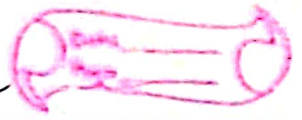


Material Technology



* Material technology :-

Branch of Applied science which is concerned with properties and structures of materials and relationship between these two.

* Material :-

Material is that out of which any thing can be made it comprises of while variety of metals and non-metals which are processed and final finished product is framed.

* Classification of ~~Metals~~ Materials :-

1) Metals :- Metals is composed of elements which forms metallic bond by ~~transferring~~ donating electrons.

:- characteristics / Property :-

1) Hardness, 2) strength, 3) Ductility, 4) Good conductor of temperature / heat and electricity, 5) high melting point, 6) Malleability, 7) Machine ability etc.

:- Metals may be sub divided into :-

1) Ferrous :- Metals having iron.

ex:- steel, iron, etc.

2) Non-ferrous:- It does not have iron.

ex:- Gold, silver, copper etc.

3) Non-metals:- Non-metals are elements which form negative by acting on electron.

sub non-metals are:- Rubber, leather, Plastic, etc.

Materials:- can also be classified as:-

1) Metals

2) Ceramics

3) Composites

4) Organic

5) Semi-conductor.

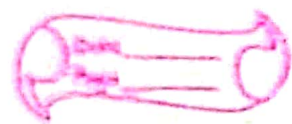
* Properties of Materials:-

(a) Physical properties:- (i) Melting / Freezing point / Melting temperature.

Temperature at which solid melts and liquid freezes.

(ii) Boiling point / temperature:- temperature at which liquid starts to form.

(iii) Density:- Mass / unit / Volume.

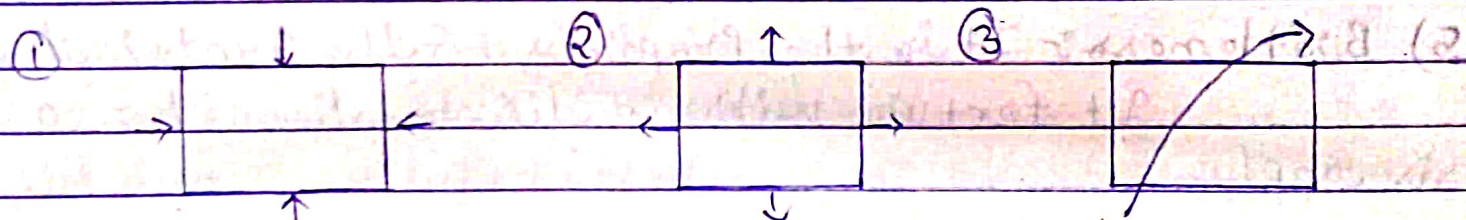


(iv) Linear ~~coefficient~~ coefficient of expansion:- Increase in length of solid per unit length if 1°C temperature rises.

(v) Thermal conductivity:- Ability to flow heat through it.

(b) Mechanical Properties:-

(i) **Strength**:- Ability to withstand various forces or load which are subjected or applied during a test or in service.



Compressive

Tensile

Torsional

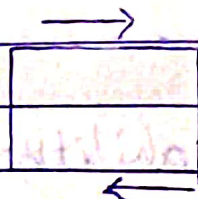


compressive
strength

Tensile
strength

Torsional
strength

(4)



Shear load

Shear strength

2) Elasticity:- A material is said to be elastic if it come back to its original dimension and shape after applied load is removed.

3) Plasticity:- Property of material by which material does not come back to its original dimension or shape after the load is removed.

4) Hardness:- It is the property by which material becomes scratch resistance hard material does not wear or tear easily.

5) Brittleness:- It is the property of the material to get fracture without deformation when a load is apply.

6) Ductility:- It is the property of the material by which it can be drawn into wire easily.

7) Malleability:- It is the property by which material can get easily converted into thin strips or plates or sheets.

8) Toughness:- It is the ability of a material to absorb energy from elastic limit upto fracture.

9) Resilience:- It is the ability of material to ~~with~~ ~~stand~~ absorb energy when it elastically deforms.

10) Impact strength:- Ability of the material to ~~with~~ withstand shock or impact load is called as impact strength.

11) Creep:- The time depended and permanent deformation of material when subjected to constant load or is loaded for very long time.

12) Fatigue:- When the material is subjected to repeated or fluctuating load it develops a characteristic ~~now~~ known as fatigue.

13) Yield strength:- When material is subjected to force or load it gets deformed as the load increases. The point where deformation suddenly increases by a very little force (load) or no load is called as yield point. Its strength at this point is called as yield strength.

14) Ultimate tensile strength:- The maximum stress which a material can with

Stand before breaking or failure during a tensile load is called as ultimate tensile strength.

Homework:-

① Magnetic Properties of materials:-

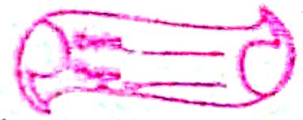
The magnetic properties of a material describe how it reacts to a magnetic field.

:- Some magnetic properties of materials include:-

1) Magnetic susceptibility:- Measures how much a material will be magnetized when placed in an external magnetic field. Diamagnetic materials have a small negative magnetic susceptibility because they repel magnetic fields.

2) Magnetic Permeability:- A constant that measures how easily a material can be magnetized or support a magnetic field.

3) Magnetic intensity:- The capacity of a magnetic field to magnetize.



a material.

4) Intensity of magnetization:- The extent to which a material is magnetized when placed in a magnetic field.

5) Magnetic retentivity:- The ability of a material to retain magnetization after the external magnetic field is removed.

6) Coercivity:- The intensity of the magnetic field needed to demagnetize a material.

:- Some types of magnetism are as follows:-

force-

1) ~~Para~~ ferromagnetism:- matter creates a magnet.

2) Para magnetism:- matter creates a magnetic field.

3) Diamagnetism:- an applied magnetic field in them in the opposite direction, causing a repulsive force.

4) ~~Para~~ Anti ferromagnetism:-
The magnetic iron

moment keeps changing from atom to atom, resulting in antiferromagnetism.

(2) Electrical Properties of material include :-

1) Electrical resistance:-

The property of a substance that opposes the flow of electrons or electric current. The unit of electrical resistance is Ohm.

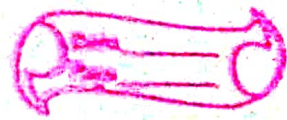
2) ^{Di} ~~Dielectric~~ electric strength:-

Electrical strength of insulating materials. Materials with higher dielectric strength allow a higher order of electrical current to flow, resulting in greater thermal insulation.

3) Thermoelectricity:-

The property of some materials that produce a noticeable voltage when subjected to a temperature gradient. These materials have high electrical conductivity.

4) Super conductivity:- ^{Coolest} ~~An anti~~ electronic state



that some substance exhibit at low temperature. This state results in anomalous electromagnetic and thermal properties.

5) electrical conductivity:- The property of a substance that allows electric current to flow easily through it.

6) electron emission:- electron emission is the ejection of an electron from the surface matter in beta decay (β -decay), where a beta particle is emitted from an atomic nucleus transforming the original nuclide to an isobar.

* Mechanical Property:-

15) Machinability:- The property of a material by which it can get machined. If material if small amount of material can be removed by using different machine (grinder, lathe etc). Then the material said to have machinability property.

16) Refractoriness:- ~~The~~^{It} is the property of a material by which the material with stand bear by high temperature or heat.

* Crystal structures:-

⇒ crystalline material :- It consists of atoms or molecules arranged in a regular pattern in a 3D way. ~~properties~~ ~~radius~~ ~~terms~~ used for crystalline materials are as follows :-

1) crystal :- Crystal is a solid in which atoms or molecules are arranged in a systematic or regular geometric pattern.

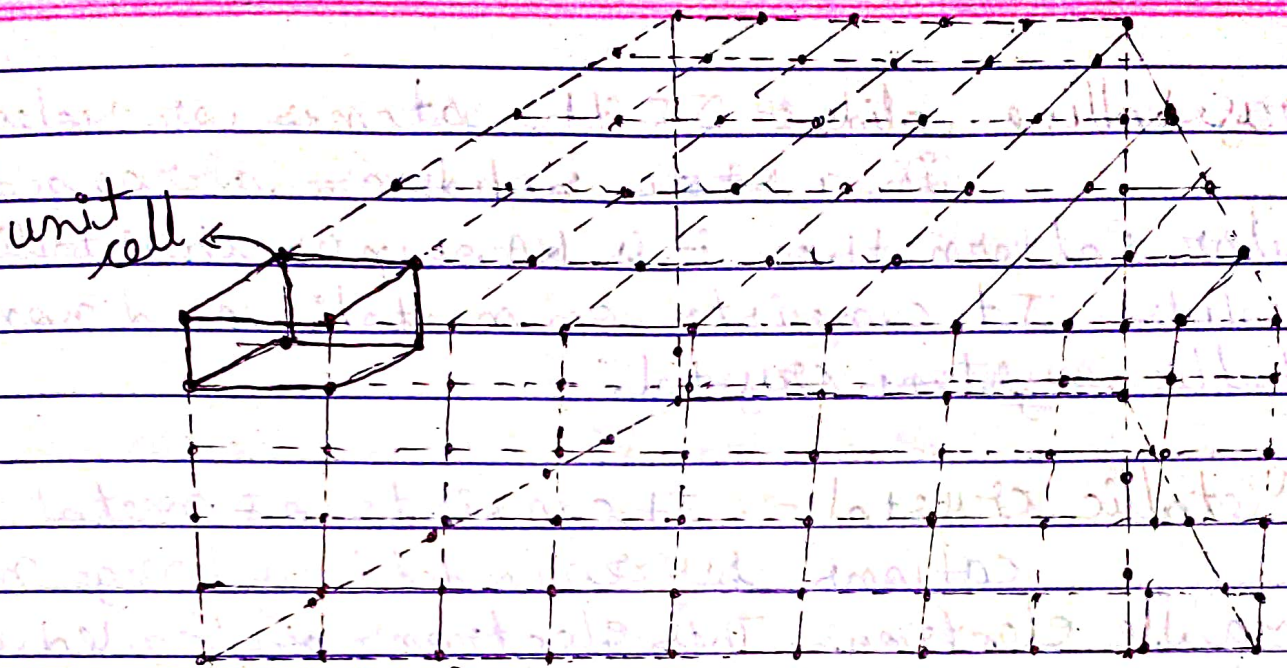
2) structure :- It is the arrangement of atoms inside a crystal.

