Solid State

Question1

A solid contains elements A and B. Anions of B form ccp lattice. Cations of A occupy 50% of octahedral voids and 50% of tetrahedral voids. What is the molecular formula of the solid?

TG EAPCET 2025 (Online) 2nd May Evening Shift

Options:

A.

AB_3

B.

A_3B_2

C.

A_2B_3

D.

AB

Answer: B

Solution:

Let the number of B atom in $ccp = N$

Number of octahedral voids $= N$

Number of tetrahedral voids $= 2N$

Number of A atoms from octahedrals voids $= \frac{N}{2}$

Number of A atoms from tetrahedral voids $= \frac{1}{2} \times 2N = N$

Total number of A atoms $= \frac{N}{2} + N = \frac{3N}{2}$

Ratio of $A : B = \frac{3N}{2} : N$ or $3 : 2$

Thus molecular formula A_3B_2.

Question2

A substance has a density of 2 g cm^{-3}. It crystallises in the fcc crystal with an edge length of 600 pm . The molar mass of the substance (in gmol^{-1}) is $\left(N_A = 6 \times 10^{23} \text{ mol}^{-1}\right)$

TG EAPCET 2025 (Online) 2nd May Morning Shift

Options:

A.

54.8

B.

64.8

C.

74.8

D.

84.7

Answer: B

Solution:

Using the formula to calculate molar mass,

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

For fcc crystal, $x = 4$,

$$M = \frac{2 \times 10^{23} \times 2.16 \times 10^{-22}}{4}$$
$$= 64.8 \text{ g/mol}$$

Question3

In bcc lattice containing X and Y type of atoms, X type of atoms are present at the corners and Y type of atoms are present at the centers. In its unit cell, if three atoms are missing in the corners, the formula of the compound is

TG EAPCET 2024 (Online) 11th May Morning Shift

Options:

A. X_5Y_8

B. X_8Y_5

C. X_3Y_5

D. X_5Y_3

Answer: A

Solution:

In a body-centered cubic (bcc) lattice consisting of two types of atoms, X and Y, X atoms are located at the corners of the unit cell, and Y atoms are at the center. To determine the formula of this compound, we need to consider the contributions of atoms in the unit cell.

Corner Atom Contribution:

In a bcc lattice, each corner atom is shared by 8 adjacent cells. Therefore, the contribution of a corner atom to one unit cell is:

Contribution of each corner atom $= \frac{1}{8}$

Effective Number of X Atoms:

Let's assume three corner X atoms are missing. Originally, all eight corners would contribute:

Total contribution of corners (without missing atoms) $= 8 \times \frac{1}{8} = 1$ atom

Since three corner atoms are missing, the effective number of atoms at the corners is:

$X = 1 - \frac{3}{8} = \frac{5}{8}$ atoms

Center Atom Contribution:

In a bcc structure, the Y atom located at the center is not shared and contributes entirely to the unit cell:

$Y = 1$ atom

Ratio of Atoms:

To find the ratio of X to Y, we equate their contributions:

$X : Y = \frac{5}{8} : 1$

By scaling this ratio to whole numbers, we multiply both by 8 to eliminate the fraction:

$X : Y = 5 : 8$

Therefore, the formula for the compound is X_5Y_8.

Question4

The molecular formula of a crystal is AB_2O_4. Oxygen atoms form ccp lattice. Atoms of A occupy $x\%$ of tetrahedral voids and atoms of B occupy $y\%$ of octahedral voids. x and y are respectively

TG EAPCET 2024 (Online) 10th May Evening Shift

Options:

A. $12.5\%, 50\%$

B. $50\%, 12.5\%$

C. $33.3\%, 66.6\%$

D. $66.6\%, 33.3\%$

Answer: A

Solution:

The molecular formula is AB_2O_4. Oxygen atoms form a ccp (cubic close-packed) arrangement.

Effective number of O atoms in ccp: 4

Number of tetrahedral voids: 8

Number of octahedral voids: 4

Atoms of A occupy tetrahedral voids, and atoms of B occupy octahedral voids.

Calculations:

Fraction of octahedral voids occupied by B:

$\frac{2}{4} \times 100 = 50\%$

Thus, $y = 50\%$ (since 2 atoms of B occupy octahedral voids).

Fraction of tetrahedral voids occupied by A:

$\frac{1}{8} \times 100 = 12.5\%$

Therefore, $x = 12.5\%$ (since 1 atom of A occupies tetrahedral voids).

Question5

An element with molar mass 2.7×10^{-2} kg mol^{-1} forms a cubic unit cell with edge length of 405 pm . If its density is 2.7×10^{3} kg m^{-3}, the number of atoms present in one unit cell of it is(Given; $N_A = 6.023 \times 10^{23}$ mol^{-1})

TG EAPCET 2024 (Online) 10th May Morning Shift

Options:

A. 2

B. 4

C. 6

D. 12

Answer: B

Solution:

Given,

Molar mass $(M) = 2.7 \times 10^{-2}$ kg/mol

Edge length $(a) = 405$pm

Density $= 2.7 \times 10^{3}$ kg/m^{3}

Density is given for unit cell by formula, $d = \frac{z \times M}{a^3 \times N_A}$

(where, z is atom per unit cell)

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

Substitute all values (known) in Eq. (i), $z = \frac{2.7 \times 10^3 \times (405 \times 10^{-12})^3 \times 6.022 \times 10^{23}}{2.7 \times 10^{-2}} = 4$

Question6

Identify the correct statement about the crystal defects in solids.

