Solid State Physics

Books

:- Kittel
:- Aschroft & Mermin
:- Puri & Babber
:- Wahab

Matter

There are 4 states of matter

i) Solid
ii) liquid
iii) gas
iv) Plasma

We need to study the Properties of solids :-

Electrical properties :- To differentiate b/w insulator, conductor & semiconductor.

Magnetic properties :- Magnets are ferromagnetic materials. To know about para, dia, ferro, we need this prop.

Thermal properties :- To know which solid is thermal insulator or thermal conductor.

Mechanical properties :- To know which solid is mechani-cally stoorg.

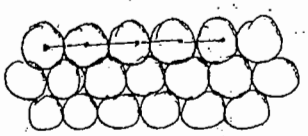
Optical / optoelectronic properties :- which material is require to make solar cell is decided by optical prop.

Types of Solids :-

- Solid
  - Crystalline
    - Single (Quartz, Dimond)
    - Poly Crystalline (Cu, Au, Ag)
  - Non-Crystalline (Amorphous) (Plastic, glass)

Crystalline solids are characterised by regular or periodic arrangment of atoms or molecules.

Every solid is made up of atoms or molecules.



Atoms are repeating themselves after a certain distance.

Non Crystalline solids are characterised by random arrang-ment of atomes or molecules.

→ Arrangnment of atoms will decide their properties.

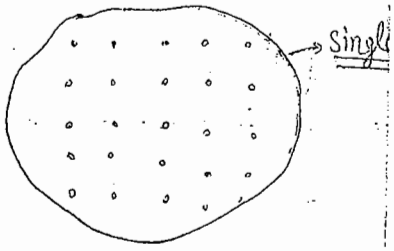
→ Plastic is Non-crystaline.

→ Cupper is crystalline.

→ Dimond & Cupper both are crystalline but dimond is a single crystal & cupper is poly-crystalline.

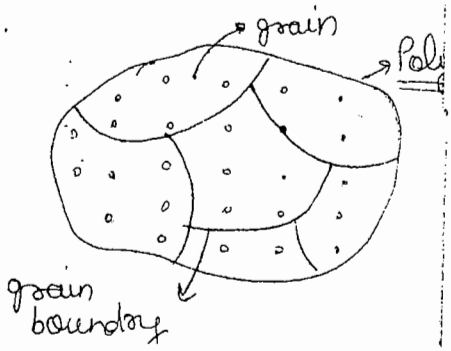
Single :-

Throught the crystal, we have same type of arrangment then the crystal will be single crystal.



- Polycrystalline crystalline :-

Polycrystalline is the ~~arrangment of~~ aggrigate of large no. of single crystals. The small singl crystals are known as Grain & boundries seperating these crystals are Grain Boundry.



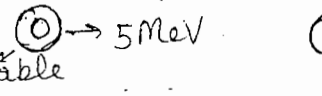
If we consider graphite & quarts then their properties are different bcoz their properties depends upon their bonding.

In nature, Most of the solids are in the form of crystalline solids bcoz crystalline solid is more stable as compare to amorphous solids as energy released during the formation of crystalline material is more than amorphous solid.

→ As More energy released in the formation of a crystal, crystal will be more stable.

e.g. Helium nucleus is formed by 2 deuterium nuclei & energy released → 5 MeV. To break He into $_1H^2$ & $_1H^2$ we need to supply 5 MeV energy.

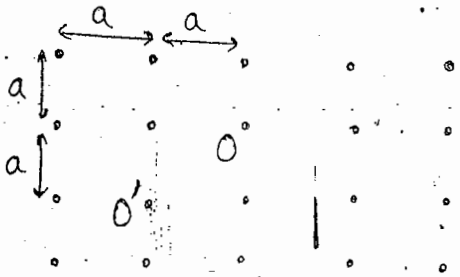
$$_1^2H + {}_1^2H \longrightarrow {}_2^4He + 5\ MeV$$



Study the Crystal Structure :-

Lattice :- Lattice is periodic arrangment of imaginary points in the space.

