g cm^{-3}. The molar mass of the metal is _______. (N_0, Avogadro's constant = 6.02×10^{23} mol^{-1}) **[NEET 2013]**
(A) 40 g mol^{-1} (B) 30 g mol^{-1}
(C) 27 g mol^{-1} (D) 20 g mol^{-1}

1.6 Packing in voids of ionic solids

47. Which of the following statements is INCORRECT? **[IIT 1998]**
(A) The coordination number of each type of ion in CsCl crystal is 8.
(B) A metal that crystallizes in bcc structure has a coordination number of 12.
(C) A unit cell of an ionic crystal shares some of its ions with other unit cells.
(D) The length of the unit cell in NaCl is 552 pm (r_{Na^+} = 95 pm; r_{Cl^-} = 181 pm).

48. A crystal lattice with alternate +ve and –ve ions has radius ratio of 0.524. Its coordination number is _______. **[Manipal PMT 2002]**
(A) 4 (B) 3 (C) 6 (D) 12

49. A solid compound contains X, Y and Z atoms in a cubic lattice with X atoms occupying the corners, Y atoms in the body centred positions and Z atoms at the centres of faces of the unit cell. What is the empirical formula of the compound?
[Kerala PET 2008]
(A) XY_2Z_3 (B) XYZ_3
(C) $X_2Y_2Z_3$ (D) X_8YZ_6

50. In a solid AB having the NaCl structure, A atoms occupies 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 _______.
[IIT Screeing 2001]
(A) AB_2 (B) A_2B
(C) A_4B_3 (D) A_3B_4

51. In the crystals, which of the following ionic compounds would you expect maximum distance between centres of cations and anions?
[CBSE 1998]
(A) LiF (B) CsF
(C) CsI (D) LiI

52. The atoms of element 'Y' form hexagonal close packing and the atoms of element X occupies $\frac{2}{3}$rd portion of the number of tetrahedral voids. Write the formula of the compound formed by X and Y.
[GUJ CET 2014]
(A) X_2Y_2 (B) X_2Y
(C) X_3Y_4 (D) X_4Y_3

53. An ionic compound has a unit cell consisting of A ions at the corners of a cube and B ions on the centres of the faces of the cube. The empirical formula for this compound would be _______.
[AIEEE 2005]
(A) A_2B (B) AB
(C) A_3B (D) AB_3

54. A solid has a structure in which 'W' atoms are located at the corners of a cubic lattice, 'O' atoms at the centre of edges and 'Na' atoms at the centre of the cube. The formula for the compound is _______.
[KCET 1996]
(A) $NaWO_2$ (B) $NaWO_3$
(C) Na_2WO_3 (D) $NaWO_4$

55. A compound is formed by elements A and B. This crystallizes in the cubic structure when atoms A are the corners of the cube and atoms B are at the centre of the body. The simplest formula of the compound is _______.
[KCET 1993; CBSE 2000; Kerala (Med.) 2003]
(A) AB (B) AB_2
(C) A_2B (D) A_2B_2

56. A substance A_xB_y crystallises in a face centered cubic (fcc) 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_xB_y. **[IIT 2002]**
(A) AB_3
(B) A_4B_3
(C) A_3B
(D) Composition cannot be specified

57. If we know the ionic radius ratio in a crystal of ionic solid, what can be known of the following? **[CET (Gujarat) 2006]**
(A) Magnetic property
(B) Nature of chemical bond
(C) Type of defect
(D) Geometrical shape of crystal

1.7 Defects in crystal structure

58. Schottky defect defines imperfection in the lattice structure of a _______.
[AIIMS 2002]
(A) solid (B) liquid
(C) gas (D) plasma

59. What type of crystal defect is indicated in the diagram below? **[AIEEE 2004]**

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

(A) Frenkel defect
(B) Schottky defect
(C) Interstitial defect
(D) Frenkel and Schottky defects

60. Which defect causes decrease in the density of crystal? **[KCET 2000]**
(A) Frenkel (B) Schottky
(C) Interstitial (D) F-centre

61. Which one of the following crystals does NOT exhibit Frenkel defect? **[MP PET 2002]**
(A) AgBr (B) AgCl
(C) KBr (D) ZnS

62. The solid NaCl is a bad conductor of electricity since _______. **[AIIMS 1980]**
(A) in solid NaCl, there are no ions
(B) solid NaCl is covalent
(C) in solid NaCl, there is no velocity of ions
(D) in solid NaCl, there are no electrons

