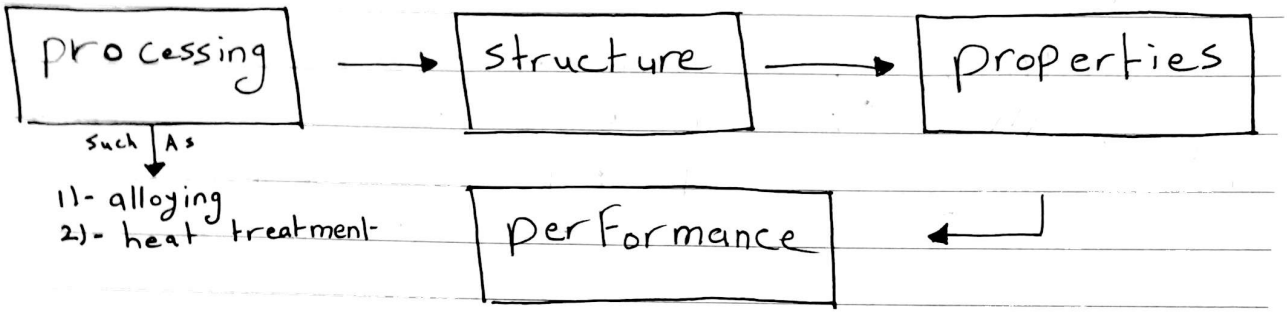
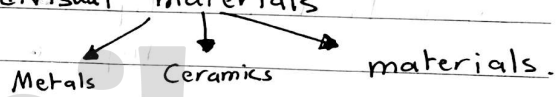
CH 1 :- Introduction.

* Diagram of Materials :-



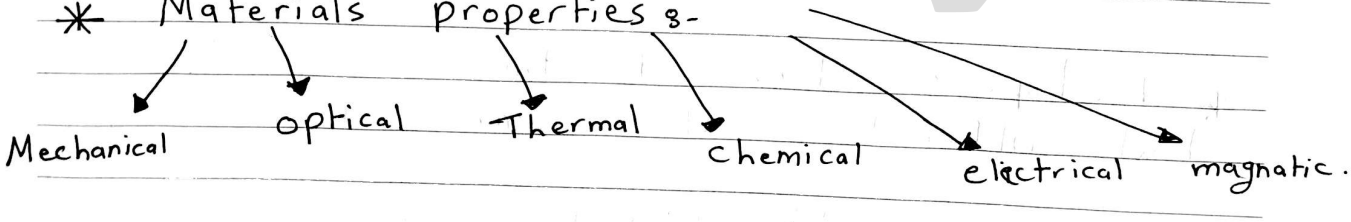
* Type of materials :-

1)- Metals. Ex:- Al, Fe ...
2)- Ceramics Ex:- clay, Cement, glass.
3)- polymers Ex :- plastic, rubber.
4)- Composite Ex:- Wood.
↳ Composed of two indivisual materials



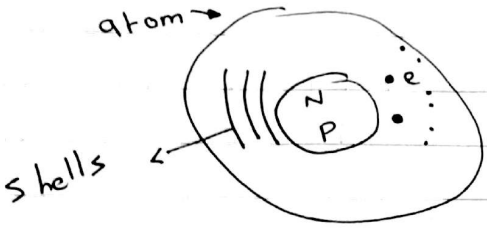
5)- Advanced Materials :- "Self Reading"

* Materials properties :-



CH_2 :- Atomic structure.

* Bohr's atomic model :-



such that :-
N → neutrons [No charge]
p → protons [positive]
e → electrons [negative]

* A shell is where an electron be.
* protons and neutrons are placed in the nucleus.

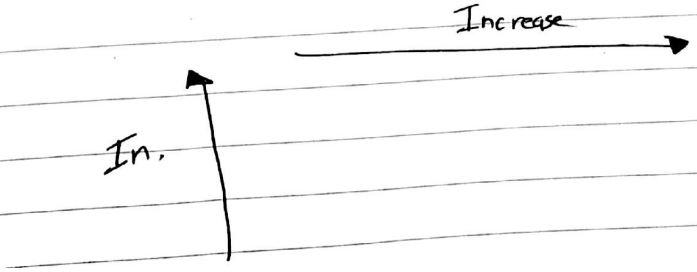
* Atomic Number = Number of protons
= Number of electrons.

* Atomic Mass = $n_p \times m_p + n_N \times m_N$
such that :- n_p → number of protons
m_p → mass of proton
n_N → number of neutrons
m_N → mass of neutron.

* Isotope :- atoms of the same element but different in it's number of neutrons.

* Atomic weight :- Weighted avarage of the atomic masses of the atom's naturally occuring isotopes. (g/mol).

* Electronegativity :- tendecy to acquire electrons.
↳ Increases From left to right and From bottom to top in the periodic table.



Bonding.

- primary (between different elements).
  - Covalent
  - Metallic
  - Ionic
- Secondary
  - Vander Walls (between chains).
    - A special case is the Hydrogen bond. (review book.)

* Primary Bonds :-

1)- Ionic
- Ex :- NaCl
- Involves electron transfer.
- Non - directional Bond.
- Ocurrs between high difference in electronegtivity.
- A strong bond.

2)- Metallic
- Ex :- Al - Al
- Strong bond
- Ocurrs between the atoms of same element.
- No secondary bond.
- Non directional bond.

3)- Covalent
- Ex :- CH_4 , H_2O ---
- No electrons transfer.
- directional bond
- Ocurrs in C, S, 4th group elements.

* Ionic character :-

$$IC = 1 - e^{-0.25 [X_A - X_B]} \times 100\%$$

X_A , X_B → Electronegativities of bond elements.

CH3 :- Crystalline Solids.

* Solidification :-
  - Liquid $\xrightarrow{\text{turns to}}$ Solid.

* Crystal → atomic arrangement.

Types of materials packing
- Crystalline → regular
- amorphus → random.

* Unit cell :- Small repeated entites.
  - Building block of Atoms.

* Unit cell is defined using parameters :-
  - 3 edges lengths.
  - 3 interaxial angels

* Review table "3.2" :-

Types of Metallic crystals
- Face centered Cubic (FCC)
- Body centered Cubic (BCC)
- Hexagonal

1)- Body centered Cubic :- spheric Cubic
- Type of crystall diagram

→ Coordination number = 8
  - Number of boundary Atoms

→ Number of atoms per unit cell = 2
  Face atoms + corner atoms + Body atoms.

* Atomic packing Factor :-

→ What fraction of volume of the unit cell is occupied by atoms.

$$APF = \frac{\text{Volume of atoms}}{\text{Volume of UC}}$$

* Comparison :-

properties	BBC	FCC
Coordination Number	8	12
Number of Atoms	2	4
relation between Unit cell length (a) and Atomic radius (R).	$a = \frac{4R}{\sqrt{3}}$	$a = 2\sqrt{2}\,r$
APF	0.68	0.74.

