SAMPLE CONTENT

Challenger

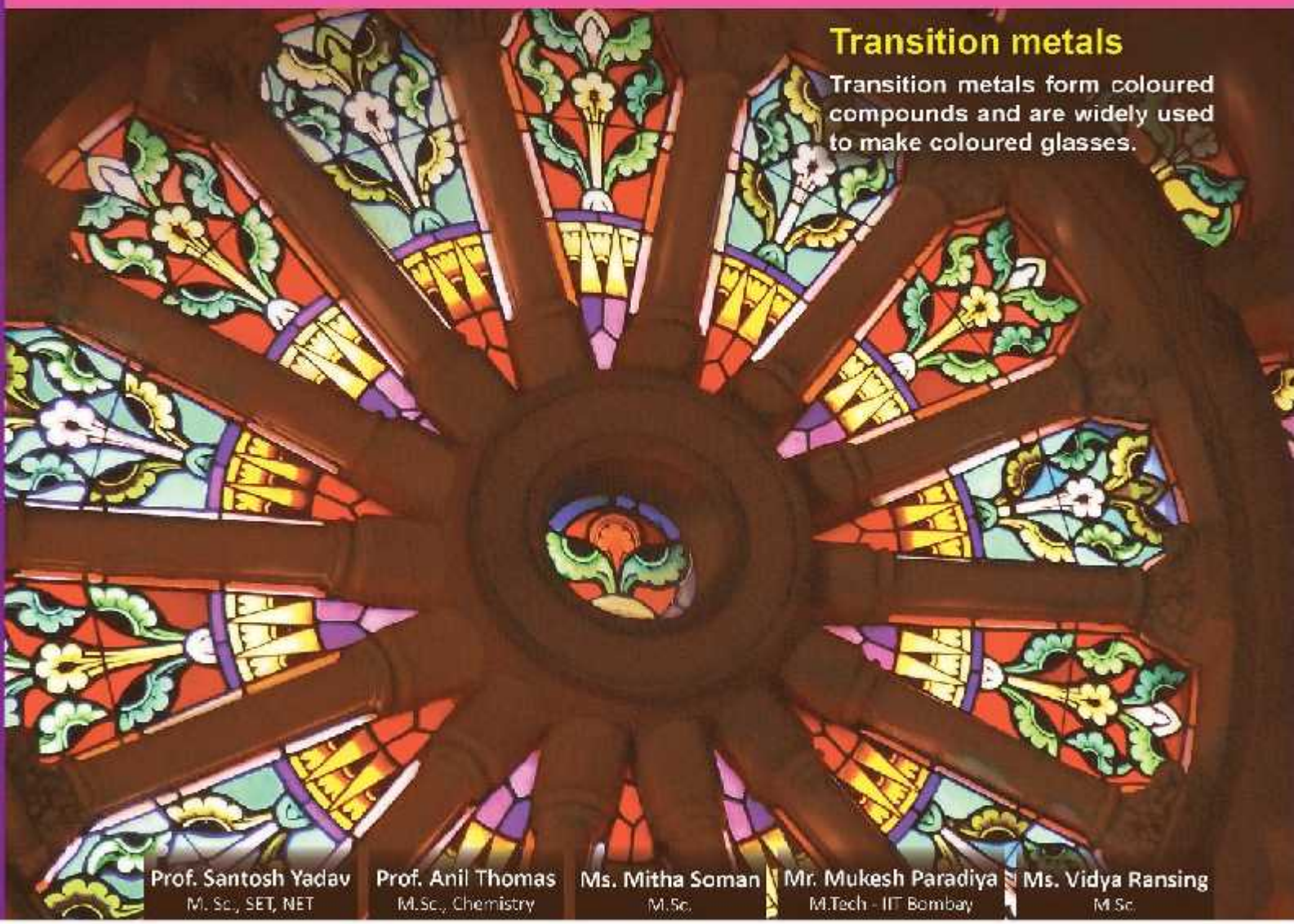
# CHEMISTRY Vol - II

## NEET - UG & JEE (Main)

Now with more study techniques

2080 MCQs with Hints

For all Agricultural, Medical, Pharmacy and Engineering Entrance Examinations held across India.




Prof. Santosh Yadav
M. Sc., SET, NET

Prof. Anil Thomas
M.Sc., Chemistry

Ms. Mitha Soman
M.Sc.

Mr. Mukesh Paradiya
M.Tech - IIT Bombay

Ms. Vidya Ransing
M.Sc.

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# Challenger

## NEET – UG & JEE (Main)

# Chemistry Vol. II

Now with more study techniques

## Salient Features

- Concise theory for every topic.
- Eclectic coverage of MCQs under e[illegible]h sub-topic
- '2080' questions including MCQs fro[illegible]previo[illegible] NEET and JEE examinations.
- Includes selective solved MCQs upto NEET Phase-I & II 2020, JEE (Main) 2020.
- Includes NEET Phase-II [illegible]020 [illegible]d JEE (Main) 2020 2nd September (Shift - II) Question Paper a[illegible] Answ[illegible]r K[illegible]y a[illegible]ng with Hints.
- Multiple Study Techn[illegible]ques [illegible]Enhance Understanding and Problem Solving.
- Hints provided [illegible]ver[illegible]eemed necessary.
- Includes Nu[illegible]rical Va[illegible]ue Type Questions (NVT).
- Inclusi[illegible]f 'Pr[illegible]lem[illegible]To Ponder' to engage students in scientific enquiry.



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# PREFACE

**'Challenger Chemistry Vol - II'** is a compact guidebook, extremely handy for preparation of various competitive exams like NEET, JEE (Main). This edition provides an unmatched comprehensive amalgamation of theory with MCQs. The chapters are aligned with the syllabus for NEET (UG) and JEE (MAIN) examinations and runs parallel to NCERT curriculum. The book provides the students with scientifically accurate context, several study techniques and skills required to excel in these examinatio

Each chapter in the book consists of:

- **Consice theory** covering concepts that form a vital part of preparation any competitive exa tion in the form of pointers, tables, charts and diagrams.
- **Concept Building Problems** section is designed to boost prerequisite understanding of conc 's.
- **Practice Problems** section contains questions crafted for thorough revision.
- **Diagram Based Problems** section contains questions that facilita stu ts' c nceptual understanding and enhance their spatial thinking ability.
- **Numerical Value Type** section cater to newly added NVT questions JEE Main).
- **Problems to Ponder** section offers MCQs of diverse pattern c ted to still the attitude of concentrating on the problems and to understand the applicati ario concepts in Chemistry.

All the questions included in a chapter have been specially creat d and co piled to enable students solve complex problems which require strenuous effort with ompt ness.

All the features of this book pave the path of a stu ent to excel n examination.The features are designed keeping the following elements in mind: Time n nagement, e sy memorization or revision and non-conventional yet simple methods for MCQ solving.

To keep students updated, selected questions from most recent examinations of NEET (UG) 2020 and JEE (Main) 2020 are covered exclusively.

NEET-UG 2020 (Phase II) and JEE (Ma ) 20 2nd SEPTEMBER (Shift – II) Question Papers and Answer Keys have been provided to of stu glim se of the complexity of questions asked in entrance examination. The paper has been sp t un vis to let the students know which of the units were more relevant in the latest examinati

*We hope the book benefits th earner a we have envisioned.*

*A book affects eternit e ca neve ell where its influence stops.*

From,
Publisher

**Edition:** Fourth

The j rney t reate a complete book is strewn with triumphs, failures and near misses. If you think we've earl mi ed s ething or want to applaud us for our triumphs, we'd love to hear from you.

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# FEATURES

## Strategy

*'Strategy'* illustrates a general step-by-step approach towards solving a problem.
*This is our attempt to guide students to map out a strategy for solving the problem.*

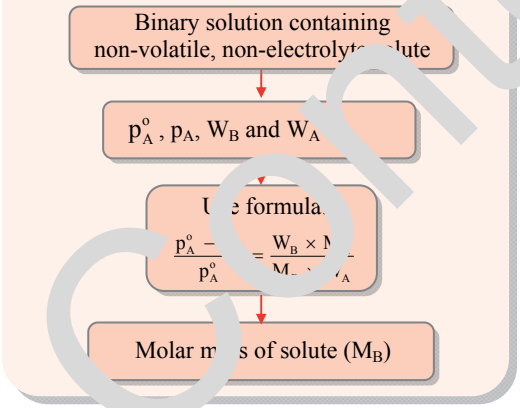
5. The vapour pressure of acetone at 20 °C is 185 torr. When 1.2 g of a non-volatile substance was dissolved in 100 g of acetone at 20 °C, its vapour pressure was 183 torr. The molar mass (g $mol^{-1}$) of the substance is _____.
**[JEE (Main) 20 5]**

(A) 32 (B) 64
(C) 128 (D) 488

5. (B)

5.