1.8 Electrical properties

63. Which type of solid crystals will conduct heat and electricity? **[RPET 2000]**
(A) Ionic (B) Covalent
(C) Metallic (D) Molecular

64. Which of the following shows electrical conduction? **[AFMC 2002]**
(A) Sodium (B) Potassium
(C) Diamond (D) Graphite

65. To get a n-type semiconductor, the impurity to be added to silicon should have which of the following number of valence electrons? **[KCET (Engg.) 2001]**
(A) 1 (B) 2 (C) 3 (D) 5

66. Doping of silicon with boron leads to _______. **[UPSEAT 2004]**
(A) n-type semiconductor
(B) p-type semiconductor
(C) metal
(D) insulator

67. A semiconductor of Ge can be made p-type by adding _______ impurity. **[MP PET 2002]**
(A) trivalent (B) tetravalent
(C) pentavalent (D) divalent

Miscellaneous

68. In a crystal, the atoms are located at the position of _______. **[AMU 1985]**
(A) maximum potential energy
(B) minimum potential energy
(C) zero potential energy
(D) infinite potential energy

69. The CORRECT statement in the following is, _______. **[MP PET 1997]**
(A) the ionic crystal of AgBr has Schottky defect
(B) the unit cell having crystal parameters, $a = b \neq c$, $\alpha = \beta = 90°$ and $\gamma = 120°$ is hexagonal
(C) in ionic compounds having Frenkel defect, the ratio $\frac{\gamma_+}{\gamma_-}$ is high
(D) the coordination number of Na^+ ion in NaCl is 4

70. Which of the following statement is NOT CORRECT? **[CBSE (PMT) 2008]**
(A) The number of carbon atoms in a unit cell of diamond is 4.
(B) The number of Bravais lattices in which a crystal can be categorised is 14.
(C) The fraction of the total volume occupied by the atoms in a primitive cell is 0.48.
(D) Molecular solids are generally volatile.

71. Which of the following statements is CORRECT for $CsBr_3$? **[NCERT 1996]**
(A) It is a covalent compound.
(B) It contains Cs^{3+} and Br^- ions.
(C) It contains Cs^+ and Br_3^- ions.
(D) It contains Cs^+, Br^- and lattice Br_2 molecule

72. Suppose the mass of a single Ag atom is 'm'. Ag metal crystallizes in fcc lattice with unit cell of length 'a'. The density of Ag metal in terms of 'a' and 'm' is _______. **[WB JEEM 2015]**
(A) $\frac{4m}{a^3}$ (B) $\frac{2m}{a^3}$
(C) $\frac{m}{a^3}$ (D) $\frac{m}{4a^3}$

73. Volume occupied by single CsCl ion pair in a crystal is 7.014×10^{-23} cm^3. The smallest 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 _______. **[KCET 2014]**
(A) 4.4 Å (B) 4.3 Å
(C) 4 Å (D) 4.5 Å

74. A crystalline solid XY_3 has ccp arrangement for its element Y. X occupies _______. **[KCET 2014]**
(A) 66% of tetrahedral voids
(B) 33% of tetrahedral voids
(C) 66% of octahedral voids
(D) 33% of octahedral voids

75. What is the difference between the number of atoms per unit cell in face centred cube and the number of atoms per unit cell in body centred cube? **[GUJ CET 2014]**
(A) 2 (B) 1 (C) 4 (D) 6

76. Which metal among the following has the highest packing efficiency? **[MH CET 2015]**
(A) Iron (B) Tungsten
(C) Aluminium (D) Polonium

77. Select a ferromagnetic material from the following. **[MH CET 2015]**
(A) Dioxygen
(B) Chromium (IV) oxide
(C) Benzene
(D) Dihydrogen monoxide

Answer Key

Classical Thinking

1. (D)	2. (C)	3. (A)	4. (A)	5. (D)	6. (C)	7. (A)	8. (A)	9. (D)	10. (A)
11. (A)	12. (C)	13. (C)	14. (A)	15. (C)	16. (B)	17. (D)	18. (C)	19. (D)	20. (B)
21. (A)	22. (A)	23. (B)	24. (C)	25. (C)	26. (D)	27. (B)	28. (C)	29. (D)	30. (D)
31. (D)	32. (A)	33. (B)	34. (A)	35. (B)	36. (D)	37. (A)	38. (C)	39. (C)	40. (D)
41. (B)	42. (A)	43. (D)	44. (D)	45. (D)	46. (A)	47. (B)	48. (B)	49. (B)	50. (B)
51. (A)	52. (C)	53. (C)	54. (B)	55. (D)	56. (B)	57. (C)	58. (B)	59. (B)	60. (C)

