دفتر..

علم المعادن

سكند

لجنة الميكانيك

Polytechnic

0789434018

Mech.MuslimEngineer.Net

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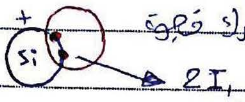
* semi conductors:-



- above specific
e^{-1} will leave it's position
→ hole if V is applied
→ hole & e^{-1} will make small flow current
→ $\sigma = |n| \, |e| \, \mu_e + p|e| \, |\mu_h|$
of e^{-1} per m^3 → # of hole/m^3
→ $\sigma = n_i |e| (\mu_e + \mu_h)$

$$n = p = n_i \quad (1, 2, 3, 6, 19)$$

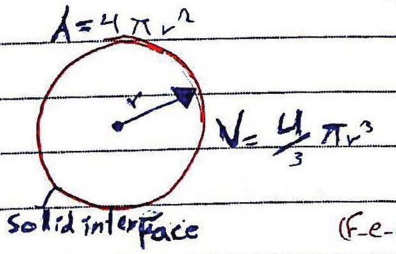
CH-9 :-

Solidification:- (تصلب)

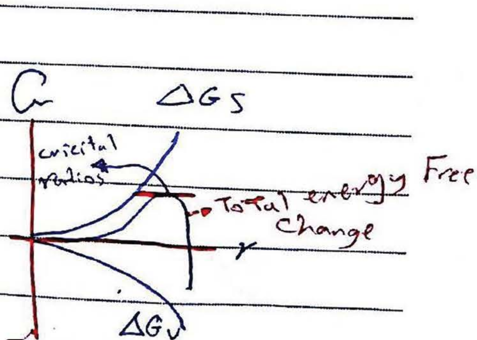
- Nucleation :- is the formation (تشكيل) of the first Nano crystallite from molten (منصهرة) Material   Ex:- Water Freezing

Nucleation refers (يرجع) to the initial stage (المرحلة) of formation (تشكيل) of one phase from another phase

Material will solidify when it cool to just below Freezing point



(F-e-c)



ΔG_v:- Volume free energy (طاقة شاحنة حرة) change
ΔG_s:- surface free energy change

*Entropy (عشوائية) internal energy
S u

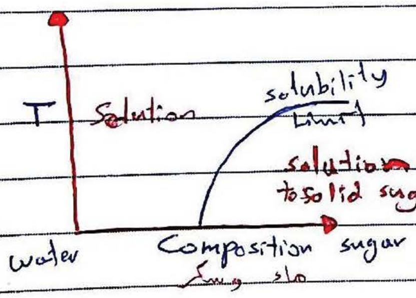
(متجانس) Homogenous Nucleation :- nuclei of the new phase form uneformly throughout the material

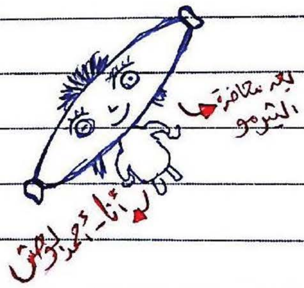
(غيرمتجانس) Heterogenous :- nuclei form Prefer enittaly at structures

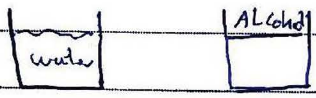
Heat of Fusion (الإنصهار) :-
energy Required to change a gram of substance From solid to liquid state without changing it's temp
(latent heat)

latent heat :- energy Released or absorbed By a Body of system during constant Temp Proces

(ذائبية) Solubeility limit :-
at some specific Temp, there is Maximum concentration of solute atoms that may dissolve in the solvent to form solid solution





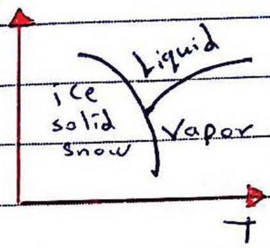


unlimited solubility :-
It can be soluble in any percentage

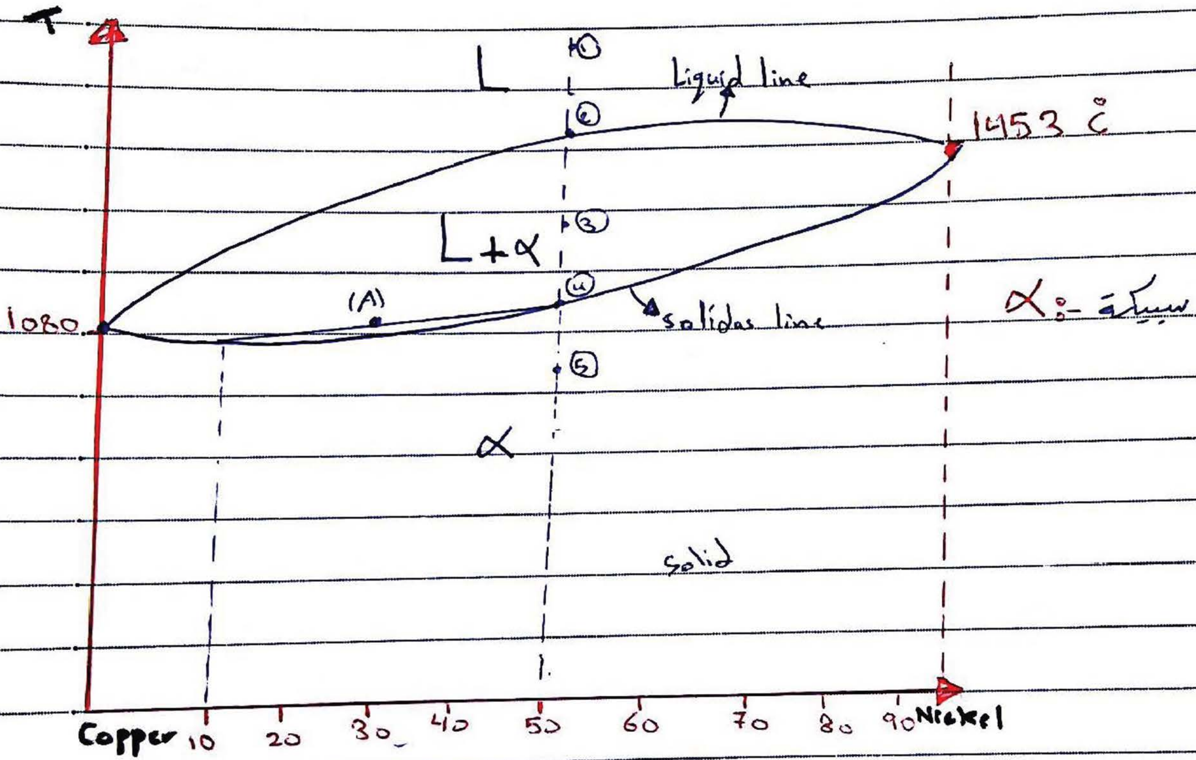
Limited solubility :-
Like like salt & water / when we have too much salt → 1 phase
⇒ excess salt will be at the bottom → 2 phase

