

Semester I

MPC-104

Condensed matter Physics

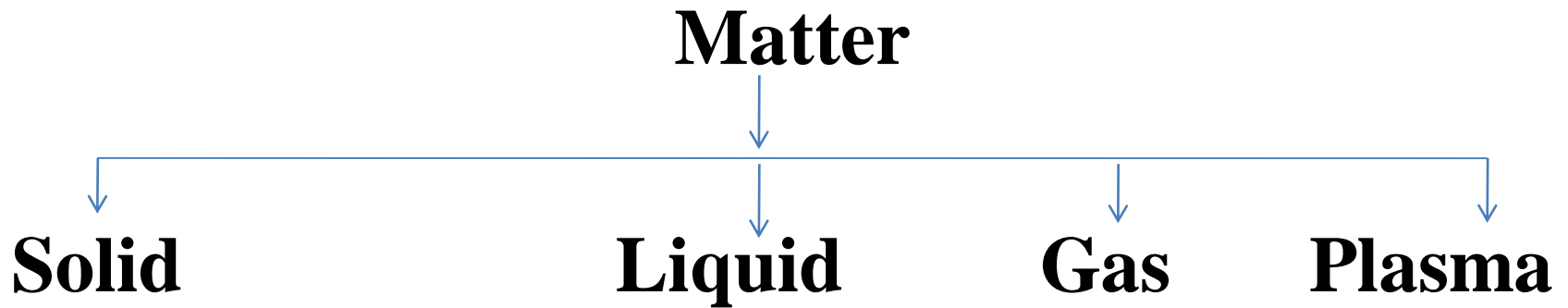
It is the study of substances in their solid state. This includes the investigation of both crystalline solids and amorphous solids.

Solid State Physics

It is the largest branch of condensed matter physics in which we study about rigid matter or solids through methods such as quantum mechanics, crystallography, electromagnetism and metallurgy.

An Introduction

Matter: It is a substance that has mass and takes up space by having volume. Matter is made of atom.



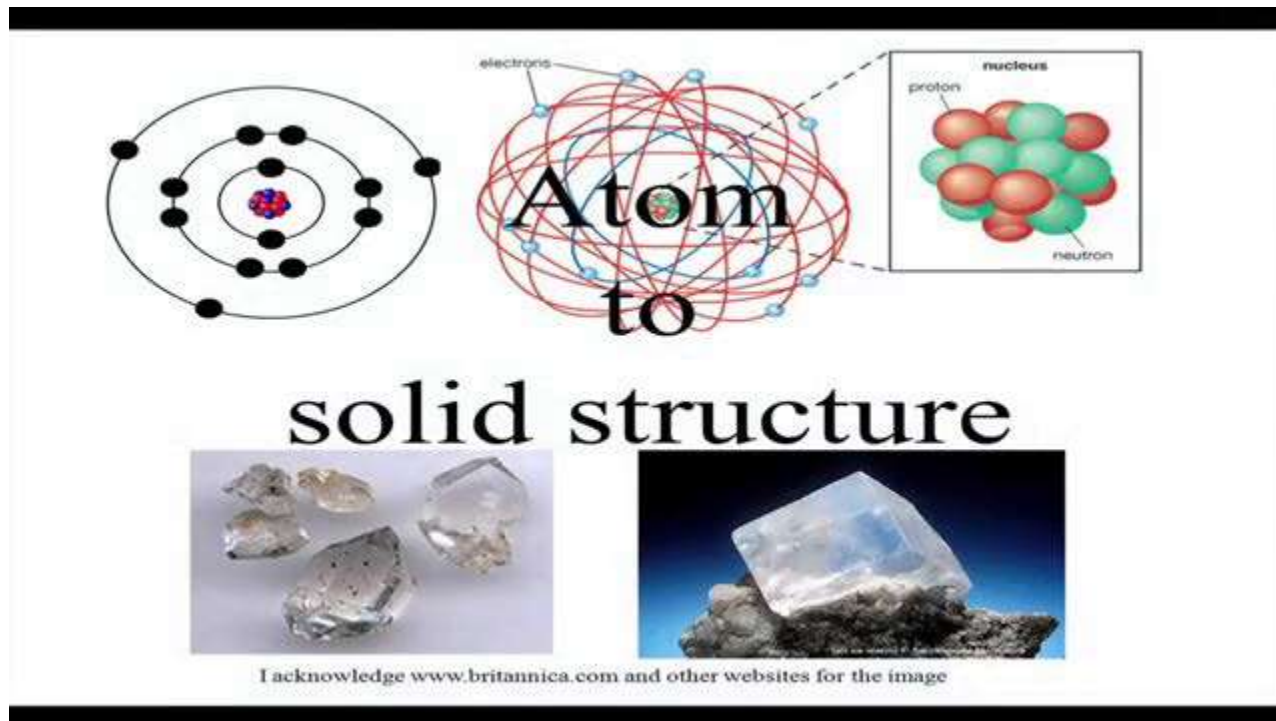
Matter in universe is found mainly in four types, or in four states. One is in solid state. Then it is found in liquid state, gaseous state and plasma state. Mainly these are the four states, we see matter in universe; but there are some other states of matter under some extreme conditions, which are not found in nature; but one can artificially create some other states also.

