CLASSIFICATION OF CRYSTALLINE SOLIDS

Crystalline solids are categorized into different groups based on the type of constituent particles and the nature of the intermolecular forces between them.

1. Ionic solid
2. Molecular Solids
3. Covalent or Network Solids
4. Metallic Solids

Polar Molecular Solids

The configuration of these solids is characterized by a negative charge on one side and a positive charge on the other side. The cohesive force binding them together is the dipole-dipole attraction. While their melting and boiling temperatures exceed those of non-polar molecular solids, they remain relatively low compared to other solid substances.

Examples of polar compounds encompass ethanol and ammonia.

Hydrogen Bonding Molecular Solid

In these crystalline formations, molecules occupy the lattice points within the unit cells, except in solidified noble gases where the units consist of atoms. The cohesive forces in such cases are attributed to Vander Waals' forces and dipole-dipole forces. Given the non-directional nature of Vander Waals' forces, the crystal's structure is solely determined by geometric considerations. Well-known examples of crystals governed by Vander Waals' forces include solid H_2, N_2, O_2, CO_2, I_2, and sugar. Additionally, ice serves as a common illustration where dipole-dipole forces of attraction, specifically hydrogen bonding, are in effect. Many organic and inorganic crystals involve hydrogen bonds, which, although relatively weaker, play a crucial role in determining the structures of substances such as polynucleotides and proteins.

1. Ionic Solids

These crystals are created through a pairing of highly electro-positive ions (cations) and highly electronegative ions (anions). Consequently, a robust electrostatic force of attraction operates within the ionic crystals, demanding a substantial amount of energy to disassociate the ions.

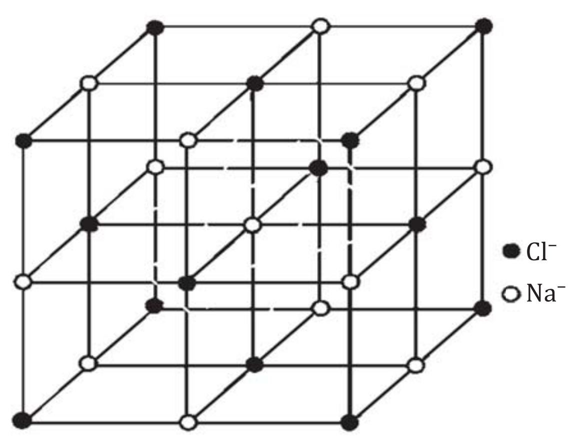
The specific crystal lattice structure is contingent upon two key factors:

(i) The size of the ions.

(ii) The imperative to maintain electrical neutrality.

Hence, the arrangement in ionic crystals involves alternating cations and anions in equivalent proportions.

Examples of such crystals include NaCl, KF, CsCl, and the like.



Crystal structure of NaCl

2. **Metallic Solids**

These structures are produced through the fusion of atoms from electropositive elements, bound together by metallic bonds. This bonding phenomenon can be described as follows: The force that unites a metal ion with a cluster of electrons within its sphere of influence is termed a metallic bond.
Alternatively,
It is a bond established between electropositive elements.

Or,

The compelling force that maintains the cohesion of atoms in two or more metals within a metal crystal or alloy.
The robust attraction force between metal ions and valency electrons is instrumental in creating a densely packed solid structure for metals.

3. **Covalent or Network Solids**

These structures arise from the sharing of valence electrons between two atoms, giving rise to the creation of a covalent bond. The covalent bonds expand in two or three dimensions, giving rise to an extensive interlocking arrangement known as a network. Diamond and graphite serve as excellent illustrations of this category.
The important characteristics of the various types of crystals are given in the following table:

Some Important Characteristics of Various types of Crystals

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_2SO_4	Diamond, graphite, Quartz, (SiO_2), Sic	H_2O(s), CO_2 (s), Sulphur, Sugar, Iodine, noble gases	Na, Cu, Ag, Fe, Pt, alloys