Chemistry Worksheets Class 12 on Chapter 1 Solid State with Answers - Set 4

Q-1: An octahedral void is surrounded by ___ spheres.

a) 4
b) 6
c) 8
d) 12

Answer: (b.)

Explanation: An octahedral void is surrounded by six spheres.

Q-2: Schottky defect is observed when:

a) An unequal number of cations and anions are missing from the lattice
b) An equal number of cations and anions are missing from the lattice
c) Anions occupy the interstitial site
d) Density of the crystal is decreased

Answer: (b.)

Explanation: Schottky defect is observed when an equal number of cations and anions are missing from the lattice.

Q-3: A and B form a cubic structure in which A atoms occupy the corners of the cube and B atoms lie at the face centres. Derive the formula of the compound.

Answer: A atoms occupy the corners of the cube.
Contribution of A atom at one corner of the cube = ⅛
So, number of A atoms present in one unit cell (having 8 corners) = ⅛ x 8 = 1
B atoms are present at the face centres and a cube has 6 faces.
Contribution of B atom at one face of the cube (having 6 faces) = ½
So, number of B atoms present in one unit cell = ½ x 6 = 3
Hence, A and B exist in the ratio of 1:3 in one unit cell.
Hence, the formula of the compound formed by A and B is AB_3.

Q-4: The number of tetrahedral holes in a close packed array of N-spheres is:

a) N/2
b) N

c) 2N
d) 4N

Answer: (c.)

Explanation: The number of tetrahedral holes in a close packed array of N-spheres is 2N and that of octahedral holes is N. For instance, in a FCC unit cell containing 4 atoms, the number of tetrahedral voids is 8 and that of octahedral voids is 4.

Q-5: The B anions in a crystalline structure are arranged in a cubic close packing. The A cations are distributed equally among the tetrahedral and octahedral voids. Calculate the formula of the solid if all its octahedral voids are occupied.

Answer: Let us assume the number of anions B = N
So, the number of octahedral voids = N
The number of tetrahedral voids = 2N
Given that the cations A are equally distributed among the octahedral and the tetrahedral voids, and the octahedral voids are completely filled. This implies that N number of cations A are present in each of the octahedral and tetrahedral voids.
This means that in total, N anions of B and (N + N) cations of A are present in the solid. Thus, the ratio of cations (A) and anions (B) are 2N:N = 2:1.
∴ the formula of the solid must be A_2B.

Q-6: The geometry of the match box is:

a) Cubic
b) Monoclinic
c) Tetragonal
d) Orthorhombic

Answer: (d.)

Explanation: For a orthorhombic structure, the dimensions of the unit cell are:

$$a \neq b \neq c; \text{ and}$$
$$\alpha = \beta = \gamma = 90^o$$

The length of all sides of the orthorhombic unit cell are different from each other with all angles being equal to 90º. Hence, the geometry of the match box is orthorhombic.

Q-7: In a solid AB with a CsCl type structure, the length of the edge of the unit cell is 404 pm. Calculate the closest approach distance between the cations A^+ and the anions B^-.

Answer: Given a = 404 pm

To determine the distance of the closest approach between the cations and the anions, the distance between the nearest neighbours i.e. d must be calculated.
Now, as CsCl has a BCC structure, the nearest neighbour distance for the given solid is:

$$d = (\sqrt{3}/2)a = (1.732/2) \times 404 = 349.9 \text{ pm}$$

Hence, the closest approach distance between the cations A^+ and the anions B^- is 349.9 pm.

Q-8: The radius of the cation and anion of the MgO crystal are 65 pm and 140 pm respectively. Find the coordination number of the cation and the structure of the MgO crystal.

Answer: The coordination number and the structure can be predicted by the radius ratio of the cation and the anion.

$$\text{Radius Ratio} = \text{Radius of the cation } (r_+) / \text{Radius of the anion } (r_-)$$

$$\text{Radius Ratio} = r_+/r_- = 65 / 140 = 0.464$$

The obtained value of the radius ratio lies in the range of 0.414 - 0.732.
Hence, the coordination number of the cation is 6 and the structure of the MgO crystal is octahedral.

Q-9: How many chloride ions are present around the sodium ion in a sodium chloride crystal?

a) 3
b) 4
c) 6
d) 8

Answer: (c.)

Explanation: In the sodium chloride crystal, every ion is surrounded by 6 other counter ions.

Q-10: Explain why the LiCl crystal acquires a pink hue when it is heated in Lithium (Li) vapours.

Answer: This happens because an excess of Lithium atoms create the F-centres in the LiCl crystal. On heating, the Li atoms get oxidised to Li^+ ions by leaving an electron and the negative ions (Cl^-) from the crystal (LiCl) leave the lattice sites creating a hole. These holes are occupied by the electrons and thus create the F-centres. The entrapped electrons at the F-centres are responsible for the pink hue of the crystal.

Q-11: Define metal excess defect.

Answer: The metal excess defect is created by the stoichiometric disturbance in the ionic crystal. This happens when the negative ions leave the lattice sites creating a void or by the addition of extra cations to the crystal. In such cases, the voids are filled up by the electrons and thus these crystals are generally coloured. These solids also act as the semiconductors due to the presence of free electrons trapped in the lattice sites.

Q-12: Calculate the approximate number of unit cells present in 9.2 g of sodium that crystallises in a BCC unit cell.

