Solid State

1. Solid State

Solid state is the state of matter in which particles are closely packed and have fixed positions. They are mainly classified on the basis of incompressibility, rigidity and their mechanical strength. The molecules or atoms or ions that make a solid structure are closely packed and held together through strong cohesive forces. These particles are not allowed to move randomly. The molecular, ionic or atomic arrangements are well ordered in the solids.

Solids such as NaCl, Sulphur or Sugar have a proper geometric configurations and hence they are known as crystalline solids. The particles are arranged in well-defined pattern in a 3-D network. On the contrary, those solids (glass, rubber, plastics) which do not have regular arrangement of atom, molecules or ions are known as amorphous solids.

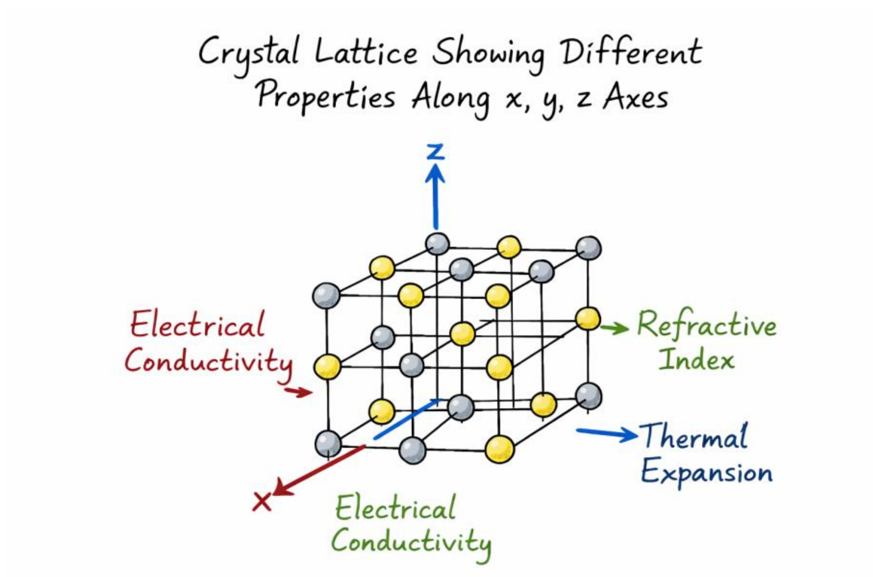
Key characteristics of solids include:

- **Definite shape and volume**
- **Strong intermolecular/interionic forces**
- **Low compressibility**
- **High density**

2. Types of Solids:

	Crystalline	Amorphous
Geometry	Definite and regular geometry due to definite & ordered arrangement in 3-D space. Have a long-range order.	Does not have any pattern of particle arrangement and no definite geometry. Have a short-range order

Melting Point	Sharp melting point. Abruptly changes into liquid state. Solid state conditions are mainly applied for crystalline.	Range of melting point. Slowly changes into liquid state. They are normally considered "liquid at all temperatures".
Isotropy/Anisotropy	Shows varying electrical & thermal conductivity, mechanical strength and refractive index are in different direction. They are anisotropic in nature.	Shows electrical & thermal conductivity, mechanical strength and refractive index are same in every direction. They are isotropic in nature.



3. Laws of Crystallography

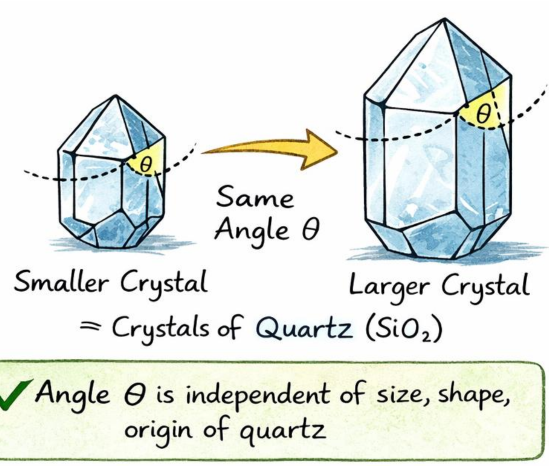
(a) Law of Constancy of Interfacial Angles: The law of constancy of interfacial angles states that the angle between any two corresponding faces of crystals of the same substance is always constant, irrespective of the size, shape, or origin of the crystal. Crystals of a substance may grow under different conditions such as temperature, pressure, or time. Due to this, their external shape and size may differ. However, the internal arrangement of atoms or ions is fixed and identical for a given substance. Since interfacial angles depend on the internal atomic structure, these angles do not change. Therefore, even though crystals look different externally, the angles between corresponding faces remain the same. This law proves that crystals have a regular and ordered internal structure.