Mixture:- contains more than one phase

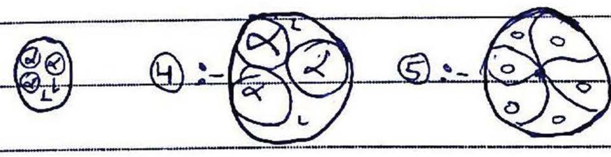
phase diagram:- single phase



(*) Binary phase Diagram:-



1:- Liquid   2:- Liquid   3:-   4:-   5:-



(A): $\frac{40}{50} = 0.8$

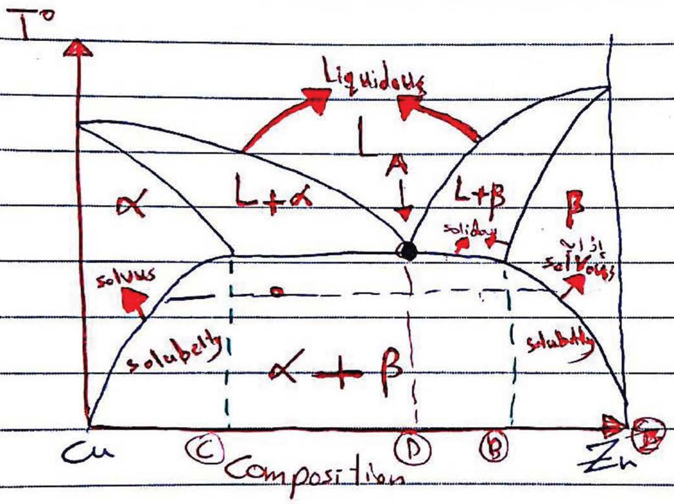
Liquid L :- is a homogenous Liquid solution composed of both copper & Nikle

α :- solid solution consisting of Both copper & Nickel atoms and having fcc crystal structure

under 1080 C :- all composion of Both copper & Nickel have complete solubility since they have Both Fcc structure solid solution, α, β,

① complete solubility
② have fcc crystal structure

Eutectic system :-



$$W_L = \frac{S}{R+S} = \frac{C_\alpha - C_o}{C_\alpha - C_L}$$

A :- Eutectic system.

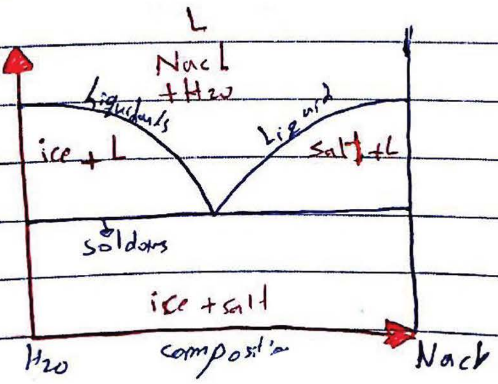
$$W_\alpha = \frac{R}{R+S} = \frac{C_o - C_L}{C_\alpha - C_L}$$

Eutectic reaction :-

$$L(Zn)_{D} \underset{Heating}{\overset{Cooling}{\rightleftharpoons}} \alpha(C) + \beta(B)$$

لـ دائماً "الذي كاليمين

EX :-

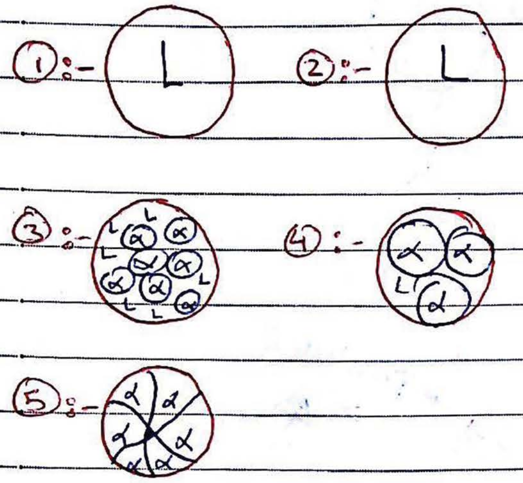


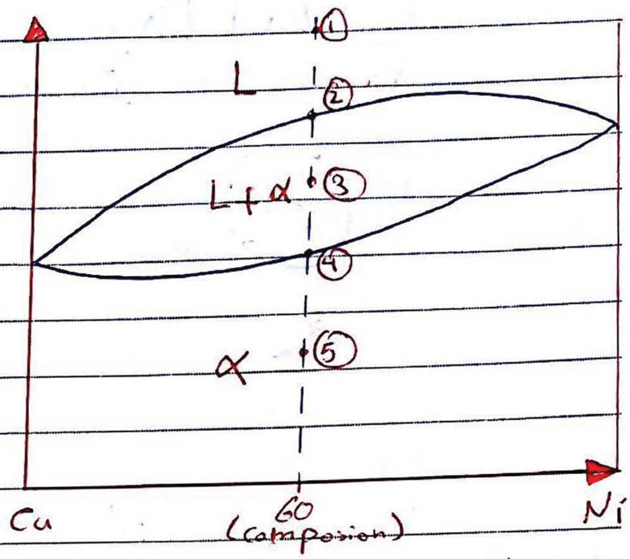
Ex [9,2] [9,3]