**Strategy**




$$\frac{p_A^\circ - p_A}{p_A^\circ} = \frac{W_B M_A}{M_B W_A}$$

$$\frac{185-183}{185} = \frac{1.2\times 58}{M_B \times 100}$$

$$M_B = \frac{1.2}{2}\times\frac{58}{100}\times 185 = 64.38 \approx 64 \text{ g/mol}$$

## Smart tip - 1

i. **For dilution,** $M_1V_1 = M_2V_2$
(Initial) (Final)

ii. **Resulting molarity of the two mixtures (solutions),** $M = \frac{M_1V_1 + M_2V_2}{V_1 + V_2}$

## Smart tip

*'Smart tips'* comprise important theoretical or formula based short tricks considering their usage in solving MCQ.
*This is our attempt to highlight content that would come handy while solving questions.*

# FEATURES

## Caution

*'Caution'* apprises students about mistakes which are made while solving an MCQs.
*This is our attempt to make a student aware of possible common mistakes.*

**CAUTION**

Ensure to convert edge length from Å to cm before substituting in the density formula.

## SMART CODE - 2

**For 3d series:** Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn.
*Scary Tiny Vicious Creature May Fear Cows and Nice Cute Zebras.*
**For 4d series:** Y, Zr, Nb, Mo, Tc, Ru, Rh, Pd, Ag, Cd.
*Yes, Zebras can Never, but Most Technicians can Read Rhymes Properly And Correctly.*
**For 5d series:** La, Hf, Ta, W, Re, Os, Ir, Pt, Au, Hg.
*Late Harry Took a Walk and Reached Office In Pajamas After an Hour.*

## Smart Code

*'Smart Code'* showcases simple and smart mnemonic created for selected concepts.
*This is our attempt to offer students a memory technique that facilitates easy recollection.*

## Q.R. Codes

*'Q.R. code'* provides access to a video in order to boost understanding of a concept or activity.
*This is our attempt to facilitate learning with visuals.*

*Students can scan the adjacent QR code to get further conceptual clarity on seven crystal systems.*

## Formulae

1. **Reduction potential** = – Oxidation Potential
2. $E^\circ_{cell}$ **(e.m.f)** = $E^\circ_{(cathode)} - E^\circ_{(anode)}$
   $= E^\circ_{(Right)} - E^\circ_{(Left)}$
3. **Gibbs energy change and e.m.f. of a cell:**
   $\Delta_rG = -nFE_{cell}$ and $\Delta_rG^\circ = -nFE^\circ_{cell}$
   Where, $\Delta_rG$ = Gibbs energy change
   $\Delta_rG^\circ$ = Standard Gibbs energy change

## Formulae

*'Formulae'* includes all of the key formulae in the chapter.
*This is our attempt to offer students tools of formulae accessible while solving problems and last minute revision at a glance.*

# FEATURES

3. A compound 'X' upon reaction with $H_2O$ produces a colourless gas 'Y' with rotten fish smell. Gas 'Y' is absorbed in a solution of $CuSO_4$ to give $Cu_3P_2$ as one of the products. Predict the compound 'X'.

**[NEET (Odisha) 2019]**

(A) $Ca_3(PO_4)_2$ (B) $Ca_3P_2$
(C) $NH_4Cl$ (D) $As_2O_3$

## Clock Symbol

*'Clock Symbol'* instructs students that given MCQ can be solved apace by applying either smart tips, smart codes or thinking hatke.
*This is our attempt to make students attentive towards their perception of approaches possible for solving an MCQ.*

## Miscellaneous

Miscellaneous MCQs covers concept of different sub-topics of same chapter or from different chapters.
*This is our attempt to develop cognitive thinking in the students essential to solve questions involving fusion of multiple key concepts.*

### MISCELLANEOUS

2. Phenol $\xrightarrow{a}$ X $\xrightarrow{b}$ Toluen
Identify reagents 'a' and 'b'
(A) a = NaOH b $CO_2/H^+$
(B) a = $CHCl_3$/NaOH b = $OH/H^+$
(C) a = Zn dust. b $CH_3Cl$, anhydrous $AlCl_3$
(D) a = $Na_2Cr_2O_7/H^+$ b = Raney Ni

## Thinking Hatke

*'Thinking Hatke'* reveals quick witted approach to crack the specific question.
*This is our attempt to develop skill of lateral thinking in students.*

2. 0.44 mole of electrons were passed through four electrolyte solutions for 1 second connected in series. If the solutions are of $AlCl_3$, $ZnSO_4$, $AuCl_3$ and $AgNO_3$, find the CORRECT decreasing order of the amount of each metal deposited at cathode of each cell. (M.W.: Al = 27, Zn = 65.4, Ag = 108, Au = 197)
(A) Ag > Au > Zn > Al (B) Al > Zn > Ag > Au
(C) Au > Ag > Zn > Al (D) Al > Zn > Au > Ag

2. (A)

2. According to Faraday's second law of electrolysis, mass of product deposited ∝ equivalent weight

$E_{eq}(Al^{3+}) = \frac{27}{3} = 9$, $E_{eq}(Ag^+) = \frac{108}{1} = 108$

$E_{eq}(Zn^{2+}) = \frac{65.4}{2} = 32.7$, $E_{eq}(Au^+) = \frac{197}{3} = 65.6$

Hence the correct decreasing order of amount of different metals deposited is:
Ag > Au > Zn > Al

**Thinking Hatke - Q.2**

Since, same quantity of electricity is passed through all the electrolytes; mass of metal deposited in each case will be proportional to their respective equivalent weights. Equivalent weight of Ag is highest among these metals. Hence, option (A) is the correct answer.

## Frequently Asked Questions

### Why Challenger Series?

Gradually, every year the nature of competitive entrance exams is inching towards conceptual understanding of topics. Moreover, it is time to bid adieu to the stereotypical approach of solving a problem using a single conventional method.

To be able to successfully crack the NEET/JEE (Main) examinations, it is imperative to develop skills such as data interpretation, appropriate time management, knowing various methods to solve a problem, etc. With Challenger Series, we are sure, you'd develop all the aforementioned skills and take a more holistic approach towards problem solving. The way you'd tackle advanced level MCQs with the help of hints, Smart tips, Smart codes and Thinking Hatke would give you the necessary practice that would be a game changer in your preparation for the competitive entrance examinations.

### What is the intention behind the launch of Challenger Series?

The sole objective behind the introduction of Challenger Series is to severely test the student's preparedness to take competitive entrance examinations. With an eclectic range of critical and advanced level MCQs, we intend to test a student's MCQ solving skills within a stipulated time period.

### What do I gain out of Challenger Series?

After using Challenger Series, students would be able to:

a. assimilate the given data and apply relevant concepts with utmost ease.
b. tackle MCQs of different pattern such as match the columns, diagram based questions, multiple concepts and assertion-reason efficiently.
c. garner the much needed confidence to appear for competitive exams.
d. easy and time saving methods to tackle tricky questions will help ensure that time consuming questions do not occupy more time than you can afford per question.

### How to derive the best advantage of this book?

To get the maximum benefit of the book we recommend :

a. Go through brief theory given at the beginning of a chapter for a quick revision. Commit Smart Tips into memory and pay attention to Caution.
b. Know all the Formulae compiled at the end of theory by heart.
c. Using subtopic wise segregation as a leverage, complete the Concept Building Problems at your own pace. Questions from various competitive exams such as JEE (Main), NEET-UG, NEET (Odisha) are tagged and placed along the flow of subtopic. Mark these questions specially to gauge the trends of questions in various exams.
d. Be extra receptive to Thinking Hatke, Alternate Method and application of Smart Tips. Assimilate them into your thinking.
e. After mastering stimulating questions, take up Practice Problems as self-assessment and verify answers as well as methods. Check if you could apply smart tips, alternate method, etc. as mentioned in hint. Find out if you have invented ingenious solution mapping to thinking hatke explicated in hints.
f. Watch the linked video for an efficient revision of chapter theory.
g. Ruminate over questions from Problems To Ponder and appreciate aesthetics of the concepts.

### *Can the Questions presented in Problems to Ponder section be a part of the NEET Examination?*

No, the questions would not appear as it is in the NEET Examination. However, there are fair chances that these questions could be covered in parts or with a novel question construction.

*Best of luck to all the aspirants!*

# CONTENTS



**Note** * marked subtopic in a chapter is listed only in the JEE syllabus and ** marked subtopic in a chapter is listed only in the NEET syllabus. However, since questions based on the same have appeared in the recent examinations, these subtopics are covered judiciously in the book.

