Date: 09/11/2021

Subject: Chemistry

Topic : Solid State   Class: Standard XII

1. Which among the following will show anisotropy?

    ✗ **A.** Quartz glass

    ✔ **B.** $NaBr$

    ✗ **C.** Starch

    ✗ **D.** Rubber

    Anisotropic is a property of solid by which they show variation of physical properties with directions.

    Crystalline solids shows anisotropic property. This is due to the long range ordered arrangement in crystalline solids. Thus, there will be variation in physical property in different direction.

    Amorphous solids shows isotropic property which can show same value for physical properties in all directions. These solids don't show any long-range order and their arrangement is disordered. Thus, it gives same physical properties value in all directions.

    NaBr is a crystalline solid so it shows anisotropic property.
    Quartz glass, starch and rubber are amorphous solids so it shows isotropic property.

2. Lithium metal crystallises in a body-centred cubic crystal. If the length of the side of the unit cell of lithium is 351 pm, the atomic radius of lithium will be:

✔ **A.** 151.8 pm

✗ **B.** 300.5 pm

✗ **C.** 75.5 pm

✗ **D.** 240.8 pm

Since, Li crystallises in body centered cubic crystal, atomic radius,
$r = \dfrac{\sqrt{3}a}{4}$ (a = edge length)
$r = \dfrac{\sqrt{3}}{4} \times 351 = 151.8 \text{ pm}, \ a = 351 \text{ pm}$

3. Element 'B' forms ccpstructure and 'A' occupies half of the octahedral voids, while oxygen atoms occupy all the tetrahedral voids. The structure of bimetallic oxide is:

✗ **A.** A_4BO_4

✔ **B.** AB_2O_4

✗ **C.** A_2B_2O

✗ **D.** A_4B_2O

The number of element ' B ' in the crystal structure $= 4N$
Number of tetrahedral voids $= 2N$
Number of octahedral voids $= N$
Numberof'A' in the crystal = $\dfrac{N}{2} = \dfrac{4}{2} = 2$
Number of oxygen (O) atoms $= 2N = 2 \times 4 = 8$
The structure of bimetallic oxide $= A_2B_4O_8 = AB_2O_4$

4. Which primitve unit cell has unequal edge lengths $(a \neq b \neq c)$ and all axial angles are unequal and different from $90°$?

   ✗ **A.** Hexagonal

   ✗ **B.** Monoclinic

   ✗ **C.** Tetragonal

   ✔ **D.** Triclinic

Among the seven basic or primitive crystalline systems, the triclinic system is most unsymmetrical.
Triclinic primitive unit cell has dimensions as $(a \neq b \neq c)$ and $\alpha \neq \beta \neq \gamma \neq 90^0$.

5. Fraction of total volume occupied by atoms in simple cubic cell is:

   ✗   **A.** $\dfrac{\pi}{2}$

   ✗   **B.** $\dfrac{\sqrt{3}\pi}{8}$

   ✗   **C.** $\dfrac{\sqrt{2}\pi}{6}$

   ✔   **D.** $\dfrac{\pi}{6}$

We know that,

Effective number of atoms present in simple cubic structure $= \dfrac{1}{8} \times 8 = 1$

Volume occupied by an atom in simple cubic structure is $1 \times \dfrac{4}{3}\pi r^3$

In simple cubic structure, atoms are present in corners of the cube and they will be touching each other, hence
$\text{Edge length} = 2 \times \text{radius}$
$a = 2 \times r$

Fraction of volume occupied by atoms in simple cube $= \dfrac{\dfrac{4}{3}\pi r^3}{a^3}$

Substituting, $r = \dfrac{a}{2}$

Fraction of volume occupied by atoms in simple cube $= \dfrac{\dfrac{4}{3}\pi \left(\dfrac{a}{2}\right)^3}{a^3}$

Fraction of volume occupied by atoms in simple cube $= \dfrac{\dfrac{4}{3}\pi \left(\dfrac{a^3}{8}\right)}{a^3}$

$\qquad = \dfrac{\pi}{6}$

6. In a solid AB having the $NaCl$ structure, 'A' atoms occupy the corners of the cubic unit cell. If all the face centred atoms along one of the axes are removed, the resultant stoichiometry of the solid is:

    ✗ **A.** AB_2

    ✗ **B.** A_2B

    ✗ **C.** A_4B_3

    ✓ **D.** A_3B_4

    Face centred atoms along one of the axis = 2

    Effective number of A^- or Cl^- (normally) $= \left(8 \times \dfrac{1}{8}\right) + \left(6 \times \dfrac{1}{2}\right) = 4$

    Effective number of A^- after removing atoms along one axes
    $= \left(8 \times \dfrac{1}{8}\right) + \left(4 \times \dfrac{1}{2}\right) = 3$

    Effective number of B^+ or $Na^+ = \left(12 \times \dfrac{1}{4}\right) + 1 = 4$

    $\therefore$ The formula is A_3B_4.
    Hence (D) is correct option.

7. How many space lattices (bravais lattices) are obtainable from the different crystal systems?

    ✗ **A.** 4

    ✗ **B.** 7

    ✓ **C.** 14

    ✗ **D.** 8

    There are seven unique and basic unit cell shapes (primitive unit cells) with varying elements of symmetry in a three-dimensional space.

8. If we mix a pentavelent impurity in a crystal lattice of Germanium, what type of semiconductor formation will occur?

✔ **A.** n-type semiconductor

✘ **B.** p-type semiconductor

✘ **C.** Both (A) and (B)

✘ **D.** None of these

When an impurity atom with 5 valence electrons (as arsenic) is introduced in a Germanium crystal, it replaces one of the Germanium atoms. Four of the five valence electrons of the impurity atom forms covalent bonds with the neighbouring Germanium atoms and fifth valence electron becomes free to move in the crystal structure. This free electron acts as a charge carrier. Thus a Germanium crystal which is doped with a pentavalent atom is called n-type semiconductor because in it charge carriers are negative (free electrons).

9. A solid element exists in simple cubic crystal. If its atomic radius is $1.0 \overset{o}{A}$ and the ratio of packing fraction to density is $0.1 \ cm^3/g,$ then the atomic mass of the element is $(N_A \approx 6 \times 10^{23})$

✔ **A.** 8π

✘ **B.** 16π

✘ **C.** 6π

✘ **D.** 4π

Given element exist in simple cubic crystal
$\therefore$
$Z_{eff} = 1$
Atomic radius, $r = 1.0 \overset{o}{A} = 10^{-8} \ cm$
For sc,

$$\text{Packing fraction } = \frac{Z \times \text{Volume occupied by sphere}}{\text{Volume of the cube}}$$

$$\text{Packing Fraction, P.F. } = \frac{Z \times \dfrac{4}{3}\pi r^3}{a^3}$$

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

where, a is edge length of unit cell.

$$\text{Ratio of } \frac{P.F.}{\rho} = \frac{4\pi r^3 \times N_A}{3 \times M} = 0.1$$

$$\Rightarrow \frac{4\pi \times (10^{-8})^3 \times 6 \times 10^{23}}{3 \times M} = 0.1$$

$$M = 8\pi$$

10. Which of the following statements is incorrect regarding the defects in solids?

     (✗) **A.** $AgBr$ crystal show both Schottky and Frenkel defect

     (✗) **B.**   Solids containing F-centers are paramagnetic

     (✓) **C.**   Doping in crystal introduces dislocation defect

     (✗) **D.**   Metal excess defect can occur with extra cation present in the interstitial voids

$AgBr$ shows both, Frenkel as well as Schottky defects.
Thus, statement (a) is correct.

F-centers are vacant site of crystal lattice, which is occupied by electrons and can show color after excitation. Solids containing F-centers are paramagnetic, as the electrons occupying the vacant sites are unpaired.
Thus, statement (b) is correct.

Doping a different valency metal may either result in a free electron or positive hole. It does not make ions to move away from their lattice sites and occupy interstitial positions
So, statement (c) is an incorrect.

Some solids contain less amount of metal as compared to the stoichiometric proportion. These shows metal deficiency defect.
Example:
FeO is found, mostly, with a composition of $Fe_{0.95}O$. Here, loss of some Fe^{2+} ions is compensated by presence of required number of Fe^{3+} ions
So, statement (d) is correct.