A Classic Example Quartz (SiO_2):

- Quartz crystals are found in many shapes and sizes in nature.
- Some crystals are long and thin, while others are short and thick.
- Despite this difference, the angle between the same pair of faces in all quartz crystals is always the same.

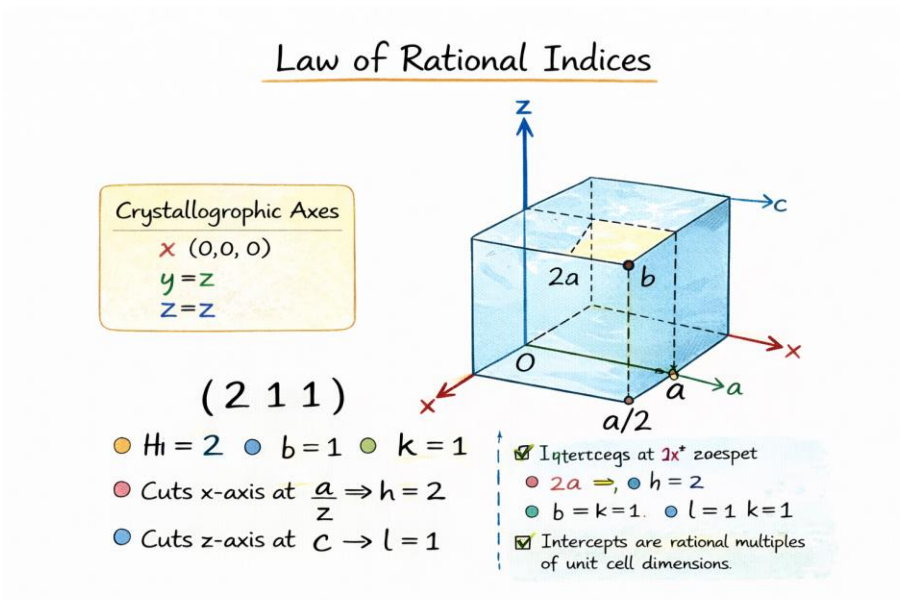
Applications:

- Helps in identification of minerals
- Confirms the crystalline nature of solids
- Forms the basis of crystallography



(b) Law of Rational Indices: The Law of Rational Indices states that the intercepts made by the faces of a crystal on the crystallographic axes are either equal to the unit cell dimensions or simple whole-number multiples of them. In other words, the intercepts of a crystal face on the x, y, and z axes are always in simple rational ratios such as 1, 1/2, 2, 3, etc., and never irrational values. In crystalline solids, atoms or ions are arranged in a regular and periodic three-dimensional lattice. Due to this regular arrangement, crystal faces intersect the crystallographic axes at fixed and orderly positions. These positions correspond to simple fractions or multiples of the unit cell lengths (a, b, c). As a result, the intercepts of any crystal face can be expressed as rational numbers. This law explains why crystal planes can be represented mathematically and forms the foundation of the Miller indices system.

The intercepts made by crystal faces on crystallographic axes are simple whole-number ratios of the unit cell dimensions.



Basis of Miller indices

Miller indices are a set of three integers (h k l) used to represent the orientation of crystal planes in a crystal lattice. The basis of Miller indices lies in the fact that crystal faces intersect the crystallographic axes at rational distances, as explained by the Law of Rational Indices.

Need of Miller Indices

- Crystal faces can cut axes at different distances
- Direct use of intercepts leads to fractions and confusion
- Miller indices provide a simple, uniform, and mathematical method to describe planes

- Miller indices describe the orientation of crystal planes.

Steps to find Miller indices:

1. Prepare a 3-column table with the unit cell axes at the top of the columns. Find intercepts on x, y, z axes (in terms of a, b, c)
2. Take reciprocals of all the numbers.
3. Multiply to remove fractions
4. Write as (h k l)

Example

Intercepts: a, b, ∞ → Reciprocals: 1, 1, 0 → Miller indices = (110)