* The Hexagonal Crystal structure :-

→ Number of atoms = body + face + corner
= 3 + $\frac{1}{2}$. 2 + 2 ($\frac{1}{6}$ × 6)
= " 6 " atoms

→ Coordination Number → " 12 "
→ APF → " 0.74 "
→ Example → " Mg "

* " HCP and FCC "
↳ " incommon in APF and Coordination Number. "

* Polymorphism :-
↳ Changing in Crystal sturcture accordaing to Change in atmosphere " Temprature ".

* Iron and Titanum are polymorphism Metals.

* Theoreitical density :-

$$\rho = \frac{n \text{ (atoms/unitcell)} \; A \text{ (Atomic weight)}}{V_c \text{ (Volume/unit cell)} \; N_A \text{ (Avogadro's number)}}$$

$$= \frac{\text{atoms} \cdot \frac{g}{mol}}{cm^3 \cdot \frac{\text{atom}}{mol}} = \frac{g}{cm^3}$$

Ex:- Copper has an atomic radius of 0.128 nm, an Fcc crystal and an atomic weight of 63.5 g/mol, compute it's density.

$$\rho = \frac{4 \times 63.5}{a^3 \times 6.02 \times 10^{23}}$$

$$= 8.8 \; g/cm^3 .$$

R = 0.128 nm

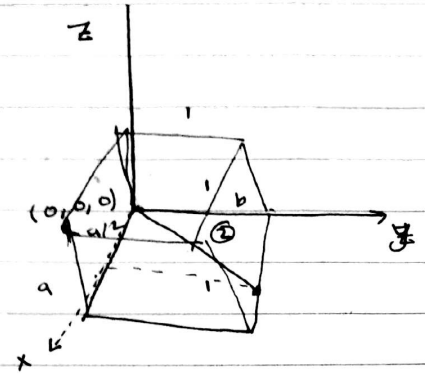
$a = 2\sqrt{2} \times 0.128$

$= \; nm$

$= \; \times 10^{-7} \; cm$

* Crystallographic points, directions, and planes :-

* point position :-



Ex :- point 2 → (1, 1, 1).

* Review slides For the progress to find directions.

* Direction analysis :-

- Projection method :-

	x	y	z
Projections	$\frac{1}{2}$	1	0
Projections (in terms of a, b, c)	a/2	b	0
Reduction	a	2b	0
Enclosure	[1, 2, 0]		

- difference between two points :-

↳ 2(a/2, b, 0) - (0, 0, 0) = [a, 2b, 0]
= [1, 2, 0].

* planes :-

↳ Three or more directions.

- If the plane passes through origin we should
↳ shift the origin one unit cell.
↳ or shift the plane.

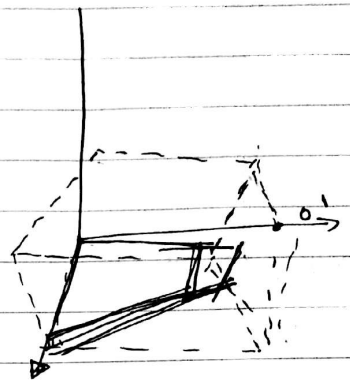
Tips :-

* shift origin in the y - axis.
* shift origin so that the plane becomes before

* We define the intersection points with the new origin shifted.

x	y	z
∞	-1	$\frac{1}{2}$
(0	-1	2)

reverse →



* Review slide for example.

Miller Indices.
↳ Name of planar indices.

* Stacking Sequence :

- FCC
↳ stacking sequence is repeated every three plane
↳ "ABC"

- HCP
↳ repeated every two planes
↳ "AB"

* Poly Crystals :-
↳ All Metals are poly Crystalian, more than 1 Crystal.

* Crystal solidification :-

* small crystals → growth → grains.

- grains → Face crystals

- the border of grains → appears on the microscope.

* Metals differ in Mechanical properties with different directions.

↳ Anisotropy.

↳ directionality of properties.

- Isotropic Materials :-

↳ properties are independent of the direction.

* Microscopes gives → optical surface properties only.

* X-ray diffraction :-

↳ used to see lattice and depth of unit cells.

- Source of X-Ray

↳ Material

↳ diffraction

↳ analysis of structure.

* Scattering event :-

such as ↳ atom, unit cell, direction, plane.

↳ where a x-ray diffracte.

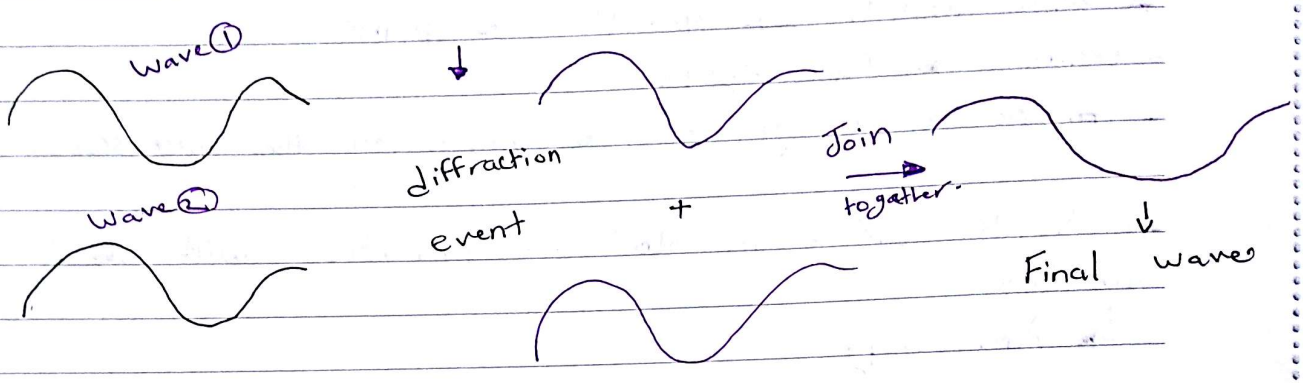
↳ cause an increase of λ

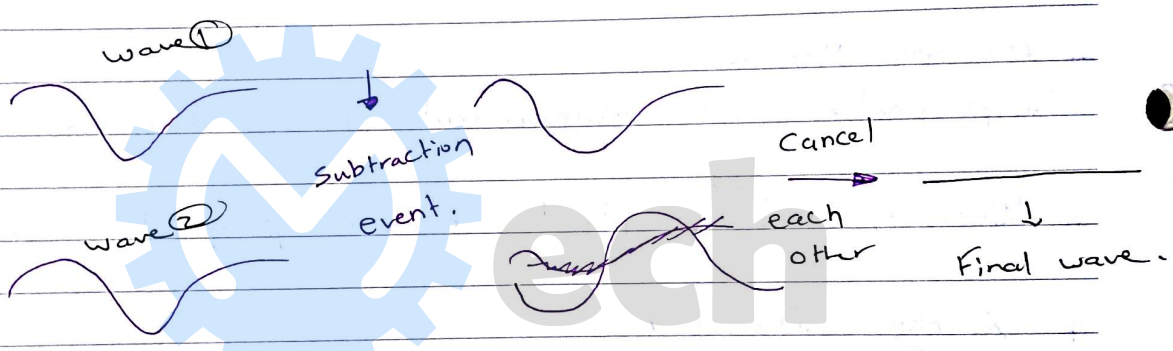
↳ every two waves join togather.