TG EAPCET 2024 (Online) 9th May Evening Shift

Options:

A. Frenkel defect is favoured when the difference between sizes of cation and anion is very small.

B. Frenkel defect is not a dislocation effect.

C. Schotthy defects have no effect on physical properties of solids.

D. Trapping of electrons in lattice leads to the formation of F-centres.

Answer: D

Solution:

Among the given statements, option (d) is correct, while all other are incorrect. Their correct forms are :

In Frenkel defect, the difference between cation and anion size is much larger,

Frenkel defect is a dislocation defect.

Schottky defect alter's the physical properties of solids.

Question7

The molecular formula of a compound is AB_2O_4. Atoms of O form ccp lattice. Atoms of A (cation) occupy $\frac{1}{8}$ th of tetrahedral voids. Atoms of B (cation) occupy a fraction of octahedral voids. What is the fraction of vacant octahedral voids?

Options:

A. $\frac{3}{4}$

B. $\frac{1}{4}$

C. $\frac{1}{3}$

D. $\frac{1}{2}$

Answer: D

Solution:

In AB_2O_4, the number of atom/ions ratio, $A^{2+} : B^{3+} : O^{2-} = 1 : 2 : 4$ (spinel structure) ... (i)

$\Rightarrow$ Considering their occupied positions,

$$\begin{array}{ccc} A^{2+} & : B^{3+} & : 0^{-} \\ \left(\frac{1}{8} \times \text{Tv}\right) & \left(\frac{1}{x} \times \text{OV}\right) & (\text{CCP}) \end{array}$$

$$\begin{bmatrix} \because \text{ TV } = \text{ Tetrahedral void} \\ \text{OV } = \text{ octahedral void} \end{bmatrix}$$

$$= \frac{1}{8} \times 8 : \frac{1}{x} \times 4 : 4$$

$$= 1 \quad : \frac{4}{x} \quad : 4 \quad \ldots \text{(ii)}$$

$\Rightarrow$ Comparing Eqs. (i) and (ii),

$$\frac{4}{x} = 2$$

$$\frac{1}{x} = \frac{2}{4} = \frac{1}{2}$$

Question8

Identify the crystal system in which primitive unit cell has edge lengths $a = b = 200\text{pm}$ and $c = 300\text{pm}$ and all axial angles are same

TS EAMCET 2023 (Online) 12th May Evening Shift

Options:

A. tetragonal

B. rhombohedral

C. monoclinic

D. cubic

Answer: A

Solution:

In tetragonal crystal system, two edge lengths are same while one is different and all axial angles are same i.e. $a = b \neq c, \alpha = \beta = \gamma = 90^{\circ}$.

Question9

Assertion (A) Graphite is used as a dry lubricant in machines which run at high temperatures.

Reason (R) The layers of graphite slip one over the other when pressure is applied.

The correct option among the following is

TS EAMCET 2023 (Online) 12th May Morning Shift

Options:

A. (A) is true but (R) is false

B. (A) is false but (R) is true

C. (A) and (R) are true and (R) is the correct explanation of (A)

D. (A) and (R) are true, but (R) is not the correct explanation of (A)

Answer: C

Solution:

Let's break down the statements:

Statement (A) says that graphite is used as a dry lubricant in machines running at high temperatures. This is true because graphite maintains its lubricating properties even at high temperatures, making it suitable for such applications.

Statement (R) explains that the layers of graphite slip over each other when pressure is applied. This is also true. Graphite has a layered structure where the layers are weakly held together by van der Waals forces, allowing the layers to easily slide past one another, which is the key reason for its lubricating properties.

Since both statements are true and (R) correctly explains why graphite works as a dry lubricant, the correct answer is:

Option C: (A) and (R) are true and (R) is the correct explanation of (A).

Question10

At $T(\mathrm{~K})$, copper (atomic mass $=63.5 \mathrm{u}$) has fce structure with an edge length of x. The density of copper (in gcm^{-3}) at that temperature approximately is $\left(N_A=6.0 \times 10^{23} \mathrm{~mol}^{-1}\right)$

TS EAMCET 2023 (Online) 12th May Morning Shift

Options:

A.

$\frac{423}{x}$

B.

$\frac{4.23}{x^3}$

C.

$\frac{423}{x^3}$

D.

$\frac{212.5}{x^3}$

Answer: C

Solution:

To calculate the density of copper, given its face-centered cubic (fcc) unit structure, we will use the following information:

Edge length $= x$ Å

Atomic mass of copper (Cu) $= 63.5\,\text{u}$

Avogadro's number $N_A = 6.0 \times 10^{23}\,\text{mol}^{-1}$

Number of atoms per fcc unit cell $Z = 4$

The formula to calculate the density d of a crystalline structure is given by:

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

Where:

Z is the number of atoms per unit cell

M is the atomic mass

a^3 is the volume of the unit cell in cubic centimeters (since $a = x \times 10^{-8}\,\text{cm}$ for edge length x Å)

N_A is Avogadro's number

Substituting the given values into the equation:

$d = \frac{4 \times 63.5}{(x \times 10^{-8})^3 \times 6.0 \times 10^{23}}$

Simplifying further:

$d = \frac{254}{6 \times x^3 \times 10^{-24}}$

$d = \frac{254 \times 10^{24}}{6 \times x^3}$

$d = \frac{2540}{6 \times x^3}$

$d = \frac{423}{x^3}\ \text{g/cm}^3$

Therefore, the density of copper at the given temperature, expressed in grams per cubic centimeter, is approximately $\frac{423}{x^3}\ \text{g/cm}^3$.