Eutectic Reaction:-

L → S

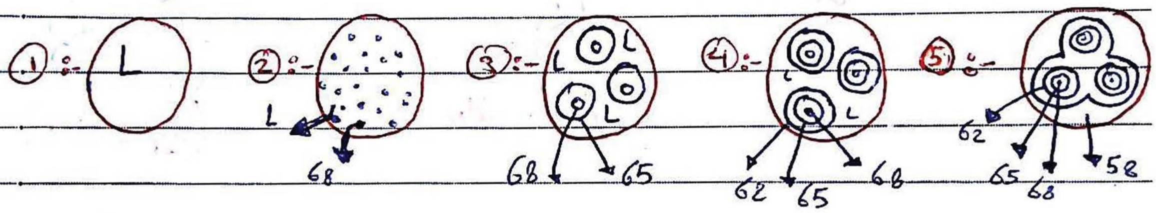
* equilibrum cooling:-



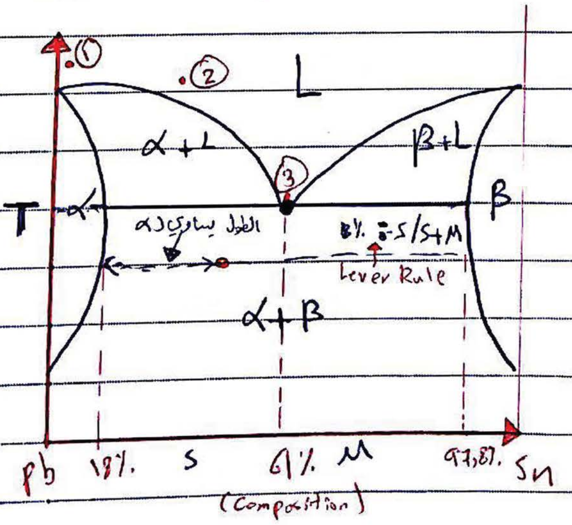


الـ 60 "تكون دماً" التي على اليمين وهي الـ Ni

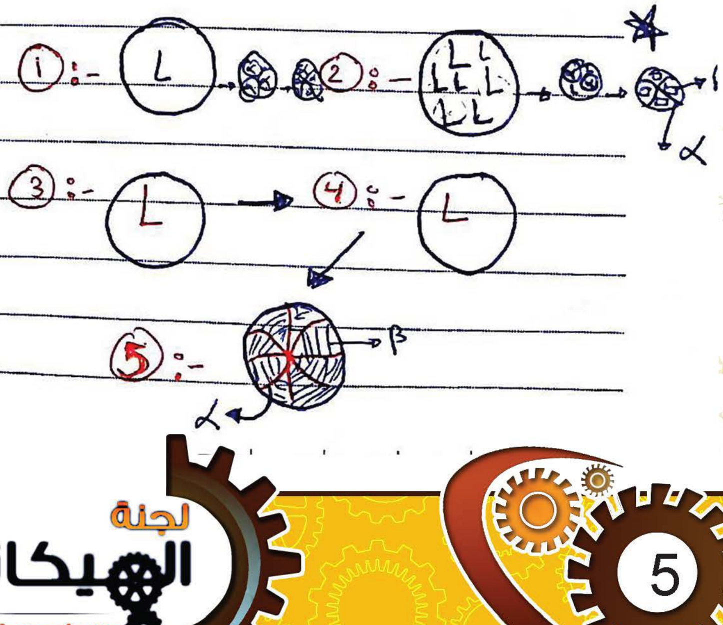
* Non equilibrum cooling:-



* Development of Microstructure in Eutectic alloy:-



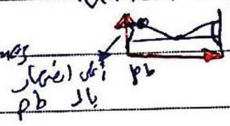
$$L(61\%) \underset{\text{Heating}}{\overset{\text{Cooling}}{\rightleftharpoons}} \alpha(18,3\%) + \beta(97,8\%)$$

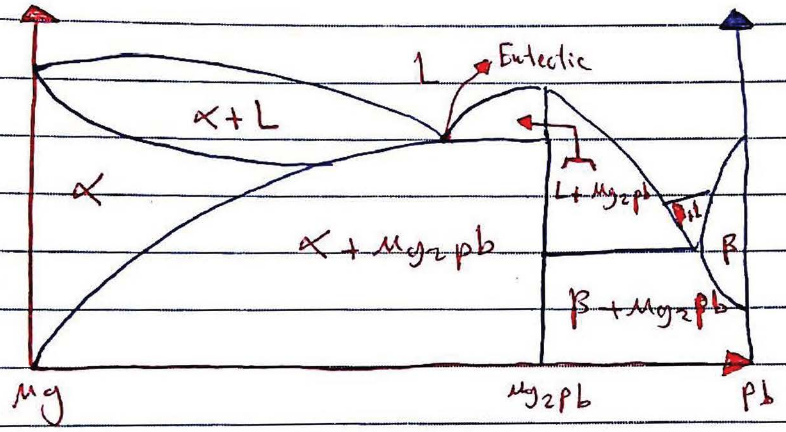


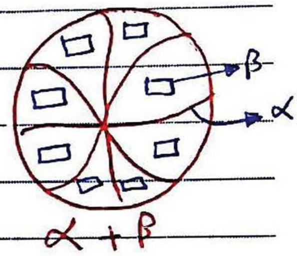
9.13] equilibruim Diagrams having intermediate (وسطي) phases or compounds:-

* in Eutectic Diagrams they have 2 solid phases α, β it's called (terminal (طرفي) α+β solid solution) because exist overcomposition range near the concentration (تركيز) extremities (كميات عالية)

* For other alloys (المركبات) systems, intermediate solid solution may be found at other than the two extremes







