1.10. SYMMETRY IN SOLIDS

INTRODUCTION:

Solid is one of the states of the matter, its constituent particles have fixed positions and oscillate about their mean positions.

- In other words, a form of matter in which the ions, atoms/molecules hold strongly so that they cannot easily move away from each other are called Solid.

Solid is a rigid form of matter which has definite shape and volume.

- The word symmetry denotes a "certain pattern."
- If an object is brought into "self-coincidence" after some operation is said to possess symmetry w.r. to that operation.

Symmetry operation:

- The "movement" which keeps that object self-coincidence is called symmetry operation.
- Symmetry operations can be used to describe crystals such as
  - (i)Translation
  - (ii)Reflection
  - (iii)Rotation
  - (iv)Inversion
- **Also,** we have the hybrid operations
  - (i)Roto reflection
  - (ii)Roto inversion
  - (iii)Screw Translation
  - (iv)Glide Reflection.

Law of Crystal Symmetry:

"Every Crystal shows various types of symmetry, and all crystals of the same substance possess the same elements of symmetry."

Elements of Symmetry (or) Types of symmetry:

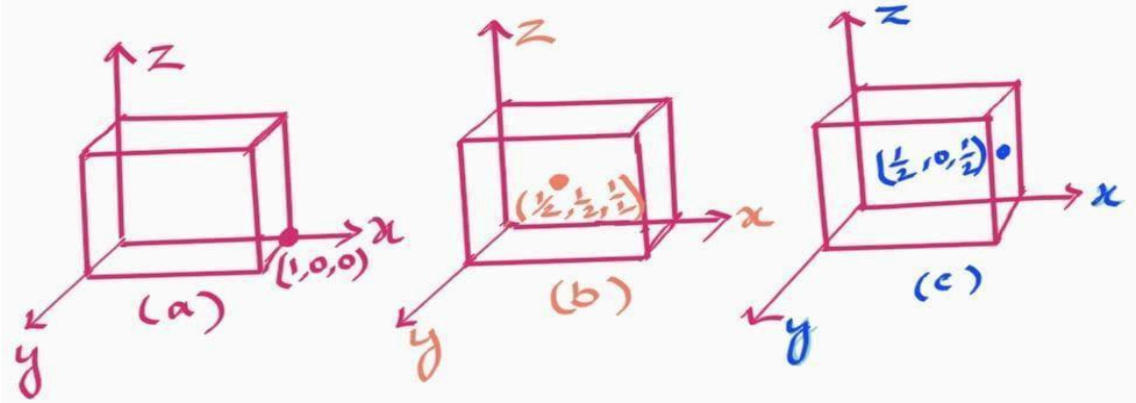
- Various types of symmetry in a crystal are known as elements of symmetry.
- The main types of symmetry elements are
  - (i)Centre of symmetry
  - (ii)Plane of symmetry

(iii)Axis of symmetry.

(i)Centre of symmetry:

- The center of symmetry is defined as an imaginary point within the crystal such that any line passing through this point intersects the opposite face of the crystal at equal distances.
- **In other words**, any line drawn through this point will intersect the surface at equal distance in both directions. Only one center of symmetry for a cubic system.

***Example*:** If there is an atom at some distance at one end, there is also an atom at the other end with the same distance.



(a)=>coordinates of Corner Lattice point (1,0,0)

(b)=>coordinates of Body-centered Lattice point (1/2, 1/2, 1/2)

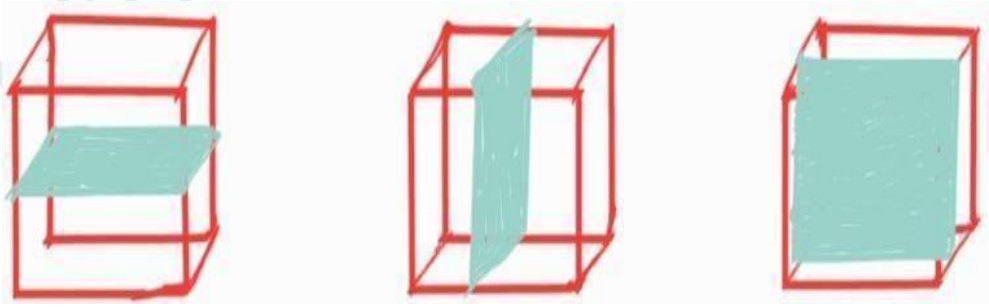
(c)=>coordinates of Face-centered Lattice point (1/2, 0, 1/2)

(ii)Plane of Symmetry:

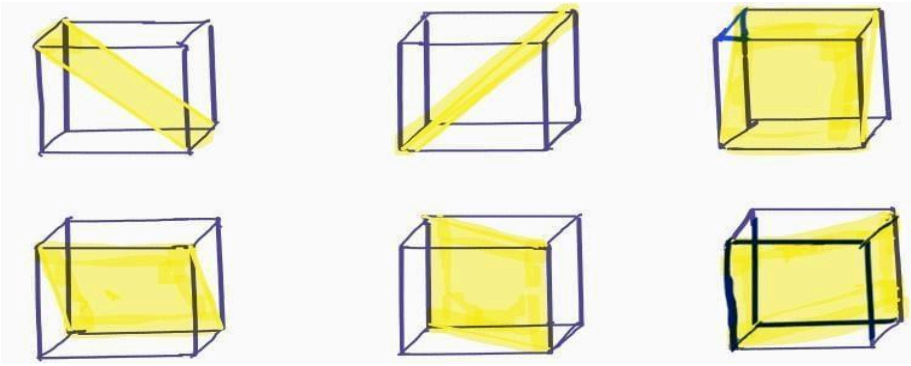
- Plane of symmetry is defined as an imaginary plane which divides the crystal into two equal parts such that one is the mirror image of the other.

Example: Regular cubic structure can have 9 planes of symmetry.

- 3-planes of symmetry are parallel to the cube faces



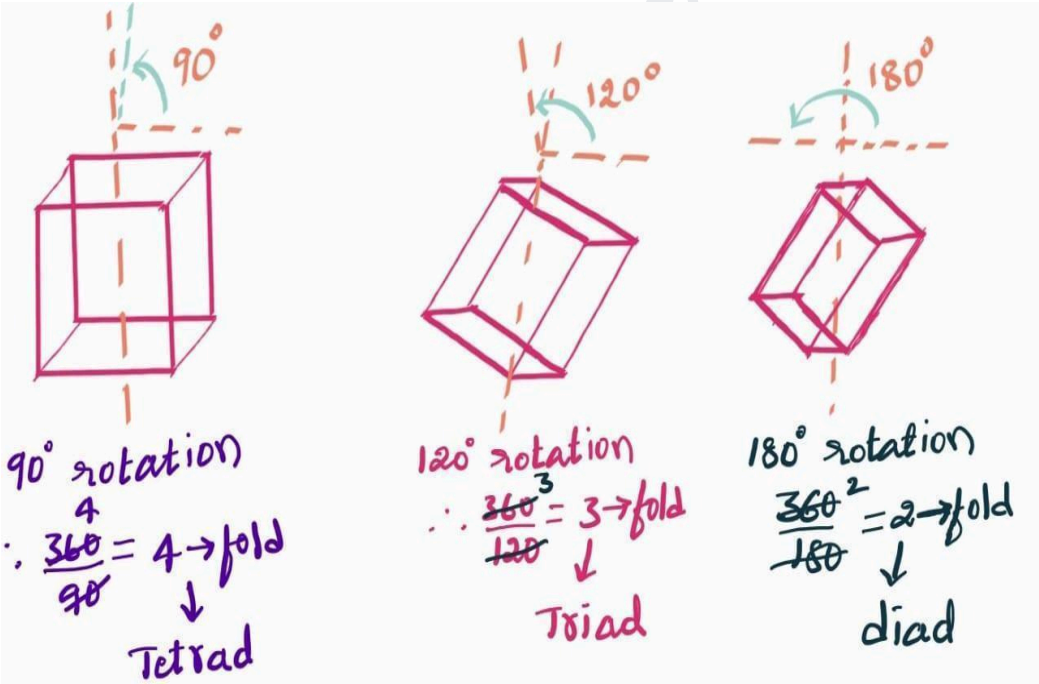
- 6-planes of symmetry to diagonals passing through opposite cube edges



(iii)Axis of Symmetry:

- Axis of Symmetry is defined as "a line about which the crystal may be rotated such that it presents the same appearance more than once during the complete revolution (360°).
- If a crystal presents the same appearance 'n' times in one complete revolution, the axis is said to be 'n'-fold symmetry.

Example: The cubic crystal of NaCl has 13 axes of symmetry out of which 6 are 2-fold, 4 are 3-fold and 3 are 4-fold.



→ 3 axes of symmetry are 4-fold known as tetrad.

→ 4 axes of symmetry are 3-fold known as triad.

→ 6 axes of symmetry are 2-fold known as diad.

NOTE: Number of folds in axis of symmetry= 360/angle of rotation.