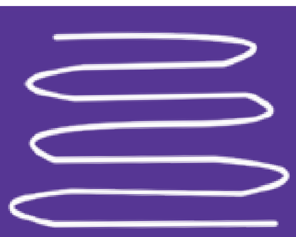
Solid state

Part - 1

Amorphous

- Randomly organised
- No specific shape
- Melting and boiling points have range
- Short order arrangement of particles
- No break points hence break unevenly
- Super cooled liquid.

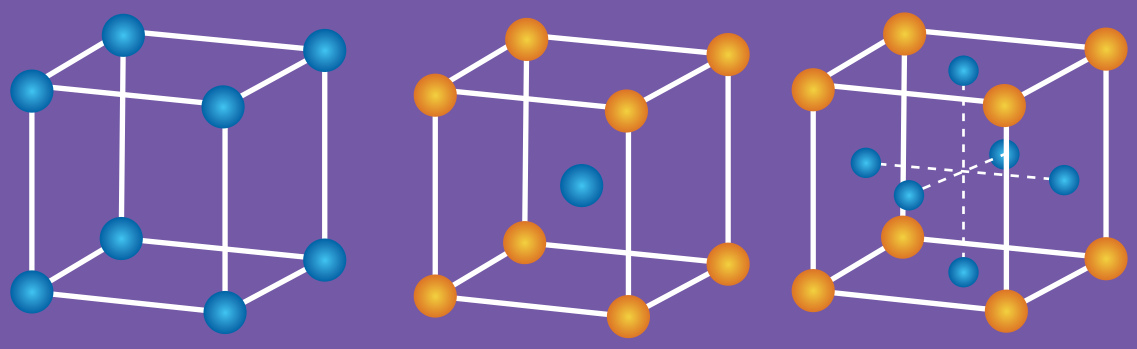


Crystalline

- Orderly arranged
- Specific geometrical shape
- Sharp melting and boiling point
- Long order arrangement of particles
- Break points
- True Solids

Crystal lattice is an array of points in a particular order which describes the arrangement of particles of a crystalline solid.

Unit cell The smallest repeating structure in a crystal.



Unit Cell	Simple Cubic	Body centred Cubic	Face centred Cubic
Location of particles	Only at Corners	Corners + Body centre	Corners + Faces
Number of particles in a unit cell	$(\frac{1}{8})\times8=1$	$(\frac{1}{8})\times8+1\times1=2$	$(\frac{1}{8})\times8+(\frac{1}{2})\times6=4$
Packing efficiency	52.4%	68%	74%

Bravais Lattices

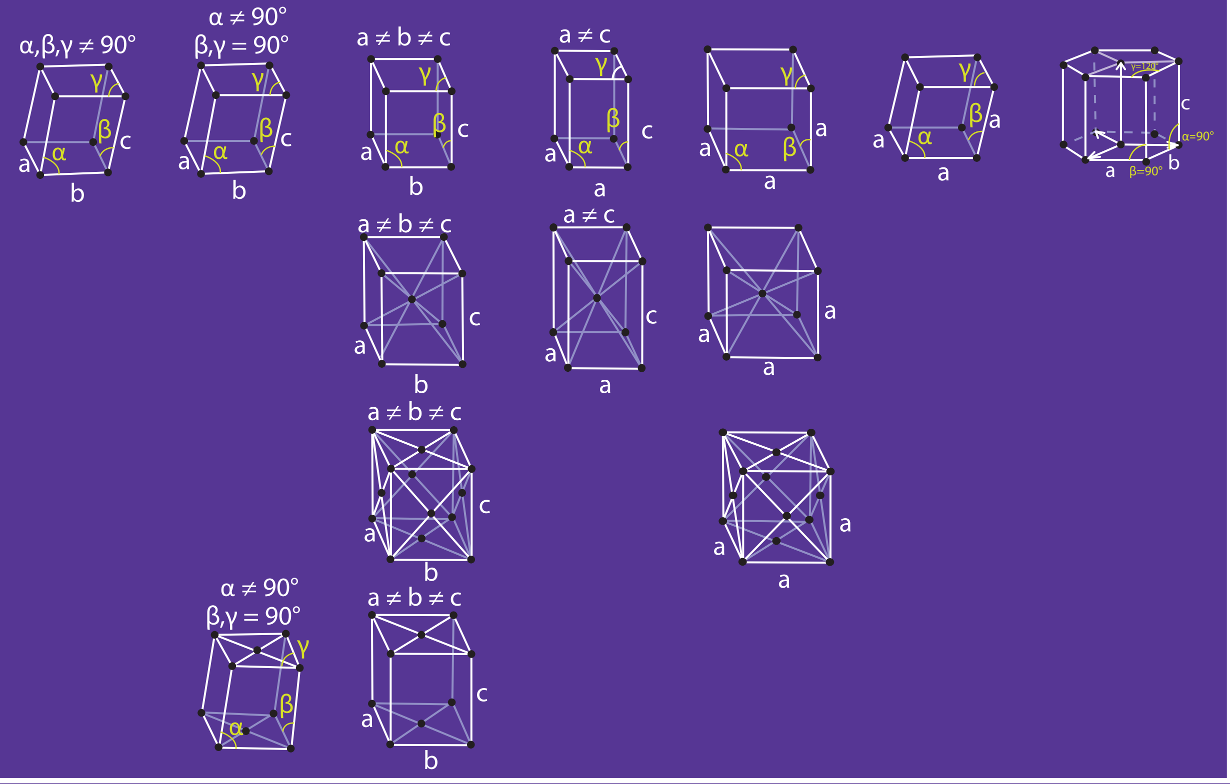
Triclinic	Monoclinic	Ortho-rhombic	Tetragonal	Cubic	Trigonal/ rhombohedral	Hexagonal
a≠b≠c	a≠b≠c	a≠b≠c	a=b≠c	a=b=c	a=b=c	a=b≠c
α≠β≠γ≠90°	α=γ=90° β≠120°	α=β=γ=90°	α=β=γ=90°	α=β=γ=90°	α=β=γ≠90°	α=β=90° γ=120°