* Subtraction event :-

↳ No output.

↳ two waves at different direction cancel each others.

* 

* 

* $n\lambda = 2d_{hkl}\sin\theta$ (amplitude)

* $d_{hkl} = \frac{a}{\sqrt{k^2+h^2+l^2}}$.

* Suggested:
3.14 / 3.7 / 3.31 / 3.32 / 3.41 / 3.42 / 3.62 / 3.65 / 3.66 / 3.64.

* Output graph :- / Difraction pattern / :-

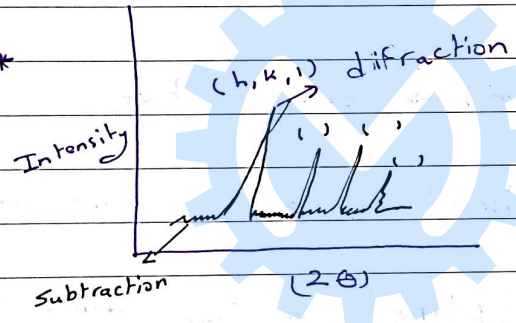
- x - axis → Difraction angle (2θ).
- y - axis → Intensity (ampitude).

* at peaks → Difraction happened.

* To know the crystal structure using the graph :-

- BBC → h + K + l → even
- FCC → h, K, l, all of them → even / odd.

*



* Linear and planar Densities :-

- Linear densities : number of atoms centered on direction vector / length of direction vector. (LD).

- planar ~~Densities~~ Densities :- number of atoms centered on plane / Area of plane.

* Linear and planar densities are important in deformation.

* For cubic structures :-

- Miller Indices with same indices, but different order are parallel or within the same family of planes.

CH4 :- Imperfections in solids.

* Solids
  - Crystal structure.
* Imperfections :-
  - defects
    - A lattice irregularity.

* alloy
  - addition of two metals.
    - better properties.
      - enhance properties.

* Defects :-
  - 1)- point defects → (atom) → one or two
  - 2)- Linear defects → (direction) → one dimensional
  - 3)- Interfacial defects → (plane) → Two dimensional
  - 4)- Bulk defects → (lattice). Three dimensional.

* All crystal structures include defects.

1)- Point defects :-

a)- Vacancies
  - empty or vaccum atomic site.

b)- Self - Interstitials :-
  - an atom placed in the wrong atomic site.

* To define whether there is a defect or not we use " Equilibrium number of Vacancies " :-

$$N_v = N \exp\left(-\frac{Q_v}{kT}\right)$$

- N_v : equilibrium number of vacancies
- N : atomic site
- Q_v : activation energy
- k : Boltzman's Contant.
- T : abs. temp.

* For most metals, $\frac{N_v}{N} = 10^{-4}$

↳ A Vacancie evrey 10000 atomic site.

- Find N_v of in $1m^3$ of Cu at 1000 C°, given:-

$\rho = 8.4 \frac{g}{cm^3}$, $A_{Cu} = 63.5 \frac{g}{mol}$, $Q_v = 0.9$ eV/atom

$N_A = 6.02 \times 10^{23}$ atoms/mole, $K = 8.62 \times 10^{-5}$ eV/atom.K.

$N_v = 2.7 \times 10^{-4}$

point defects

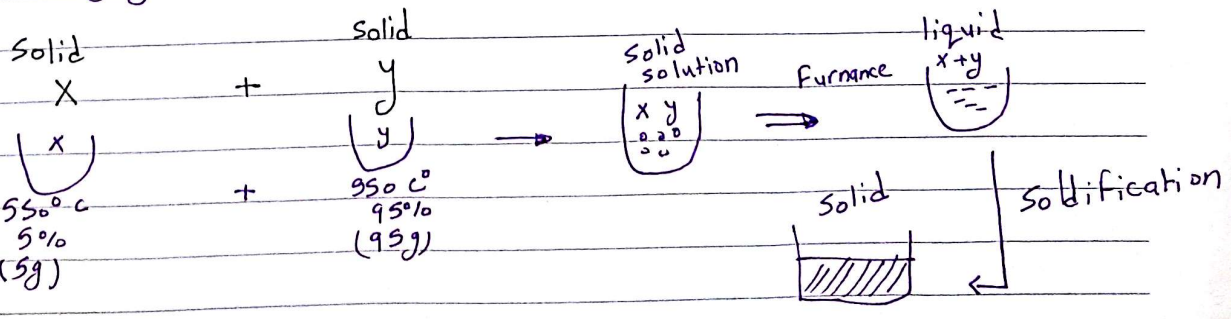
- Vacincies
- Self intersitial
- impurties.
  - existance of other metals in a pure metal structure.
  - *↳ (less than 1%)*

* binary
  ↳ alloy of (2) metals.

* Impurties and alloying :-

X + y → 10% / 20%.

- alloying → depends on solubility.



* In alloying we should reach the melting point of the element with the bigger melting point.

- X → host material

- atoms of y → go to the vacancies of elemet x.

* Solubility might be in (solid state).
  - Complete
  - partial
  - Un soluble (rare).

* Cd → an element that is unsoluble
  - Can't make alloys.

* Solubility Effects:-
1. Crystal structures
2- atomic radius
3- Electronegativity.
4- Valance electrons.

* Solvent → host, higher concentration.

* Identification of Solubility :-

1)- Same crystal structure "FCC with FCC" ...

2)- Atomic radius approximatly the same.

* Weight percent :- C = Composition.

$$C_1 = \frac{m_1}{m_1 + m_2} * 100\% \quad , \quad C_i = \frac{m_i}{m_i + m_H + m_n + \dots}$$

First ↵ mass.

$$= \frac{m}{\text{total mass}}$$

* 2)- Dislocations - Linear Defects :-

- Types :-

a)- Edge

b)- Screw

c)- Mixed.