Critical Thinking

1. (D)	2. (C)	3. (A)	4. (D)	5. (D)	6. (B)	7. (C)	8. (B)	9. (D)	10. (C)
11. (D)	12. (C)	13. (B)	14. (C)	15. (D)	16. (A)	17. (D)	18. (D)	19. (A)	20. (B)
21. (D)	22. (A)	23. (A)	24. (C)	25. (C)	26. (A)	27. (B)	28. (C)	29. (A)	30. (B)
31. (B)	32. (C)	33. (B)	34. (A)	35. (C)	36. (A)	37. (D)	38. (B)	39. (C)	40. (B)
41. (A)	42. (A)	43. (C)	44. (C)	45. (A)	46. (A)	47. (A)	48. (D)	49. (C)	50. (D)
51. (B)	52. (B)	53. (C)	54. (B)	55. (C)	56. (B)	57. (B)	58. (A)	59. (C)	60. (B)
61. (C)	62. (B)	63. (B)	64. (D)	65. (B)	66. (C)	67. (B)	68. (A)	69. (B)	70. (B)
71. (C)	72. (C)	73. (A)	74. (B)	75. (B)	76. (B)	77. (B)	78. (B)	79. (A)	80. (C)
81. (A)	82. (C)	83. (C)	84. (D)	85. (C)	86. (A)	87. (C)	88. (B)	89. (C)	90. (A)
91. (C)	92. (A)	93. (B)	94. (C)	95. (A)	96. (A)	97. (A)	98. (D)	99. (A)	100. (D)
101. (B)	102. (A)	103. (A)	104. (A)	105. (C)	106. (C)	107. (D)	108. (A)	109. (B)	110. (B)
111. (D)	112. (B)	113. (B)	114. (B)						

Competitive Thinking

1. (B)	2. (A)	3. (A)	4. (A)	5. (B)	6. (D)	7. (C)	8. (C)	9. (D)	10. (C)
11. (D)	12. (B)	13. (B)	14. (B)	15. (A)	16. (B)	17. (C)	18. (D)	19. (D)	20. (D)
21. (B)	22. (B)	23. (B)	24. (A)	25. (C)	26. (D)	27. (B)	28. (A)	29. (C)	30. (D)
31. (B)	32. (A)	33. (C)	34. (C)	35. (A)	36. (A)	37. (B)	38. (B)	39. (C)	40. (A)
41. (A)	42. (C)	43. (A)	44. (B)	45. (C)	46. (C)	47. (B)	48. (C)	49. (B)	50. (D)
51. (C)	52. (D)	53. (D)	54. (B)	55. (A)	56. (A)	57. (D)	58. (A)	59. (B)	60. (B)
61. (C)	62. (C)	63. (C)	64. (D)	65. (D)	66. (B)	67. (A)	68. (B)	69. (B)	70. (C)
71. (C)	72. (A)	73. (C)	74. (D)	75. (A)	76. (C)	77. (B)			

Hints

Classical Thinking

23. Total number of spheres in body centered cubic unit cell = 1/8 × 8 + 1 = 2 spheres (atoms, ions or molecules).

33. Volume of unit cell = $\dfrac{64r^3}{3\sqrt{3}}$

Volume occupied = $\dfrac{8}{3}\pi r^3$

Volume occupied by two atoms in unit cell or packing = $\dfrac{8}{3}\pi r^3 \times \dfrac{3\sqrt{3}}{64r^3} \times 100 = 68.04$ %.

34. Total volume of unit cell = $8\sqrt{8}\,r^3$

Volume occupied = $\dfrac{16}{3}\pi r^3$

∴ Packing efficiency = $\dfrac{16}{3}\pi r^3 \times \dfrac{1}{8\sqrt{8}r^3} \times 100$

$= 74.0$ %

38. $r_{Na^+} = 0.95$ Å $\qquad r_{Cl^-} = 1.81$ Å

Radius ratio = $\dfrac{r_{Na^+}}{r_{Cl^-}} = \dfrac{0.95}{1.81} = 0.5248$

Critical Thinking

40. Density of unit cell

$$= \frac{z(\text{no. of atoms in unit cell}) \times M(\text{molecular weight})}{a^3(\text{volume of unit cell}) \times N_0(\text{Avogadro's number})} \text{g cm}^{-3}$$

