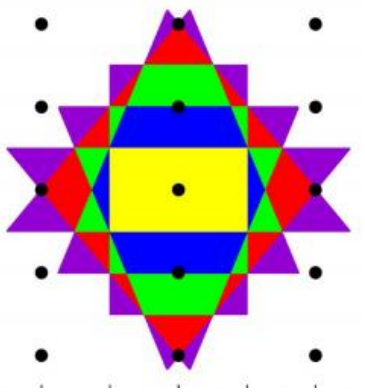
**Syllabus for Test 08**: L 18 (partial) , L 19 (partial) and L20:

L18: Brillouin Zone in 2D/3D

L19: Crystal Defects: Point defects : Vacancy, impurity, Fresnel defects, Schottky defects;

L20: Line defects: Dislocations (Screw and Edge), disclination , Surface defects: Free surface, Grain boundary, Twin Boundary, Stalking Fault, Volume defects: Pores, inclusions, cracks, Problems on crystal structure, Packing fraction of Diamond.



1. For the 2D rectangular lattice, the second, third and fifth Brillouin zones are fragmented into _____ parts, respectively.

Four, six, eight
Four, six, sixteen
Four, ten, sixteen
Four, six, twelve
Four, eight, twelve

Ans: Four, ten, sixteen

2. The following are statements about the Brillouin zones for a particular lattice:

(a) They all have the same area / volume.
(b) They all have the same shape.
(c) They all have the same symmetry.
Which one of these are true and/or false?

(a) True, (b) False, (c) True
(a) False, (b) True, (c) True
(a) True, (b) False, (c) False
(a) False, (b) False, (c) True
All are true

Ans: (a) True, (b) False, (c) True

3. The first Brillouin zone of a body centered cubic lattice is:

(a) Wigner-Seitz cell of a scaled face-centered cubic
(b) Rhombic dodecahedron
(c) Truncated octahedron

Only (a) is true
Only (b) is true
Only (c) is true
Both (a) and (b) are true
Both (a) and (c) are true

Ans: Both (a) and (b) are true

4. A small sized atom belonging to the same material occupying the void space in the parent crystal without disturbing the parent atoms from their regular sites is a type of:


dislocation defect
impurity defect
substitutional defect
interstitial defect
None of the other defects mentioned.

Ans: interstitial defect.

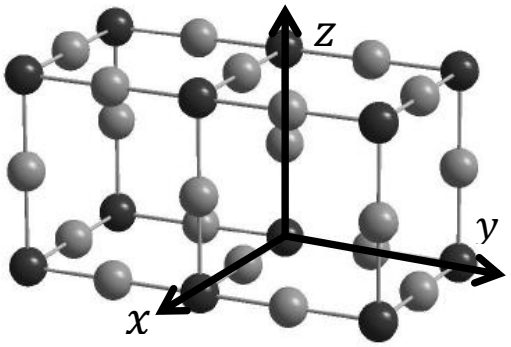
Explanation:
(a) A dislocation defect is a defect created by displacement of atoms/ions in a crystal. Its example is Frenkel defect.

(b) An impurity is a foreign atom/ion/body inside a host material.

(c) A substitutional defect is foreign atom that substitutes for or replaces a parent atom in the crystal. It is the same as impurity.

(d) In an interstitial defect, an extra atom of the host material is placed at the void between the atoms in the host crystal.

5. What type of Bravais lattice does the lattice in the figure belong to and what is the number of atoms in the basis?

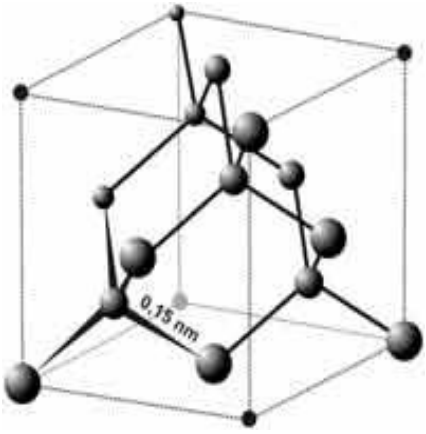



FCC, 2 atoms/basis
BCC, 2 atoms/basis
FCC, 3 atoms/basis
SC, 3 atoms/basis
SC, 4 atoms/basis

Ans: SC, 4 atoms/basis

Explanation: It is an **edge-centered cubic**. The Bravais lattice is a simple cubic lattice with 4 atom basis. The position of the atoms are: $a(0,0,0)$, $a(1/2,0,0)$ , $a(0,1/2,0)$ and $a(0,0,1/2)$

6. If $a$ is the length of a conventional unit cell of the diamond structure, what is the nearest neighbor distance between the C atoms, in terms of a?