* Burger Vector :- Distance between 2- planes.

- Edge dislocation → Dislocation line and burger vector ⊥

- Srew dislocation → Dislocation line and burger vector //

3)- Interfacial defects :- (plane, Area).

- Types of planar defects :-

a)- External Surfaces :-

↳ where crystal structure terminates.

→ surface atoms are in high energy state.

↳ not bound to maximum No. of nearest neighbors.

↳ minimize surface area.

b)- Grain boundaries :-

↳ different crystallgrophic orientations.

↳ atomic mismatch.

- Types :- → High angle grain boundary.

→ Small (low)

Tilt boundary → edge dislocation.

Twist boundary. → screw dislocation

* grain boundary are more chemically reactive than grains.

c)- Twin boundaries :-

↳ There is a specific mirror lattice symmetry.

↳ region of materials between is termed "Twins".

↳ results from mechanical shear force (displacment). or annealing heat treatment.

4)- Bulk (volume) defects :-

Ex:- 1)- Cracks
2)- Pores
3)- Vibrations
4)-

→ selfstudy

* Microscopy :- (self reading).
↳ "How to calculate grain size".

- optical microscope:-
↳ "grains"

* Types :-
- Reflection. [✓] → We see the reflections of the surface.
- transmission. (X)

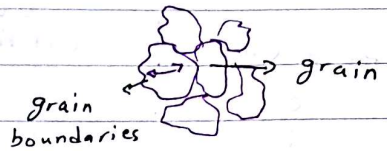
- How To make the metal surface a mirror surface :-

1- Cutting.
2- grinding.
3- polishing, letching. → diamond paste.
↓ mirror surface.
↓ grain boundaries

CH4. Suggested :-
4.3 - 4.4 - 4.20 - 4.18 - 4.23 - 4.31 - 4.25 - (4.32 - 4.33 - 4.34 - 4.35).

* grain size calculation :-

* magnification :-
  ↳ microscope effects.



(microscope view)

Two ways → intercept. (mathmatically).
→ AST (comparison).
↳ n = 1, 2, 3, ... → (standard).

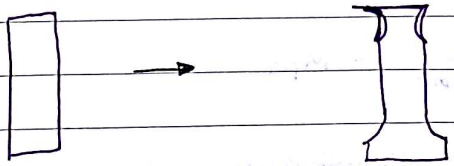
-# Self reading #.

* CH 6 : Mechanical Behaviour *

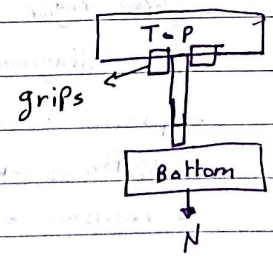
Strength.
- universal tensile testing machine (UTM)
  ↳ Measures ultimate stress.
- UTM differs for materials :-
  ↳ load capacity.

Hardness.

* When testing, we should avoid sharp edges.
  ↳ stress Concentration.



* UTM :-



- For cylinders
  ↳ V shape grips

For sheets
  ↳ Flat grips

* The load will increase until the necking happens.

* Example for data observed.

Load (N)	DL elongation (mm)
0	0
⋮ (Gradually increasing)	⋮
load of Fracture	elongation at Fracture.

- define :-

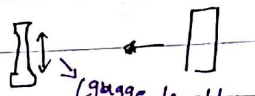
Sample :- mild steel

geometry / cylinder (πr^2)

\ flat (width * thickness).

* guage length

↳ length of the sample after the cut

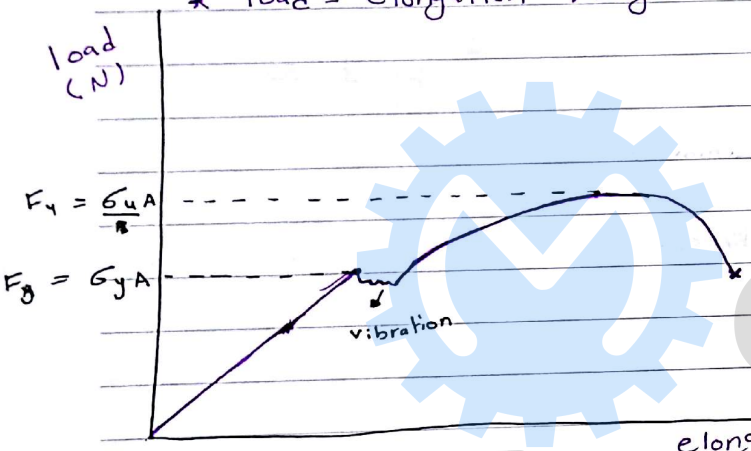


(guage length)

ASTM.

* Stress - strain Diagrams -

* load - elongation Diagram :-



σ_y = yield stress.

σ_u = ultimate stress.

* Cross head speed

↳ $\frac{\text{change in load}}{\text{time}}$.

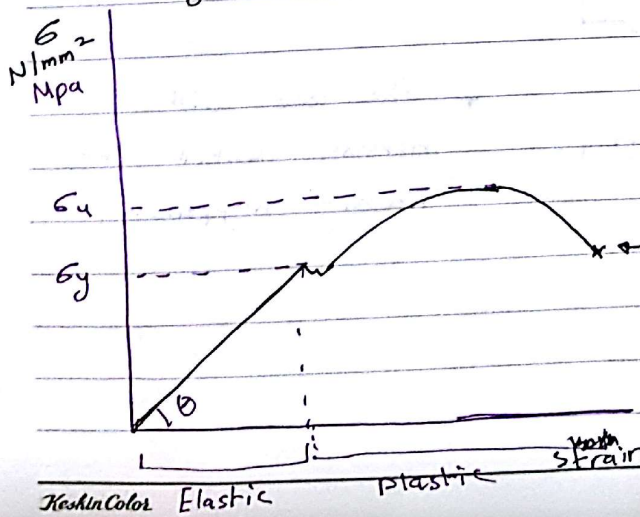
↓

usually small

* Stress = $\frac{F}{A_{orginal}}$ $\frac{N}{mm^2}$ = Mpa

* Strain = $\frac{DL}{L_o}$ → dimensionless.

- Diagram :-



- Elastic region → linear part of the diagram (0 to σ_y).
- plastic region → non linear
- stiffness → modulus of elasticity.
- resilence →
- Fracture - toughness →

yield point → end of elastic region

ultimate point → Start of failure.

KeshinColor

* Elastic Region :-

- Turn on → yield
- Small stress ⟺ small strain
- stress and strain → propotional (linear).

$y = ax + b$ (b → zero)

$\sigma = a\epsilon$ → $\sigma = E\epsilon$

E: modulus of Elasticity.

