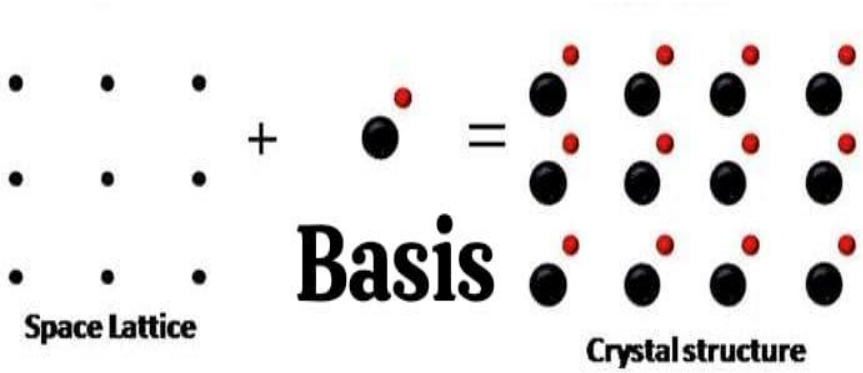
CRYSTAL STRUCTURE OR CRYSTAL SYSTEMS

- **Definition:** A crystal structure is the specific, ordered, and repeating arrangement of atoms or ions or molecules within a crystalline solid.
- In a crystal, the building units (atoms, ions, or molecules) are arranged in a 3D periodic pattern that extends throughout the material.
- This arrangement is described using a lattice and a basis.



- **Because of this repeating arrangement of atoms:**
  (i)Crystals exhibit definite geometrical shapes.
  (ii)They possess characteristic cleavage planes (smooth flat surfaces).
  (iii)They show unique physical properties.

Classification of Crystal Structures

- All crystal structures can be categorized into 7 unique crystal systems based on lattice parameters (a, b, c and angles α, β, γ).
- These systems, when combined with possible lattice centering, give rise to 14 Bravais lattices.
- Seven Crystal Systems with 14 Bravais lattices are as follows….

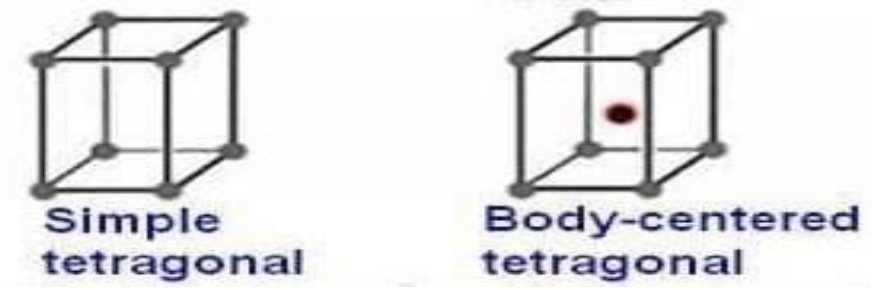
1. Cubic System

- Most symmetrical systems with unit cells, shaped like a cube.
- **Parameters:** a = b = c ; α = β = γ = 90°
- This system has **3 Bravais lattices**. They are:
  (i) Simple Cubic (P) → **Example:** Polonium (Po)
  (ii) Body-Centered Cubic (I) → **Examples:** Sodium (Na), Potassium (K)
  (ii)Face-Centered Cubic (F) → **Examples:** Copper (Cu), Gold (Au)

2. Tetragonal System

- Similar to the cubic system, but one axis is longer or shorter, forming a rectangular prism with a square base.
- **Parameters:** $a = b \neq c$; $\alpha = \beta = \gamma = 90°$
- This system has **2 Bravais lattices**. They are:

  (i) Simple Tetragonal (P) (ii) Body-Centered Tetragonal (I)



