Question1

Which of the following crystals has the unit cell such that $a = b \neq c$ and $\alpha = \beta = 90°, \gamma = 120°$?

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Options:

A. Zinc blende

B. Graphite

C. Cinnabar

D. Potassium dichromate

Answer: B

Solution:

The given crystal system is hexagonal crystal system. Among the given options only graphite will satisfy the given condition.

Question2

The number of atoms in 4.5 g of a face-centred cubic crystal with edge length 300 pm is(Given : Density $= 10$ g cm^{-3} and $N_A = 6.022 \times 10^{23}$)

Options:

A. 6.6×10^{20}

B. 6.6×10^{23}

C. 6.6×10^{19}

D. 6.6×10^{22}

Answer: D

Solution:

Given, Face centred crystal, so $Z = 4$

edge length $(a) = 300\text{pm} = 300 \times 10^{-10}$ cm
density $(d) = 10$ g/cm^3
$N_A = 6.022 \times 10^{23}$

Using the formula

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

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

$$= \frac{10 \times 6.022 \times 10^{23} \times \left(300 \times 10^{-10}\right)^3}{4}$$

$$\Rightarrow \quad M = 40.65 \text{ g}$$

So, 40.65 g contains 6.022×10^{23} atoms

Let 4.5 g contains x atom

$$\Rightarrow \quad x = \frac{6.022 \times 10^{23}}{40.65} \times 4.5 = 6.6 \times 10^{22} \text{ atoms}$$

Question3

If 'a' stands for the edge length of the cubic systems. The ratio of radii in simple cubic, body centred cubic and face centred cubic unit cells is

Options:

A. $1a : \sqrt{3}a : \sqrt{2}a$

B. $\frac{1}{2}a : \frac{\sqrt{3}}{4}a : \frac{1}{2\sqrt{2}}a$

C. $\frac{1}{2}a : \frac{\sqrt{3}}{2}a : \frac{\sqrt{2}}{2}a$

D. $\frac{1}{2}a : \sqrt{3}a : \frac{1}{\sqrt{2}}a$

Answer: B

Solution:

For simple cube,

$r = \frac{a}{2}$

For bcc, $r = \frac{a\sqrt{3}}{4}$

For fcc, $r = \frac{a}{2\sqrt{2}}$

where, $a =$ edge length, $r =$ radius

Thus, ratio of radii of the three unit cells will be $\frac{1}{2}a : \frac{\sqrt{3}}{4}a : \frac{1}{2\sqrt{2}}a$

Question4

Match the column A (type of crystalline solid) with the column B (example for each type)

	A		B
P.	Molecular solid	i.	SiC
Q.	Ionic solid	ii.	Mg
R.	Metallic solid	iii.	H_2O
S.	Network solid	iv.	MgO

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Options:

A. P - iii, Q - i, R - ii, S - iv

B. P - iv, Q - iii, R - ii, S - i

C. P - ii, Q - iv, R - iii, S - i

D. P - iii, Q - iv, R - ii, S - i

Answer: D

Solution:

To match the type of crystalline solid (column A) with the correct example (column B), we'll need to understand what characterizes each type of solid:

- **Molecular solids** are composed of molecules held together by intermolecular forces, such as London dispersion forces, dipole-dipole interactions, or hydrogen bonds.
- **Ionic solids** are formed by the electrostatic attraction between oppositely charged ions.
- **Metallic solids** consist of closely packed metal atoms arranged in a lattice where the outer electrons are delocalized over the entire solid, giving rise to metallic bonding.
- **Network solids** (also known as covalent network solids) are made up of atoms connected by covalent bonds in a continuous network extending throughout the material.

Let's identify each given substance:

- **SiC (Silicon Carbide)** is a network solid. Atoms of silicon and carbon are bonded together through strong covalent bonds, forming a rigid three-dimensional structure.
- **Mg (Magnesium)** is a metallic solid. It consists of magnesium atoms in a metallic lattice with delocalized valence electrons.
- **H_2O (Water, in solid form as ice)** is a molecular solid. The water molecules are held together by hydrogen bonds, which are a type of intermolecular force.
- **MgO (Magnesium Oxide)** is an ionic solid. It is composed of Mg^{2+} and O^{2-} ions held together by strong electrostatic forces.