This is a periodic arrangmeat of atoms. This is a Mathematical concept



This Lattice will be a Bravais Lattice or Space lattice if each lattice point has identical surroundings.

e.g. Lattice point O & O' has same surrounding.

Basis :- Basis is an atom or group of atoms. By attaching the basis to each lattice point, we'll get Crystal Structure.

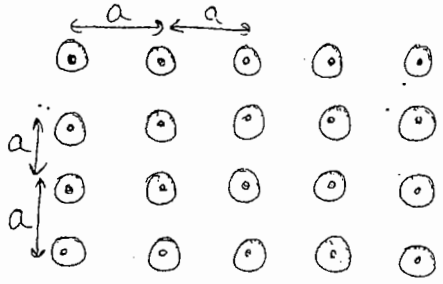
Lattice + Basis = Crystal

It is also called Motif

Basis of 1 atom is called Monoatomic Crystal

" " more than 1 atom is called Polyatomic crystal.

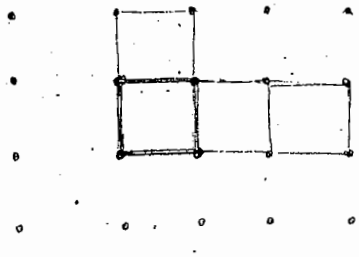
If we are attaching atoms on each lattice point so this will become physical.



→ As lattice points are periodic so atoms will be periodic so this arrangment will become Crystalline Solid.

Unit Cell :- Ideal crystal is infinite in dimensions but real crystal can not be infinite.

Nothing can be Ideal so it must have finite dimension. Unit cell is the smallest unit of the crystal or lattice which on continous repetation can generate whole lattice. This is the representative of lattice or crystal structure.



If we want to construct the crystal structure then we have to arrange the unit cells side by side.

→ Grain can contain large no. of unit cells.

Unit Cells are of 2 types,

{ dim. of unit cell tells → at what distance lattice point will repeat itself.

i) Primitive
ii) Non-primitive

Primitive :- Lattice points are belonging only to the corners of the unit cells.

OR

Effective no. of lattice points per unit cell is one.

Non-primitive :- Lattice points are belonging to the corners as well as to the other position of the unit cell.

OR

Effective no. of lattice points are more than one.

1 atom basis → Each lattice point will contain 1 atom
2 " " → " " " 2 "

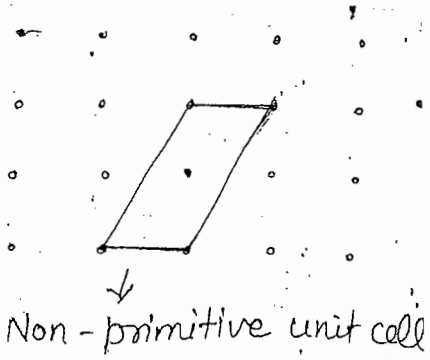
→ (Sides of unit cell → lattice constant or lattice parameter)

A primitive cell can have more than 1 atom but have only 1 lattice point.

1 lattice point is shared by 4 unit cells for primitive cell.

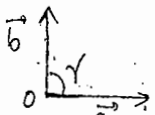
$$\frac{1}{4} \times 4 = 1$$

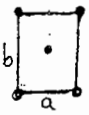
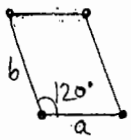
For Non-primitive ⟶ Angle/360°



Non-primitive unit cell

Types of lattice in 2-dim. :- To define a lattice $\vec{a}$, $\vec{b}$ & γ.



	Crystal Structure	Lattice	Condition
1.	Square	1. Square (primitive) 	$a = b$, $\gamma = 90°$
2.	Rectangular	2. Rectangular Primitive  3. Rectangular Centred 	$a \neq b$, $\gamma = 90°$
3.	Hexagonal	4. Hexagonal primitive 	$a = b$, $\gamma = 120°$
4.	Oblique	5. Oblique primitive	$a \neq b$, $\gamma \neq 90°$

So in 2 dim, there are 5 types of lattice (Bravais) & 4 types of crystal structure.

Here square, rectangle & Hexagonal are the special cases of Oblique.