9.14] Eutectoid & peritectic Reaction:-

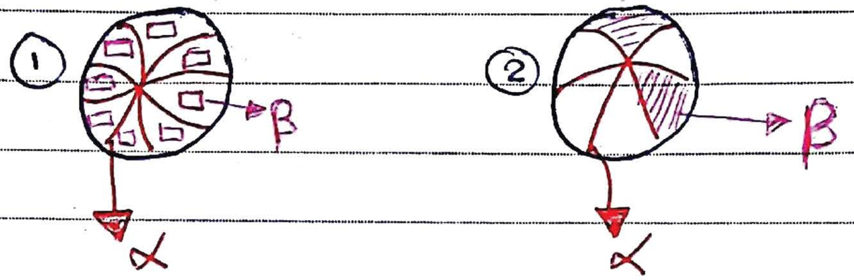
* peritectic Reaction:- $\beta + L \underset{Heat}{\overset{Cooling}{\rightleftharpoons}} \alpha$ (solid → Liquid + solid)

* Eutectoid Reaction:- $\alpha \rightleftharpoons \beta + \epsilon$ (solid ⇌ two (2) solids)

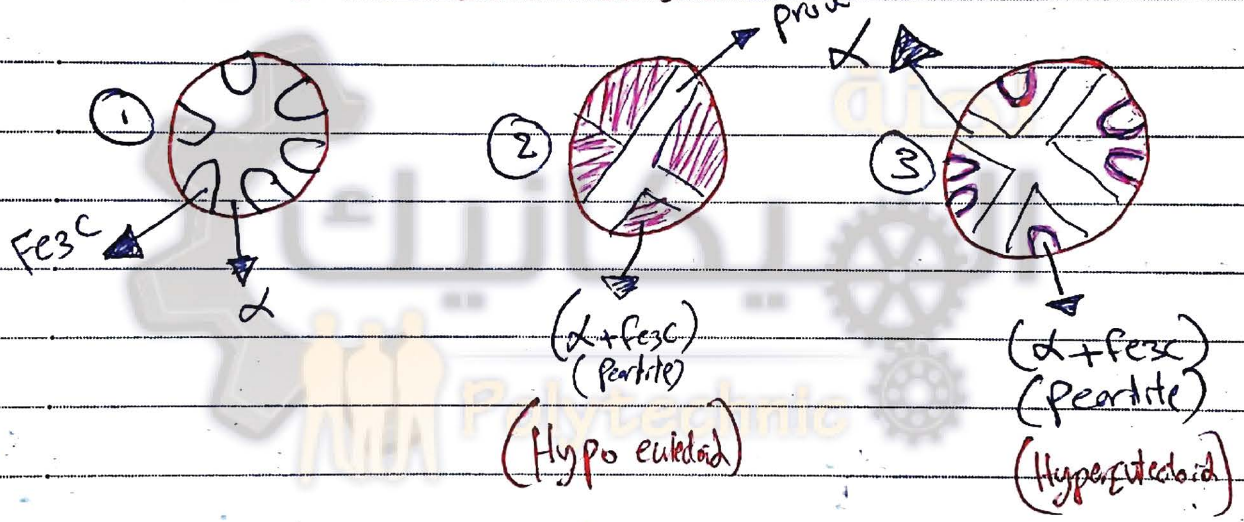
* Eutectic Reaction:- $L \rightleftharpoons \beta + \alpha$ (Liquid → two solids)

For Last EX:-

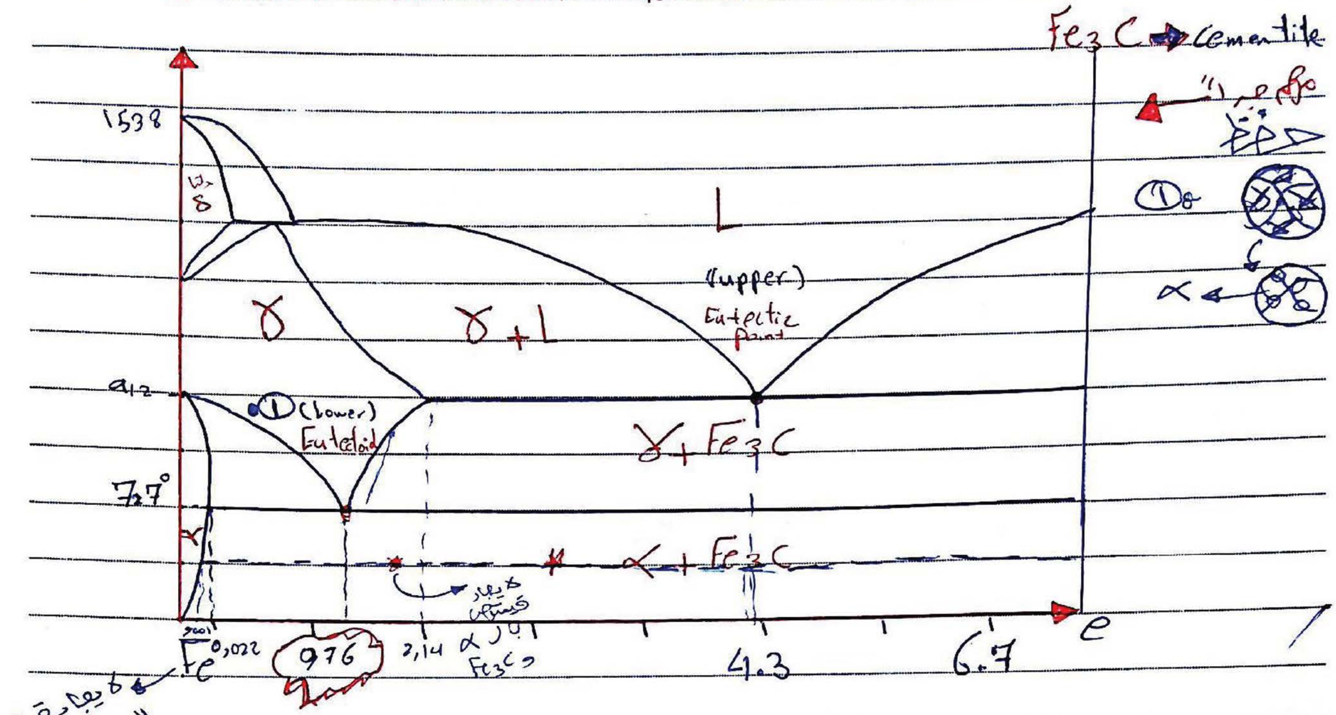
Forms of $(\alpha + \beta)$:- *why



Form of $(\alpha + Fe_3C)$:-



IRon carbon steel:-



eutectoid $\gamma(0{,}76) \underset{H}{\overset{C}{\rightleftharpoons}} \alpha(0{,}022) + Fe_3C\ (6{,}7)$ $\alpha + L$ (727°)