(or) crystal lattice

3) space lattice :- The atoms arranged themselves in a particular pattern in space inside a crystal which is called space lattice.

4) Unit cell :- It is the smallest group of atoms with symmetry of crystal.

The material crystal can be considered as consisting of tiny blocks which are ~~repeated~~ repeated in 3D pattern. These tiny blocks formed by the arrangement of atoms are called as unit cells.



5) crystallographic plane:- The layer of atoms allows with the plane in which atoms are arranged.

6) lattice parameter:- Lattice parameter are edge lengths and interfacial angle inside a crystal.

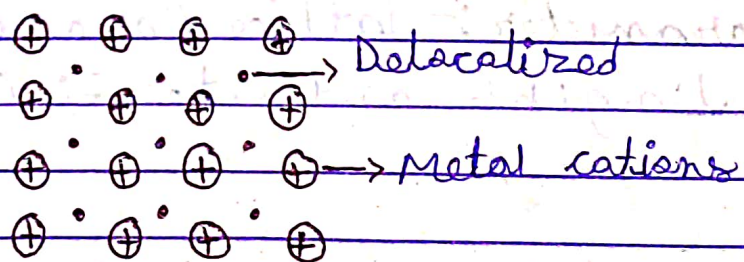
* Types of solids:- A solid is a state of matter in which atoms are closely packed as compare other two states.

Solids may be classified into:-

- 1) Crystalline solids
- 2) Amorphous solids

1) crystalline solids:- If the atoms or molecules in a ~~state~~ solids are arranged in regular pattern then it is known as crystalline solids. It consists of metallic and non-metallic ~~systems~~ crystal.

(a) Metallic crystal:- It consists of metal cations surrounded by large no. of mobile electrons. These electrons are called as delocalized electron since it does not belong to any atom but are capable to move through entire crystal structures. Due to this movement of electrons metal are good conductor of electricity. Atoms have metallic bands.



Ex:- 1) FCC $\rightarrow$ (copper, silver etc.)

2) BCC $\rightarrow$ (chromium, sodium etc.)

3) HCP $\rightarrow$ (Hg, Zinc etc.)

(b) Non-metallic crystal:- It has co-valent or Ionic bonding or combination

of its bonds. Non-Metallic crystals are more brittle than metallic crystals.

2) Amorphous solids:- In this atoms are arranged in irregular lattices. It has negligible elasticity and elasticity is higher than its other solids.

Ex:- Glass.

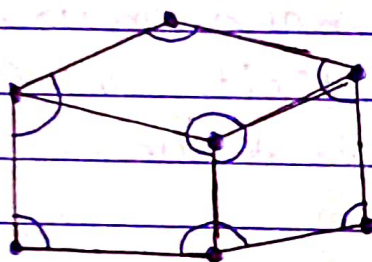
* Bravais space lattice:- The atoms in crystalline material are arranged in repeatative 3D pattern known as lattice structure and the point of intersection of atoms in known as lattice point. There are 14 ways in which point can be arranged in space so that each point is identical to its surrounding. This 14 space lattices are called as Bravais space lattice.

:- crystal structures for metallic elements:-

- (i) simple cubic cell. (SCC)
- (ii) face centered cubic structure. (FCC)
- (iii) Body centered cubic structure. (BCC)
- (iv) Hexagonal close packing structure. (HCP)

(i) simple cubic cell:- (SCC)

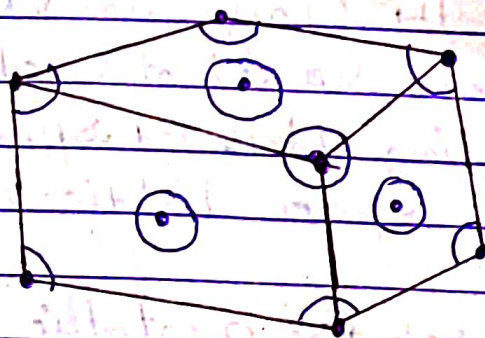
In this crystal structures every corner of the cube or unit cell has $\frac{1}{8}^{\text{th}}$ part of atom.



SCC

(ii) ~~Body~~ Face centered cubic structure:- (FCC)
 $\frac{1}{8}^{\text{th}}$ part + $\frac{1}{2}$

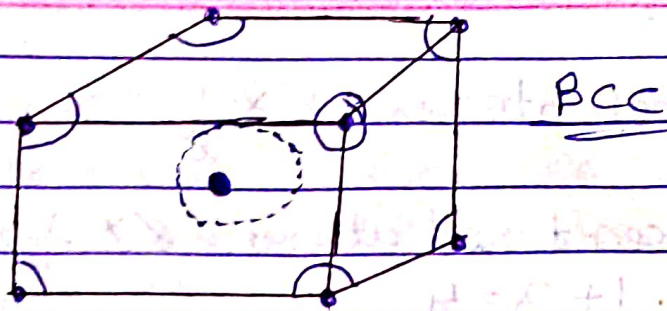
In this atoms are located at every corner of the cube and centre of each face.
ex:- (Copper, Silver, Gold etc.)



FCC

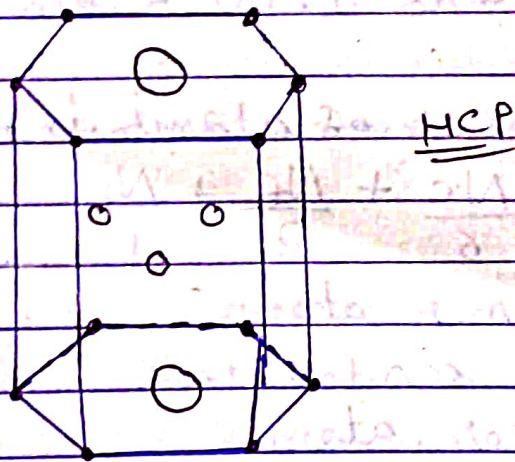
(iii) Body centered cubic structures:- (BCC)

In this atoms are present at every corner and one atom is present in the center of cubic structure.
ex:- (Lithium, Sodium etc.)



(iv) Hexagonal closed packing structure:- (HCP)

In this the unit cell has atoms at each 12 corners of the hexagonal prism, atom at each two faces and three atoms in side the body of the cell.



* characteristic:-

Number of atoms per unit cell.

(i) SCC :- (i) Number of atoms in SCC.

$$8 \times \frac{1}{8} = 1 \text{ atom}$$

(every corner)

(ii) Hence total number of atoms in SCC is one.

(ii) FCC :- (i) Number of atom in FCC.

$$\text{corner atoms} = 8 \times \frac{1}{8} = 1$$

$$\text{Face centered atoms} = 6 \times \frac{1}{2} = 3$$

$$1 + 3 = 4$$

(ii) Hence FCC has total 4 atoms.

$$(iii) \text{ BCC :- (i) corner atoms} = 8 \times \frac{1}{8} = 1$$

$$\text{Body centered atoms} = 1$$

$$1 + 1 = 2$$

(ii) Hence BCC has total 2 atoms.

(iv) HCP :- (i) Number of atoms in HCP

$$N = \frac{N_c}{6} + \frac{N_f}{2} + \frac{N_i}{1}$$

where,

N_c = corner atom

N_f = face center atom

N_i = center atom

$$N = \frac{12}{6} + \frac{2}{2} + \frac{3}{1} = 6$$

(ii) Hence HCP has total 6 atoms in it.

* Coordination number :- (C.No.)

The number of nearest atoms which are directly surrounding the given atom is called as coordination number.

(a) SCC:- $\rightarrow$

$\rightarrow$ coordination number of SCC = 6.

$\rightarrow$ If (a) is the side of each unit cell then given the distance between nearest atoms in SCC = (a).

(b) FCC:-

$\rightarrow$ coordination number of FCC is = 12.

$\rightarrow$ Distance between nearest atoms $a\sqrt{2}$.

(c) BCC:-

$\rightarrow$ coordination number of BCC is = 8.