$E = \text{slope} = \tan\theta = \frac{\Delta\sigma}{\Delta\epsilon}$ → Mpa

E ↓ stiffness

more elastic → bigger (E).

* Elastic Region :-

- Turn on → yield

① Small stress ⟺ small strain

② stress and strain → propotional (linear).

$y = ax + b$ (b → zero)

$\sigma = a\epsilon$, → $\sigma = E\epsilon$

E: modulus of Elasticity.

E = slope = $\tan\theta = \frac{\Delta\sigma}{\Delta\epsilon}$ → Mpa

↓ stiffness

more elastic → smaller (E).

- Hook's law → $\sigma = E\epsilon$

- less stiffnes → closer to polymers.

* Cylinder, $x = l_o$, area = πr^2

$\epsilon_{area} = \frac{\Delta area}{A_o} = \frac{\Delta d}{d_o}$

* Sheet x, y, z,

$\epsilon_{length} = \frac{\Delta L}{L_o}$, $\epsilon_{width} = \frac{\Delta W}{W_o}$, $\epsilon_{thick} = \frac{\Delta t}{t_o}$

③ In the elastic region, upon removing load, the sample returns to it's original dimensions.

$E \gg \sigma_{yield}$ → always.

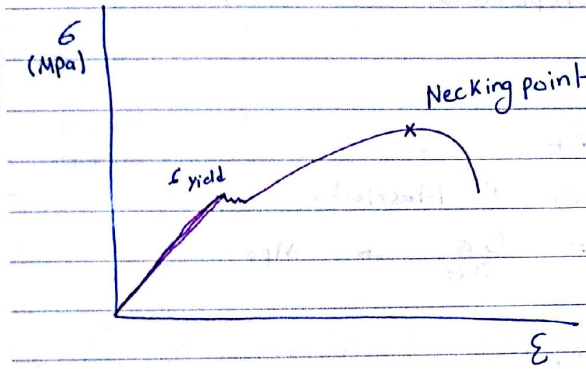
④ area under elastic region = modulus of resilience.

$= \frac{1}{2}\epsilon_y \sigma_y$.

* to Find yield stress, offset Method.

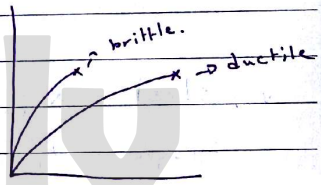
* Poissons ratio (ν) = $\frac{\varepsilon_L}{\varepsilon_a}$ → change in dimensions relative to each other's

* plastic Region :-



* Modulus of toughness.
  - Energy absorbed under the whole curve. (per unit volume).
  - Area under the whole curve. (Mpa) (N/mm²).

* ductility :- (Function of strain).
  - the bigger the strain, ~~the bigger~~ more ductile is the material.
  - = elongation percent = $\frac{L_f - L_o}{L_o} \times 100\%$.
  - = Areal reduction = $\frac{A_f - A_o}{A_o} \times 100\%$.



- True Stress :-
  - Considering area change.
  - $\sigma_T = \frac{F}{A_i}$

/ Engineering stress $\frac{F}{A_o}$

- True strain = $\ln \frac{L_f}{L_o}$

/ Engineering strain $\varepsilon = \frac{\Delta L}{L_o}$

* $L_c = L_o + \Delta L$ at any point.

* Volume is constant :-
  $A_o L_o = A_c L_c$

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* Mechanical behavior :-

$\sigma_T = K \epsilon_T^n$

σ_T ↙ True stress, ϵ_T ↘ True strain.

K :- strength coefficient

n :- strain hardening index.

↳ indication to

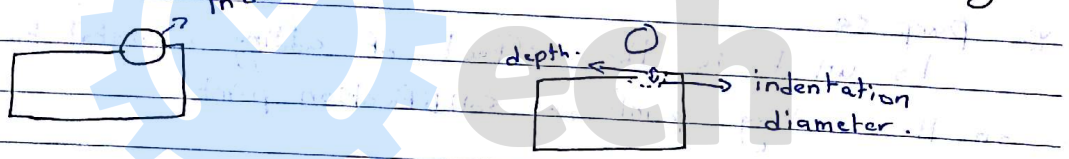
- $\sigma_T = \sigma_e (1 + \epsilon_e)$
- $\epsilon_T = \ln (1 + \epsilon_e)$.

* hardness :-

↳ Surface deformation (indents)

↳ ability of material to cut another.

↳ ability of the material to resist scratching.



- Thickness of th material is function to the
  ↳ indentation diameter
  ↳ " depth

th = 10 x I.depth.

* Indention Tests :-

1). Brinel shape → ball → Ceramics

2). Vickers shape → peramid → diamond.

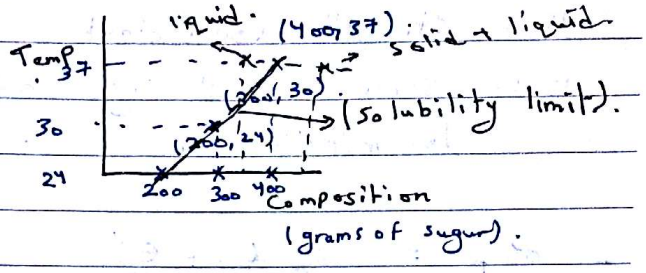
3). Rockwell shape → Cone / steel → sphere / diamond.

- difference between Rockwell C, B, A
  ↳ Load Scale.

CH 9 :- phase Diagram :-

Ex :- water + Salt.

- Solubility → depends on :- , - temperature
- Solid solution.



Max. Solubility
↓
(x , y)
↙ Composition
↘ Temp.

- Component → water + Sugar.
- phases
  - ↳ liquid → Component → water, sugar.
  - ↳ solid
  - ↳ liquid + solid.

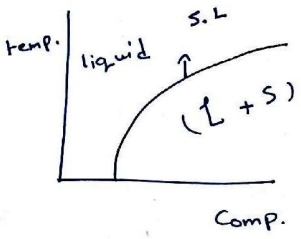
* Purpose
  ↳ What is the effect of adding a metal to another on the melting point or solidification point.

* phase diagram :-

- effect of adding a metal to another on the melting point (solidification point).

- Keywords :- Solubility limit. (S.L). (max sol / min sol) → (Comp, temp).

Case	liquid	solid	Resultant. phase diagram
①	complete.	complete.	Isomorphus
②	"	partial.	partial
③	"	insoluble.	eutetic.



→ X + y ⇒ X y

So So

" or "

" 90 10

let X melting point be 800 c°

for X → L - 700
600 → melting point (solidification point).
S - 500
400

* Solubility in liquid state is
  - Turn the Furnance on to the temp. of the biggest melting temp.
  - always Complete.