We can define states of matter in terms of inter atomic distance. **The inter atomic distance** is basically the distance between the centres of two atoms .

- When inter atomic distance is very small, atoms are compact, then it is in solid state. in case of solid, the inter-atomic distance is in the range of 2 to 4 Å
- When this inter atomic distance is very large, then it is in gaseous state. In case of gaseous state, the average inter atomic distance is around 30 Å
- And when inter atomic distance is between these two, then it is basically in liquid state. and in liquid, it is in around 5 to 10 Å.
- Plasma state is basically a gaseous state of negatively charge electron, and highly positively charged ions, created by heating of gas, or by applying a strong electromagnetic wave to gas. Other three states are basically having neutral atoms. But in plasma state, atom is in ionized form. As for example, the lightning storms, then interior of sun and stars are basically in plasma states.

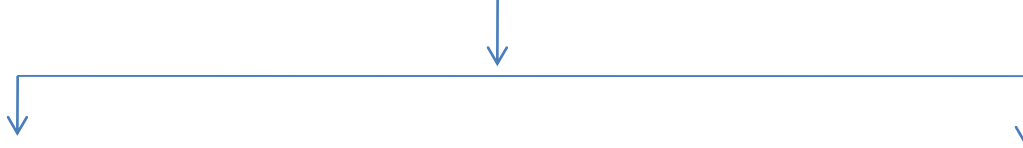
Solid

- In solid state of matter, atoms are very close to each other, and they hold each other.



- the origin of the force to hold them together is electrostatic force; magnetic force is also there; but it is very weak. So, mainly electrostatic force holds atoms together in solid.
- electrostatic force are coming. Say, if you take the atoms; two atoms at a distance of r ; that is inter-atomic distance, r . These atoms have nucleus and negative charge. So, when they come close to each other, then repulsive forces between electron-electron and nucleus-nucleus, and attractive force between electron-nucleus of two atoms will act. So, both attractive force and repulsive force are acting in the system upto say two atoms.
- In solids, there are many atoms and similar way, such type of force will act among other atoms also. So, this repulsive force and attractive force acting on the system, and generally, we say, this force is basically proportional to the electrostatic force.

Solid

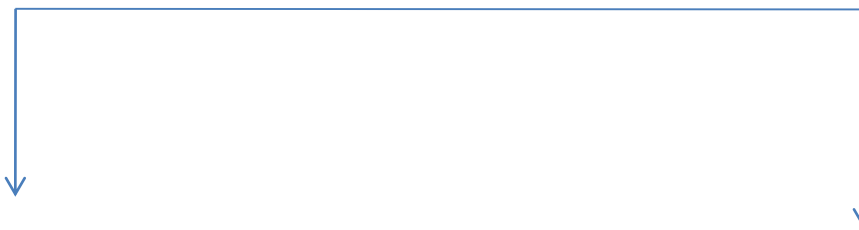


Crystalline Solids

Non-Crystalline Solids

or

Amorphous Solids



Single crystalline

Poly crystalline

In nature, whatever the solids we found, most of them are crystalline solids; but there are some materials which are amorphous. As for example, the glass is an amorphous solid.

Crystalline solid: When atoms are arranged orderly in the solid, then it is known as the crystalline solid.

Amorphous solid: When atoms are not arranged orderly, they are arranged randomly in the solid, then it is called the amorphous solid.

The crystalline solid, again it is two types: one is single crystalline solid and another is polycrystalline solid. Difference between these two are basically: in **single crystalline solid**, there is a long range ordering of the atoms in the solid and in **polycrystalline solid**, there is basically a short range ordering of the atoms in the solid.

We will concentrate our discussion on the crystalline solid, basically on the single crystalline solid

- In a piece of material (crystalline material, single crystalline material), atoms or the group of atoms are arranged orderly in this piece of material.
- if we know the pattern unit of a crystal, then basically we know everything about the structure of that crystal, because pattern unit contains all information about the crystal and repetition of the pattern unit basically forms the crystal structure.
- To study the crystal structure of a material, basically we will study the pattern unit of that material.