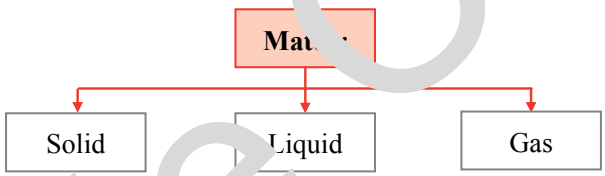
# 1 Solid State



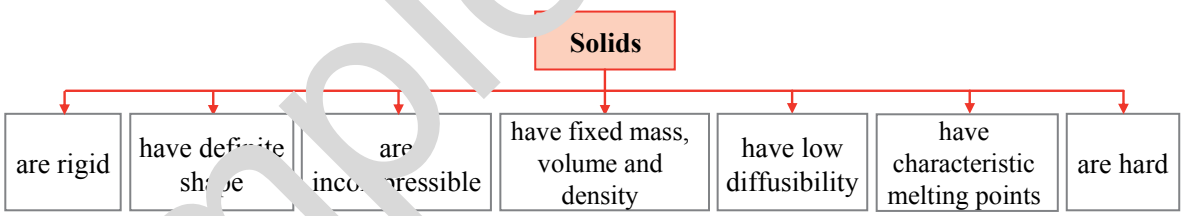
* marked section is only for JEE (Main) **marked section is for N G

## 1.0 Introduction

➢ **States of matter:** Matter can exist in three physica states.




➢ **General characteristics of soli tate.**




## 1.1 Classif cat n of solids

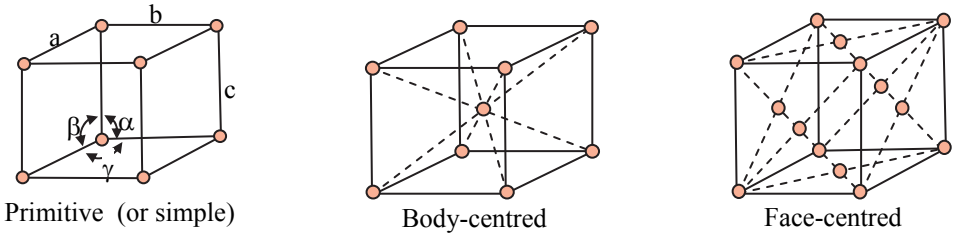
➢ **Classi ficatio f solids:**
Sc ds a class fied into the following two types on the basis of the presence or absence of orderly a ang nei f the constituent particles:

i. **Crys alline solids:** *A **crystalline solid** is a homogeneous solid in which the constituent particles, atoms, ions or mo es are arranged in a definite repeating pattern in three dimensional space.*

ii. **A orphous solids:** *The substances that appear like solids but do not have well developed perfectly ordered ar ngement of constituent particles are called **amorphous** (no form) **solids**.*

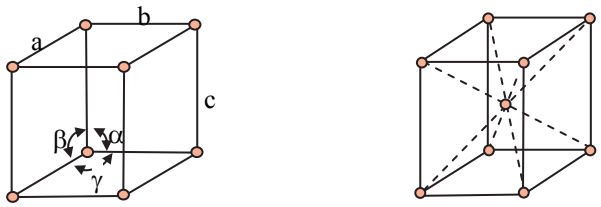
| | Property | Crystalline solids | Amorphous solids |
|---|---|---|---|
| a. | Shape | They have definite characteristic geometrical shape due to the orderly regular long range arrangement of constituent particles. | They have irregular shape i.e., lack characteristic geometrical shape due to the short ranged orderly arrangement of constituent particles. |
| b. | Melting point | They have sharp and characteristic melting point. | They do not have sharp melting point. They gradually soften over a range of temperature. |

ii. The unit cells of 14 types of Bravais lattices are shown in the following figure:



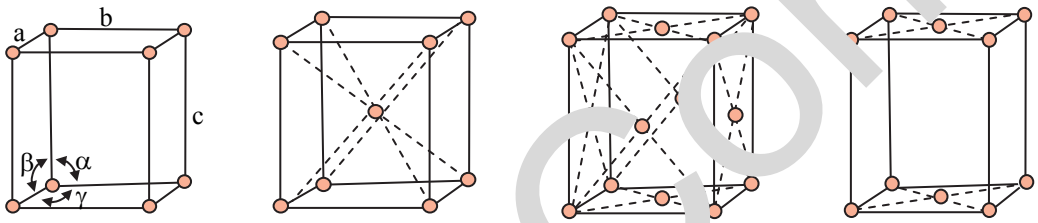

Primitive (or simple) Body-centred Face-centred

**Three Type of Cubic Cells (a = b = c, α = β = γ = 90°)**



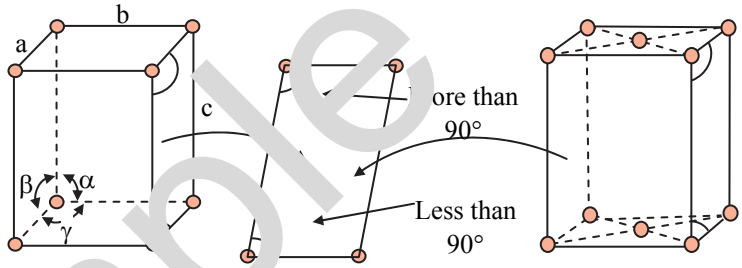

Primitive Body-centred

**Two Types of Tetragonal Unit Cells (a = b ≠ c, α = β = γ = 90**



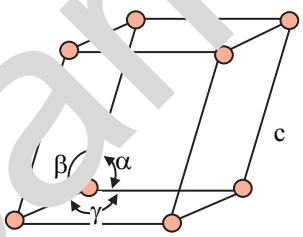

Primitive Body-centred Face-cent d End-centred

**Four Types of Orthorhombic Unit Ce b ≠ c, α = β = γ = 90°)**

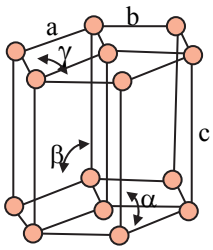



Pri mitiv End-centred

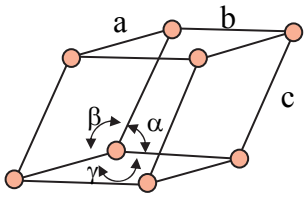
**Ty ypes of onoc ic Unit Cells ( a ≠ b ≠ c, α = β = 90°, γ ≠ 90°)**




**Triclinic Unit Cell**
**( a ≠ b ≠ c, α ≠ β ≠ γ ≠ 90°)**




**Hexagonal Unit Cell**
**(a = b ≠ c, α = β =90°, γ = 120°)**




**Rhombohedral Unit Cell**
**(a = b = c**
**α = β = γ ≠ 90°)**

*Students can scan the adjacent QR code to get further conceptual clarity on seven crystal systems.*

b. The following table gives the limiting values of radius ratio, the coordination number of the cation and the structural arrangement of anions around cations.

| Radius ratio $\left(\frac{r^+}{r^-}\right)$ | Coordination number of cation | Structural arrangement of anions around cations | 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 |

**ii. Structures of some ionic solids:**

| | Ionic solid | Arrangement of ions | Coordination number |
|---|---|---|---|
| a. | NaCl (Sodium chloride) | $Cl^-$ ⇒ fcc arrangement<br>$Na^+$ ⇒ occupy all octahedral sites | $Cl^-$ =<br>= 6 |
| b. | CsCl (Caesium chloride) | $Cl^-$ ⇒ simple cubic arrangement<br>$Cs^+$ ⇒ occupy cubic sites | Cl<br>$Cs^+$ = 8 |
| c. | ZnS (Zinc blende) | $S^{2-}$ ⇒ fcc arrangement<br>$Zn^{2+}$ ⇒ occupy half of the tetrahedral sites | S = 4<br>$Zn^{2+}$ = 4 |
| d. | $CaF_2$ (Calcium fluoride) | $Ca^{2+}$ ⇒ fcc arrangement<br>$F^-$ ⇒ occupy all tetrahedral sites | $Ca^{2+}$ = 8<br>$F^-$ = 4 |

**iii. Sizes of tetrahedral and octahedral voids:**
Radius (r) of tetrahedral void = 0.225 R
Radius (r) of octahedral void = 0.414 R
R = radius of the spheres in the close packed arrangement.