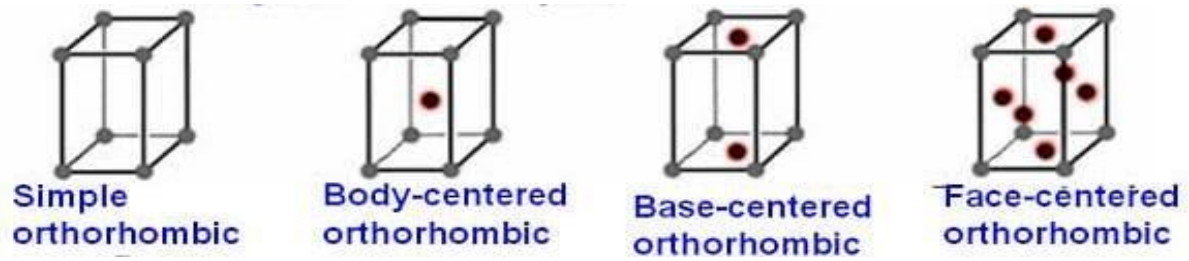
- **Examples:** Tin (Sn), TiO_2, SnO_4

3. Orthorhombic System

- All three axes are of different lengths, but meet at right angles.
- **Parameters:** $a \neq b \neq c$; $\alpha = \beta = \gamma = 90°$
- This system has **4 Bravais lattices**. They are:

  (i)Simple Orthorhombic (P) (ii)Body-Centered Orthorhombic (I)

  (iii)Base-Centered Orthorhombic (C) (iv)Face-Centered Orthorhombic (F)



- **Examples:** Sulphur (S), $PbCO_3$, $BaSO_4$, KNO_3

4. Monoclinic System

- Three axes of unequal lengths, with one angle not equal to 90°.
- **Parameters:** $a \neq b \neq c$; $\alpha = \gamma = 90°$, $\beta \neq 90°$
- This system has **2 Bravais lattices**. They are:
- (i)Simple Monoclinic (P) (ii)Base-Centered Monoclinic (C)

- **Examples**: Gypsum, Coyote, Orthoclase Feldspar

5. Triclinic System

- Least symmetrical system; all axes of different lengths and none of the angles are 90°.
- **Parameters:** $a \neq b \neq c$; $\alpha \neq \beta \neq \gamma \neq 90°$
- This system has **1 Bravais lattice**. That is (i)Simple Triclinic (P)

- **Examples:** $CuSO_4 \cdot 5H_2O$ (Blue vitriol), H_3BO_3 (Sassolite), $K_2Cr_2O_7$

6. Hexagonal System

- Features a four-axis system: three equal axes in one plane intersect at 120°, and a fourth axis perpendicular to them.
- **Parameters:** $a = b \neq c$; $\alpha = \beta = 90°$, $\gamma = 120°$
- This system has **1 bravais lattice**. That is:
- (i)Simple Hexagonal (P)

- **Examples:** Zn, Cd, SiO_2

7. Trigonal (Rhombohedral) System

- A cube distorted along one of its body diagonals.
- **Parameters:** a = b = c ; α = β = γ ≠ 90°
- This system has **1 bravais lattice**. That is (i)Simple Trigonal (P)

- **Examples:** Quartz, $CaCO_3$, As_2S_3

BRAVAIS LATTICE

- The Bravais lattices were introduced by Auguste Bravais in 1848.
- **Definition:** Bravais lattice is a 3-D arrangement of points in which each lattice point has an identical environment and represents the position of identical atoms in the crystal.

(or)

- Bravais lattice is a 3-D arrangement of identical atoms at lattice points such that every point has the same surroundings.

(or)

- If all the atoms at lattice points in the unit cell are identical, then it is called Bravais lattice.
- Bravais lattices are used to describe the orderly arrangement of atoms in a crystal/unit cell.
- Each point has one or more atoms in the actual crystal and if the points are connected by lines, a crystal lattice is formed.
- 7 types of crystal systems + 4 lattice centering types = 14 Bravais lattices (based on primitives a, b, c and interfacial angles α, β & γ).
- The 14 types of Bravais lattices are: 3 in CS, 2 in TS, 4 in OS, 2 in MS, 1 in TS, 1 in HS & 1 in RS as explained above.