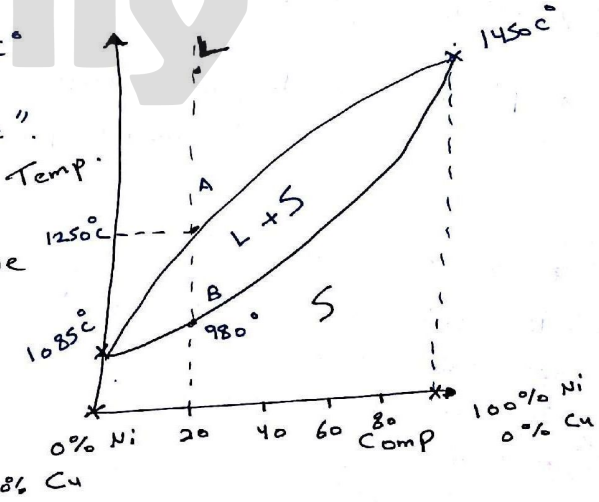
* phase diagrams differ as a result of solubility Types.

* Isomorphus phase diagram :-

ex :- Ni → same C.S → nearby atomic radiuses ---→ complete solubility.
Cu

melting point of Ni → 1450 c°
" " Cu → 1085 c°

* To Find Temp. change we use " Thermo Couple ".



* When Solidification starts
  - Temp. is held constant for a long time relative to before soldification start.
  - Cooling rate = $\frac{\Delta T}{\Delta t}$

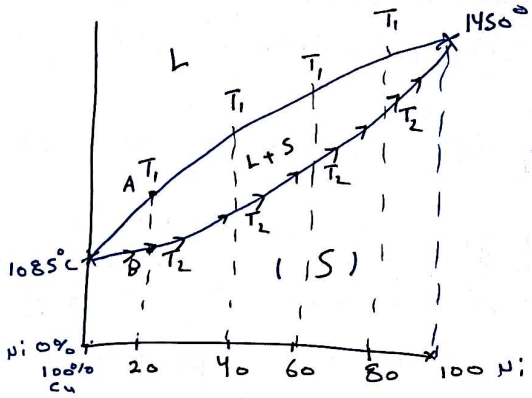
* When the cooling rate decrease
  - Solidifaction beggening.

- point A → Solidification begins.
- point B → Solidification Ends.

* adding more Ni to Cu

↳ //Cu Melting point increases//

1085C° → ≃1400C° * (T_2) *



* adding more Cu to Ni

↳ Ni Melting point decreases.

1450°C → ≃1100 * (T_1) *

given a Composition :- 60% Ni at 1500 C°

1)- what is the phase present?

2)- phase Composition?

3)- phase amount ?

4)- Microstructure ?

5)- at what temp. the alloy will begin to solidify? which element solidify first?

6)- at what Temp. the alloy is completely solid ?

* Isomorphus phase diagram.

↳ Same graph for all materials (standard).

↳ Liquid state solubility is wided along the curve (Complete solubility).

↳ Solid state is wided along the curve (Complete solubility).

* when it is 100% of a metal, it is donated (Metal) is the phase diagram.

* Phase amount → [weight Liquid + weight solid = 100%]

↳ weight percent of the Liquid or solid.

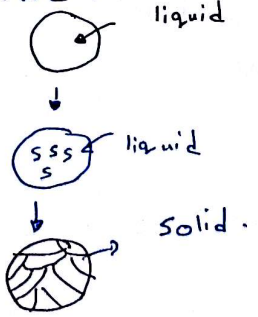
* To draw micro structure :-

1)- draw a circle

2)- label liquid.

3)- add solid grains.

4)- grains.



at 60% Ni

at 1150 °C :-

1)- Solid

2)- $C_s = C_\alpha =$ 40%Ni 60% Cu

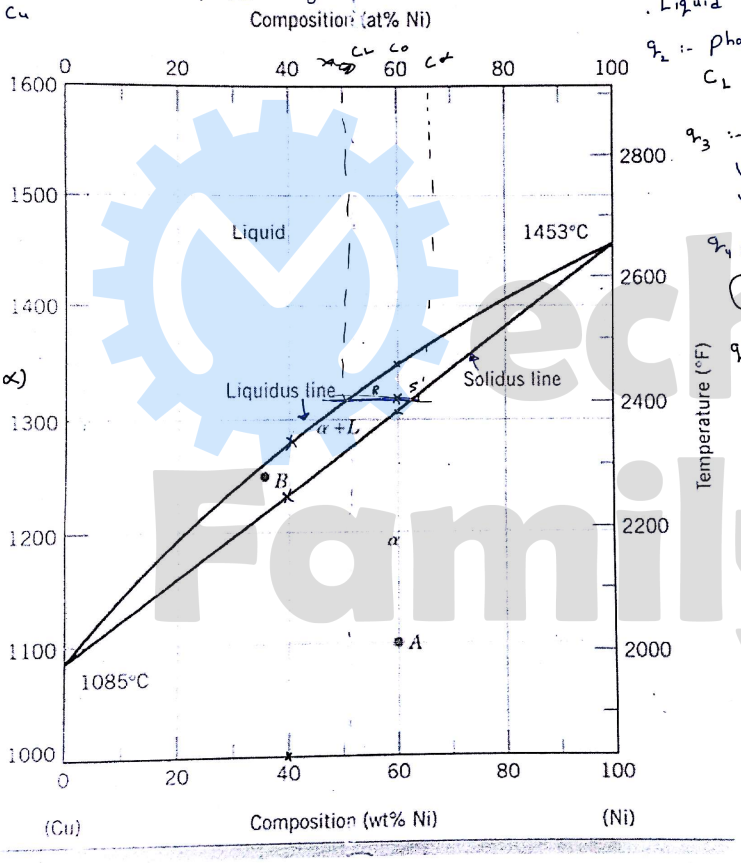
3)- $W_s = 100\%$

4)- Same.

5)- 1280 c°

6)- 1220 c°.

Isomorphus.
phase diagram



at 60 % Ni

T = 1310 c°

1)- Solid + Liquid (L + α)

2)- C_L = 64 % Ni
C_α = 51 % Ni

3)-

4)-

5)- 1350

6)-

- at 40% Ni , 1500 c°

q_1 :- What is the phase present ?

. Liquid

q_2 :- phase Composition ?

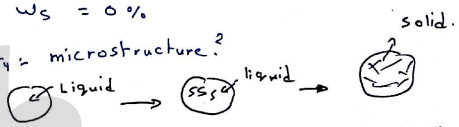
C_L → 40%Ni 60 % Cu

q_3 :- phase amount ?

W_L = 100%

W_S = 0 %

q_4 :- microstructure ?



q_5 :- At what temp. the alloy will begin to solidify ?.