## 1.8 PACKING EFFICIENCY

➢ **Packing efficiency:**

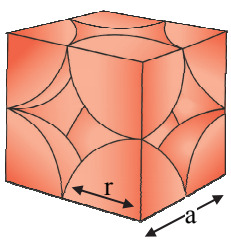
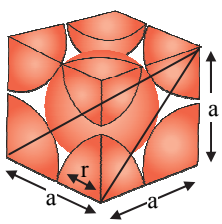
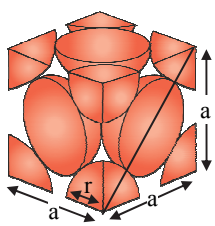
*The **packing efficiency** is the percentage of total space occupied by the particles.*

i. Packing efficiency is given by following formula:

$$\textbf{Packing efficiency} = \frac{\textbf{Total volume occupied by spheres in unit cell}}{\textbf{Volume of the unit cell}} \times 100$$

ii. The magnitude of packing efficiency gives a measure of how tightly particles are packed together.

➢ **Packing efficiency in different unit cells:**

| | Simple cubic unit cell | Body-centred cubic unit cell (bcc) | Face-centred cubic unit cell (fcc) or cubic close packing (ccp) |
|---|---|---|---|
| Unit cell diagram |  |  |  |
| Total number of spheres per unit cell | 1 | 2 | 4 |
| Relation between a (edge length of unit cell) and r (radius of sphere) | $r = \frac{a}{2}$ | $r = \frac{\sqrt{3}}{4}a$ | $r = \frac{a}{2\sqrt{2}}$ |

| | | | |
|---|---|---|---|
| Volume of one sphere | $\frac{4}{3}\pi \times \left(\frac{a}{2}\right)^3 = \frac{\pi a^3}{6}$ | $\frac{4}{3}\pi \times \left(\frac{\sqrt{3}}{4}a\right)^3 = \frac{\sqrt{3}\pi a^3}{16}$ | $\frac{4}{3}\pi \times \left(\frac{a}{2\sqrt{2}}\right)^3 = \frac{\pi a^3}{12\sqrt{2}}$ |
| Total volume of spheres = Number of spheres per unit cell × volume of sphere | $1 \times \frac{\pi a^3}{6} = \frac{\pi a^3}{6}$ | $2 \times \frac{\sqrt{3}\pi a^3}{16} = \frac{\sqrt{3}\pi a^3}{8}$ | $4 \times \frac{\pi a^3}{12\sqrt{2}} = \frac{\pi a^3}{3\sqrt{2}}$ |
| Packing efficiency = $\frac{\text{Total volume of spheres}}{\text{Volume of unit cell}} \times 100$ | $\frac{\pi a^3/6}{a^3} \times 100 = 52.4\ \%$ | $\frac{\sqrt{3}\pi a^3}{8\,a^3} \times 100 = 68\%$ | $\frac{\pi a^3}{3\sqrt{2}\,a^3} \times 100$ |
| Empty space | 47.6% | 32% | 26% |
| Coordination number of sphere | 6 : four in the same layer, one directly above and one directly below | 8 : four in the layer below and one in the layer above | 12 : six in its own layer, three above and three below |

## Smart tip - 1

From the above derivations, we can deduce the following relations between edge length (a) of the unit cell and **radius of particle, volume of one particle** and **total volume occupied by particles in a unit cell:**

| | Simple cubic unit cell | | bcc unit cell | | fcc/ccp unit cell |
|---|---|---|---|---|---|
| i. | Radius of particle (r) = 0.5000 a | ii. | Radius of particle (r) = 0.4330 a | | Radius of particle (r) = 0.3535 a |
| iv. | Volume of one particle = 0.524 $a^3$ | v. | Volume of one particle = 0.34 $a^3$ | vi. | Volume of one particle = 0.185 $a^3$ |
| vii. | Total volume occupied by particles in unit cell = 0.524 $a^3$ | viii. | Total volume occupied by particles in unit cell = 0.68 $a^3$ | ix. | Total volume occupied by particles in unit cell = 0.74 $a^3$ |

➢ **Relationship between the nearest neighbour distance (D) and the edge length (a) of a cubic unit cell:**

| No. | Type of unit cell | Relation between D and a |
|---|---|---|
| i. | Simple cubic | D = edge length = a |
| ii. | Body-centred cubic | D = $\frac{1}{2}$ × body diagonal = $\frac{1}{2} \times \sqrt{3}\,a$ |
| iii. | Face-centred cubic | D = $\frac{1}{2}$ × face diagonal = $\frac{1}{2} \times \sqrt{2}\,a = \frac{a}{\sqrt{2}}$ |

**Note: Packing efficiency in hexagonal close packing (hcp) arrangement:**

i. A hcp unit cell contains 12 corner spheres, 2 face-centred spheres and 3 body-centred spheres.

Number of spheres per unit cell = $\left(12 \times \frac{1}{6}\right) + \left(2 \times \frac{1}{2}\right) + 3 = 2 + 1 + 3 = 6$

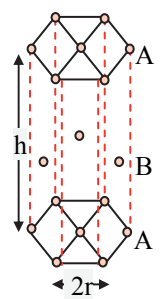
ii. Let 'r' represent the radius of the sphere

Height of unit cell = $4r.\sqrt{\frac{2}{3}}$

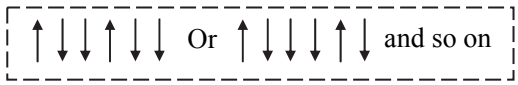
Base area of regular hexagon = $6 \times \frac{\sqrt{3}}{4}(2r)^2 = 6 \times \sqrt{3}\,r^2$

iii. Volume of unit cell = Base area × height (h) = $6\sqrt{3}\,r^2 \times 4r.\sqrt{\frac{2}{3}}$

$= 24\sqrt{2}\,r^3$



**Section view of hcp type unit cell**

| | | | |
|---|---|---|---|
| Ferrimagnetic materials | • The domains align in such a way that there is a small net magnetic moment.<br>• The number of domains that are aligned in parallel direction is not equal to the number of domains that are aligned in anti-parallel direction.<br>  <br>• Weakly attracted by a magnetic field.<br>• Change to paramagnetic solid when heated. | $Fe_3O_4$ (magnetite), Ferrites like $MgFe_2O_4$, $ZnFe_2O_4$, etc. | — |

## Formulae

**1. Packing efficiency**

$$= \frac{\text{Volume occupied by spheres in unit cell}}{\text{Volume of unit cell}} \times 100$$

**2. Relationship between radius of atom (r) and edge length (a):**

| Simple cubic unit cell | Body-centred cubic unit cell | Face-centred cubic unit cell |
|---|---|---|
| $r = \frac{a}{2}$ | $r = \frac{\sqrt{3}}{4}a$ | $r = \frac{a}{2\sqrt{2}}$ |

**3. Volume of one particle in unit cell:**

| Simple cubic unit cell | Body-centred cubic unit cell | Face-centred cubic unit cell |
|---|---|---|
| $\frac{\pi a^3}{6}$ | $\frac{\sqrt{3}\pi a^3}{16}$ | $\frac{\pi}{12\sqrt{2}}$ |

**4. Total volume occupied by particles in unit cell:**

| Simple cubic unit cell | Body-centred cubic unit cell | Face-centred cubic unit cell |
|---|---|---|
| $\frac{\pi a^3}{6}$ | $\frac{\sqrt{3}\pi a}{8}$ | $\frac{\pi a^3}{3\sqrt{2}}$ |

**5. Distance between the nearest neighbours (D) in a unit cell:**

| Simple cubic unit cell | bcc unit cell | fcc unit cell |
|---|---|---|
| $D = a$ | $D = \frac{\sqrt{3}a}{2}$ | $D = \frac{a}{\sqrt{2}}$ |

**6. Density of unit cell (d):**

$$d = \frac{\text{Mass of unit cell}}{\text{Volume of unit cell}} = \frac{Z \times M}{a^3 \times N_A} \text{ g cm}^{-3}$$

where, a is the edge length of unit cell in cm
Z is the number of atoms per unit cell
M is the molar mass (g/mol)
$N_A$ is Avogadro number ($6.022 \times 10^{23}$ mol$^{-1}$)
For fcc, Z = 4, for bcc, Z = 2 and for simple cubic, Z = 1

**7. Number of atoms in x g of metal** $= \frac{xZ}{d \times a^3}$

**8. Number of unit cells in x g of metal** $= \frac{x}{d \times a^3}$

**9. Number of unit cells in volume (V) of metal** $= \frac{V}{a^3}$

**10. Some unit conversions:**
1 pm $= 1 \times 10^{-12}$ m $= 1 \times 10^{-10}$ cm
1 Å $= 1 \times 10^{-8}$ m = 100 pm

## Concept Building Problems

### 1.0 Introduction

1. The properties that are characteristics of solid state are:
   i. Easily compressible as compared to liquids and gases
   ii. Definite volume
   iii. Definite mass
   iv. High rate of diffusion as compared to liquids and gases
   v. Stronger intermolecular forces as compared to liquids and gases
   vi. Smaller intermolecular distance between the particles as compared to liquids and gases
   (A) (i), (ii), (iii)
   (B) (ii), (iii), (iv) and (vi)
   (C) (ii), (iii), (v) and (vi)
   (D) (i), (ii), (iii), (v) and (vi)

### 1.1 Classification of Solids

1. Which of the following is NOT true about crystalline solids?
   (A) They have long range order.
   (B) They have sharp and characteristic melting points.
   (C) Their measured electrical conductance changes with the change in direction of measurement.
   (D) They are also known as super cooled liquids.