11. Which of the following substances does not posses a net magnetic dipole moment in magnetic field?

   ⊗ **A.** Paramagnetic

   ⊗ **B.** Ferromagnetic

   ⊗ **C.** Ferrimagnetic

   ✔ **D.** Antiferromagnetic

Paramagnetic substances are magnetised in the same direction as the magnetic filed. Thus, they have a net magnetic moment.

In ferromagnetic substance, in presence of an applied field, domains get aligned with the applied magnetic field. The combined effect of the atomic magnetic moments results in a relatively large magnetization.

In ferrimagenetic substance, due to the unequal magnetic moments in opposite direction, resulting in a net magnetic moment in one direction. Magnetic moments of the domains are aligned in parallel and anti-parallel directions in unequal numbers.

Antiferromagnetic substances possess unpaired electrons but they do not possess net magnetic moment due to presence of equal and opposite magnetic moments.
Some metals, alloys and salts of transition elements such as $MnO, MnSe,$ etc. are examples of antiferromagnetic substances.

Thus, option (d) is correct.

12. The ionic radii of Rb^+ and I^- are 1.46 and 2.16 $\overset{o}{A}$. The coordination number for the cation is :

   ✗ **A.** 2

   ✗ **B.** 4

   ✓ **C.** 6

   ✗ **D.** 8

Ionic radii of Rb^+, $r_{Rb^+} = 1.46$ $\overset{o}{A}$

Ionic radii of I^-, $r_{I^-} = 2.16$ $\overset{o}{A}$

$\Rightarrow \dfrac{r_{Rb^+}}{r_{I^-}} = \dfrac{1.4A}{2.16} = 0.67$

Radius ratio for RbI is 0.67

Since,

$0.414 < 0.67 < 0.77$

Octahedral void is occupied.

Thus, the coordination number is 6.

13. Given below are two statements labelled as Assertion (A) and Reason (R).

   Assertion (A): The total number of atoms present in a simple cubic unit cell is one.

   Reason (B): Simple cubic unit cell has atoms at its corners, each of which is shared between eight adjacent unit cells.

   ✓ **A.** Both A and R are true and R is the correct explanation of A

   ✗ **B.** Both A and R are true but R is not the correct explanation of A

   ✗ **C.** A is true but R is false

   ✗ **D.** A is false but R is true

In simple cubic unit cell each atom is present al corners having contribution $1/8$. Hence, total number of atoms present per unit in scc is $\dfrac{1}{8} \times 8 = 1$

Thus, both Assertion and Reason are correct

14. Given below are two statements labelled as Assertion (A) and Reason (R).

    Assertion (A): The packing effieciency is maximum for fcc structure.

    Reason (B): The coordination number is 12 in the fcc structure.

    ✖ **A.** Both A and R are true and R is the correct explanation of A

    ✔ **B.** Both A and R are true but R is not the correct explanation of A

    ✖ **C.** A is true but R is false

    ✖ **D.** A is false but R is true

    Assertion and Reason both are correct statements but reason is not the correct explanation of assertion.
    Packing efficiency is maximum for fcc structure because it consists of total four atoms per unit cell. Packing efficiency is maximum in fcc structure which is equal to 74%.

15. Given below are two statements labelled as Assertion (A) and Reason (R).

    Assertion (A): Total number of octahedral voids present in the unit cell of cubic close packing including the one that is present at the body center, is four.

    Reason (B): Besides the body center there is one octahedral void present at the center of each of the six faces of the unit cell and each of which is shared between two adjacent unit cells.

    ✖ **A.** Both A and R are true and R is the correct explanation of A

    ✖ **B.** Both A and R are true but R is not the correct explanation of A

    ✔ **C.** A is true but R is false

    ✖ **D.** A is false but R is true

    Assertion is true but Reason is false.
    Correct reason is that beside the body centre there is one octahedral void at centre of each of 12 edges which is surrounded by six atoms. Out of six atoms four belongs to same unit cell (2 at corner and 2 at face centre) and 2 atoms belongs to adjacent unit cell.

16.

Column - I (Type of solid)	Column - II (Properties)
(i) Ionic solids	(A) Giant molecules
(ii) Network solids	(B) Volatile liquids or soft solid at room temperature
(iii) Metallic solids	(C) No free ion to move in solid state
(iv) Hydrogen bonded molecular solid	(D) Positive ion surrounded by sea of electrons

Which of the following is the best matched option?