eutectic $\alpha \Rightarrow$ Ferrite $L(4{,}3) \underset{\text{Heating}}{\overset{\text{cooling}}{\rightleftharpoons}} \gamma(2{,}14) + Fe_3C(6{,}7)$

IRon carbon system:-

(s,d) α :- Ferrite, BCC only (small concentrations) of carbon are soluble (0,022)

Because the shape & size of Bcc Make it difficult to carbon atoms

→ (More ductile)

Mechanical properties :- soft, ductile (رخو)

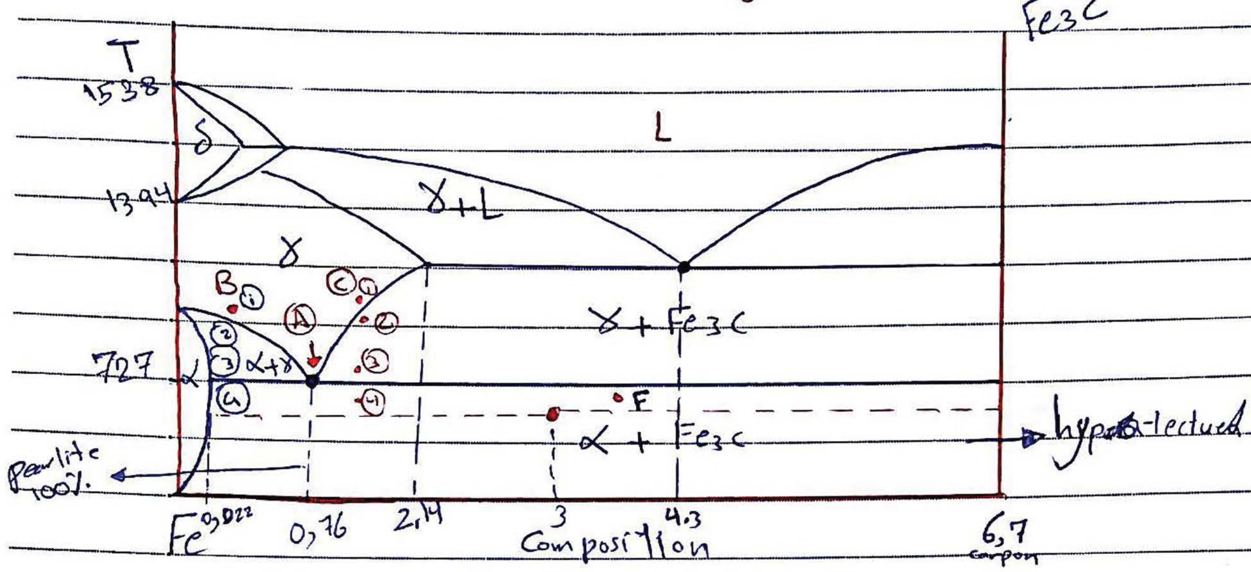
Magntic below 768° (density 7,88 g/cm³)

Austenite (γ) :- is not stable below 727°

* Maximum solubility :- 2,14 % C

δ :- δ - Ferrites - sam as α except Range of temp (0,022)