4. Which is the INCORRECT statement?
[NEET (UG) 2017]
(A) Density decreases in case of crystals with Schottky's defect.
(B) NaCl(s) is insulator, silicon is semiconductor, silver is conductor, quartz is piezoelectric crystal.
(C) Frenkel defect is favoured in those ionic compounds in which sizes of cation and anions are almost equal.
(D) $Fe_{0.98}O$ has stoichiometric metal deficiency defect.

5. For a compound the expected structure was fcc lattice, in which 'A' occupies all corner positions and 'B' occupies all face center positions. The molecular formula of such a compound must be $AB_3$. However, the formula is found to be $A_2B_5$. This is because _____.
(A) One atom of A is missing in the lattice
(B) One atom of B is missing in the lattice
(C) One atom of A is replaced with one atom of B in the lattice
(D) One atom of B is replaced with one atom of A in the lattice

## Practice Problems

### 1.1 Classification of Solids

1. Which of the following is TRUE about quartz and quartz glass?
(A) Quartz is an amorphous solid while quartz glass is a crystalline solid
(B) Both quartz and quartz glass are amorphous solids.
(C) Both quartz and quartz glass are crystalline solids.
(D) Quartz is a crystalline solid while quartz glass is an amorphous solid

### 1.2 Classification of Crystalline Solids

1. 'X' is an insulator as a solid but conducts electricity in its fused state. 'X' is hard and brittle in nature. Identify 'X'.
(A) Silver (B) Calcium fluoride
(C) Diamond (D) Sulphur dioxide

2. Match the following solids in column I with the major bonding/attractive force between the constituent particles in column II.

| | Column I | | Column II |
|---|---|---|---|
| i. | Dry ice | a. | Covalent bonding |
| ii. | Magnesium | b. | London forces |
| iii. | Graphite | c. | Electrostatic forces |
| iv. | Common salt | d. | Metallic bonding |

(A) i – a, ii – c, iii – b, iv – d
(B) i – b, ii – d, iii – a, iv – c
(C) i – a, ii – d, iii – b, iv – c
(D) i – c, ii – d, iii – a, iv – b

### 1.4 Bragg's Law and Its Applications

1. At what value of angle of incidence would the second order diffraction occur, when a [illegible] has $\lambda = d = 160$ pm?
(A) 30° (B) 45°
(C) 60° (D) [illegible]

### 1.5 Seven Crystal Systems

1. A dice represents _____ crystal system.
(A) cubic (B) tetragonal
(C) orthorhombic (D) monoclinic

2. For which of the following pairs of crystal sytems the relationship $a \neq b \neq c$ is CORRECT?
(A) Hexagonal and tetragonal
(B) Tetragonal and rhombohedral
(C) Orthorhombic and triclinic
(D) Monoclinic and cubic

3. Match the following:

| | Crystal system | | Example |
|---|---|---|---|
| i. | Triclinic | a. | $TiO_2$ |
| ii. | Orthorhombic | b. | $K_2Cr_2O_7$ |
| iii. | Hexagonal | c. | $BaSO_4$ |
| iv. | Tetragonal | d. | ZnO |

(A) i – b, ii – c, iii – d, iv – a
(B) i – c, ii – b, iii – a, iv – d
(C) i – b, ii – a, iii – d, iv – c
(D) i – c, ii – d, iii – b, iv – a

### 1.7 Packing in Solids

1. Which of the following is INCORRECT regarding the ABAB type, two-dimensional arrangement?
(A) The coordination number of each sphere is 6.
(B) This arrangement forms hexagonal close packed structure.
(C) A regular hexagon is formed when the centres of six neighbouring spheres, surrounding a central sphere, are joined.
(D) The spheres of successive layers have horizontal and vertical alignment.

2. A sample of metal has $5 \times 10^3$ fcc unit cells. Calculate the number of tetrahedral voids present.
(A) $2 \times 10^3$ (B) $5 \times 10^3$
(C) $2 \times 10^4$ (D) $4 \times 10^4$

3. A mixed oxide has oxide ions arranged in ccp array. One-fifth of tetrahedral voids are occupied by X ions, while one-half of the octahedral voids are occupied by Y ions. The formula of this oxide is _____.
(A) $X_4Y_5O_{10}$ (B) $X_8Y_5O_{13}$
(C) $X_4Y_5O$ (D) $X_5Y_4O_{10}$

4. Identify the CORRECT increasing order of coordination number of the cations in the crystals of MgS, MgO and CsCl on the basis of data given below:
Radius in Å: $Mg^{2+} = 0.65$, $Cs^{+} = 1.69$, $O^{2-} = 1.40$, $S^{2-} = 1.84$, $Cl^{-} = 1.81$
(A) MgS < MgO < CsCl
(B) MgO < MgS < CsCl
(C) CsCl < MgO < MgS
(D) MgS < CsCl < MgO

## 1.8 PACKING EFFICIENCY

1. Three different metal atoms crystallize in simple cubic, bcc and fcc lattice structures. If the edge length is 88 pm for all the three unit cells what is the ratio of the radii $r_1$ in simple cubic lattice, $r_2$ in bcc lattice, $r_3$ in fcc lattice?
(A) 1.41 : 1.22 : 1 (B) 1.87 : 2.24 : 1
(C) 1.24 : 1.87 : 1 (D) 1.41 : 1 : 1.22

2. CsI crystallizes in body-centred cubic lattice. Which of the following expressions is CORRECT for CsI?
(A) $r_{Cs^+} + r_{I^-} = 3 \times$ edge length
(B) $r_{Cs^+} + r_{I^-} = \frac{3}{2} \times$ edge length
(C) $r_{Cs^+} + r_{I^-} = \frac{\sqrt{3}}{2} \times$ edge length
(D) $r_{Cs^+} + r_{I^-} = \frac{\sqrt{3}}{\quad}$ body d...

## 1.9 CALCUL...TION OF DE...SITY OF UNIT C...LS

1. A ...etal atom c...stallises in a cubic system with a ...packi...g ...fficiency of 74%. If the edge length is 10... pm a...d the atomic mass is M, the density of th... ...nit cell is given by _____ g $cm^{-3}$.
(A) 1.66 × M (B) 2.40 × M
(C) 3.32 × M (D) 6.64 × M

...X' crystallizes in fcc lattice. Suppose the atomic radius of 'X' is 130 pm and molar mass is 63.5 g/mol. The volume of its unit cell and density of 'X' are _____ respectively.
(A) $5.68 \times 10^{-23}$ $cm^3$, 4.9 g/$cm^3$
(B) $5.68 \times 10^{-23}$ $cm^3$, 2.9 g/$cm^3$
(C) $4.97 \times 10^{-23}$ $cm^3$, 8.5 g/$cm^3$
(D) $4.97 \times 10^{-23}$ $cm^3$, 5.6 g/$cm^3$

3. A metal 'X' has fcc structure with atomic radius 140 pm. If the density is 12.69 g/$cm^3$, metal 'X' is _____.
(A) Ag (B) Zn
(C) Sn (D) Fe

4. An unknown element 'X' crystallizes in ...fcc lattice. If radius of the atom is 70.7 pm ... density is 41.6 g $cm^{-3}$, how many atoms of 'X' are contained in 200 g sample of the ele...
(A) $6.0 \times 10^{23}$ atoms (B) $1.7 \times 10^{24}$ ato...
(C) $2.4 \times 10^{24}$ atoms (D) $3.5 \times ...^{25}$ atoms

5. Calcium crystallizes in a face-centr... cubi... unit cell with a = 0.556 nm. Cal...late ...ne ...ensity if it contained 0.2% Sc... ...y d... ...ts.
(A) 1.475 g $cm^{-3}$ (B) ... g $cm^{-3}$
(C) 1.718 g $cm^{-3}$ (D) 1.903 g $cm^{-3}$

6. AB crystalli... in a bo...-centred cubic lattice, with unit cell e... length, $8.12 \times 10^{-8}$ cm. If the radius ... ion ...303 pm, radius of $B^{2-}$ ion is _____.
(A) ...9 × 10... cm (B) 400 pm
(C) ... ...$^{-8}$ cm (D) 1100 Å