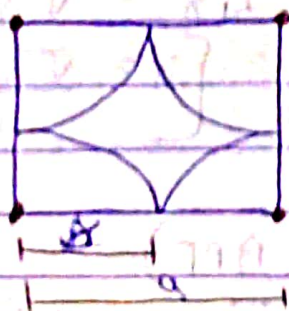
$\rightarrow$ nearest distance between atoms = $\frac{\sqrt{3}a}{2}$.

(d) HCP:-

$\rightarrow$ coordination number of HCP is = 12.

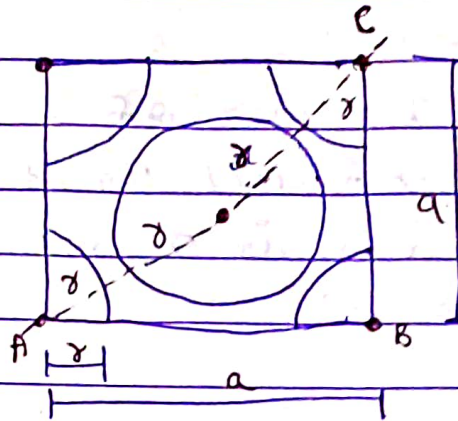
* Atomic radius:-

1) SCC:-



$$[r = \frac{a}{2}]$$

② FCC :-



In $\triangle ABC$

$$AC^2 = AB^2 + BC^2$$

$$(2r + 2r + 2r)^2 = a^2 + a^2$$

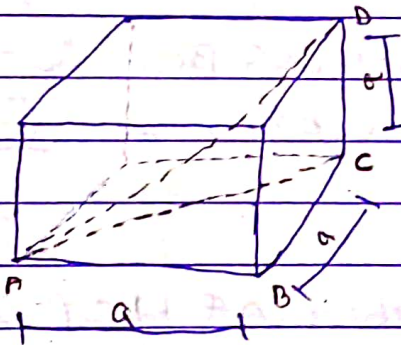
$$(4r)^2 = 2a^2$$

$$4r = \sqrt{2}a$$

$$4r = \sqrt{2}a$$

$$\left[r = \frac{\sqrt{2}a}{4} \right]$$

③ BCC :-



In $\triangle ACD$

In $\triangle ACD$

$$AD^2 = AC^2 + CD^2$$

$$(2r + 2r + 2r)^2 = AC^2 + a^2$$

$$(4r)^2 = (\sqrt{2}a)^2 + a^2$$

$$(4r)^2 = 2a^2 + a^2$$

$$4r = \sqrt{3}a$$

$$\left[r = \frac{\sqrt{3}a}{4} \right]$$

In $\triangle ABC$

$$AC^2 = AB^2 + BC^2$$

$$AC^2 = a^2 + a^2$$

$$\left[AC = \sqrt{2}a \right]$$

* Atomic Packing factor :- (APF)

The density of packing in a crystal is determined by according packing factor.

$$APF = \frac{\text{Volume of atom per unit cell}}{\text{Volume of unit cell}}$$

1) SCC :-

$$APF = \frac{1 \times \frac{4}{3} \pi r^3}{a^3} \Rightarrow \frac{1 \times \frac{4}{3} \pi \left(\frac{a}{2}\right)^3}{a^3}$$

$$\Rightarrow \frac{\frac{4}{3} \pi \cancel{a^3}}{\cancel{a^3} \times (2)^3} \Rightarrow \frac{4\pi}{3 \times 8} \Rightarrow [APF_{SCC} = 0.52]$$

2) FCC :-

$$\frac{4 \times \frac{4}{3} \pi r^3}{a^3} \Rightarrow \frac{16}{3} \pi \left(\frac{\sqrt{2} a}{4}\right)^3$$

$$[APF_{FCC} = 0.74]$$

3) BCC :-

$$\frac{2 \times \frac{4}{3} \pi r^3}{a^3} \Rightarrow \frac{8}{3} \pi \left(\frac{\sqrt{3} a}{4}\right)^3$$

$$[APF_{BCC} = 0.68]$$

4) HCP :-

$$APF_{HCP} = 0.74$$

S. No.	Crystal	No. of atoms per unit cell	coordination Number	APF	Atomic Radius	Example
1	SCC	1	6	$a/2$	Po,	
2	FCC	4	12	$\frac{\sqrt{3}a}{4}$	Al, Ni, Ag etc.	
3	BCC	2	8	$\frac{\sqrt{3}a}{4}$	Fe, Cr, W	
4	HCP	6	12		Be, Cd, Mg	

APF

1) 0.52

2) 0.74

3) 0.68

4) 0.74

Unit -3 :- Phase Diagram

* Alloy & compound

* **Alloy**:- If two element combined in such way that resulting microstructure reflects/shows the property of individual element is called alloy.

* **compound**:- If two elements combined together in such way that individual way lighter loses its property or having property other than the two combining elements. then the resulting microstructure is name as compound.



2) Then two elements combined and produced a single phase then it is known as alloy.

1) **Phase**:- Physically distinct
mechanically separable
chemically homogeneous

2) **component**:- No. of individual chemical formula.

3) **Degree of freedom (F)**:- No. of independent variables (like:-

Temperature, Pressure) required to define state of any metal. [Independent Intensive Properties]

Gibbs Phase rule:-

$$\underbrace{P + F = C + 2}_{\substack{\text{No. of Phase} \quad \downarrow \quad \text{Degree of freedom}}} \quad \xrightarrow{\text{Component}}$$

* Solutionizing / Solid solution:-

Mixing of impurity atom in the parent atom in such a way when the bond between them leads for formation of single phase microstructures.

Overall when two element combined together in such a way that the resulting microstructure is a single phase then it is known as solutionizing / Solid solution.

* Phase in metallurgy:- In metallurgy we say we have two different phase when:-

- 1) Crystal structure is different.
- 2) size of unit cell is not same.

* Inter Metallic Inclusion:- In metallurgy generally compound are known as inter metal

Intrusion or inclusion. i.e. Impurity atomic either already present or if added then it forms

a compound by attaching four, five atoms at parent a and it appears distinctly in the micro-
-scope.

It is consider Problem in the material as it as tendence to break the tool and causing chattering point of tool.

* Hume Rothery Rule:- Two elements combined to form alloy when condition of Hume Rothery Rule are satisfied.

- > Crystal structure same.
- > Valencies should be comparable.
- > Difference in their atomic radius $< 15\%$.
- > Their electronegativity & electroaffinity should be comparable.

* Phase Diagram: Phase Diagram is a plot/graph on temperature - % composition space showing stability of various phases.

In other words phase Diagram tells as what will be melting point of alloy.

* Classification of Phase Diagram:-

On the basis of no. of components.

$\rightarrow C=1$, unary phase Diagram $\Rightarrow$ Thermodynamics graph
[P-h, T-S, P-V, h-S]

$\rightarrow C=2$, Binary Phase Diagram $\Rightarrow$ CU-Ni / Pb-Sn / Fe-Fe₃C
 Iron-Iron carbide Diagram.
 Iron-carbon Diagram.
 $\rightarrow$ Isomorphism $\rightarrow$ CU-Ni.
 $\rightarrow C=3$, Ternary Phase Diagram

