

THE SOLID STATE

CLASSIFICATION OF CRYSTALLINE SOLIDS

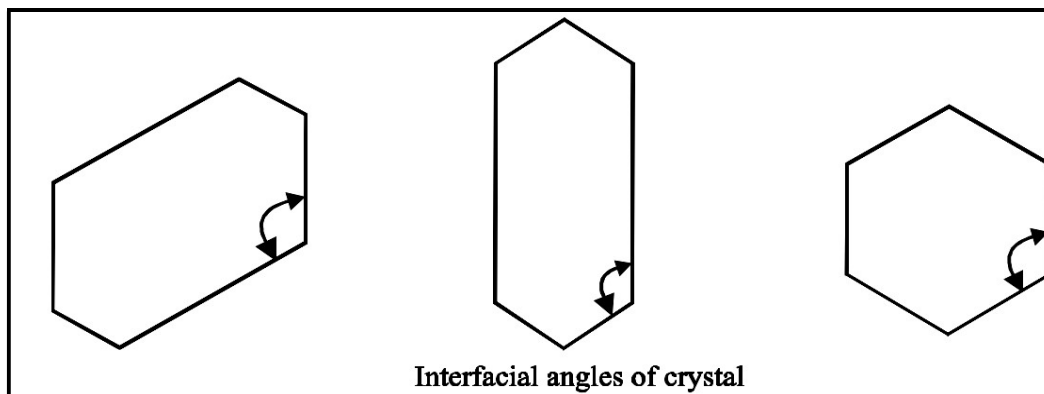
CRYSTALLINE SOLID AND ITS TYPES: -

"A crystal is a solid composed of atoms (ions or molecules) arranged in an orderly repetitive array".

Most of the naturally occurring solids are found to have definite crystalline shapes which can be recognized easily. These are in large size because these are formed very slowly thus particles get sufficient time to get proper position in the crystal structure. Some crystalline solids are so small that appear to be amorphous. But on examination under a powerful microscope, it is also seen to have a definite crystalline shape. Such solids are known as micro crystalline solids. Thus, the crystallinity of a crystal may be defined as "a condition of matter resulting from an or orderly, cohesive, three-dimensional arrangement of its component particles (atoms, ions or molecules) in space". This three-dimensional arrangement is called crystal lattice or space lattice. The position occupied by the particles in the crystal lattice are called lattice sites or lattice points. The lattices are bound by surface that usually planar and known as faces of the crystal.

"The smallest geometrical position of the crystal which can be used as repetitive unit to build up the whole crystal is called a unit cell."

The angle between the two perpendiculars to the two intersecting faces is termed as the interfacial angle which may be same as the angle between the unit cell edges. Goniometer is used to measure the interfacial angle. It is important to note that interfacial angle of a substance remains the same although its shape may be different due to conditions of formation.



CRYSTALLINE SOLID AND ITS TYPES:-

Depending upon the type of constituent particles and the nature of intermolecular forces between them, the crystalline solids are classified into following categories:

- Ionic solid
- Molecular Solids
- Covalent or Network Solids
- Metallic Solids

POLAR MOLECULAR SOLIDS: -

The geometry of these solids is such that one side has a negative charge and the other side has a positive charge on the same side. The dipole — dipole force of attraction – that holds them together is the driving force. Their melting and boiling temperatures are higher than those of non-polar molecular solids, but they are still comparatively low compared to other solids. Polar compounds include ethanol and ammonia, to name a couple of examples.