P Simple/Primitive

I Body Centered

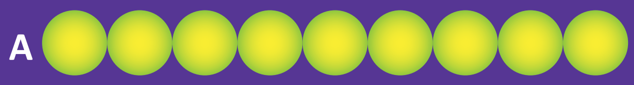
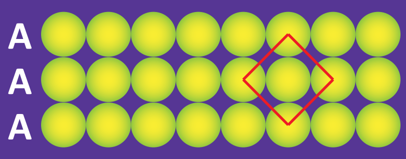
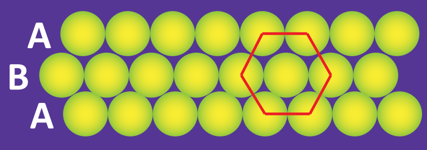
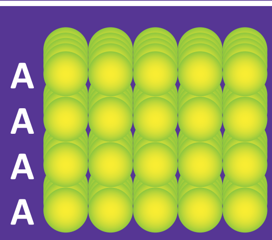
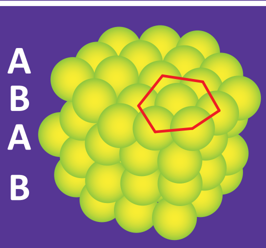
F Face Centered

C Base Centered



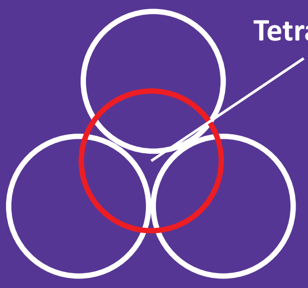
Close packing in Crystal structures

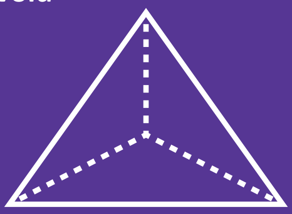
Part - 2

In 1 dimension		
In 2 dimension	 AAA type Simple Cubic Packing in 2D	 ABA type Hexagonal closed Packing-HCP in 2D
In 3 dimension	 Simple Cubic Packing-SCP	 Hexagonal closed Packing-HCP

Voids :- Gaps in the arrangement of atoms is called voids

Tetrahedral Void

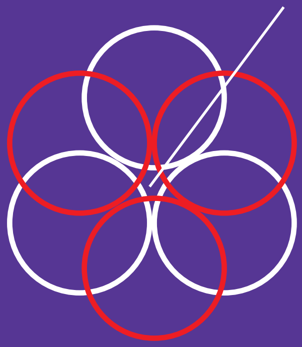


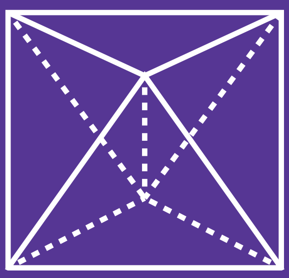


Tetrahedon

- Found in CCP
- Triangular shape
- 2 X Number of atoms in a unit cell
- Coordination number 4