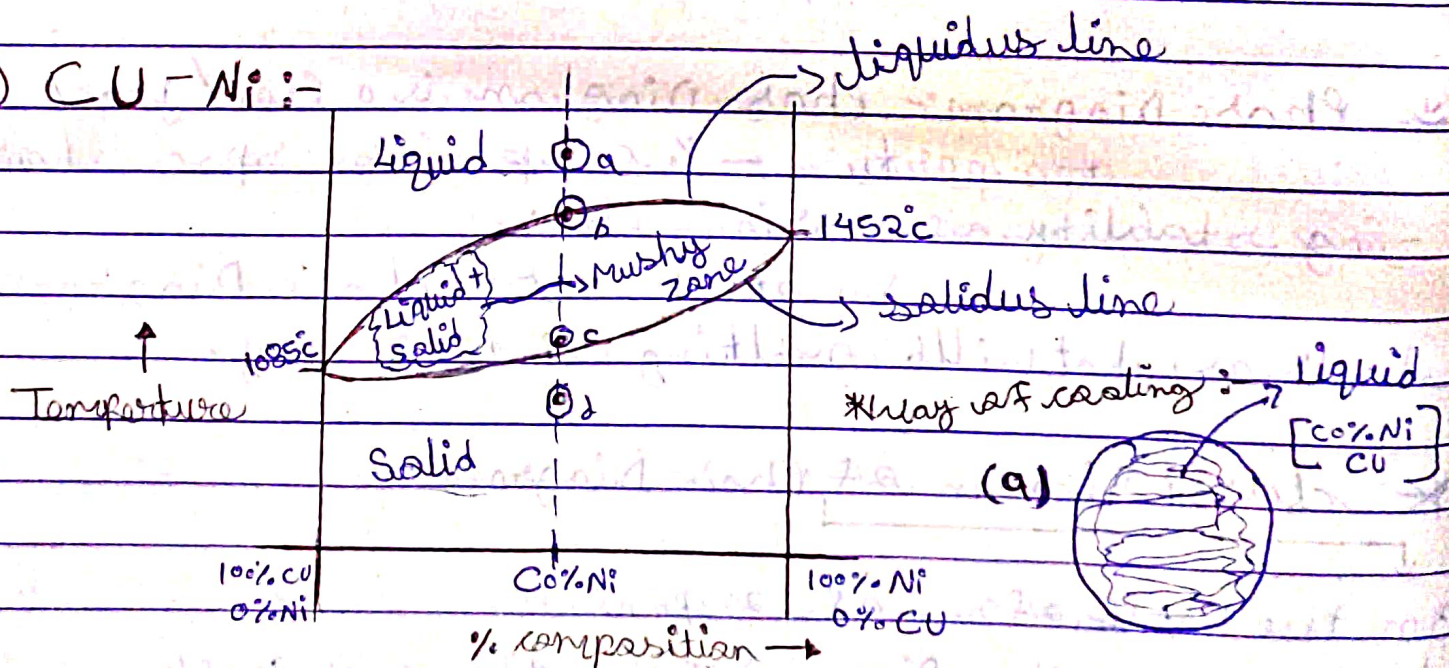
* Binary Phase Diagram:-

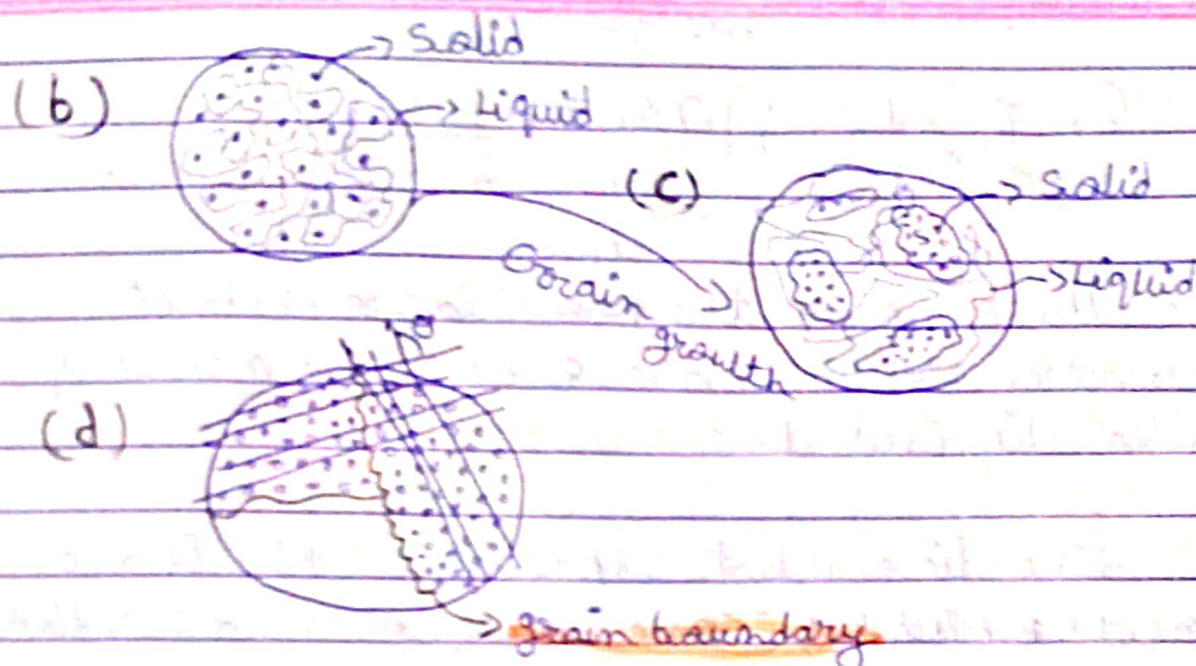
Type-I:- Isomorphism:-

Material which are completely soluble in both liquid as well as in solid state.

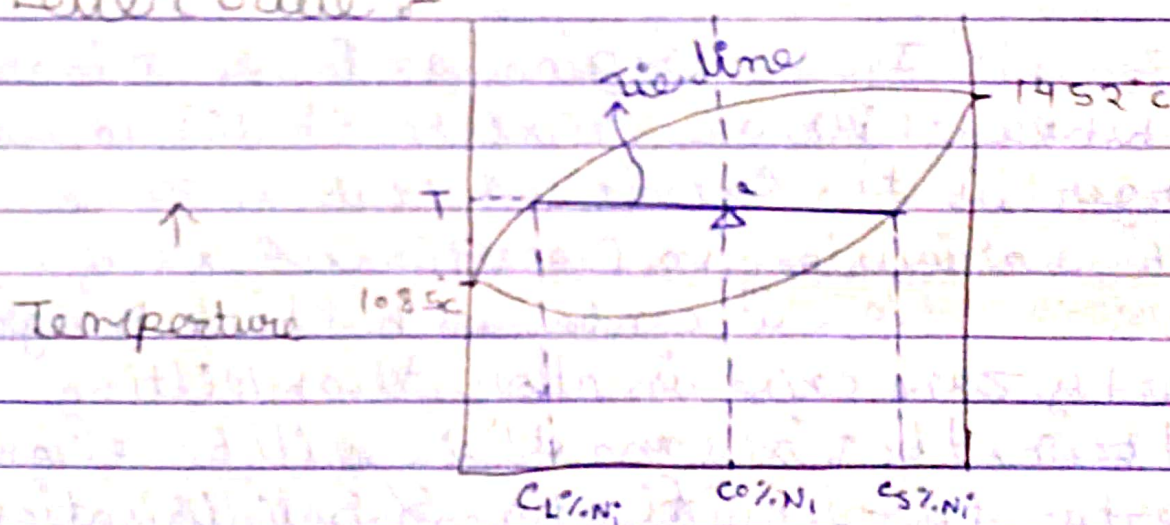
ex:- CU-Ni / Pb-Sn etc.
(Lead - Tin)

(a) CU-Ni:-





* Lever rule :-



C_0 = overall composition

C_S = solid composition

C_L = liquid composition

$$M_S + M_L = 1 \quad \text{--- (1)}$$

$$M_S \times (C_S \%) + M_L \times (C_L \%) = C_0 \% \quad \text{--- (2)}$$

most snip.

most snip.

$$M_s = \frac{C_0 - C_L}{C_S - C_L} ; M_L = \frac{C_S - C_0}{C_S - C_L}$$

* liquidus:- The line in the ^{phase} ~~for~~ Diagram that separates liquid phase from the mushy zone is called liquidus line.

* solidus:- The line that separates solid phase from the mushy zone is known as solidus line.

* Mushy zone:- It is a region on phase diagram where there are mixture of liquid and solid. Larger is the extent of mushy zone, more will be variation in properties of alloy.

As it can be seen phase diagram that if mushy zone exist in alloy, then melting point will not be fixed and there will be a range of temperature for liquification & solidification.

* Lever rule can only be applied to two phase ~~Diagram~~ region:-

① A sample of Cu & Ni with 60% Ni is along line of slowly.

② Point A is above liquidus line so entire structure will be in liquid phase.

③ The moment temperature of a sample slowly decrease to point b solid starts nucleating in microstructure of 1000 phases.

④ Upon decreasing the temperature of a sample from point b for slowly following conclusions can be drawn by using lever rule:-

(i) As the temperature decrease mass fraction of solid phase keeps on increasing.

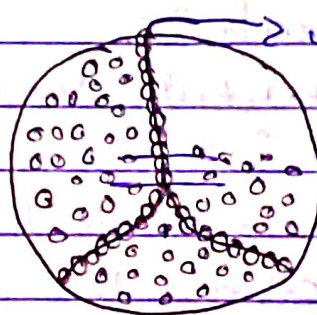
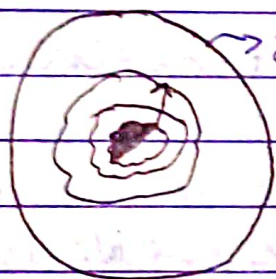
(ii) The moment solid nucleated % of Ni in solid was quite high. upon decrease, the temperature % of Ni in solid keeps on decreasing and approaches the overall composition Co in outer region of solid % of Ni will be less.

(iii) At high temperature phenomenon called diffusion appears in solid metal which tries to homogenise the composition if in solid that every 20°C increase in temperature diffusion multiplies by 2. So Ni will diffuse from centre to outward direction and make the composition uniform throughout. so within solid phase composition of Cu & Ni will be uniform.

(iv) Each and every solidification front will have a

Particular arrangement of atoms. the moment temp. of sample slightly decrease below solidus line different solidification front will fuse together & entire micro structure will convert into solid phase.

- (v) The regions with different solidification front meeting their will be mismatch in orientation of atoms. These regions of orientation mismatch are called Grain Boundary.



→ on grain boundary bond length more so inter-atomic site is more.

- (vi) At a grain boundary since bond length is large so easily bond can break. so the atmospheric oxygen first attach grain boundary material and corrodes it that's why it is said that grain boundary are at higher energy level.

- (vii) To increase the corrosive resistance of any material chromium is added in it. chromium after reacting with oxygen form chromium oxide Cr_2O_3 and gets accumulated at grain boundaries protecting grain boundary atoms from attack of oxygen.