41. $z = \frac{d \times N_0 \times a^3}{M}$

$$= \frac{2.75 \times 6.022 \times 10^{23} \times (6.54 \times 10^{-8})^3}{119}$$

$$= \frac{2.75 \times 6.022 \times 27.97}{119} = \frac{463.197}{119} = 3.89 \cong 4$$

42. For fcc lattice,

$4r = \sqrt{2}\ a$

a = 620 pm;

$r = \frac{\sqrt{2} \times 620}{4} = \frac{1.414 \times 620}{4} = 219.17 \cong 219.20$ pm

43. $N_0 = \frac{z \times M}{d \times a^3} = \frac{1 \times 108}{8 \times (3 \times 10^{-8})^3}$

$$= \frac{108 \times 10^{+24}}{216} = 0.5 \times 10^{24} = 5 \times 10^{23}$$

46. $d = 3.4$ g cm^{-3}, z = 4, M = 98.99 g mol^{-1}

$d = \frac{z \times M}{N_0 \times a^3}$

$a^3 = \frac{4 \times 98.99}{6.022 \times 10^{23} \times 3.4}$

∴ $a^3 = \frac{395.96 \times 10^{-23}}{20.47}$ ∴ $a^3 = 19.34 \times 10^{-23}$

∴ $a = \sqrt[3]{1.934 \times 10^{-22}} = 5.783 \times 10^{-8}$ cm

$= 5.783 \times 10^{-10}$ m = 5.783 Å

47. Cell length, a = 4.24 Å = 4.24×10^{-10} m

$= 4.24 \times 10^{-8}$ cm

In bcc lattice, z = 2, M = 23 g mol^{-1}

$d = \frac{z \times M}{N_0 \times a^3} = \frac{2 \times 23}{6.022 \times 10^{23} \times (4.24 \times 10^{-8})^3}$

$$= \frac{46 \times 10^{24}}{6.022 \times 76.22 \times 10^{23}}$$

$= 0.1002 \times 10^1 = 1.002$ g cm^{-3}

48. In tetrahedral voids four spheres are involved in its formation.

54. Number of atom of B = $\frac{1}{8} \times 8 + 1 = 2$

∴ The formula of solid is AB_2.

55. Cu = ccp = 4

Ag = 12 (edges) × $\frac{1}{4}$ = 3

Au = 1 ∴ Cu_4Ag_3Au

61. $2r^+ + 2r^- = 552$; $r^+ + r^- = \frac{552}{2} = 276$

$r^- = 276 - 95 = 181$ pm.

62. $r^+ + r^- = \frac{400}{2} = 200$ pm

∴ $r^- = 200 - 75 = 125$ pm

63. radius ratio = $\frac{r^+}{r^-} = \frac{95}{181} = 0.52$

Since the radius ratio is in between 0.414 to 0.732, the coordination number of cation is 6.

64. $2r^+ + 2r^- = 520$

∴ $r^+ + r^- = \frac{520}{2} = 260$; $r^- = 260 - 80 = 180$ pm.

68. There is one octahedral hole per oxide ion and only $\left(\frac{2}{3}\right)^{rd}$ of these holes are occupied.

∴ the ratio should be $\frac{2}{3} : 1 = 2 : 3$

69. $2r^+ + 2r^- = \sqrt{3}\ a$

$r^+ + r^- = \frac{\sqrt{3} \times 387}{2} = \frac{1.732 \times 387}{2}$

$= \frac{670.284}{2} = 335.142$

∴ $r^+ = 335.142 - 181 = 154.14$ pm

71. One-eighth of each corner atom (Au) and one half of each face centered atom (Cu) are contained within the unit cell of the compound. Thus, the number of Au atoms per unit cell $= 8 \times \frac{1}{8} = 1$ and the number of Cu atoms per unit cell $= 6 \times \frac{1}{2} = 3$. The formula of the compound is $AuCu_3$.

72. An atom at the corner of a cube is shared among 8 unit cells. As there are 8 corners in a cube, number of corner atom [A] per unit cell $= 8 \times \frac{1}{8} = 1$

A face- centered atom in a cube is shared by two unit cells. As there are 6 faces in a cube, number of face- centered atoms [B] per unit cell $= 6 \times \frac{1}{2} = 3$

An atom in the body of the cube is not shared by other cells.
Thus, number of atoms [C] at the body centre per unit cell = 1
Hence, the formula of the solid is AB_3C