Octahedral Void





Octahedron

- Found in HCP
- Octahedral shape
- 1 X Number of atoms in a unit cell
- Coordination number 6

Radius Ratio rule predicts the location of Cations in the crystal lattice

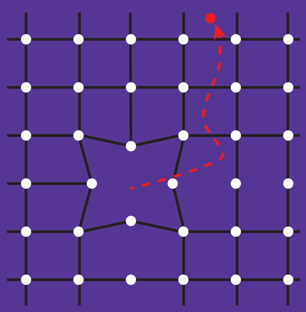
Radius Ratio	Coordination number	Type of void	Example
< 0.155	2	Linear	
0.155 - 0.225	3	Triangular Planar	B_2O_3
0.225 - 0.414	4	Tetrahedral	ZnS, CuCl
0.414 - 0.732	6	Octahedral	NaCl , MgO
0.732 - 1.000	8	Cubic	CsCl , NH_4Br
1	12	Close packing (ccp and hcp)	Metals

Part - 3

Imperfections in Solids

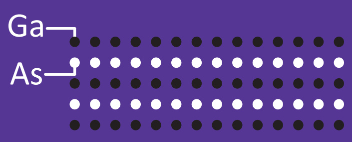
Point defects

Occur at a point in a crystal

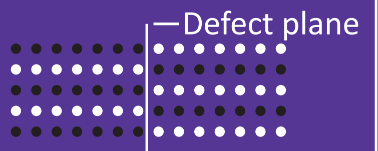


Line Defects

When there is an abnormality in the arrangement of an entire row, then it is a line defect.



Normal Crystal

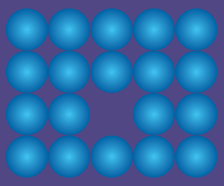


Crystal with antiphase defect plane

Stoichiometric Defects

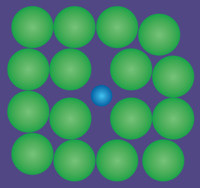
Stoichiometry is maintained

Vacancy Defect



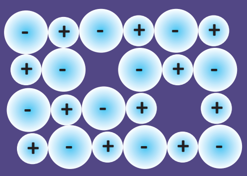
- Vacancy is present
- Density of crystal reduces

Interstitial Defect



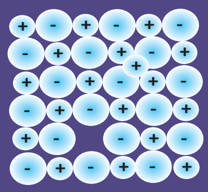
- Extra Particles present at interstitial sites
- Density of crystal increases

Schottky Defect



- Missing cations =Missing anions
- Density reduces
- Electrical neutrality remains

Frenkel Defect



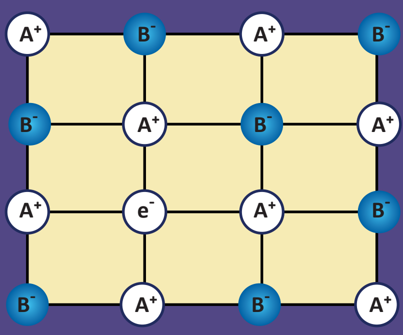
- Ions missing from normal position , occupy interstitial sites
- Density remains same
- Electrical Neutrality remains

Non Stoichiometric defects

Stoichiometry is not maintained.

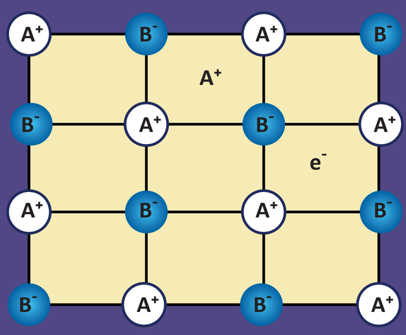
Metal Excess Defects

Anionic vacancies



- Anions are missing
- F centres present
- Have colour

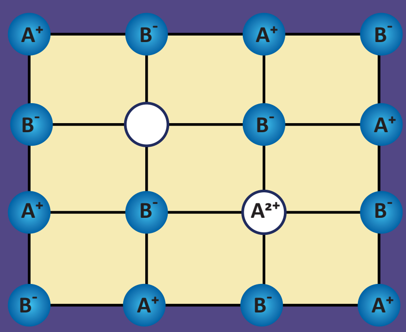
Extra Cation



- Extra interstitial Cations
- Excess metal

Metal deficiency defects

Deficiency of metal in the space lattice



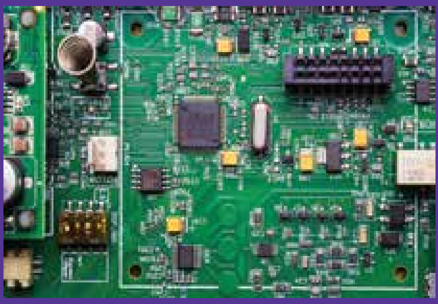
- Cations missing
- Replaced by cations having higher charge
- Shown by transition metals with many valancies