✗ **A.** i-A, ii- D, iii- C, iv-B

✔ **B.** i-C, ii- A, iii- D, iv-B

✗ **C.** i-D, ii- D, iii- A, iv-B

✗ **D.** i-C, ii- B, iii- D, iv-A

In **ionic solids**, strong coulombic forces binds the ions together, so they are not free to move. However, in aqueous state or in molten state, these forces get weaker and ions get free to move so they can conduct electricity.
Network solids are intact giant molecules due to their large three dimensional structure.
In **metallic solid,** positive ions arc surrounded by the sea of electrons.
Hydrogen bonded molecular solids may be volatile liquids or soft solids at room temperature.

17. Which of the following analogies is correct?
    Graphite : Hexagonal :: Titanium dioxide :

    ✗ **A.** Triclinic

    ✓ **B.** Tetragonal

    ✗ **C.** Hexagonal

    ✗ **D.** Cubic

    Graphite belongs to hexagonal system where $a = b \neq c$ and
    $\alpha = \beta = 90^o$, $\gamma = 120^o$.
    Titanium dioxide (TiO_2) is an example of tetragonal crystal system having
    $\alpha = \beta = \gamma = 90^o$ and $a = b \neq c$

18. The crystalline solids have definite orderly arrangement of their constituent
    particles in three dimensions known as lattice. The smallest repeating part
    in the lattice is known as unit cell. The unit cell are described as simple
    cubic face centred and body centred unit cell.
    For the stable ionic crystalline structures, there is definite radius ratio limit
    for a cation to fit perfectly in the lattice of anions called radius ratio rule. This
    also defines the coordination number of an ion.
    (i) The number of atoms per unit cell in simple cubic (s), body centred (b)
    and face centred (f) unit cell decreases as:

    ✓ **A.** $f > b > s$

    ✗ **B.** $s > b > f$

    ✗ **C.** $b > f > s$

    ✗ **D.** $f > b = s$

    The number of atoms per unit cell in simple cubic $(s = 1)$, body centred
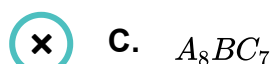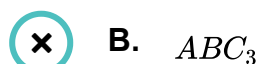 $(b = 2)$ and face centred $(f = 4)$.
    Thus decreasing order of number of atoms is:
    $f > b > s$

19. The crystalline solids have definite orderly arrangement of their constituent particles in three dimensions known as lattice. The smallest repeating part in the lattice is known as unit cell. The unit cell are described as simple cubic face centred and body centred unit cell.

For the stable ionic crystalline structures, there is definite radius ratio limit for a cation to fit perfectly in the lattice of anions called radius ratio rule. This also defines the coordination number of an ion.

(ii) In a cubic lattice ABC, A atom present at all corners except one at corner which is occupied by B atoms. C atoms are present at face centres. The formula of the compound is:

(✗) **A.** $A_7B_{24}C$

(✗) **B.** ABC_3

(✗) **C.** A_8BC_7

(✓) **D.** A_7BC_{24}

Number of atom of A $= 7 \times \dfrac{1}{8} = \dfrac{7}{8}$

Number of atom of B $= 1 \times \dfrac{1}{8} = \dfrac{1}{8}$

Number of atom of C $= 6 \times \dfrac{1}{2} = 3$

Formula of the compound is $A_{\frac{7}{8}}B_{\frac{1}{8}}C_3$ or A_7BC_{24}

20. The crystalline solids have definite orderly arrangement of their constituent particles in three dimensions known as lattice. The smallest repeating part in the lattice is known as unit cell. The unit cell are described as simple cubic face centred and body centred unit cell.

For the stable ionic crystalline structures, there is definite radius ratio limit for a cation to fit perfectly in the lattice of anions called radius ratio rule. This also defines the coordination number of an ion.

(iii) Gold crystallises in a face centred unit cell. Its edge length is 0.410 nm. The radius of gold atom is:

(×) **A.** 0.205 nm

(×) **B.** 0.290 nm

(✓) **C.** 0.145 nm

(×) **D.** 0.578 nm

Given: $a = 0.410 \text{ nm}$
As we know, in face centered unit cell,
$$r = \frac{a}{2\sqrt{2}}$$
$$= \frac{0.410}{2 \times 1.414} = 0.145 \text{ nm}$$