- ① Ni is a phase stabilizer. In case of Iron Ni is Austenite phase ~~stabilizer~~ stabilizer and Chromium is ferrite phase stabilizer.
- ② To protect any material from grain boundary corrosion either foreign phase has to be accumulated at " " or the grain boundary should be completely removed from material. Materials with no grain boundaries are called super alloys.
- ③ Super alloys in this section are called whiskers.
- ④ More stability does not mean more M.T.

① Austenite steel we need - as it is has good ductility.
So we want to stabilize this Austenite phase at room temp. (Austenite phase not stable at room temp.)
↓ So

Ni added

* Binary phase diagram of type-II (Eutectic system)
Pb-Sn
Partial solid solubilities

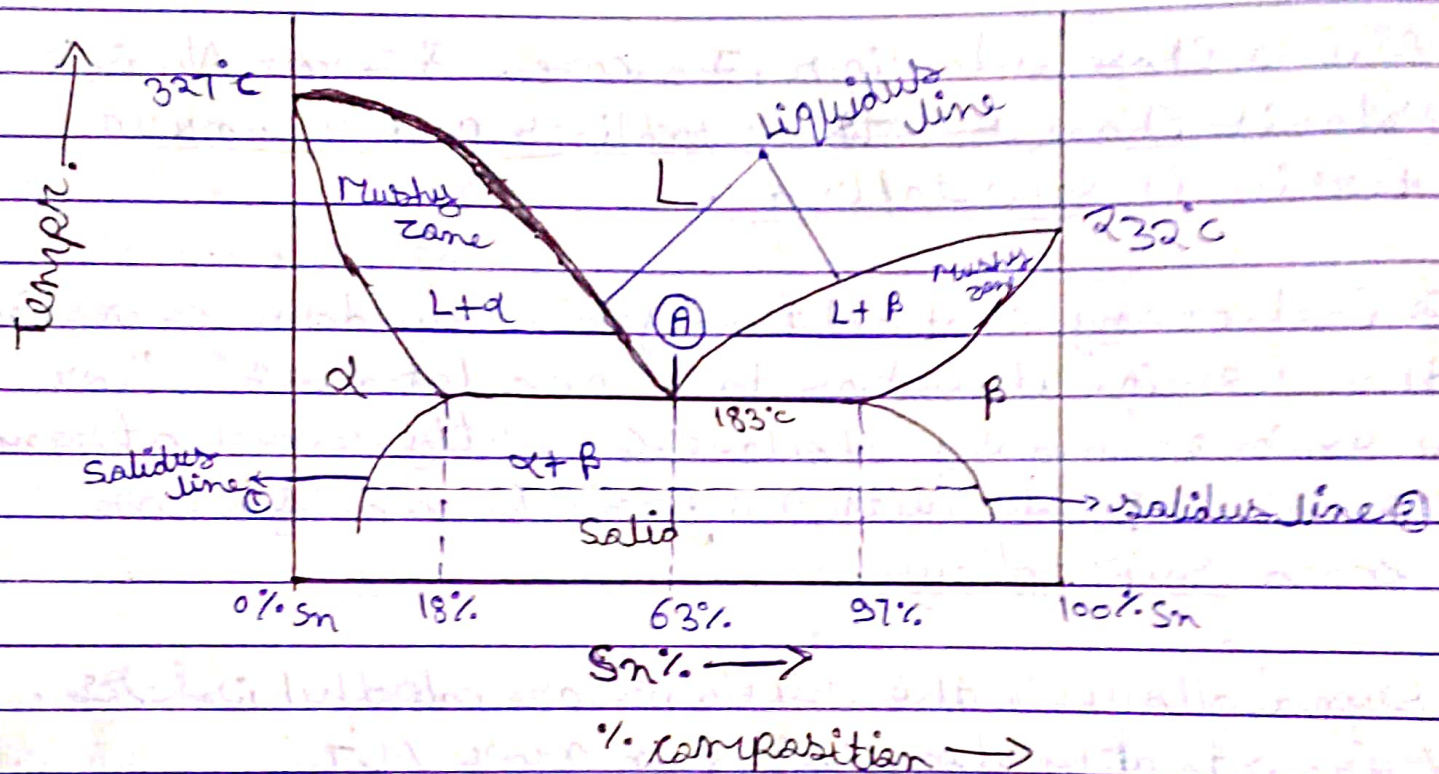
63% Sn + 37% Pb = Alloy

↳ In the Best in world as Best Solder.

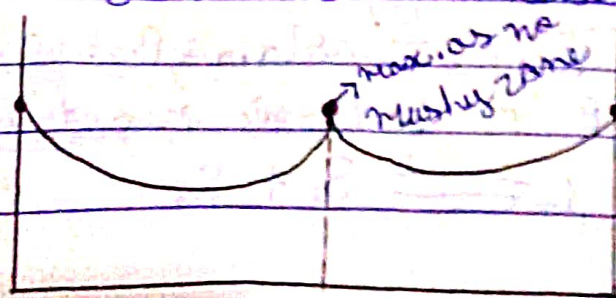
$A \xrightleftharpoons[63\%]{183^\circ\text{C}} \alpha + \beta$ $\rightarrow$ Eutectic reaction

$L \rightleftharpoons S_1 + S_2$

Type II Draw eutectic equation



- * Weld decay: $\text{Cr}_2\text{O}_3 \rightarrow$ chromium oxide and the grain boundary exposed to corrosion.
- α -Phase is solid solution of tin in lead (Sn-Pb) and max 18% tin can be dissolved in Pb at 183°C. This solid solubility decreases with decreasing the temperature.
 - β -Phase is solid solution of Pb in Sn at max 3% lead and 97% Sn can be dissolved at 183°C in lead. This solid solubility decreases with decrease in temperature.



→ any line in a phase diagram that separates a single solid phase with misc. of solid phase is a solvus.

- Pressure is also a kind of degree of freedom for 2 phase this DoF is

- ∴ The point where no mushy zone called eutectic point (nice melting point) at this invariant DoF = 0

$$\therefore C + (2 - 1) = (F - 1) + P$$

$$\therefore C + 1 = F + P$$

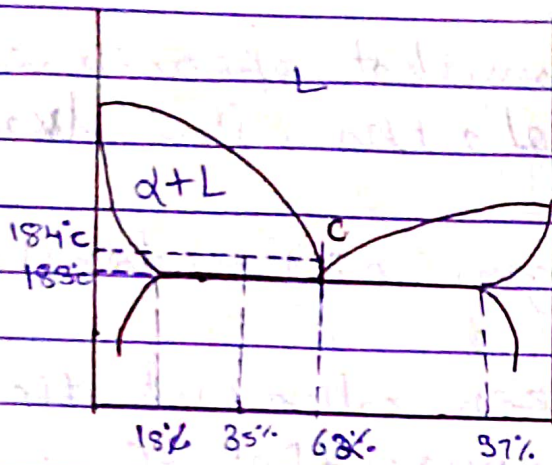
$$\therefore C = 2 \therefore P = 3$$

- All the binary phase diagrams are plotted at constant pressure. but P is one of the DoF so we are restricting one DoF this will change the Gibbs equation.

- Invariant means DoF = 0 so according to modified Gibbs phase rule 3 phases will be in equilibrium at eutectic point.

- The temperature at which eutectic reaction appears is called eutectic temperature and the composition at which eutectic reaction appears is called eutectic composition.

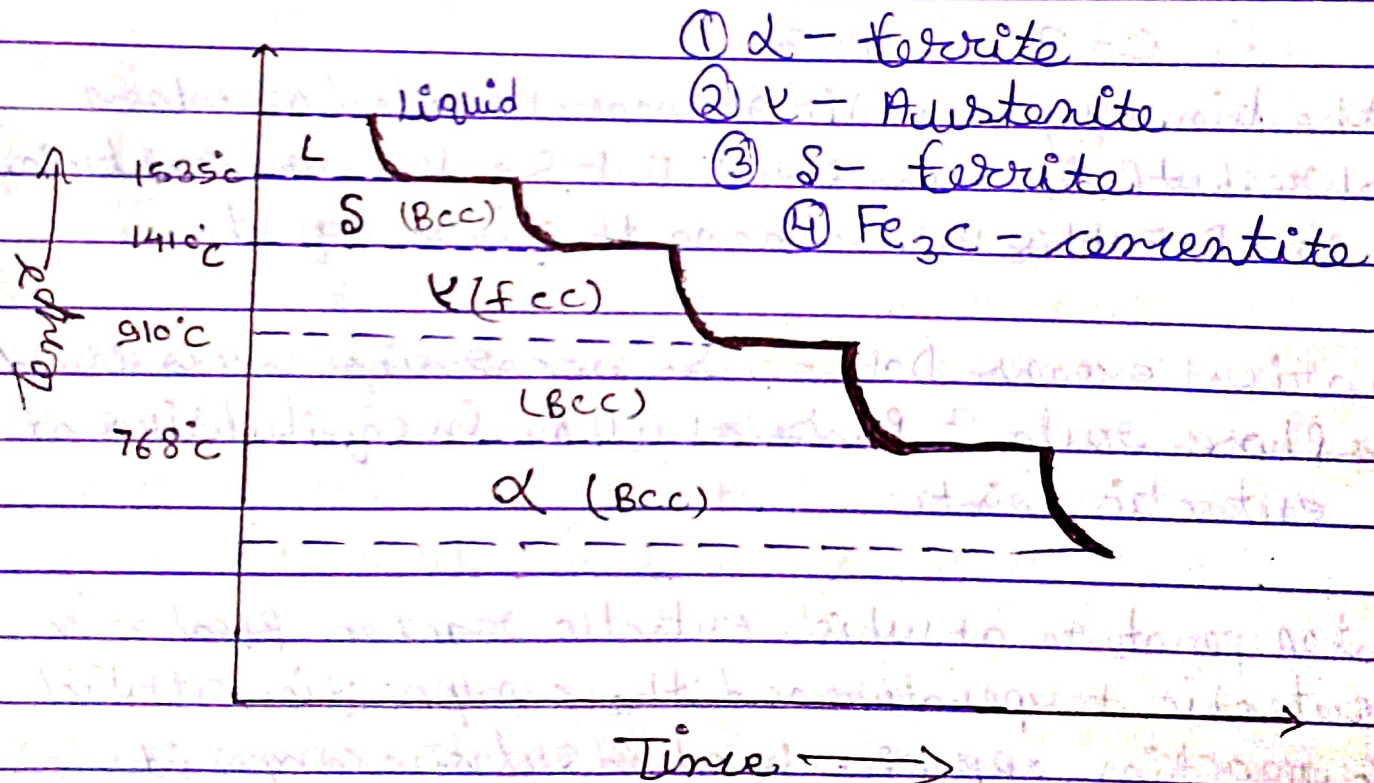
Q. calculate the mass fraction of phase present in a lead and tin alloy with 35% tin and at 184°C