73. $\frac{r_{Na^+}}{r_{Cl^-}} = 0.55, \quad \frac{r_{K^+}}{r_{Cl^-}} = 0.74$

$\frac{r_{Na^+}}{r_{Cl^-}} + 1 = 0.55 + 1$

$\frac{r_{K^+}}{r_{Cl^-}} + 1 = 0.74 + 1$

$\frac{r_{Na^+} + r_{Cl^-}}{r_{Cl^-}} = 1.55$

$\frac{r_{K^+} + r_{Cl^-}}{r_{Cl^-}} = 1.74$

$\frac{r_{K^+} + r_{Cl^-}}{r_{Cl^-}} \times \frac{r_{Cl^-}}{r_{Na^+} + r_{Cl^-}} = \frac{1.74}{1.55}$

$\therefore \quad \frac{r_{K^+} + r_{Cl^-}}{r_{Na^+} + r_{Cl^-}} = 1.122$

77. radius ratio = $\frac{r^+}{r^-} = \frac{1.46Å}{2.16Å} = 0.67$
Since the limiting value is in between 0.414 to 0.732, the probable structure is NaCl type.

78. $r_+ / r = \frac{180}{187} = 0.962$ which lies in the range of 0.732 – 1.000.
Hence, coordination number = 8 i.e., the structure is CsCl type.

102. Number of cation vacancies per mol
$= \frac{10^{-3} \times 6.023 \times 10^{23}}{100}$
$= 6.023 \times 10^{18}$ vacancies per mol

108. 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.

112. $2r^+ + 2r^- = \sqrt{3}\,a$

$r^+ + r^- = \frac{\sqrt{3}}{2}a = \frac{\sqrt{3}}{2} \times 267 = 231.2$ pm

113. Number of atoms of A = $6 \times \frac{1}{8} = \frac{3}{4}$

Number of atoms of B = $6 \times \frac{1}{2} = 3$

$A : B = \frac{3}{4} : 3 = 1 : 4$

$\therefore$ Composition of alloy = AB_4

114. Cl^- in CsCl adopt bcc type of packing hence the coordination of Cs^+ is equal to that of Cl^-, that is 8.

Competitive Thinking

6. Ionic crystals exhibit non-directional properties of the bond.

10. Silicon due to its catenation property form network solid.

14. Unit cell dimension of hexagonal crystal
$= a = b \neq c$ and $\alpha = \beta = 90°, \gamma = 120°$

19. The bcc cell consists of 8 atoms at the corners and one atom at centre.

$\therefore \quad n = \left(8 \times \frac{1}{8}\right) + 1 = 2$

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.

$\therefore \quad n = 8 \times \frac{1}{8} + \left(6 \times \frac{1}{2}\right) = 4$

24. There are two atoms in a bcc unit cell. So, number of atoms in 12.08×10^{23} unit cells
$= 2 \times 12.08 \times 10^{23}$
$= 24.16 \times 10^{23}$

25. 58.5 g of NaCl = 1 mole = 6.023×10^{23} NaCl units. One unit cell contains 4 NaCl units.
Hence, the number of unit cells present
$= \frac{6.023 \times 10^{23}}{4} = 1.5 \times 10^{23}$

30. $a\sqrt{2} = 4r \qquad a = 2\sqrt{2}\,r$

Packing fraction = $\frac{\text{Occupied area}}{\text{Total area}}$

$= \frac{2\pi r^2}{(2\sqrt{2}r)^2} \times 100 = 78.5\ \%$

32. In fcc, $4r = \sqrt{2}\,a$,
Where r = radius of the sphere
a = edge length of the unit cell = 620 pm
$r = \frac{\sqrt{2}\,a}{4} = \frac{\sqrt{2} \times 620}{4} = 219.20$ pm

33. Volume occupied by one atom of radius 'r'= $\frac{4}{3}\pi r^3$.

In fcc unit cell, there are 4 atoms present.

∴ Total volume occupied by the atoms present in fcc unit cell = $4\times\frac{4}{3}\pi r^3 = \frac{16}{3}\pi r^3$

34. Simple unit cell, $r = a/2$

Body centered unit cell, $r = \frac{a\sqrt{3}}{4}$

Face centered unit cell, $r = \frac{a}{2\sqrt{2}}$

35. Radius of Na (in bcc lattice)

$= \frac{\sqrt{3}a}{4} = \frac{\sqrt{3}\times 4.29}{4} = 1.857\ \text{Å} \approx 1.86\ \text{Å}$

36. $N_0 = \frac{z\times M}{d\times a^3} = \frac{4\times 100}{10\times(10^{-8})^3} = 4\times 10^{25}$