IRon carbon steel Diagrame:-

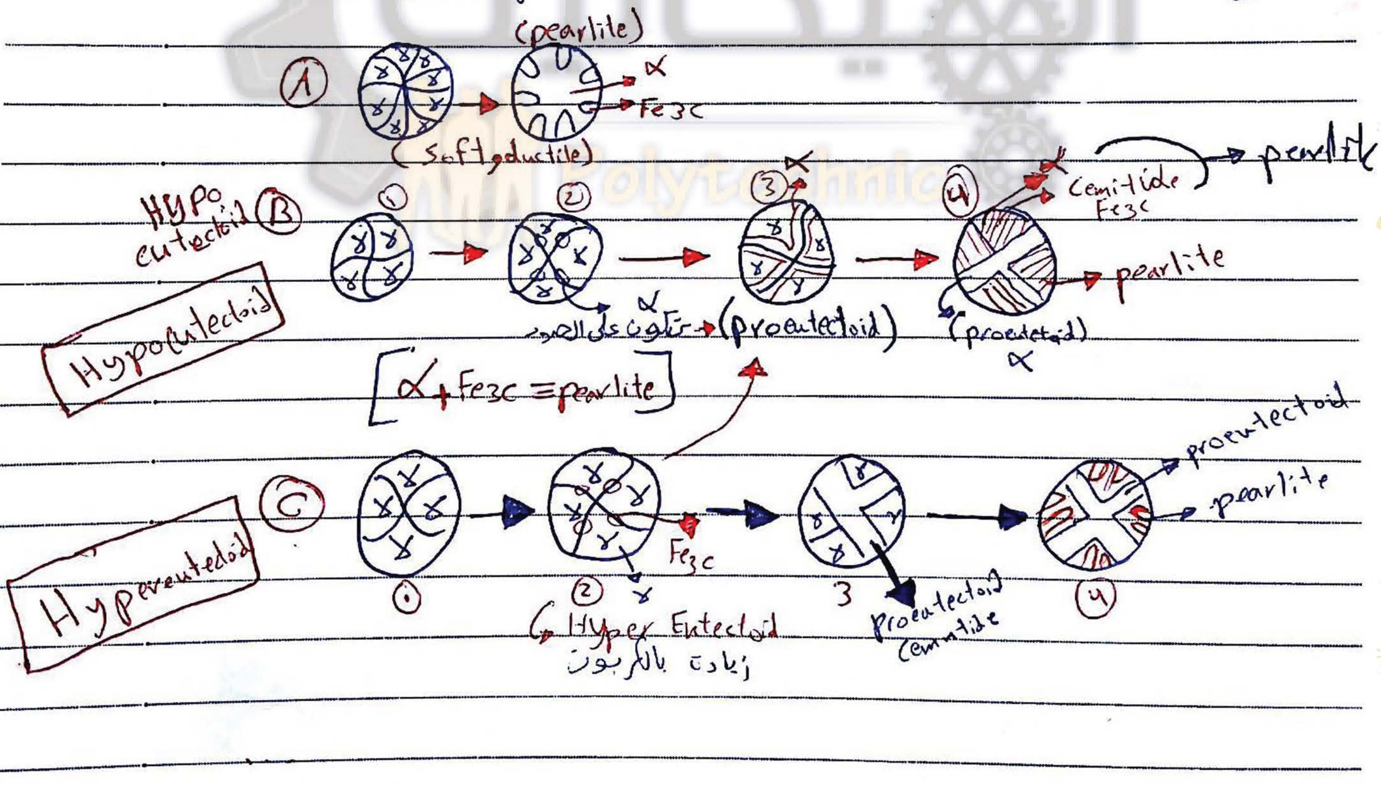


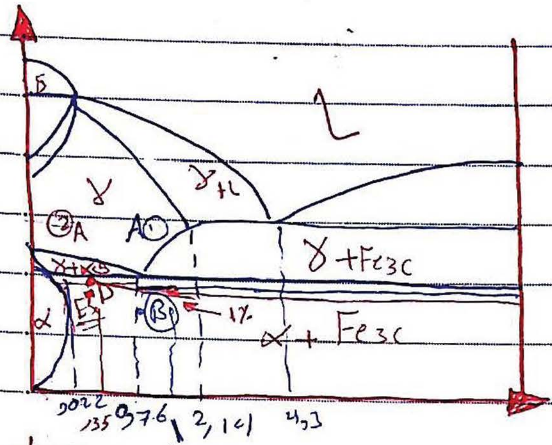
نسبة ال Fe3c نمط

$\% Fe_3C = \frac{3 - 0.022}{6.7 - 0.022}$

+ نسبة الحديد بال α 0,022-100

* 9.19 development of Microstructure in IRon Carbonalloy





① p%
② α, Fe3C eutectoid 1-%p
③ sharp
④ eutectoid 3-2 0,978
⑤ % Fe3C or % α 100-3 / 6,678

EX:- imagine you are at just under Eutectoid
Carbon % , 35

① A %P: $\frac{0,35 - 0,022}{0,76 - 0,022} = 0,44 \approx 44\%$
parlite

$\alpha = \alpha_{Eutectoid} + \alpha_{proeutectoid}$

② $\alpha_{proeutectoid} = 1 - 44\% = 56\%$

③ $\alpha = \frac{6,7 - 0,35}{6,7 - 0,022} = ,95$ نسبة الـ α هو الخط الواصل لل Fe3C بالجزء كامل

④ $\alpha_{eutectoid} = 0,95 - 0,56 = 0,39$ ⑤ % Fe3C = 0,05 ← ,100 - ,95

B %C = 1%

$Fe_3C = Fe_3C_{Eutectoid} + Fe_3C_{proeutectoid}$

① $\%p = \frac{6,7 - 1}{6,7 - 0,76} = 94\%$

② % proeutectoid cementite $= 1 - 0,94 = 6\%$

③ % Cementite total $= \frac{1 - ,022}{6,7 - 0,022} = 14,6$ ليس

④ Cementite eutectoid $= 8,6\%$ 14,6 - 6%

⑤ $\% \alpha_{eutectoid} = 85,4\%$ 100 - 14,6

There are 3 Types of iron:-

IRon:- % [C < 0,008] ⟹ ferrite

steel:- % [0,008 → 2,12] ⟹ $\alpha + Fe_3C$

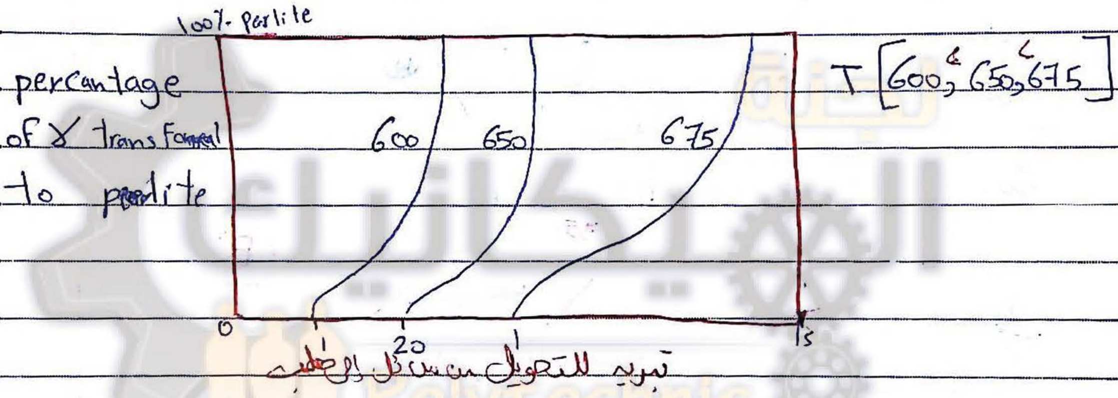
Castiron:- % less than 4.5% [< 4.5%]

