1 The Solid State

LESSON AT A GLANCE

- **Solid:** The state of the substance in which it has definite mass, volume and shape.
- **Amorphous solids:**
  - A substance whose constituent particles do not possess a regular orderly arrangement.
  - They behave like super cooled liquids consequently.
  - Glass, plastics, rubber, starch, etc. are amorphous solids.
- **Crystalline solids:**
  - There is long range order in the arrangement of their constituent particles.
  - They have sharp melting points.
  - They are anisotropic in nature.
- **Crystal:** A solid with a regular polyhedral shape.
- **Crystal Lattice:** The regular pattern of atoms, ions or molecules in a crystalline substance. A crystal lattice can be regarded as produced by repeated translations of a unit cell of the lattice.
- **Bravais Lattice:** There are fourteen different types of lattices which are called as Bravais lattices.
- **Unit cell:** For each crystal lattice it is possible to select a group of lattice points which is repeated again and again.
- **Close packing:** Close packing of particles results in two highly efficient lattices
  - Hexagonal close-packed (hcp)
  - Cubic close-packed (ccp)

  In both of the packing 74% are space filled.
- **Body-centred cubic lattice:** 68% are space filled.

- **Cubic lattice:** 52.4% are space filled.
- **Photovoltaic substances:** The material which converts sunlight into electricity is called photovoltaic substances, *e.g.* amorphous silicon.
- **Crystallinity:** The degree of internal order in a crystal is called crystallinity.
- **Anisotropic:** It denotes a medium in which certain physical properties are different in different directions. Wood, for example, is an anisotropic material: its strength along the grain differs from that perpendicular to the grain.
- **Covalent solids:** Covalent bonds are formed by sharing of valence electrons rather than by transfer. For instance, hydrogen atoms have one outer electron ($1s^1$).

  Covalent solids have covalent bonds throughout the solid. They are also known as network solids.
- **Crystalline solids:** The solid which has a regular internal arrangements of atoms, ions or molecules is called crystalline solid.
- **Crystallography:** The study of geometry and symmetry of crystal form and structure is called crystallography.
- **Unit cell:** The group of particles (atoms, ions, or molecules) in a crystal that is repeated in three dimensions in the crystal lattice, is called a 'unit cell'.
- **Primitive cubic unit cell:** Primitive cubic unit cell has atoms only at its corner. Since each cubic unit cell has 8 atoms on its corners, the total number of atoms in one unit cell is $8 \times \frac{1}{8} = 1$ atom.
- **Body-centred Cubic Unit Cell:** A unit cell having a lattice point at the centre of the body, in addition to the lattice points at the corners, is called body-centred unit cell. Each corner atom makes 1/8 contribution and the atom at the body centre belongs only to the particular unit cell.
- **Face-centred Cubic Unit Cell:** A face-centred cubic (*fcc*) unit cell contains one atom at each corner (there are eight corners of a cube) and one atom at the centre of each face (six faces of a cube) of the cube. That each atom located at the face centre is shared between two adjacent unit cells and makes a contribution of only 1/2 to a particular unit cell.

- **Close-packed structure:** When the constituent particles are packed most efficiently within a crystal, so that the empty space is minimum, the arrangement is referred to as 'close-packed structure'.
- **Packing Efficiency:** The percentage of total space filled by the constituent particles (atoms, molecules or ions) is called packing efficiency.
- **Conductors:** The solids with conductivities ranging between 10^4 to 10^7 ohm^{-1} m^{-1} are called conductors. Metals have conductivities in the order of 10^7 ohm^{-1} m^{-1} are called good conductors.
- **Insulators:** These are the solids with very low conductivities ranging between 10^{-20} to 10^{-10} ohm^{-1} m^{-1}.
- **Semiconductors:** These are the solids with conductivities in the intermediate range from 10^{-6} to 10^4 ohm^{-1} m^{-1}.
- **Paramagnetism:** These materials are weakly attracted by a magnetic field. They can be magnetised in a magnetic field in the same direction. Paramagnetism is due to the presence of one or more unpaired electrons which are attracted by the magnetic field.

  O_2, Cu^{2+}, Fe^{3+}, Cr^{3+} are some examples of such substances. They loss their magnetism in the absence of magnetic field.
- **Diamagnetism:** Diamagnetic substances are weakly repelled by a magnetic field.

  They do not have unpaired electrons. Pairing of electrons cancels their magnetic moments and they loss their magnetic character. Some examples of such substances are H_2O, NaCl and C_6H_6.
- **Ferromagnetism:** They have strong attraction towards the magnetic field. These substances can be permanently magnetised.
- **Antiferromagnetism:** In these substances their domains are aligned in such a way that net magnetic moment is zero. This type of magnetism is called antiferromagnetism. For example, MnO has antiferromagnetism.
- **Ferrimagnetism:** When the magnetic moments of the domains in the substance are aligned in parallel and antiparallel direction in unequal numbers.