37. $d = \frac{z\times M}{a^3\times N_0\times 10^{-30}}$

$= \frac{2\times 100}{(400)^3\times(6.02\times 10^{23})\times 10^{-30}} = 5.188\ \text{g / cm}^3$

38. Since, there are four metal atoms in one unit cell, the given metal crystallizes in fcc lattice. For fcc lattice;

$r = \frac{\sqrt{2}a}{4} = \frac{\sqrt{2}\times 361}{4}$

$= \frac{1.414\times 361}{4} = 127.6\ \text{pm.} \approx 127\ \text{pm}$

39. $z = \frac{V\times N_0\times d}{M}$

$= \frac{4.2\times 8.6\times 8.3\times 10^{-24}\times 6.023\times 10^{23}\times 3.3}{155}$

$= 3.84 \approx 4$

40. Let the units of ferrous oxide in a unit cell = z, molecular weight of ferrous oxide (FeO) $= 56 + 16 = 72\ \text{g mol}^{-1}$,

weight of z units = $\frac{72\times z}{6.023\times 10^{23}}$

Volume of one unit = (length of corner)^3

$= (5\ \text{Å})^3 = 125\times 10^{-24}\ \text{cm}^3$

Density,

$4.09 = \frac{\text{wt. of cell}}{\text{volume}}$

$= \frac{72\times z}{6.023\times 10^{23}\times 125\times 10^{-24}}$

$z = \frac{3079.2\times 10^{-1}}{72} = 42.7\times 10^{-1} = 4.27 \approx 4$

41. $z = \frac{a^3\times d\times N_0}{M} = \frac{(405\times 10^{-10})^3\times 2.7\times 6.023\times 10^{23}}{27} = 4$

∴ It is a face- centered cubic unit cell.

42. Mass of one unit cell = density × volume

$= d\times a^3$

$= \frac{M\times z}{N_0\times \cancel{a^3}}\times \cancel{a^3}$

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

∴ Number of unit cells in 1 g NaCl

$\frac{1}{\text{Mass of one unit cell}} = \frac{6.023\times 10^{23}}{58.5\times 4}$

$= 2.57\times 10^{21}$ unit cells

43. Distance between two oppositely charged ions

$(r^+ + r^-) = \frac{\sqrt{3}a}{2} = \frac{387\times\sqrt{3}}{2} = 335.14\ \text{pm}$

44. Closest approach in bcc lattice

$= \frac{1}{2}$ of body diagonal

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

45. Edge length = $2r^+ + 2r^-$

$\frac{508}{2} = r^+ + r^-$;

$254 = 110 + r^-$

∴ $r^- = 254 - 110 = 144$ pm.

46. Metal has fcc lattice,

∴ z = 4

$d = \frac{z\times M}{a^3\times N_0}$

$2.72 = \frac{4\times M}{\left(4.04\times 10^{-8}\right)^3\times 6.02\times 10^{23}}$

$M = \frac{2.72\times\left(4.04\right)^3\times 6.02\times 10^{-1}}{4} = 27\ \text{g mol}^{-1}$

47. A metal that crystallizes in bcc structure has a coordination number of 8.

49. Atoms of X per unit cell = $8\times\frac{1}{8} = 1$

Atoms of Y per unit cell = 1

Atoms of Z per unit cell = $6 \times \frac{1}{2} = 3$

Hence, the formula is XYZ_3

50. 'A' atoms are present at 8 corners and 6 face centres. Two face centre atoms are removed along one axis. Thus, total 4 face centred atoms are left out.
Total number of 'A' atoms in one unit cell $= 8\times\frac{1}{8}+4\times\frac{1}{2}=3$
'B' atoms occupy octahedral holes. There are 4 octahedral holes in fcc unit cell.
∴ Number of 'B' atoms in fcc unit cell = 4
∴ Stoichiometry = A_3B_4

52. Let the number of atoms of element Y in hcp unit cell be n.
∴ Number of tetrahedral voids = 2n
As 2/3rd of the tetrahedral voids are occupied by atoms of element X,
Number of atoms of element X = $2n \times \frac{2}{3} = \frac{4n}{3}$
∴ Ratio of atoms of element X : atoms of element Y $= \frac{4n}{3} : n = 4 : 3$
The formula of the compound is X_4Y_3.