$$M_s = \frac{62 - 35}{62 - 18} = 0.61 \text{ Avg.}$$

$$M_d = \frac{35 - 18}{62 - 18} = 0.39 \text{ Avg.}$$

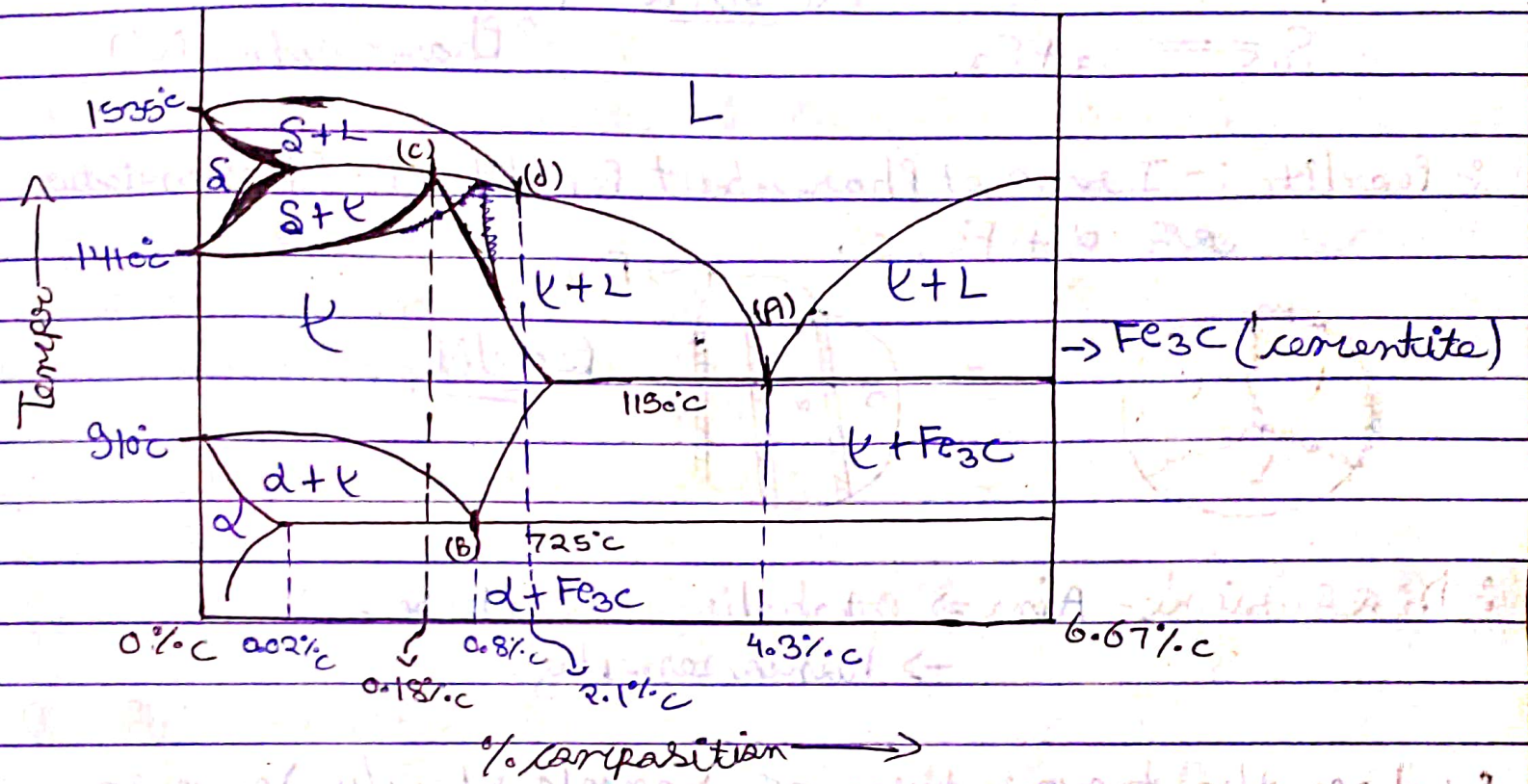
* Phases of Iron:



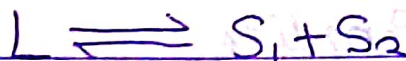
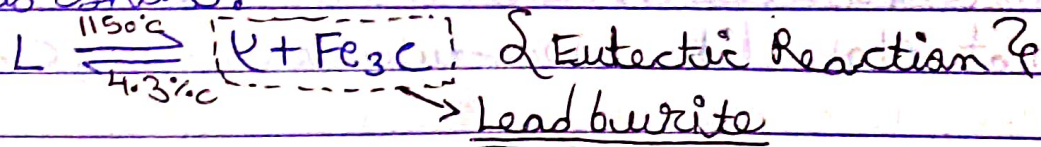
Whenever there is a phase change in material either there should be crystal change or in size as unit cell less of magnetic property same are still is a phase change.

Most imp. Type III:-

* Iron-carbon Diagram (Fe-Fe₃C) (Iron cementite phase)

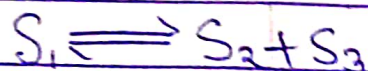
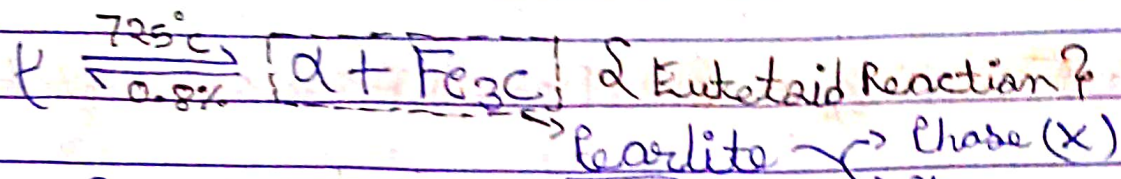


(A) Eutectic Composition:- Two elements are completely soluble in liquid state & mutually soluble in solid state.



* Ledeburite:- Not a phase but a phase mixture.

(B) Eutectoid Composition:- At 0.8% C at 725°C carbon is uniformly distributed in microstructure.

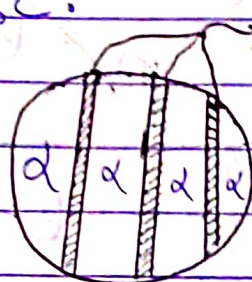


Pearlite

Phase (X)

Phase mixture (✓)

∴ Pearlite :- Is not a phase, but Pearlite is Phase mixture of $\alpha + \text{Fe}_3\text{C}$.



Fe_3C

Pearlite

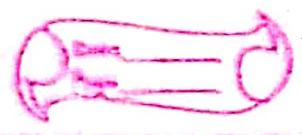
∴ Diffusion :- Aim $\Rightarrow$ stabilise the phase.
 $\rightarrow$ homogeneity.

• When the temperature of sample slowly decrease below eutectoid temperature since austenite cannot be present in stable form. So carbon diffuses from one interstitial site to another and produce a alternate plate like structure as $\alpha + \text{Fe}_3\text{C}$.

• This microstructure is called Pearlite.

• Pearlite is not a phase. It is a phase mixture of ferrite & cementite. ($\alpha + \text{Fe}_3\text{C}$).