## 1.11 CL...ASSIFICATION OF POINT D...FECTS

1. Which of the following statements are CORRECT?
I. Frenkel defect is a point defect that do not disturb the stoichiometry of the solid.
II. Non-stoichiometric defects are also called intrinsic defects.
III. Schottky defect is found in ionic compounds with high degree of ionic character.
IV. Metal excess defect is a point defect that do not disturb the stoichiometry of the solid.
V. Metal deficiency defect imparts colour to the colourless crystal due to formation of F-centres.
(A) I and III (B) III and V
(C) II, IV and V (D) I, III and IV

## MISCELLANEOUS

1. A halide ion forms a close packed structure. If radius of $X^-$ ion is 221 pm, what is the maximum radius of the cation that can just fit into the tetrahedral hole and octahedral hole respectively?
(A) 36.5 pm and 73 pm
(B) 43.8 pm and 80.7 pm
(C) 49.7 pm and 91.5 pm
(D) 58.6 pm and 100.4 pm

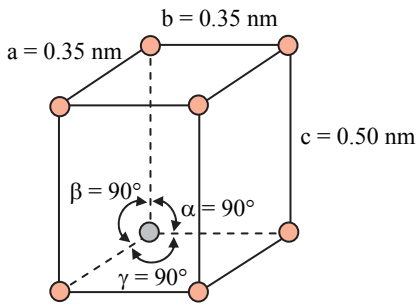
2. Which of the following statements are CORRECT about cubic close packed (ccp) 3-D structure?

I. The unit cell edge length is $2\sqrt{2}$ times the radius of the atom.
II. The number of octahedral and tetrahedral voids per atom are 1 and 2 respectively.
III. The number of the nearest neighbours of an atom present in the topmost layer is 12.
IV. The packing efficiency of the arrangement is 74%.

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

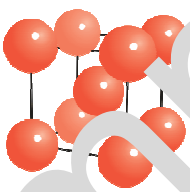
## Diagram Based Problems

1. The following figure represents a unit cell belonging to crystal system.




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

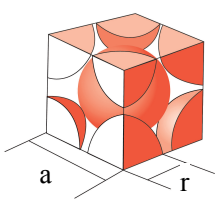
2. Identify the CORRECT option with respect to the following unit cell diagram.



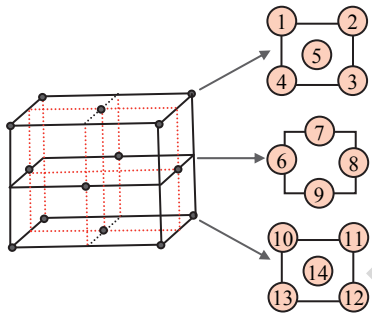
| | Coordination number | Total number of atoms per unit cell |
|---|---|---|
| (A) | 12 | 4 |
| (B) | 6 | 9 |
| (C) | 8 | 9 |
| (D) | 8 | 2 |

3. The unit cell of a metal having atomic radius of r cm is shown in the given diagram. If edge length is a cm, then the total volume occupied by the particles in the unit cell is:

(A) 0.34 $a^3$
(B) 0.68 $a^3$
(C) 0.74 $a^3$
(D) 0.185 $a^3$



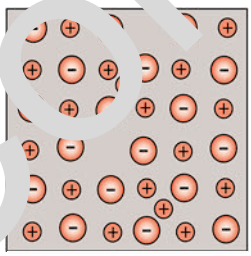

4. The following diagram shows the three layers of fcc unit cell. Each sphere represents an atom.




A face diagonal passing through the centre of atom 1 will also pass through the centre of atoms _____.

(A) 3 and 5 (B) 9 and 11
(C) 2, 4 and 10 (D) 3, 5, 6, 7, 11 and 13

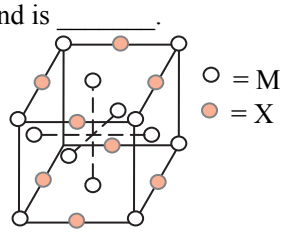
5. Which of the following is TRUE about the following crystal defect?



(A) Density of the solid decreases.
(B) Compounds having high coordination number show this defect.
(C) The substance is not electrically neutral.
(D) KCl does not exhibit this defect.

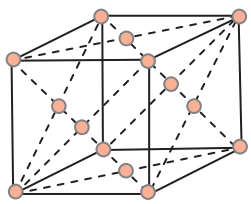
6. Unit cell structure of a certain compound is shown in the given diagram. The empirical formula of the compound is _____.

(A) $MX_2$
(B) $M_2X$
(C) $M_4X$
(D) $MX_4$

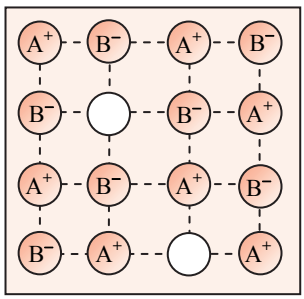



7. Find the INCORRECT equation for the given diagram.

(A) Edge length of the unit cell = $\frac{4}{\sqrt{2}}r$
(B) Volume of unit cell = $\frac{32}{\sqrt{2}}r^3$
(C) Volume of four spheres = $\frac{16}{3}\pi r^3$
(D) Fraction occupied = $\frac{\pi\sqrt{3}}{8}$



8.




How many among the following crystalline solids show the above illustrated metal defect?
NaCl, AgCl, KCl, CsCl, KBr, AgBr, AgI, ZnS

(A) 2 (B) 4
(C) 5 (D) 6

## Numerical Value Type Questions

1. A metal crystallizes in face-centred cubic lattice with edge length of 400 pm. If the density of the metal is 8 g $cm^{-3}$, then the number of atoms present in 256 g of the metal sample is $N \times 10^{24}$. Value of N is _____.

**[Ans: 2]**

2. How many total spheres of constituent particles are present in bcc type of unit cell?

**[Ans: 2]**

3. A metal sample has $5 \times 10^4$ fcc unit cells. The total number of tetrahedral voids pres re $4 \times 10^x$. The value of $x$ is:

**[A s: 5]**

4. If a metal crystallizes in face-c tred lattice with metallic rad 25 m, the number of unit cells i .00 cm of lattice is $2.8 \times 10^x$. Value of $x$ is ____.

**[Ans: 24]**

5. The edge of unit cell of Xe crystal having fcc structure is 620 pm. The radius of Xe atom is _____ pm.

**[Ans: 219.17]**

6. How many of the following compounds show ferrimagnetism?
$Fe_3O_4$; $MgFe_2O_4$; $CrO_2$; $ZnFe_2O_4$; MnO; $H_2O$

**[Ans. 3]**

7. In a face centred cubic lattice, atom A cc ies the corner positions and atom B c pies t face centre positions. If one atom f B is missing from one of the face d po the formula of the compound is $A_xB_y$ ne valu of 'y' is _____.

**[Ans: 5]**

## Problems T ond

1. It was observe that in a tain crystal of NaCl, 1.2 % N + nd C ons were found missing. The edge ength Na is 564 pm. How is the obse ed densi different from the calculated densi of NaC

(A) Ob ed density is greater than the calculated density by 0.03 g $cm^{-3}$
(B) Observed density is smaller than the calculated density by 0.03 g $cm^{-3}$
(C) Observed density is smaller than the calculated density by 0.09 g $cm^{-3}$
(D) Observed density is greater than the calculated density by 0.09 g $cm^{-3}$

2. If the edge length of fcc crystal lattice is 500 pm then what is the diameter of the greatest sphere which can be fitted into interstitial void without distortion of the lattice?