Based on this information, we can now correctly match column A with column B:

- **P. Molecular solid** should be matched with **iii. H_2O** (since water ice is a molecular solid).
- **Q. Ionic solid** should be matched with **iv. MgO** (because it's composed of ions held together by ionic bonds).
- **R. Metallic solid** should be matched with **ii. Mg** (as magnesium is a metal with a metallic bond structure).
- **S. Network solid** should be matched with **i. SiC** (because silicon carbide has a network structure with covalent bonds).

The correct match is:

- P - iii
- Q - iv

- R - ii
- S - i

This combination is provided in **Option D**.

Question5

A metal crystallises in a body centred cubic lattice with the metallic radius $\sqrt{3}\overset{o}{A}$. The volume of the unit cell in m^3 is

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Options:

A. 64×10^{-29}

B. 4×10^{-29}

C. 6.4×10^{-29}

D. 4×10^{-10}

Answer: A

Solution:

$r = \sqrt{3} \ \overset{o}{A} = \sqrt{3} \times 10^{-10} \ \mathrm{m}$

For bcc,

$r = \dfrac{\sqrt{3}a}{4}$

$a = \dfrac{4r}{\sqrt{3}} = \dfrac{4 \times \sqrt{3} \times 10^{-10}}{\sqrt{3}} = 4 \times 10^{-10}$

$a^3 = 64 \times 10^{-30} = 6.4 \times 10^{-29} \ \mathrm{m}^3$

Thus, the volume of the unit cell is $6.4 \times 10^{-29} \ \mathrm{m}^3$.

Question6

In solid state, PCl_5 is a/an

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Options:

A. octahedral structure

B. ionic solid with $[PCl_6]^+$ and $[PCl_4]$

C. ionic solid with $[PCl_4]^+$ and $[PCl_6]^-$

D. covalent solid present in the form of P_2Cl_{10}

Answer: C

Solution:

PCl_5 is an ionic solid composed of $[PCl_4]^+$ ions and $[PCl_6]^-$ ions. In an ionic solid, there is a transfer of electrons between atoms, resulting in the formation these cations and anions. These opposite charged ions held together by electrostatic forces forming a crystal lattice structure.

Question7

Vacant space in body centered cubic lattice unit cell is about

KCET 2022

Options:

A. 10%

B. 23%

C. 46%

D. 32%

Answer: D

Solution:

For bcc, number of atoms $= 2$

Percentage packing fraction $= \dfrac{V_{\text{sphere}}}{V_{\text{unit cell}}} \times 100$

$= \dfrac{2 \times \frac{4}{3} \times \pi r^2}{\left(\frac{4}{\sqrt{3}}r\right)^3} \times 100 = 68\%$

∴ Fraction of free space in bcc in $100 - 68 = 32\%$.

Question8

How many number of atoms are there in a cube based unit cell, having one atom on each corner and 2 atoms on each body diagonal of cube?

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Options:

A. 6

B. 4

C. 9

D. 8

Answer: C

Solution:

Total atoms in a cube based unit cell

$= \left[\frac{8}{8} + 2 \times 4\right] = 1 + 8 = 9$

Question9

Which of the following is not true about the amorphous solids?

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Options:

A. They may become crystalline on keeping for long time.

B. Amorphous solids can be moulded by heating.

C. They are anisotropic in nature.

D. On heating they may become crystalline at certain temperature.

Answer: C

Solution:

The correct answer is Option C.

Amorphous solids are characterized by the lack of a long-range ordered structure that is typical in crystalline solids. This means that in amorphous solids, the arrangement of particles does not repeat periodically over long distances. This structure (or lack thereof) leads to different properties as compared to crystalline solids.

Let's go over each option to see why Option C is not true:

Option A: They may become crystalline on keeping for long time.

This statement is true. Amorphous solids can sometimes transition into a crystalline state if they are kept at a steady temperature for a long time, a process known as devitrification. This is because many amorphous solids are actually supercooled liquids—substances that have been cooled below their melting points without crystallization occurring—and given time, they can rearrange themselves into a crystalline structure.