• Similarly eutectoid decomposition produces leadwhite



(c) Peritectic composition:- $S_1 + L \rightleftharpoons S_2$
 $S + L \xrightleftharpoons[0.18\%C]{1793^\circ C} \downarrow$ { Peritectic Reaction? }

• when there is a large difference in melting point of 2 materials, then in the phase diagram of such alloy. Peritectic reaction will appear & such diagram are also referred to as Peritectic diagram.
(Here Solid + Liquid $\rightarrow$ Solid)

(d) Monotectic composition:- $L_1 \rightleftharpoons S_1 + L_2$
 $L \xrightleftharpoons[\text{Heating}]{\text{Cooling}} V + L$ { Monotectic Reaction? }

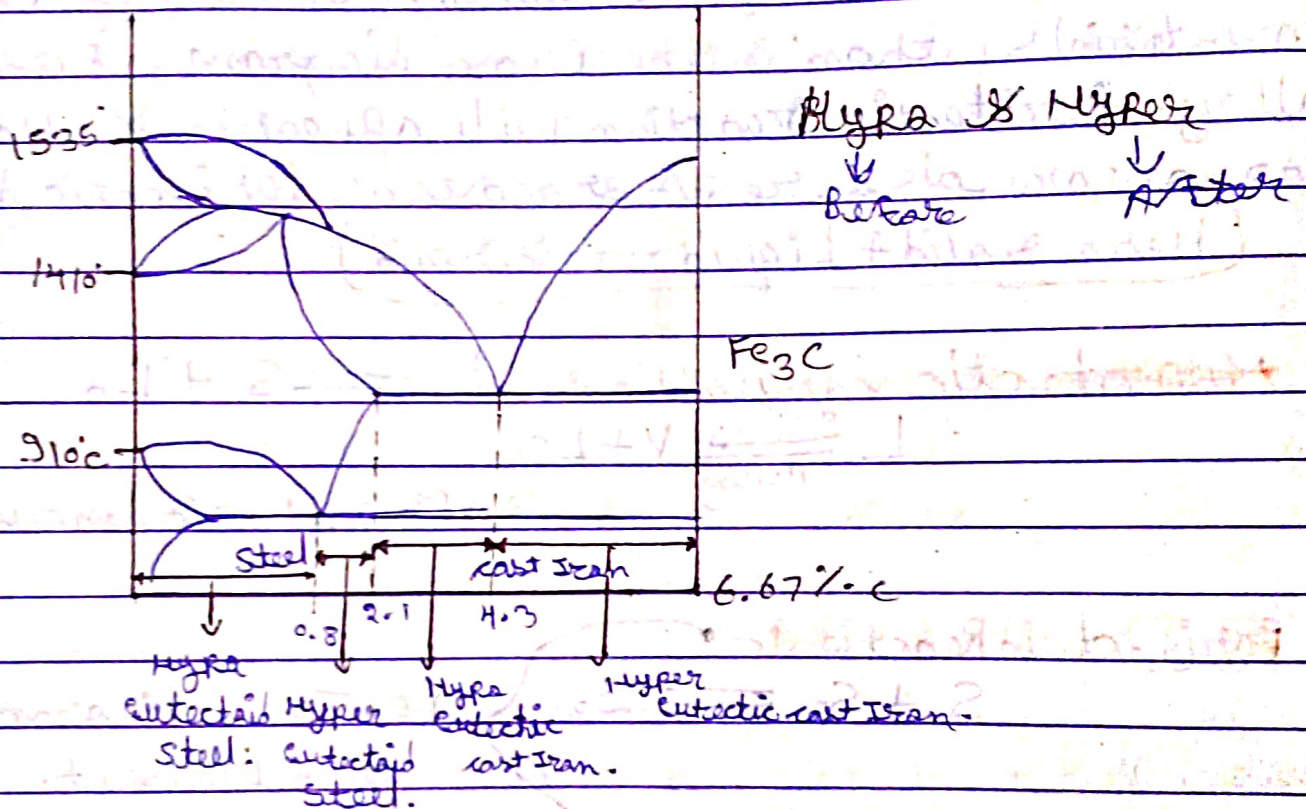
(e) Peritectoid Reaction:- $S_1 + S_2 \rightleftharpoons S_3$
Fe-Fe₃C diagram is not present.

(f) Synthetic Reaction:- $L_1 + L_2 \rightleftharpoons S_1$

* Iron-carbon diagram is such a diagram where 5 invariant reaction appears simultaneously:-

- In copper diagram we have Peritectoid reaction & it is not seen in Fe-Fe₃C diagram.
- Pearlite transformation is known as diffusion

Process of diffusion process initially stabilizes the phases & if ~~the~~ phases are stable than it will try to homogenize the composition.



Steel

Fe + { max. upto 2.1% C }

Steel

- Hypo eutectoid steel
%C < 0.8% C
- Hyper eutectoid steel
0.8% C < %C < 2.1% C

Cast Iron

Fe + { from 2.1% to 6.67% C }

cast iron

- Hypo eutectic cast iron
2.1% C < %C < 4.3% C
- Hyper eutectic cast iron
4.3% C < %C < 6.67% C

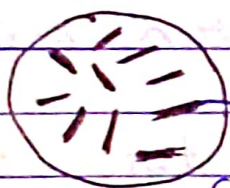


* classification of steel:-

- 1) $\%C < 0.30\%C$ - Low carbon steel / mild steel.
- 2) $0.3\%C < 0.7\%C$ - Medium carbon steel.
- 3) $\%C > 0.7\%C$ - High carbon steel.

* classification of cast Iron:-

- 1) grey cast Iron:- In pure iron carbon system when more than 6.67% carbon is added a portion of carbon comes out in the micro structure. And appears in the form of free flakes such cast Iron is known as grey cast Iron.



Slow cooling

Free form of carbon

- 2) white cast Iron:-

(fast cooling) when (%) of carbon is less than

6.67% carbon then nature or amount of carbon will

appear in combined form. Then these material are called white cast Iron. These white cast Iron are very hard and Brittle in nature.

- 3) chilled cast Iron:-

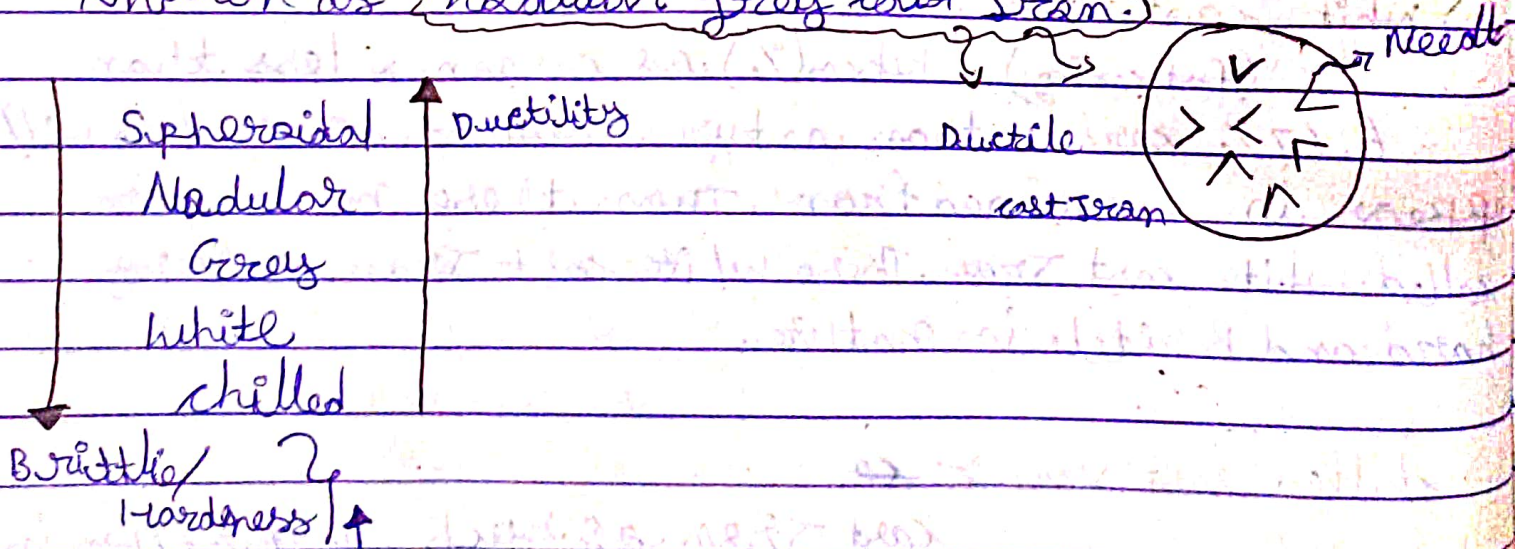
cast Iron of such composition in which normally it will freeze as grey but because it appears as white by rapid cooling is called chilled

cast Iron.

→ (or) malleable cast Iron:-

4) Spheroidal Grey cast Iron:- If the objective is to produce Ductile than small amount of Mg and silicon is added in liquid state of Iron.

- These liquid Iron is then rapidly cool to form chilled cast Iron.
- After producing chilled cast Iron the material is again heated to a temperature less than 1150°C and then cool externally slowly in the furnace.
- At 1000 of places of carbon will diffuse at centre and produce spheroid, these increases the overall Ductile of the material.
- If the cooling rate is slowly faster combined from of carbon appears in needle like form which is known as nodular grey cast Iron.



Unit-3 Etching Process.

Etching Process.