53. A as corners of cube; $\frac{1}{8} \times 8 = 1$.
B as faces of cube; $\frac{1}{2} \times 6 = 3$
A : B = 1 : 3
∴ The empirical formula for this compound would be AB_3

54. W at corner; $\frac{1}{8} \times 8 = 1$
O at centres of edges; $\frac{1}{2} \times 6 = 3$
Na at centre of cube = 1
Na : W : O
1 : 1 : 3

55. Atoms A at the corners of cube; $\frac{1}{8} \times 8 = 1$
Atom B at the centre of cube = 1
A : B at the centre of cube = 1
A : B = 1 : 1

65. For n-type, impurity added to silicon should have more than 4 valence electrons.

70. The fraction of the total volume occupied by the atoms in a primitive cell is 0.52.

72. Mass of a single Ag atom = m
∴ Mass of fcc unit cell of silver = 4m
(∵ fcc type unit cell contains total 4 atoms)
Edge length of fcc unit cell = a
Volume of fcc unit cell = a^3
Density of silver (Ag) = $\frac{\text{Mass of fcc unit cell}}{\text{Volume of fcc unit cell}}$
∴ Density of silver (Ag) = $\frac{4m}{a^3}$

73. According to the given condition,
Edge length (a) = $\sqrt[3]{\text{Volume of one CsCl ion pair}}$
$= \sqrt[3]{7.014\times10^{-23}\ cm^3}$
$= 4.12\times10^{-8}\ cm = 4.12\times10^{-10}\ m$
$= 4.12\ Å \approx 4\ Å$
So, the smallest Cs to Cs internuclear distance is nearly 4 Å.

74. The number of particles of Y in ccp unit cell = 4. The formula of the solid is XY_3. Therefore, the ratio of number of X particles to the number of Y particles is 1 : 3. So, for the unit cell, the number of X particles = $\frac{4\times1}{3} = 1.33$
Number of octahedral voids in ccp unit cell = Number of Y particles in ccp unit cell = 4
∴ Percentage of octahedral voids occupied by X particles = $\frac{1.33}{4} \times 100 = 33\%$

75. Number of atoms per unit cell in fcc = 4
Number of atoms per unit cell in bcc = 2
∴ Difference = 4 – 2 = 2

76.

Type of unit cell	Packing efficiency	Examples
Simple cubic lattice	52.4%	Polonium
Body centred cubic lattice	68%	Iron, Tungsten
Face centred cubic lattice	74%	Aluminium

Hence, among the given metals, aluminium has the highest packing efficiency.

77.

	Substance	Magnetic property
(A)	Dioxygen	Paramagnetic
(B)	Chromium (IV) oxide	Ferromagnetic
(C)	Benzene	Diamagnetic
(D)	Dihydrogen monoxide	Diamagnetic

Evaluation Test

1. Which of the following is TRUE about ionic solids?
   (A) In fused state, ionic solids do not conduct electricity.
   (B) In aqueous solution, ionic solids do not conduct electricity.
   (C) In solid state, free electrons are available in ionic solids.
   (D) In solid state, ionic solids do not conduct electricity.

2. Which of the following is the most unsymmetrical crystal system?
   (A) Orthorhombic
   (B) Monoclinic
   (C) Triclinic
   (D) Rhombohedral

3. A metal has bcc structure and the edge length of its unit cell is 4.08 Å. The volume of the unit cell in cm^3 will be _______.
   (A) 6.6×10^{-24}
   (B) 6.79×10^{-23}
   (C) 2.81×10^{-23}
   (D) 6.02×10^{-24}

4. An element crystallizes in a structure having fcc unit cell of an edge 100 pm. Calculate the density if 150 g of the element contains 18×10^{23} atoms.
   (A) 33.3 g cm^{-3} (B) 333.3 g cm^{-3}
   (C) 243.3 g cm^{-3} (D) 153.3 g m^{-3}

5. Al (at. wt. 26.98) crystallizes in the cubic system with a = 4.05 Å. Its density is 2.7 g per cm^3. Determine the cell type. Calculate the radius of Al atom.
   (A) fcc, 1.432 Å
   (B) bcc, 2.432 Å
   (C) bcc, 1.432 Å
   (D) fcc, 2.432 Å

6. Calculate the density of silver metal having fcc unit cell with edge length 409 pm (at. wt. of Ag = 108 g mol^{-1}, $N_0 = 6.022 \times 10^{23}$ mol^{-1})
   (A) 8.3 g cm^{-3}
   (B) 10 g cm^{-3}
   (C) 10.5 g cm^{-3}
   (D) 12 g cm^{-3}

7. The density of AgCl is 5.56 g cm^{-3}. Length of the unit cell is 555.2 pm. Then which of the following is TRUE about the predicted nature of the solid?
   (A) Solid has face centred cubic system with z = 4.
   (B) Solid has simple cubic system with z = 4.
   (C) Solid has face centred cubic system with z = 1.
   (D) Solid has body centred cubic system with z = 2.