1280 c° / Nickel will solidify first .

q_6 :- At what temp. the alloy will be completely solid ?

1220 c°.

* The metal with the highest original solidification point, starts solidification first.

* The "thermo couple" Temp. will stay constant at two points :-
  - where each metal starts to solidify.

* The Greek letters " α, β, δ "
  - Refers to solid solution Composition.

* When the point is in the $(L+\alpha)$ region :-
  - ① Draw the tie line :
    - intersects with Liquidus line and α line.
      - projection to the composition axis.

② - phase amount :- (Lever Rule).

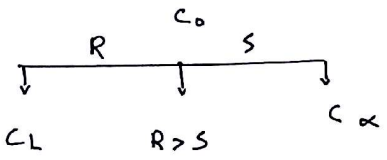
$$W_\alpha + W_L = 100\% \quad (1)$$

$$W_\alpha C_\alpha + W_L C_L = C_o \rightarrow \text{given composition.}$$

- Solve for W_α, W_L

$$W_\alpha = \frac{C_o - C_L}{C_\alpha - C_L} \quad , \quad W_L = \frac{C_\alpha - C_o}{C_\alpha - C_L}$$

From, the Tieline :-



$$R = C_o - C_L$$
$$S = C_\alpha - C_o$$
$$R + S = C_\alpha - C_L$$

$$W_\alpha = \frac{R}{R+S} \quad , \quad W_L = 100 - W_\alpha \quad \text{or} \quad W_L = \frac{S}{R+S}$$

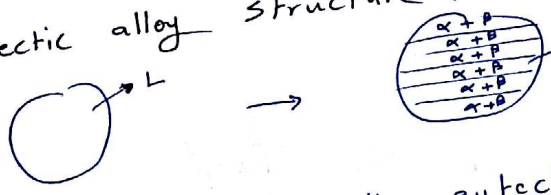
* Partial phase diagram :-
↳ solid state isn't wided all over the diagram.
- Liquid state is wided.
↓ ↓
partial solubility.
↳ partial diagram:

* Def :-
α :- solid solution rich in pb
↳ solute :- Sn
solvent :- pb.
- max. solubility of Sn in pb :-
18.3 % Sn at 183°c

β :- solid solution rich in Sn.
↳ solute :- pb
solvent :- Sn
- max solubility of pb in Sn :-
2.2 % at 183 c°.

* maximum solubility is happens at the same temp.
* Solidification is complete at the temp. of the maximum solubility.
* When $T_1 = T_2$ → eutectic composition.
* eutectic reaction :-
L ⟶ S + S
L ⟶ α + β
not L → L+S → S.

- Sn, Pb eutectic reaction
↳ L → α + β (61.9% Sn, 183°c).

* eutectic alloy structure :-
L → 

"Lamelar Layers"

* Any composition less than eutectic composition
↳ hypo - eutectic
* Any " more " " "
↳ hyper - eutectic.

partial phase diagram

Questions :-

1)- what is (α, β) :-

2)- elements solidification point :-

3)- type of phase diagram :, solubility ?

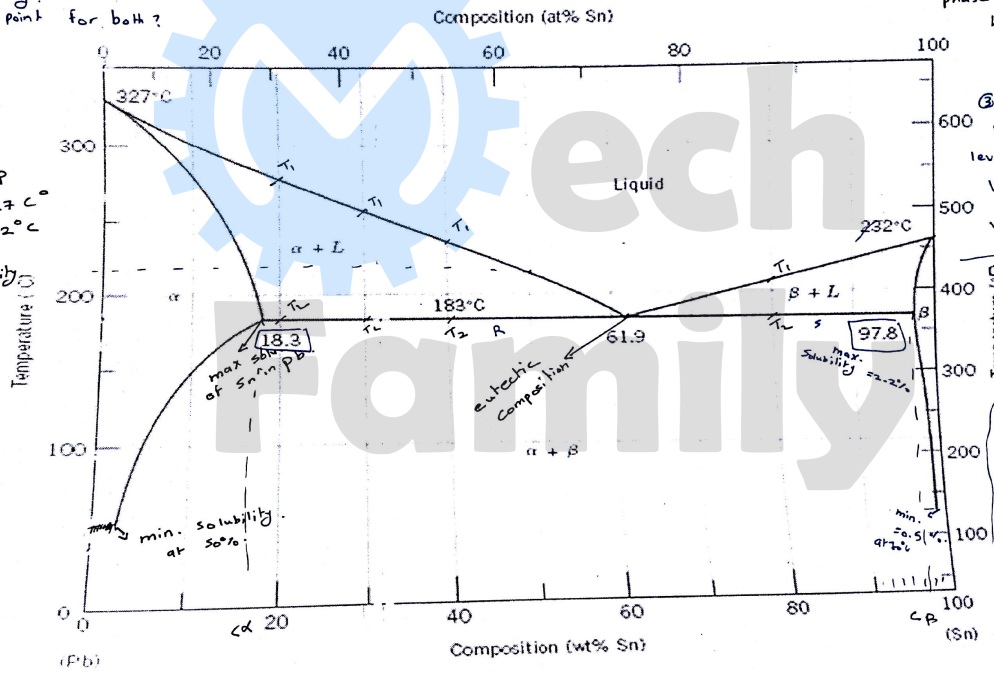
4)- effect on adding the metals on the solidification point for both ?

answers :-

1)-

element	S.P
Pb →	327 C°
Sn →	232°C

2)- partial solubility



Take :- 50% Sn, Just below eutectic temp.

Phase → (α + β) / solids. (2)

phase composition :-

- C_α = 18.3 wt% Sn
- C_β = 97.8 wt% Sn

3)- weigh of phase

$W_\alpha + W_\beta = 1$

lever (rule) :-

$W_\alpha = \frac{S}{R+S} = \frac{97.8-50}{97.8-18.3}$

$W_\beta = \frac{R}{R+S}$

$W_\beta = 1 - W_\alpha$.

4)- at what temp. the alloy will begin to solidify, which element will solidify first ?

220°C, Pb.

5)- Microstructure.

L → (α + L) → (α + β)

6)- at what temp. the alloy will be completely solid ?

183°C.

* eutectic point :-
↳ transformation from liquid to two solids.
$L \rightarrow \delta + Fe_3C$ at 1147°C, 4.3% C

*Eutectoid :-
↳ transformation from solid to two solids.

$S \rightarrow S + S$
$\delta \rightarrow Fe_3C + \alpha$; at 727°C, 0.76% C

- hypo eutectiod
  ↳ C (0 - 0.76 %)
- hyper eutectiod
  ↳ C (0.76 - 2.14 % C)
- the Material at the eutectoid is :- pearlite.