Option B: Amorphous solids can be moulded by heating.

This is also true. Due to their lack of a rigid, long-range order, amorphous solids like glass and plastics can soften and become mouldable when heated. This is in contrast to crystalline solids, which usually have distinct melting points at which they transition sharply from solid to liquid.

Option C: They are anisotropic in nature.

This statement is false, which makes it the correct answer to the question. Unlike crystalline solids, amorphous solids are isotropic, not anisotropic. Isotropic materials have properties that are the same in all directions because their molecular arrangement is similar in all orientations. Anisotropy, on the other hand, is a characteristic of crystalline solids, where the properties can vary depending on the direction due to the ordered periodic arrangement of particles.

Option D: On heating they may become crystalline at certain temperature.

True, similar to Option A, amorphous solids can transition to a crystalline state when heated to certain temperatures where the thermal energy allows the particles to overcome any barriers to rearrangement into a

more ordered structure. This is usually referred to as the glass transition temperature in materials like glass or certain polymers.

Question10

Alkali halides do not show dislocation defect because

KCET 2022

Options:

A. anions cannot be accommodated in vacant spaces

B. cations and anions have almost equal size

C. there is large difference in size of cations and anions

D. cations and anions have low coordination number

Answer: B

Solution:

Generally in alkali halides, cations and anions have almost equal size, thus they do not show dislocation defect.

Question11

In chrysoberyl, a compound containing beryllium, aluminium and oxygen, oxide ions form cubic close packed structure. Aluminium ions occupy $\frac{1}{4}$ th of octahedral voids. The formula of the compound is

KCET 2021

Options:

A. $BeAlO_4$

B. $BeAl_2O_4$

C. Be_2AlO_2

D. $BeAlO_2$

Answer: B

Solution:

Given, chrysoberyl forms ccp structure.

Oxygen occupies lattice points $= N$ (say)

Al occupies $\frac{1}{2}$ of octahedral voids $= \frac{N}{2}$

Be occupies $\frac{1}{8}$ of tetrahedral voids $= \frac{2N}{8}$

$\therefore$ The formula of compound is

$$Be : Al : O$$
$$\frac{2N}{8} : \frac{N}{2} : N$$
$$\Rightarrow \quad BeAl_2O_4$$

Question12

The correct statement regarding defects in solid is

KCET 2021

Options:

A. Frenkel defect is a vacancy defect

B. Schottky defect is a dislocation defect

C. Trapping of an electron in the lattice leads to the formation of F-centre

D. Schottky defect has no effect on density

Answer: C

Solution:

The correct statements regarding defects in solid is trapping of an electron in the lattice which leads to the formation of F-centre.

Other statements are incorrect, because Frenkel defect is dislocation defect and density decreases in case of Schottky defect as it is a vacancy defect.

Question13

A metal crystallises in bcc lattice with unit cell edge length of 300 pm and density 615 g cm^{-3}. The molar mass of the metal is

KCET 2021

Options:

A. 50 g mol^{-1}

B. 60 g mol^{-1}

C. 40 g mol^{-1}

D. 70 g mol^{-1}

Answer: A

Solution:

Given, metal crystallises in bcc lattice, therefore $Z = 2$

$$\begin{aligned} \text{Edge length} &= 300\text{pm} \\ &= 300 \times 10^{-10} \text{ cm} \end{aligned}$$

Density,

$$d = \frac{ZM}{a^3 N_A} \Rightarrow M = \frac{da^3 N_A}{Z}$$

$$= \frac{6.15 \times \left(300 \times 10^{-10}\right)^3 \times 6 \times 10^{23}}{2}$$

$$= 498150000 \times 10^{-7}$$

$$= 49.82 \text{ g mol}^{-1}$$

$$\cong 50 \text{ g mol}^{-1}$$

Question14

A metal crystallises in face centred cubic structure with metallic radius $\sqrt{2}\overset{o}{A}$. The volume of the unit cell (in m^3) is

KCET 2020

Options:

A. 4×10^{-10}

B. 6.4×10^{-29}

C. 4×10^{-9}

D. 6.4×10^{-30}

Answer: B

Solution:

For a face-centred cubic (FCC) structure, the relation between the edge length (a) and the atomic radius (r) is given by:

$a = 2\sqrt{2}r$

Given the metallic radius (r) is $\sqrt{2}\overset{o}{A}$:

$r = \sqrt{2}\overset{o}{A} = \sqrt{2} \times 10^{-10}$ m

Thus, the edge length (a) becomes:

$a = 2\sqrt{2} \times \sqrt{2} \times 10^{-10}$ m $= 4 \times 10^{-10}$ m

The volume of the unit cell (V) in cubic meters is given by:

$V = a^3$

Substituting the edge length:

$V = \left(4 \times 10^{-10} \text{ m}\right)^3 = 64 \times 10^{-30} \text{ m}^3 = 6.4 \times 10^{-29} \text{ m}^3$

Therefore, the correct volume of the unit cell is:

Option B

$6.4 \times 10^{-29} \; \mathrm{m}^3$

Question15

Silicon doped with gallium forms

KCET 2020

Options:

A. n-type semiconductor

B. both n and p-type semiconductor

C. an intrinsic semiconductor

D. p-type semiconductor

Answer: D

Solution:

Silicon belongs to group 14 and gallium comes in group 13. So, when Si is doped with Ga, p-type of semiconductor is produced as group 13 elements have only 3 valence electrons, there on combination with group 14 elements produce an electron deficient bond or have electron vacancy and as such can move through the crystal like a positive charge giving rise to electrical conductivity.

Question16

Which of the following is a network crystalline solid?

KCET 2019

Options:

A. I_2

B. AIN

C. NaCl

D. Ice

Answer: B

Solution:

AlN is a network crystalline solid. It result from the formation of covalent bonds between adjacent atoms throughout the crystal. These are also called as giant molecules. These solids are very hard, brittle and have extremely high melting points. They are insulators and do not conduct electricity. I_2 is a non-polar molecular solid. H_2O (ice) is a hydrogen bonded molecular solid and NaCl is an ionic solid.

Question17

The number of atoms in 2.4 g of body centred cubic crystal with edge length 200pm is (density $= 10$ g cm^{-3}, $N_A = 6 \times 10^{23}$ atoms /mol)

KCET 2019

Options:

A. 6×10^{22}

B. 6×10^{20}

C. 6×10^{23}

D. 6×10^{19}

Answer: A

Solution:

Given that edge length $(a) = 2 \times 10^{-8}$ cm

$N_A = 6 \times 10^{23}$ atoms/mol

Density $= 10$ g cm^{-3}

For bcc,

For bcc, $Z = 2$

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

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

$\qquad = \frac{10 \times (2 \times 10^{-8})^3 \times 6.02 \times 10^{23}}{2} = 24 \text{ g/mol}$

1 mol (i.e. 6.022×10^{23} atoms) contains 24 g.

Hence, 2.4 g contains 6.02×10^{22} atoms.

Question18

1 mole of $NaCl$ is doped with 10^{-5} mole of $SrCl_2$. The number of cationic vacancies in the crystal lattice will be

KCET 2019

Options:

A. 6.022×10^{18}

B. 6.022×10^{15}

C. 6.022×10^{23}

D. 12.044×10^{20}

Answer: A

Solution:

Key Idea Addition of $SrCl_2$ to the $NaCl$ results in formation of impurity defects. Here, each Sr^{2+} replaces two Na^+ ions.

When 1 mole of $NaCl$ is doped with little amount of $SrCl_2$ then some of the sites of Na^+ ions are occupied by Sr^{2+}. Each Sr^{2+} ion replaces two Na^+ ions. The cationic vacancies thus produced are equal in number to that of Sr^{2+} ions. Hence, addition of one Sr^{2+} produces one vacancy.

$\therefore$ Addition of 10^{-5} mole produces $6.022 \times 10^{23} \times 10^{-5} = 6.022 \times 10^{18}$ vacancies

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Question19

In FCC, the unit cell is shared equally by how many unit cells?