$a/4$
$a\sqrt{2}$
$a/\sqrt{2}$
$a\sqrt{3}/4$
$a\sqrt{3}/2$

Ans: $a\sqrt{3}/4$.

Explanation: The diamond structure is an FCC structure with 2 C atoms/basis. The atoms are displaced from each other by the vector: $\vec{d} = (a/4)(\hat{\imath} + \hat{\jmath} + \hat{k})$. Since the structure is symmetric, no C atom is at any special position, the nearest neighbor distance is the same for all C atoms and is equal to $d = |\vec{d}| = a\sqrt{3}/4$.

7. The hardest material naturally occurring on earth and one of the most slippery and softest materials are both made up of the same element, i.e. carbon. The ratio of the packing fractions in the lattice structures of the hardest material to that of the the soft material i.e. PF_hardest/PF_soft is:

$3\sqrt{6}/16$
$1/2$
$3\sqrt{3}/8$
$3\sqrt{6}/8$
$3\sqrt{3}/16$

Ans: PF_hardest/PF_soft = $(\pi\sqrt{3}/16)/(\pi/(3\sqrt{2})) = 3\sqrt{6}/16$ which is approximately equal to 0.4593

8. The number of atoms in one conventional unit cell of the diamond structure is:

4
2
6
8
12

Ans: 8.

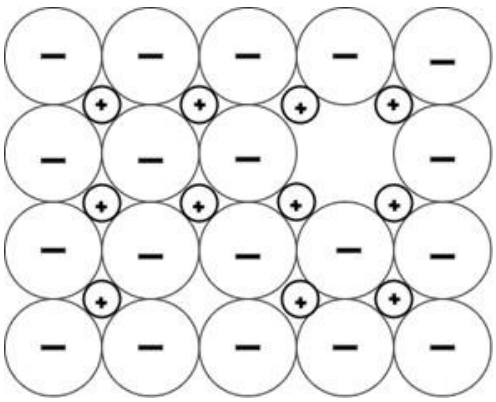
Explanation: Only four of the basis atoms sit inside the unit cube, as well as 1/8 of the 8 corner spheres and 1/2 of the 6 face centered spheres (the same as FCC). Hence the net number of atom sin the conventional unit cell is: $4 + \frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 8$

9. A displacement of the atoms in one part of a crystal relative to the rest of the crystal, in which the slip/Bergers vector is parallel to the direction of the line of the defect is called a:

Screw dislocation
Disclination
Edge dislocation
Twin boundary
Frenkel defect

Ans: Screw dislocation

10. Which defect does the following figure depict?



Vacancy defect
Schottky defect
Frenkel defect
Interstitial defect
Substitutional defect

Ans: Schottky defect.
Explanation: When a pair of positive and negative ions both disappear from a crystal lattice, the effect is called a Schottky defect.

11. Which of the following is NOT a 2-dimensional imperfection:

Twin boundary
Dislocation
Surface defect
Grain boundary
Stalking fault

Ans: Dislocation

12. Which one of the following, is not a volume defect?

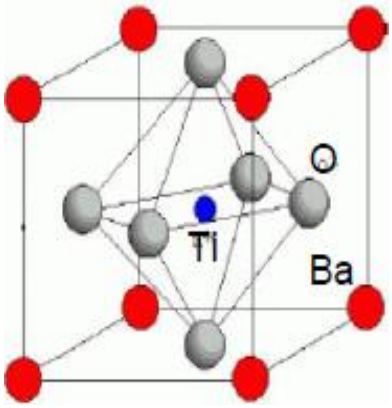
Pore
void
Cracks
Vacancy
Inclusion

Explanation: A vacancy is an empty atomic site. So vacancy is categorized as zero dimensional defect.

13. Which of the following defects decreases the density?

Substitutional impurity
Interstitial defect
Frenkel defect
Schottky defect
None of the others mentioned.

Ans: Schottky defect. Explanation: Vacancy, volume defect and Schottky defects which lead to decrease the density. In case of Frenkel defect and interstitial defect, there is no change in the density of the substance.




14. What type of Bravais lattice does the following compound has and what is the number of atoms (including different types/species) in the basis?

FCC, 4 atoms/basis
BCC, 4 atoms/basis
FCC, 3 atoms/basis
SC, 5 atoms/basis
SC, 4 atoms/basis

Ans: SC, 5 atoms/basis. The atoms are 1 Ba atom, 1 Ti atom and 4 O atoms.

15. Cations are present in the interstitial sites in which defect?

Frenkel defect
Schottky defect
Vacancy defect
Metal deficiency defect
Substitutional impurity

Answer: Frenkel defect