* Steel
↓
Fe + C

0.0 --- 2.14 %
* low carbon steel
* high " "
* Medium carbon steel
0.022 → 0.76 " hypoeutectoide.
0.76 ⚡ hyper eutectiode.

* Iron - Carbon phase diagram :-

Fe + C

↓

Steel.

Fe - C (0 - 2.14) = Steel.

* Increasing the composition of C more than (2.14%)

↳ Cast Iron → Brittle.

- Increasing Comp. of C → more than 6.7%

↳ Graphite. "not important".

* We stopped at the composition of 6.7% C :-

1)- Fe_3C (compound) is

2)- Increasing the Comp. will start to form Graphite.

* From the diagram :-

α → Solid solution rich in Fe (400 - 912) (Ferrite).

↓ Solute → C

Solvent → Fe

↳ Crystal structure of α → BCC.

Iron (α) → gray "colour"

* Maximum sol. of C in Fe :-

0.022 % C at 727°C

γ → Solid Solution rich in Fe (912 - 1400). (Austenite).

↓ solute C

Solvent Fe

↳ max. Sol. → 2.14 % C at 1147°C

- Iron (γ) → Orange "colour"

- Austenite → FCC (Increases solubility).

* Iron change it's properties when the environment change. (Allotropy).

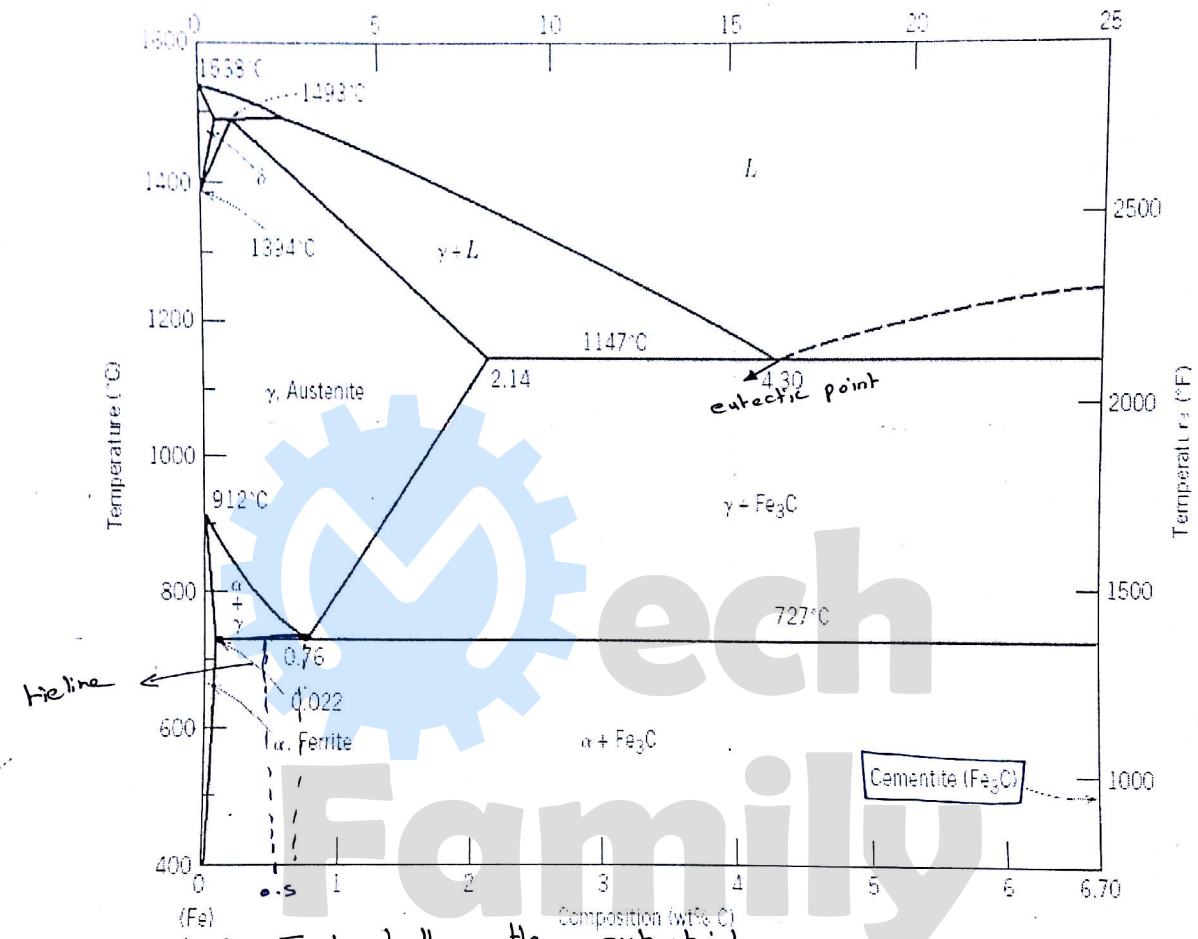
δ → 1400 - 1538 (BCC).

α → γ → δ → L

Ferrite (400 - 912) BCC

(912 - 1400) FCC

(1400 - 1538) BCC.



* 0.5% C Just bellow the eutectoid :-

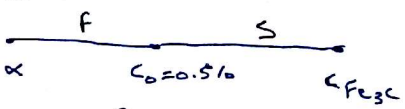
1)- phase present ?

$\alpha + Fe_3C$

2)- phase composition ?

by tie line → $C_\alpha = 0.022\%\ C$

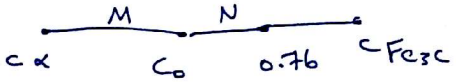
$C_{Fe_3C} = 6.7\%\ C$



3)- phase amount ?

$W_\alpha = \frac{S}{R+S}$, $W_{Fe_3C} = \frac{f}{f+s}$

4)- phase amount of pearlite ?



$M = C_0 - C_\alpha$

$N = C_{perlite} - C_0$

$W_p = \frac{M}{N+M} = 6.5\%$.

* eutectic point :-
↳ transformation from liquid to two solids.
$L \longrightarrow \delta + Fe_3C$ at 1147°C , 4.3 % C

* Eutectoid :-
↳ transformation from solid to two solids.

$S \longrightarrow S + S$
$\delta \longrightarrow Fe_3C + \alpha$; at 727°C , 0.76 % C

- hypo eutectiod
  ↳ C (0 - 0.76 %)
- hyper eutectiod
  ↳ C (0.76 - 2.14 % C)
- the Material at the the eutectoid is :- pearlite.

* Steel
↓
Fe + C

0.0 --- 2.14 %
* low carbon steel
* high " "
* Medium carbon steel
0.022 → 0.76 " hypoeutectoide.
0.76 ↯ hyper eutectiode.