8. A solid is made of two elements P and Q. Atoms P are in ccp arrangements and atoms Q occupy all the octahedral voids and half of the tetrahedral voids. The simplest formula of the compound is _______.
   (A) PQ_2 (B) P_2Q
   (C) PQ (D) P_2Q_2

9. An ionic compound AB has ZnS type of structure, if the radius A^+ is 22.5 pm, then the ideal radius of B^- is _______.
   (A) 54.35 pm (B) 100 pm
   (C) 145.16 pm (D) 200 pm

10. Copper has the fcc crystal structure. Assuming an atomic radius of 130 pm for copper atom (Cu = 63.54), what is the length of unit cell of Cu? Find the density of Cu.
    (A) 267.64 pm, 8.54 g cm^{-3}
    (B) 267.64 pm, 5.48 g cm^{-3}
    (C) 367.64 pm, 9.24 g cm^{-3}
    (D) 367.64 pm, 8.54 g cm^{-3}

11. A compound formed by elements X and Y crystallizes in the cubic structure, where X is at the corners of the cube and Y is at the six face centres. What is the formula of the compound? If side length is 5Å, estimate the density of the solid assuming atomic weight of X and Y as 60 and 90 respectively.
    (A) XY, 3.35 g/cm^3 (B) XY_3, 4.38 g/cm^3
    (C) XY_3, 3.48 g/cm^3 (D) XY_2, 2.48 g/cm^3

12. A substance has density of 2 kg dm^{-3} and it crystallizes to fcc lattice with edge length equal to 700 pm. The molar mass of the substance is _______.
    (A) 55.32 g/mol (B) 130 g/mol
    (C) 103.3 g/mol (D) 144 g/mol

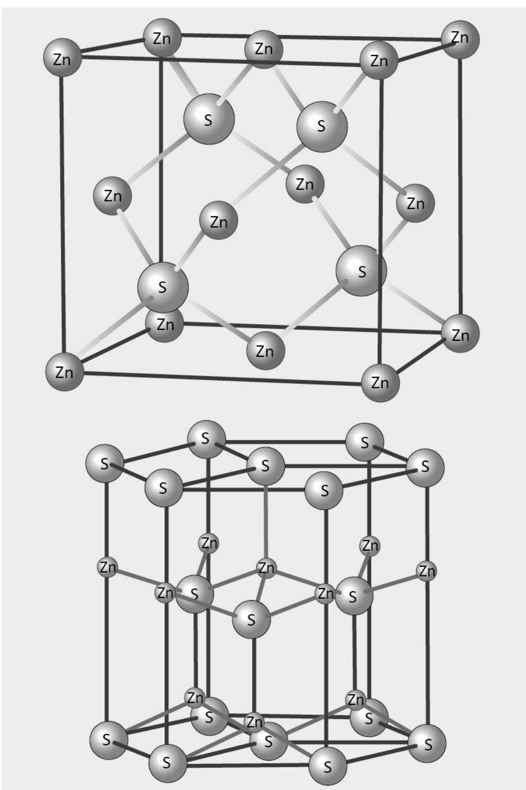
13. Lithium iodide crystal has a face centred cubic unit cell. If the edge length of the unit cell is 550 pm, determine the ionic radius of I^- ion.
(A) 144.4 pm (B) 294.4 pm
(C) 194.4 pm (D) 164.4 pm

14. When heated above 916 °C, iron changes its crystal structure from bcc to ccp structure without any change in the radius of atom. The ratio of density of the crystal before heating and after heating is _______.
(A) 0.918 (B) 0.754
(C) 1.916 (D) 2.24

Answers to Evaluation Test

1.	(D)	2.	(C)	3.	(B)	4.	(B)
5.	(A)	6.	(C)	7.	(A)	8.	(A)
9.	(B)	10.	(D)	11.	(B)	12.	(C)
13.	(C)	14.	(A)				

Zinc sulphide structure



ZnS exists in two main crystalline forms and hence is an example of polymorphism. In both polymorphism, the coordination geometry of Zn and S are tetrahedral. The more stable cubic form is known also as zinc blende or sphalerite. The hexagonal form is known as the mineral wurtzite, which can be produced synthetically. The transition from the sphalerite form to the wurtzite form occurs at around 1020 °C.