(A) 87 pm (B) 117.6 pm
(C) 139 pm (D) 146.4 pm

## Answers to MCQs

### C nc p Building Problems

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 : | 1. | (C | | | | | | | | | | | | | | | | | |
| 1 . | 1. | (D) | 2. | (C) | 3. | (A) | 4. | (B) | 5. | (D) | | | | | | | | | |
| 1.2 : | 1. | (B) | 2. | (A) | 3. | (D) | 4. | (C) | 5. | (D) | | | | | | | | | |
| 1. . : | 1. | (B) | | | | | | | | | | | | | | | | | |
| 1.5 : | 1. | (D) | 2. | (C) | 3. | (C) | 4. | (C) | | | | | | | | | | | |
| 1.6 : | 1. | (D) | 2. | (A) | 3. | (B) | | | | | | | | | | | | | |
| 1.7 : | 1. | (C) | 2. | (D) | 3. | (C) | 4. | (B) | 5. | (C) | 6. | (A) | 7. | (B) | 8. | (B) | 9. | (C) | 10. (D) |
| 1.8 : | 1. | (D) | 2. | (A) | 3. | (D) | 4. | (D) | 5. | (B) | 6. | (B) | 7. | (D) | 8. | (B) | 9. | (D) | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.9 :** | 1. | (B) | 2. | (C) | 3. | (B) | 4. | (D) | 5. | (A) | 6. | (C) | 7. | (A) | 8. | (D) | 9. | (C) |
| **1.11 :** | 1. | (A) | 2. | (C) | 3. | (C) | 4. | (B) | 5. | (A) | 6. | (B) | 7. | (C) | 8. | (B) | | |
| **1.12 :** | 1. | (B) | 2. | (C) | | | | | | | | | | | | | | |
| **1.13 :** | 1. | (B) | 2. | (D) | 3. | (C) | 4. | (C) | 5. | (B) | | | | | | | | |
| **1.14 :** | 1. | (A) | 2. | (D) | 3. | (B) | 4. | (C) | 5. | (C) | 6. | (A) | | | | | | |
| **Misc.:** | 1. | (A) | 2. | (B) | 3. | (B) | 4. | (C) | 5. | (B) | | | | | | | | |

## Practice Problems

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.1 :** | 1. | (D) | | | | | | | | | | | | | | |
| **1.2 :** | 1. | (B) | 2. | (B) | | | | | | | | | | | | |
| **1.4 :** | 1. | (D) | | | | | | | | | | | | | | |
| **1.5 :** | 1. | (A) | 2. | (C) | 3. | (A) | | | | | | | | | | |
| **1.7 :** | 1. | (D) | 2. | (D) | 3. | (A) | 4. | (A) | | | | | | | | |
| **1.8 :** | 1. | (A) | 2. | (C) | | | | | | | | | | | | |
| **1.9 :** | 1. | (D) | 2. | (C) | 3. | (C) | 4. | (C) | 5. | (B) | 6. | ( | | | | |
| **1.11 :** | 1. | (A) | | | | | | | | | | | | | | |
| **Misc.:** | 1. | (C) | 2. | (D) | | | | | | | | | | | | |

## Diagram Based Problems

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1. | (A) | 2. | (D) | 3. | (B) | 4. | ( | 5. | (D) | 6. | (B) | 7. | (D) | 8. | (C) |

## Problems To Ponder

| | | | | |
|---|---|---|---|---|
| | 1. | (B) | 2. | (D) |

## Hints to MCQs

### Concept Building Problems

#### 1.1 Classification of Solids

2. Amorphous solids exhibit isotropy. Among the given options, quartz glass is an amorphous solid and thus, it exhibits isotropy.

#### 1.2 Classification of Crystalline Solids

3. Metals contain free electrons which absorb light at one angle and transmit at a different angle. Hence, metals have lustre.

5. Diamond is a covalent or network solid and is a poor conductor of electricity.

#### 1.4 Bragg's Law and its Applications

1. $n = 1, d = 3$ Å, $\theta = 9°$
According to the Bragg's equation,
$n\lambda = 2d \sin\theta$
$\lambda = \frac{2d\sin\theta}{n} = \frac{2\times3\times\sin9°}{1}$
$= 6 \times 0.1564 = 0.94$ Å

#### 1.5 Seven Crystal Systems

1. A rhombohedral unit cell has all the sides of equal length.

3. The triclinic system has all the three sides different ($a \neq b \neq c$) and all the three angles different ($\alpha \neq \beta \neq \gamma \neq 90°$). Hence, it is the most unsymmetrical crystal system. Example is $H_3BO_3$.

3. For bcc,
$\sqrt{3}\,a = 4r$
Hence, $r = \frac{\sqrt{3}}{4} \times 288$ pm

4. Since, there are four metal atoms in one unit cell, the given metal crystallizes in fcc lattice.
Using ***Smart Tip - 1 (iii)***,
$r = 0.3535\,a$
Where r = radius of the sphere
a = edge length of the unit cell = 361 pm
$r = 0.3535 \times 361 = 127.6$ pm $\approx 127$ pm

5. The packing efficiency in bcc unit cell = 68%.
$\therefore$ The percentage of vacant space of bcc unit cell = 100 – 68 = 32%.

6. packing efficiency in fcc unit cell = 74%
packing efficiency in bcc unit cell = 68%
packing efficiency in sc unit cell = 52.4%

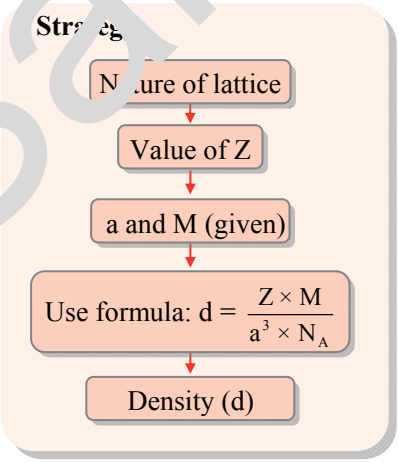
**Thinking Hatke - Q.6**
Among crystal structures, fcc type has the most efficient packing. Hence, only option (B) is valid.

8. For an fcc lattice, the nearest neighbour distance
$(D) = \frac{1}{2} \times$ face diagonal $= \frac{a}{\sqrt{2}} = \frac{640}{\sqrt{2}} = 452$ pm

9. For a bcc unit cell,
$r^+ + r^- = \frac{\sqrt{3}}{2}a$
$\therefore \quad a = \frac{275 \times 2}{\sqrt{3}}$
$= 317.5 \times 10^{-10}$ m
(since, $r^+ + r^- = 275$ pm)

## 1.9 CALCULATION OF DENSITY OF UNIT CELLS

1. **Strategy**




For bcc unit cell, Z = 2
Edge length, a = 400 pm = $400 \times 10^{-10}$ cm
Density of unit cell, $d = \frac{Z \times M}{a^3 \times N_A}\,g\,cm^{-3}$
$= \frac{2 \times 100}{(400)^3 \times (6.022 \times 10^{23}) \times 10^{-30}} = 5.189\ g/cm^3$

2. For fcc unit cell, Z = 4
Edge length = a = $x$ Å = $10^{-8}\,x$ cm,
M = 63.5 g $mol^{-1}$
$\text{Density} = \frac{Z\,M}{a^3\,N_A}\ g\,cm^{-3}$
$= \frac{4 \times 63.5\ g\ mol^{-1}}{(10^{-8}\,x\,cm)^3 \times 6.0 \times 10^{23}\ mol^{-1}}$
$= \frac{423}{x^3}\ g\ cm^{-3}$
$\therefore$ Density of copper at T (K) = $\frac{423}{x^3}\ g\,cm^{-3}$.

**CAUTION**
Ensure to convert edge length from Å to cm before substituting in the density formula.

3. $a = \pi$ Å = 3.14 Å = $3.14 \times 10^{-8}$ cm
$\therefore \quad V = (a)^3 = 3.09 \times 10^{-23}\ cm^3$
M = 128 g/mol
$\therefore \quad d = \frac{ZM}{V.N_A} = \frac{1 \times 128}{3.09 \times 10^{-23} \times 6.022 \times 10^{23}}$
$d = 6.9\ g/cm^3$

4. For bcc structure, Z = 2
$\text{Density of unit cell, } d = \frac{Z \times M}{a^3 \times N_A}\,g\,cm^{-3}$
$\therefore \quad a = \left(\frac{Z \times M}{d \times N_A}\right)^{\frac{1}{3}}$
$\therefore \quad a = \left(\frac{2 \times 6.94\ g\ mol^{-1}}{0.530\ g\ cm^{-3} \times 6.02 \times 10^{23}\ mol^{-1}}\right)^{\frac{1}{3}}$
$= \left(43.5 \times 10^{-24}\right)^{\frac{1}{3}} = 3.517 \times 10^{-8}$ cm
$= 351.7$ pm $\approx 352$ pm

**Thinking Hatke - Q.4**
We know that $\sqrt[3]{27} = 3$ and $\sqrt[3]{64} = 4$.
Therefore, $\sqrt[3]{43.5 \times 10^{-24}}$ will lie between $3 \times 10^{-8}$ and $4 \times 10^{-8}$ (i.e., between 300 pm and 400 pm).
So, only option (D) is valid.

2. 12 atoms are present at 12 corners. Each one contributes $\frac{1}{6}$ to each unit cell.

2 atoms are present at each face. Each one contributes $\frac{1}{2}$ to each unit cell.

3 atoms are completely enclosed within the unit cell.

$\therefore \quad 12 \times \frac{1}{6} + 2 \times \frac{1}{2} + 3 = 2 + 1 + 3 = 6$

3. For fcc lattice,

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

$Z = 4$, $a = 361 \times 10^{-10}$ cm

$$d = \frac{4 \times 63.5}{\left(361 \times 10^{-10}\right)^3 \times 6.022 \times 10^{23}} = 8.96 \text{ g cm}^{-3}$$

The observed density of crystal is 9.2 g $cm^{-3}$ which is higher than the calculated density. Hence, crystal has interstitial defect.