HYDROGEN BONDING MOLECULAR SOLID: -

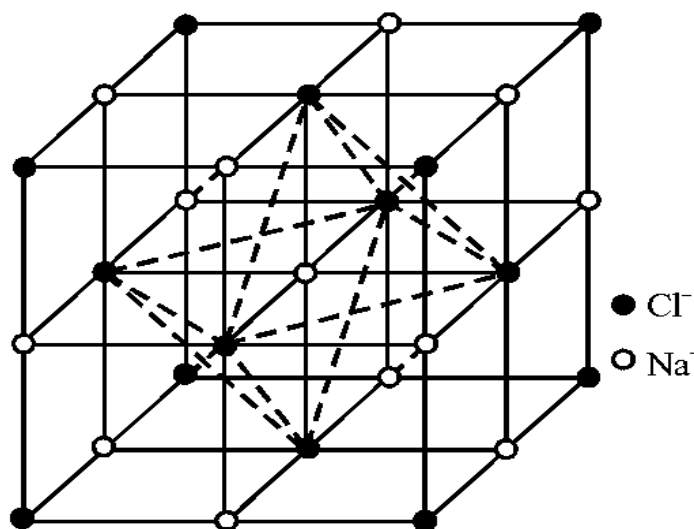
In these crystals, molecules occupy the lattice points of the unit cells, except in solidified noble gases in which the units are atoms, where the binding is due to Vander Waal's' forces and dipole-dipole forces. Since Vander Waal's forces are non-directional hence structure of the crystal is determined by geometric consideration only. Solid H₂, N₂, O₂, CO₂, I₂, sugar etc. are well known examples of such crystal in which Vander Waal's forces are acting. Ice is the common example in which dipole-dipole forces of attraction (hydrogen bonding) are active. Many organic and inorganic crystals involve hydrogen bonds. Although these are comparatively weaker but play a very important role in determining the structures of substances Ex. polynucleotides, proteins etc.

IONIC SOLIDS: -

These are formed by a combination of highly electro-positive ions (cations) and highly electronegative ions (anions). Thus, strong electrostatic force of attraction acts within the ionic crystals. Therefore, a large amount of energy is required to separate ions from one another. The type of the crystal lattice depends upon

- (i) The size of the ion
- (ii) The necessity for the preservation of electrical neutrality.

Therefore, alternate cations and anions in equivalent amounts are arranged in the ionic crystal. Ex. NaCl, KF, CsCl etc.



Crystal structure of NaCl

METALLIC SOLIDS: -

These are formed by a combination of atoms of electropositive elements. These atoms are bonded by metallic bonds.

It may be defined as:

The force that binds a metal ion to a number of electrons within its sphere of influences is known as metallic bond

OR

A bond which is formed between electropositive elements

OR

The attractive force which holds the atoms of two or more metals together in a metal crystal or in an alloy.

We know that the force of attraction between metal ions and valency electrons is very strong. This force of attraction is responsible for a compact solid structure of metal.

Covalent or network solids: -

These are formed by sharing of valence electrons between two atoms resulting in the formation of a covalent bond. The covalent bonds extend in two or three dimensions forming a giant interlocking structure called network. Diamond and graphite are the good examples of this type.

S.NO.	CHARACTERISTICS	IONIC CRYSTALS	COVALENT CRYSTALS	MOLECULAR CRYSTALS	METALLIC CRYSTALS
1	Units that occupy lattice points	Cations and anions	Atoms	Molecules	Positive ions in a "sea or pond" of electrons.
2	Binding forces	Electrostatic attraction between ions	Shared electrons	Vander Waals or Dipole-dipole	Electrostatic attraction Between positively charged ions and negatively charged electrons.
3	Hardness	Hard	Very hard Graphite is soft	Soft	Hard or soft
4	Brittleness	Brittle	Intermediate	Low	Low

5	Melting point	High	Very high	Low	Varying from moderate to high
6	Electrical	Semiconductor due to crystal imperfections, conductor is fused state	Non-conductor Graphite is good	Bad conductor	Good conductors
7	Solubility in	Soluble	Insoluble	Soluble as well as insoluble	Good conductors
8	Heat of Vaporisation (kj mol ⁻¹)	NaCl(s) 170-75	Graphite 718-43	NH ₃ (s) 23.55	Cu(s) 304.59
9	Heat of fusion (kj mol ⁻¹)	NaCl 28.45	– –	NH ₃ (s) 5.65	Cu(s) 13.016
10	Example	NaCl, KNO ₃ CsCl, Na ₂ SO ₄	Diamond, graphite, Quartz, (SiO ₂), Sic	H ₂ O(s), CO ₂ (s), Sulphur, Sugar, Iodine, noble gases	Na, Cu, Ag, Fe, Pt, alloys

The important characteristics of the various types of crystals are given in the following table:

Some Important Characteristics of Various types of Crystals