* Surface Preparation:-

Various stages of surface preparation are:-

- i) selection & cutting of specimen
 - ii) Rough Grinding
 - iii) intermediate & fine grinding
 - iv) Polishing
 - v) Etching
- } for optical microscope

→ In case of X-ray diffraction microscope, we need not have any suitable preparation for sample. But with respect to different microscope we need to prepare the sample in order to do study.

In case of micro structural characterisation we have different scales of microscope i.e. optical microscope (normal microscope), scanning electron microscope & (high magnification microscope) & mostly XRD microscope.

i) selection & cutting of specimen:-

- we need a specimen of smaller size of either circular or rectangular or square shape (approx dia- 10-15 mm)
- If the sample size is very small than the specimen / sample is mounted on thermoplastic resins eg:-
Batercite mounting.

i) Rough Grinding:-

By using file, or rotating grinding wheel or motor driven belt grinders, rough grinding is being done.

iii) Intermediate & fine grinding:-

Intermediate grinding is followed by rough grinding with the help of emery papers of coarse grain size & then it is followed by fine grain size paper.

iv) Polishing:-

Since the surface of specimen after undergoing fine grinding process it has small-small scratches & scratches which is undesirable when we undergo microscopic observation.

Therefore, we need to remove these scratches via polishing technique. Polishing removes these scratches by burnishing operation.

→ Specimen surface are polished by means of rotating cloth pad in pregnant or containing suitable polishing medium.

→ This polishing medium may be either Alumina polishing (alumina paste) or diamond polishing (containing diamond paste). Although diamond polishing can give very high ultra polishing surface.

→ Due to contact between the polishing medium & surface we will have materials removed (a small amount) which results in very smooth surface.

V) Etching :-

→ Before putting the specimen below the microscope lens, one important process we need to follow & it is known as etching.

→ In this process, the specimen surface must first be ground & polished to a smooth & mirror like finish.

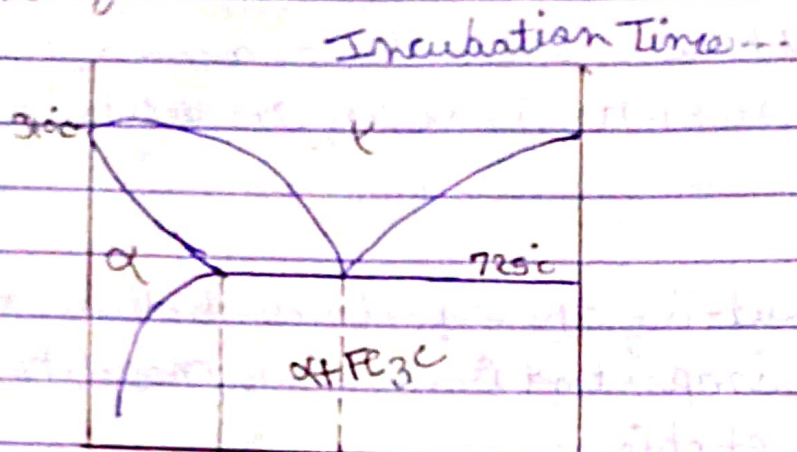
→ Then a suitable etchant is chosen depending upon the material's composition & it is put over it for specific time period.

→ This etchant helps us to differentiate the different grain boundaries by colouring them or providing them a colour contrast as a result of which we can easily differentiate the crystal & identify the atomic arrangement and atomic orientation.

→ Following are the etchants which can be used as follows :-

Nital, Picral, Keller's reagents, Dilute hydrofluoric acid etc.

* Boring Diagram:-



725°C $\rightarrow$ 700°C $\dots$ 0.80% C

Incubation time:- After coming below P at 725°C, before $\alpha + Fe_3C$ the time taken by material is called Incubation time.

750°C $\rightarrow$ 700°C

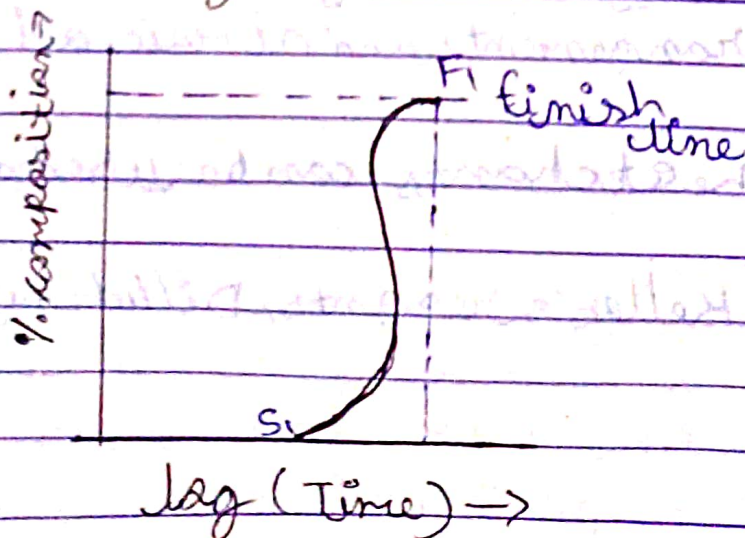
750°C $\rightarrow$ 450°C

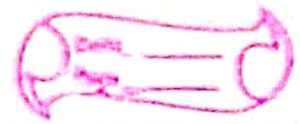
750°C $\rightarrow$ 600°C

750°C $\rightarrow$ 350°C

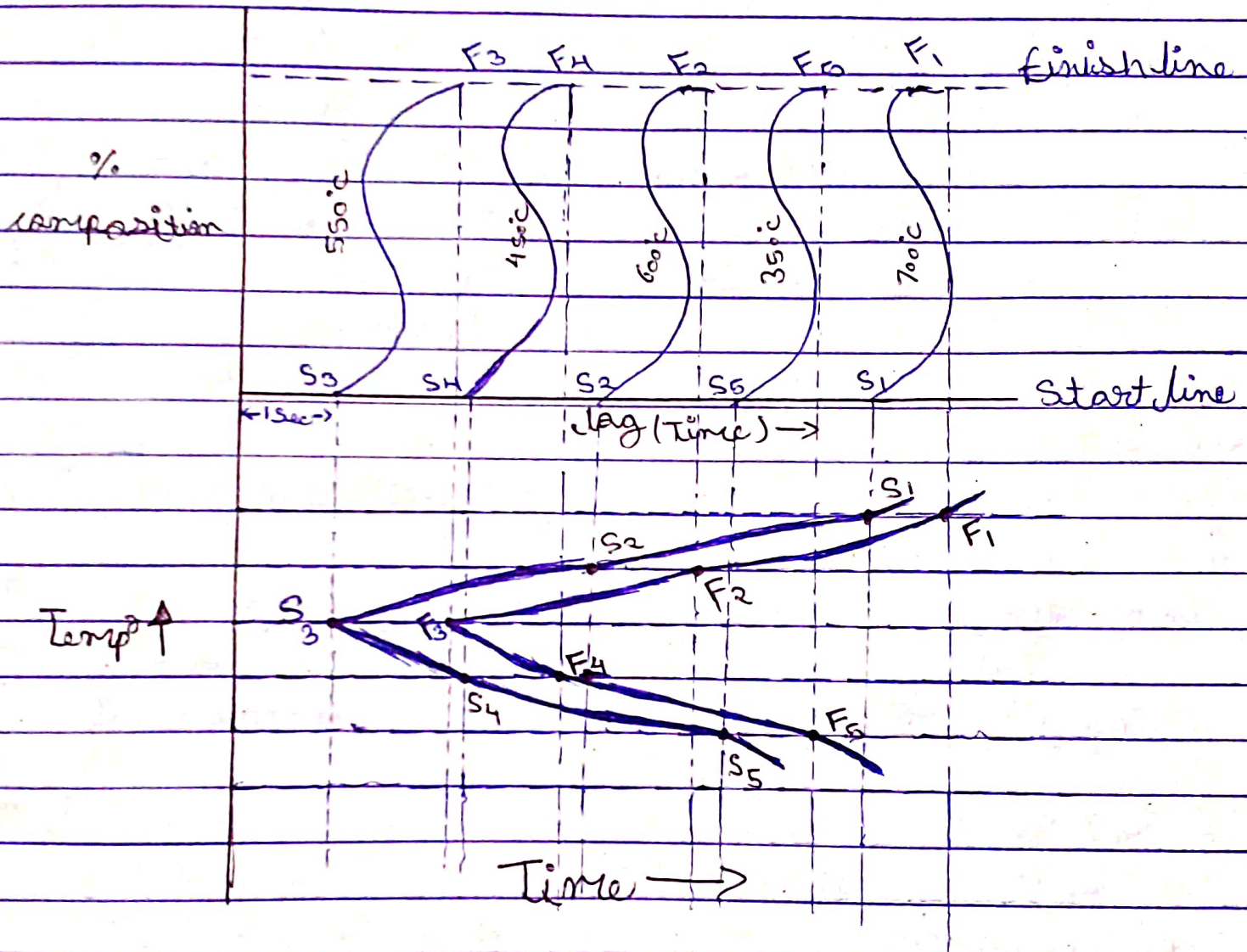
750°C $\rightarrow$ 550°C

* TTT Diagram:-





* TTT Diagram:-



It is also known as S-curve, C-curve, TTT Diagram (Time, Temperature, Transformation Diagram).