Electrical properties

Conductors

- Allow heat and electricity to pass
- Have free electrons
- Have conductivity between $10^6 – 10^8$ $(\Omega\text{-m})^{-1}$
- Used in wires and electrical appliances
- Examples : Copper ,Silver

Semi Conductors



- Between insulators and Conductors
- Conduct electricity in special conditions.
- Have conductivity between 10^{-6} to 10^4 $(\Omega\text{-m})^{-1}$.
- Used to make electronic devices like mobile phones, computers etc.
- Example:- Silicon , Germanium

Insulators

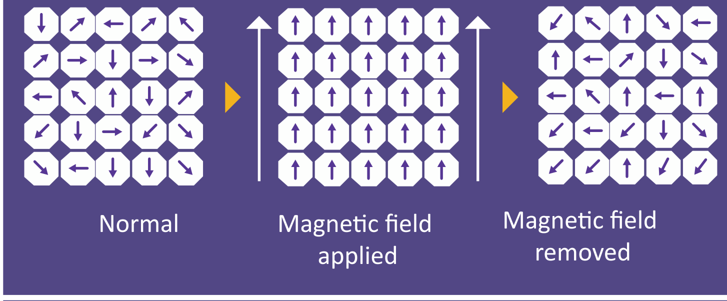
- Don't allow heat and electricity to pass through them
- Don't have free electrons
- Have conductivity between 10^{-10} to 10^{-20} $(\Omega\text{-m})^{-1}$
- Used in insulating devices
- Example:- plastic, wood

Semi Conductors

- **Intrinsic**
  - No impurities are added
  - Pure
- **Extrinsic**
  - Impurities added
  - Doped
  - **P type**: Electron deficient Impurity
  - **N type**: Electron rich Impurity

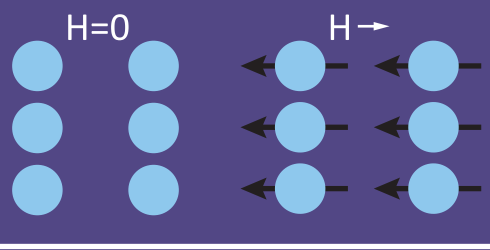
Magnetic properties

PARAMAGNETIC



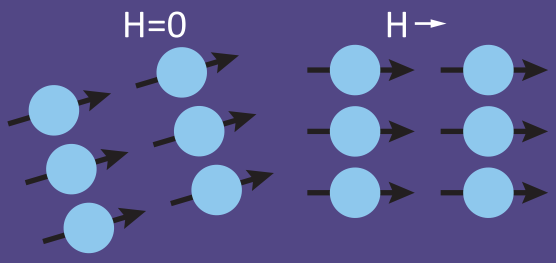
- Non magnetic without external magnetic field.
- Magnetised in the same direction of external magnetic field hence get attracted.
- Lose magnetism on removal of magnetic field
- Non permanent magnets
- Example:- Oxygen.

DIAMAGNETIC

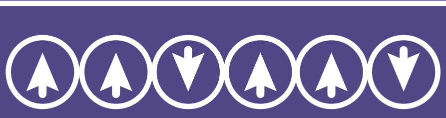


- Paired electrons, No magnetic moment
- Magnetised in the opposite direction of external magnetic field hence get repelled
- Lose magnetism on removal of magnetic field
- Non permanent magnets
- Example:- Sodium chloride ,benzene

FERROMAGNETIC

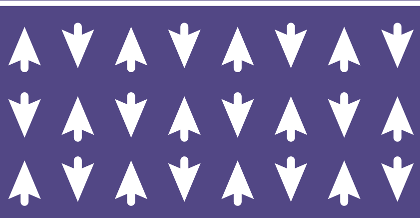


- Strongly magnetized in external magnetic field
- Magnetised in the same direction hence are attracted
- Don't lose their magnetism on removal of magnetic field
- Permanent magnets
- Example:- Cobalt, Nickel, Chromium.



FERRIMAGNETISM

- Unequally aligned magnetic moments
- Weakly attracted in magnetic field
- Lose their magnetic property on heating
- Example:- Zinc and Magnesium



ANTIFERROMAGNETISM

- Equally and oppositely aligned domains
- Cancel out each other's magnetic moment
- Example:- Haematite, Nickle Oxide.