KCET 2018

Options:

A. 10

B. 8

C. 6

D. 2

Answer: C

Solution:

FCC unit-cell is shared equally by six unit cells.

one each at left and right of the given unit cell.

one each at the top and the bottom of the given unit cell.

one each in front and in the back-side of the given unit cell.

∴ (c) is the correct option.

Question20

Edge length of a cube is 300 pm . Its body diagonal would be

KCET 2018

Options:

A. 600 pm

B. 423 pm

C. 519.6 pm

D. 450.4 pm

Answer: C

Solution:

To find the body diagonal of a cube when the edge length is given, you can use the formula:

Body diagonal $= a\sqrt{3}$

where a is the edge length of the cube.

Here's how we solve it step-by-step:

The edge length of the cube is given as $a = 300$ pm.

Substitute the value of a into the formula:

Body diagonal $= 300$ pm $\times \sqrt{3}$

Approximating $\sqrt{3} \approx 1.732$, we get:

Body diagonal $\approx 300 \times 1.732$ pm ≈ 519.6 pm

Therefore, the body diagonal of the cube is approximately 519.6 pm.

The correct answer is Option C: 519.6 pm.

Question21

In a face centred cubic arrangement of A and B atoms in which ' A ' atoms are at the corners of the unit cell and ' B ' atoms are at the face centres. One of the ' A ' atoms is missing from one corner in unit cell.The simplest formula of compounds is

KCET 2017

Options:

A. A_7B_8

B. A_7B_3

C. AB_3

D. A_7B_{24}

Answer: D

Solution:

In a face-centered cubic (fcc) arrangement of A and B atoms, 'A' atoms are positioned at the corners of the unit cell, while 'B' atoms are located at the face centers. Due to one 'A' atom being absent from a corner in the unit cell, the calculation of atoms becomes crucial to determining the simplest formula of the compound.

Calculation for Atoms of A:

Typically, there are 8 corners, with each corner contributing $\frac{1}{8}$ of an atom to the unit cell.

However, since one corner is missing an 'A' atom, there are only 7 corners occupied by 'A'.

Therefore, atoms of 'A': $7 \times \frac{1}{8} = \frac{7}{8}$.

Calculation for Atoms of B:

There are 6 face-centered positions, each contributing $\frac{1}{2}$ of an atom to the unit cell.

Thus, atoms of 'B': $6 \times \frac{1}{2} = 3$.

Ultimately, the empirical formula reflecting the simplest ratio of atoms in the compound is A_7B_{24}.

Question22

The correct statement regarding defect in solids is

KCET 2017

Options:

A. Frenkel defect is usually favoured by a very small difference in the sizes of cations and anions

B. Frenkel defect is a dislocation defect

C. Trapping of proton in the lattice leads to the formation of F-centres.

D. Schottky defect has no effect on the physical properties of solids.

Answer: B

Solution:

Frenkel defect is a dislocation defect because in this defect an atom is displaced from its lattice position to an interstitial site.

Question23

Which of the following crystal has unit cell such that $a \neq b \neq c$ and $\alpha \neq \beta \neq \gamma \neq 90°$?

KCET 2017

Options:

A. $NaNO_3$

B. K_2SO_4

C. KNO_3

D. $K_2Cr_2O_7$

Answer: D

Solution:

Identifying Triclinic Crystals

The question examines which of the given crystals features a unit cell where the conditions $a \neq b \neq c$ and $\alpha \neq \beta \neq \gamma \neq 90°$ are satisfied. These conditions describe the triclinic crystal system. Let's evaluate each option:

Sodium Nitrate ($NaNO_3$**):** This crystal is trigonal, which does not match the triclinic system.

Potassium Nitrate (KNO_3**):** This compound exists in polymorphic forms. β-KNO3 is known to be orthorhombic at room temperature, thus not triclinic.

Potassium Sulfate (K_2SO_4**):** This material crystallizes in the orthorhombic system, again not fitting the triclinic criteria.

Potassium Dichromate ($K_2Cr_2O_7$**):** This is the crystal that fits the triclinic description, with its space group $P\bar{1}$.

Thus, the correct choice is Potassium Dichromate ($K_2Cr_2O_7$), as it crystallizes in the triclinic crystal system where the lattice parameters follow the given conditions.