Answer: The number of atoms present in 1 BCC unit cell (Z) = 2
Now, 23 g sodium contains atoms = 6.022 x 10^{23}
9.2 g sodium contains atoms = (6.022 x 10^{23} / 23) x 9.2 = 2.4022 x 10^{23} atoms
Now, 2 atoms constitute to form = 1 unit cell
2.4022 x 10^{23} atoms constitute to form unit cells = ½ x 2.4022 x 10^{23} atoms = 1.204 x 10^{23} unit cells.
Hence, the approximate number of unit cells present in 9.2 g of sodium that crystallises in a BCC unit cell is 1.204 x 10^{23}.

Q-13: Calculate the radius of the unit cell of KF lattice that crystallises in CCP structure given that the edge length of the unit cell is 400 pm. Also calculate the number of fluoride (F^-) ions and the octahedral voids present in the unit cell.

Answer: For a CCP structure, 4r = √(2a)
∴ r = √(2a) / 4 = √(2 x 400) / 4 = 141.4 pm
Hence, the radius of the unit cell of the KF lattice is 141.4 pm.
∴ The number of F^- ions and the number of octahedral voids present are 4.

Q-14: Determine the density of gold given that it crystallises in FCC unit cell. The atomic radius of gold is 0.144 nm.

Answer: The atomic mass of Gold (Au) is 197 u.
Given the atomic radius of gold is 0.144 nm.
Now, for a FCC structure, a = r(2√2)
Where r = radius of the atom
a = edge length of the unit cell
∴ a = 2 x 1.414 x 0.144 nm = 0.407 nm
This implies that the edge length of the FCC unit cell of gold is 0.407 nm.
1 nm = 10^{-7} cm
Now, for FCC structure, the number of atoms per unit cell (Z) = 4
Hence, density of gold can be calculated as:

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

Where ϱ = density of the crystal (g cm^{-3})
Z = number of particles present within the unit cell
M = Atomic mass of the element (g mol^{-1})
a = edge length of the unit cell (cm)
N_0 = Avogadro's number

$$\rho = \frac{4 \times 197\ g\ mol^{-1}}{(0.407 \times 10^{-7}\ cm)^3 \times 6.023 \times 10^{23}\ mol^{-1}} = 19.4\ g\ cm^{-3}$$

Hence, the density of gold that crystallises in FCC unit cell is 19.4 g cm^{-3}.

Q-15: The coordination number of a metal that crystallises in a hexagonal close packed structure is:

a) 12
b) 8
c) 6
d) 4

Answer: (a.)

Explanation: The coordination number of a metal that crystallises in a hexagonal close packed structure is 12.

Q-16: Classify as n-type or p-type semiconductor:
a.) Si doped with P
b.) Si doped with In

Answer: a.) Since Si belongs to group 14, doping with P will infuse an extra electron for each atom of Si replaced. Hence, this is a n-type semiconductor.
b.) Since Si belongs to group 14, doping with In will infuse one less electron for each atom of Si replaced. Hence, this is a p-type semiconductor.

Q-17: The holes can exist in _____.

a) Semiconductors
b) Metals
c) Insulators
d) None of the above

Answer: (a.)

Explanation: At 0 K, the semiconductors behave as insulators as there is no excitement of valence electrons to the conduction band. However, as the temperature rises to room temperature, many electrons jump from the valence band to the conduction band. Hence, holes are created everywhere in the semiconductors.

Q-18: The radius of the cations in a close packed AB type solid is 75 pm. Calculate the maximum and minimum possible sizes of the anions that fill into the voids.

Answer: For a close packed structure, the radius ratio lies in the range 0.414 - 0.732.

$$\text{Radius Ratio} = r_+ / r_- = 0.414 - 0.732$$

∴ minimum value of $r_- = r_+ / 0.732 = 102.5$ pm

Maximum value of $r_- = r_+ / 0.414 = 181.2$ pm
Hence, the maximum and minimum possible sizes of the anions that fill into the voids are 102.5 pm and 181.2 pm respectively.

Q-19: In a BCC arrangement, the radius of an atom of an element is 75 pm. Calculate the edge length of the unit cell.

Answer: In a BCC structure, $r = (\sqrt{3}/4)a$
Where r = radius of the atom
a = edge length of the unit cell
Hence, $a = 4r / \sqrt{3} = (4 \times 75) / 1.732 = 173.2$ pm
Hence, the edge length of the unit cell is 173.2 pm.

Q-20: In a mineral having the formula $MgAl_2O_4$, the oxide ions are arranged in the cubic close packing, the Mg^{2+} ions are placed at the tetrahedral voids and the Al^{3+} ions are present at the cathedral voids.
(a.) What is the percentage of tetrahedral voids that are occupied by the Mg^{2+} ions?
(b.) What is the percentage of octahedral voids that are occupied by the Al^{3+} ions?

Answer: As per the formula, for every one Mg^{2+} ion, there are two Al^{3+} ions and 4 O^{2-} ions. As the four oxide ions (O^{2-}) are arranged in the cubic close packing, there must be 4 octahedral voids and 8 tetrahedral voids.
Thus, the Mg^{2+} ion is present in one of the 8 tetrahedral voids.
∴ the % of tetrahedral voids occupied by $Mg^{2+} = \frac{1}{8} \times 100 = 12.5\%$
Similarly, the two Al^{3+} ions are also present in the two octahedral voids.
∴ the % of octahedral voids occupied by Al^{3+}