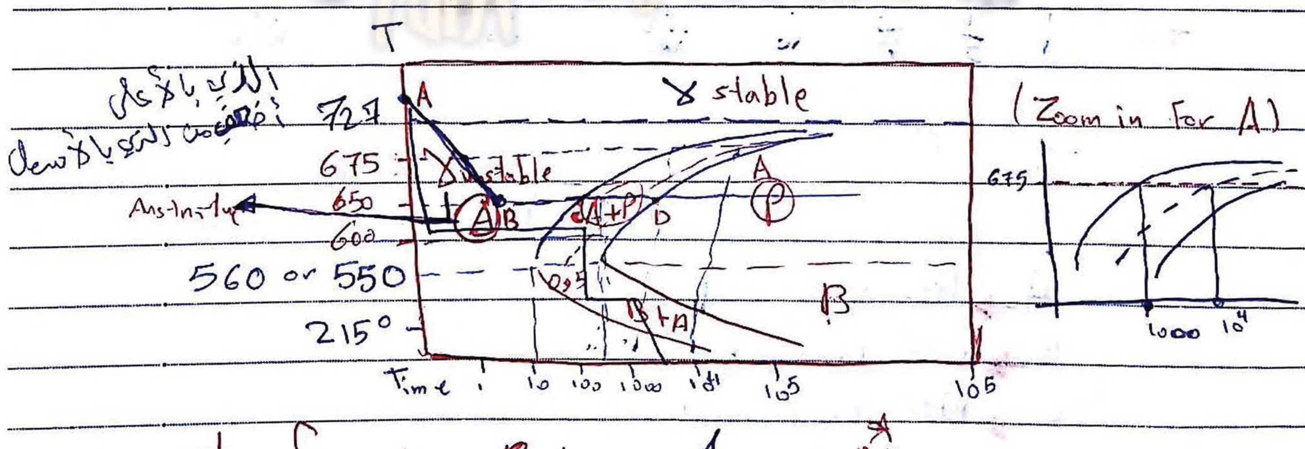
CH-10:-

H.W 9,51 / 9,28 / 9,32 / 9,54

10,5:- isothermal TransFormation Diagrams

at 727 $\gamma(0,76) \rightleftharpoons \alpha(0,027) + Fe_3C(6,7)$



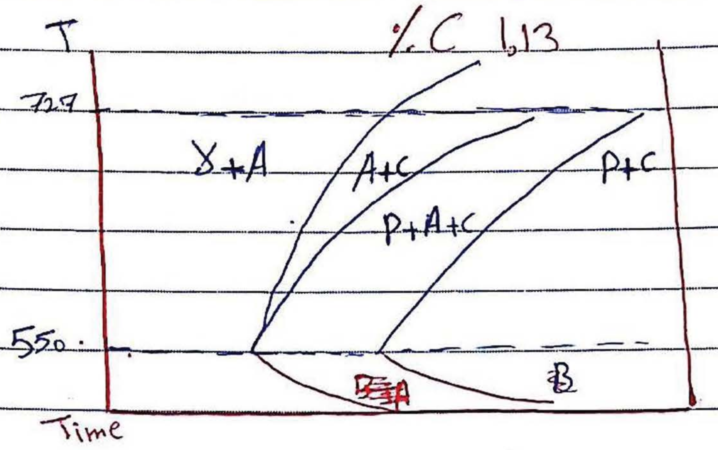


Tranformation Rate = $\frac{1}{T_{0,5}}$ → this

A → B very Rapid cooling   B → C:- unstable

C → D:- isothermal transFormation

Coars pearlite :- 650 _ 700 → (α Fe3C 8 — 1)
Fine pearlite :- 550 _ 650 → more stiFness → Fe_3C



* Bainite :- it's an austenitic transformation (it consists of $\alpha + Fe_3C$) تتضمن

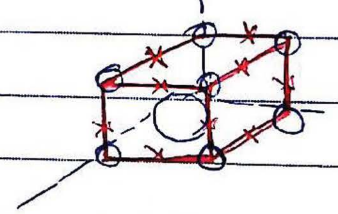
Spheroidite :- if an alloy containing pearlitic or Bainitic Micro structure is heated to and left below الأسفل eutectoid For long time at 700° For [18h - 24h]

spheres Fe_3C → α

Austnide أطلة

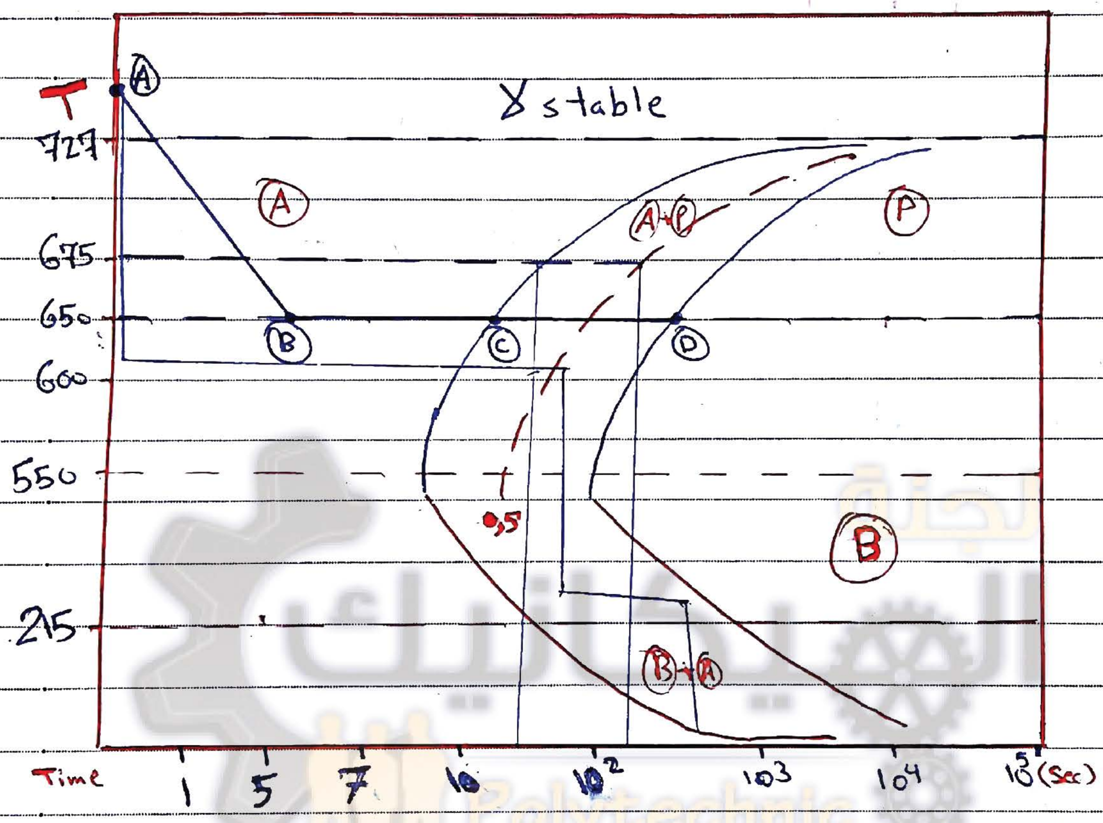
Martensite :- austenitic transformation it's Formed when γ Rapidly cooled to low temp < 215° austenit