## Practice Problems

### 1.2 Classification of Crystalline Solids

1. 'X' is calcium fluoride ($CaF_2$) which is an ionic solid. It is an insulator in solid state but conducts electricity in its fused state. It is a hard and brittle in nature.

### 1.4 Bragg's Law and its Applications

1. According to Bragg's law $n\lambda = 2d \sin\theta$

Given: $n = 2$, $d = 160$ pm, $\lambda = 160$ pm

$2 \times 160 = 2 \times 160 \sin\theta$

$\sin\theta = 1$

$\therefore \quad \theta = 90°$

### 1.7 Packing in Solids

2. In fcc unit cell, the number of tetrahedral voids is equal to twice the number of atoms per unit cell.

The number of atoms in an fcc unit cell = 4

So, the number of tetrahedral voids per unit cell = 8

Therefore, $5 \times 10^3$ unit cells have $8 \times 5 \times 10^3 = 4 \times 10^4$ voids

3. Number of oxide ions in ccp array, n = 4

Number of X ions occupying tetrahedral voids $= \frac{1}{5} \times 2n = \frac{1}{5} \times 2 \times 2 = \frac{8}{5}$

Number of Y ions occupying octahedral voids $= \frac{1}{2} \times n = \frac{1}{2} \times 4 = 2$

Ratio of X : Y : O

$= \frac{8}{5} : 2 : 4 = 8 : 10 : 20 = 4 : 5 : 10$

$\therefore$ Formula of the compound is $X_4Y_5O_{10}$.

4. From radius ratio rule:

For MgS, $\frac{r_{Mg^{2+}}}{r_{S^{2-}}} = \frac{0.65}{1.84} = 0.353$

$\Rightarrow$ tetrahedral structure with coordination number of cation = 4.

For MgO, $\frac{r_{Mg^{2+}}}{r_{O^{2-}}} = \frac{0.65}{1.40} = 0.464$

$\Rightarrow$ octahedral structure with coordination number of cation = 6

For CsCl, $\frac{r_{Cs^+}}{r_{Cl^-}} = \frac{1.69}{1.81} = 0.934$

$\Rightarrow$ Cubic structure with coordination number of cation = 8.

### 1.8 Packing Efficiency

1. Using *Smart Tip - 1 (i)*,

Radius of atom forming simple cubic lattice ($r_1$) = 0.5000 a

Using *Smart Tip - 1 (ii)*,

Radius of atom forming bcc lattice ($r_2$) = 0.4330 a

Using *Smart Tip - 1 (iii)*,

Radius of atom forming fcc lattice ($r_3$) = 0.3535 a

Ratio = $r_1 : r_2 : r_3 = 0.5000 : 0.4330 : 0.3535$

$= \frac{0.5000}{0.3535} : \frac{0.4330}{0.3535} : \frac{0.3535}{0.3535}$

$= 1.41 : 1.22 : 1$

**Thinking Hatke - Q.1**

Since edge length (a) is same, the relation between $r_1$ (sc), $r_2$ (bcc) and $r_3$ (fcc) lattice will be: $r_1 > r_2 > r_3$

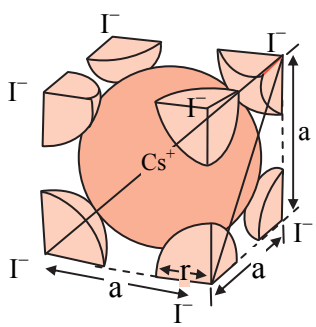
Therefore, only option (A) is valid.

2. For a body-centred cubic lattice of CsI with edge length 'a', the length of body diagonal = $\sqrt{3}$ a.

But the length of the body diagonal is also equal to $2\left(r_{Cs^+} + r_{I^-}\right)$

$\therefore \quad 2\left(r_{Cs^+} + r_{I^-}\right) = \sqrt{3}\, a$

or $r_{Cs^+} + r_{I^-} = \frac{\sqrt{3}}{2} a$




**Body-centred unit cell of CsI crystal**

8. Diagram shown is that of Schottky defect. Among the given options, NaCl, KCl, CsCl, KBr and AgBr show Schottky defect.

## Numerical Value Type Questions

1. For fcc unit cell, Z = 4.

Number of particles in '$x$' g = $\frac{xZ}{da^3}$

Number of atoms in 256 g

$= \frac{256 \times 4}{8 \times (400 \times 10^{-10})^3} = 2 \times 10^{24}$

$\therefore$ Value of N = 2

3. In fcc unit cell, the number of tetrahedral voids is equal to twice the number of atoms per unit cell.

The number of atoms in fcc unit cell = 4

$\therefore$ No. of tetrahedral voids per unit cell = 8

$\therefore$ $5 \times 10^4$ unit cells have $8 \times 5 \times 10^4$

$= 4 \times 10^5$ tetrahedral voids

Therefore,value of $x$ is 5.

4. For fcc unit cell, $r = \frac{a}{2\sqrt{2}}$

$\therefore$ Edge length (a) = $2\sqrt{2} \times r = 2\sqrt{2} \times 25$ pm

Number of unit cells in volume (V) of metal

$= \frac{V}{a^3}$

$\therefore$ Number of unit cells in 1.00 $cm^3$ of metal

$= \frac{1.00}{\left(2\sqrt{2} \times 25 \times 10^{-10}\right)^3} = \frac{1.00 \times 10^{30}}{\left(\sqrt{2} \times 50\right)^3}$

$= \frac{100 \times 100 \times 100 \times 10^{24}}{\left(\sqrt{2}\right)^3 \times 50 \times 50 \times 50} = \frac{2 \times 2 \times 10^{24}}{\sqrt{2} \times \sqrt{2} \times \sqrt{2}}$

$= 2.8 \times 10^{24}$

Therefore value of $x$ = 24.

5. The type of unit cell is fcc.

Using *Short Tip 1 (iii)*,

r = 0.3535 a

Where r = radius of the sphere

= edge length of the unit cell = 620 pm

r = 0.3535 × 620 = 219.17 pm

6.

| Substance | Magnetic property |
|---|---|
| $Fe_3O_4$ | Ferrimagnetic |
| $MgFe_2O_4$ | Ferrimagnetic |
| $CrO_2$ | Ferromagnetic |
| $ZnFe_2O_4$ | Ferrimagnetic |
| MnO | Antiferromagnetic |
| $H_2O$ | Diamagnetic |

7.

| Atom/ion | Location | Contribution to a unit cell |
|---|---|---|
| A | Corners of cube | ⅛ × 8 = 1 |
| B | Centres of 5 faces (since one atom is missing) | ½ × 5 = 5/2 |
| Ratio | A : B = 1 : 5/2 = 2 : 5 | |
| Formula | $A_2B_5$ | |

Therefore, value of y is 5.

## Problems To Ponder

1. Number of formula units in unit cell of NaCl = 4

Number of formula units missing per unit cell

$= 4 \times \frac{1.2}{100} = 0.048$

Therefore, number of formula units in a unit cell of NaCl having defects = 4 – 0.048 = 3.952

Observed density = d = $\frac{ZM}{a^3 \times N_A}$

$= \frac{3.952 \times 58.5}{1.8 \times 10^{-22} \times 6.022 \times 10^{23}} = 2.13 \text{ g cm}^{-3}$

Calculated density = d = $\frac{ZM}{a^3 \times N_A}$

$= \frac{4 \times 58.5}{1.8 \times 10^{-22} \times 6.022 \times 10^{23}} = 2.16 \text{ g cm}^{-3}$

The difference in densities = 2.16 – 2.13

= 0.03 g $cm^{-3}$

2. For fcc unit cell, radius of atom (r)

$= \frac{a}{2\sqrt{2}} = \frac{500}{2 \times 1.414} = 176.8$ pm

As octahedral void is bigger in size than tetrahedral void, the greatest sphere will fit into octahedral void.

Radius of octahedral void

= 0.414 × radius of the atom

= 0.414 × 176.8 = 73.2 pm

$\therefore$ Diameter of the greatest sphere fitting into the void = 2 × 73.2 = 146.4 pm

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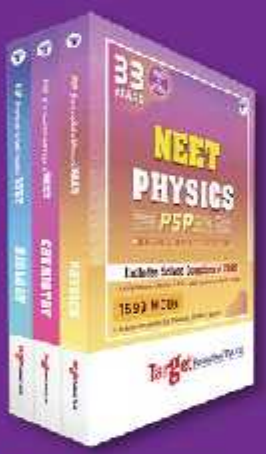


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