γ :- Fcc   M :- BCT



Bct :- Body centered TeTragonal
M :- is super saturated with carbon
* if there is any carbon diffusion
single → 2 phase $\alpha + Fe_3C$

(A) Austnide

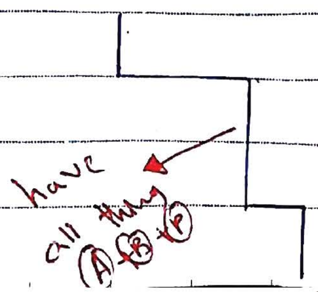


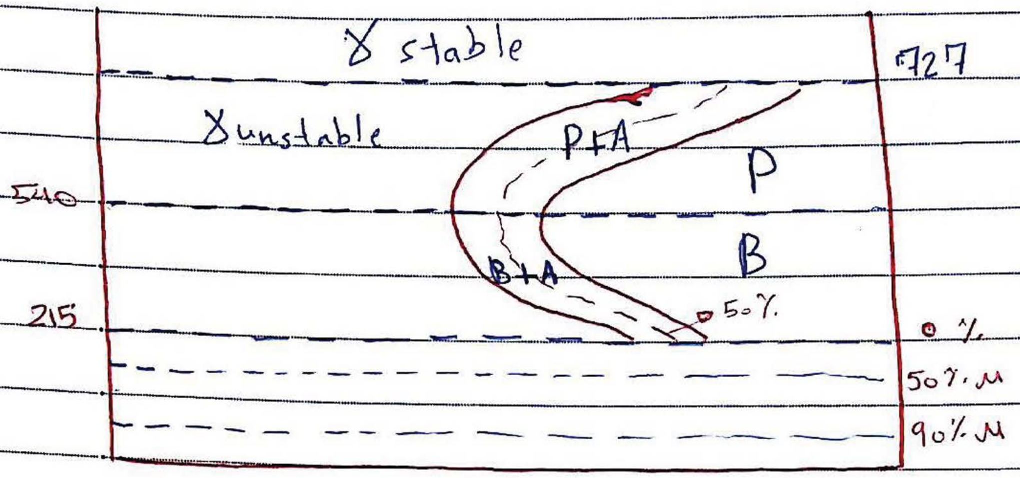
$$\text{Trans formation Rate} = \frac{1}{T_{0.5}}$$ → this

A → B :- Very Rapid cooling (سريع)

B → C :- unstable (غير مستقر)

C → D :- isothermal transformation





540 or 560 → Pearlite

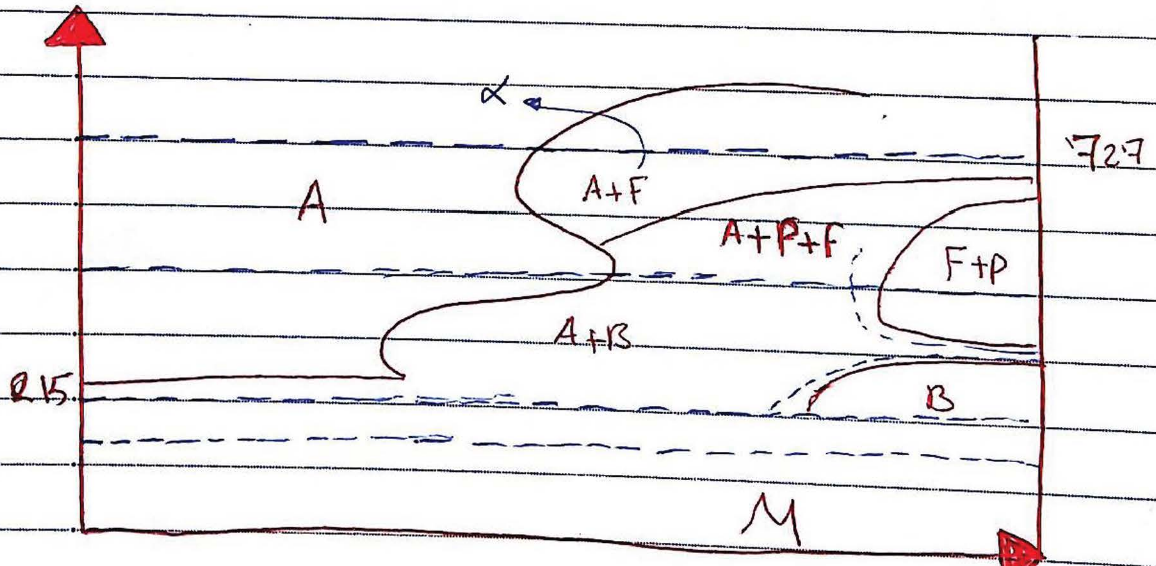
540 → Bainite

other alloying elements (Cr, Ni, Mo):- (this)

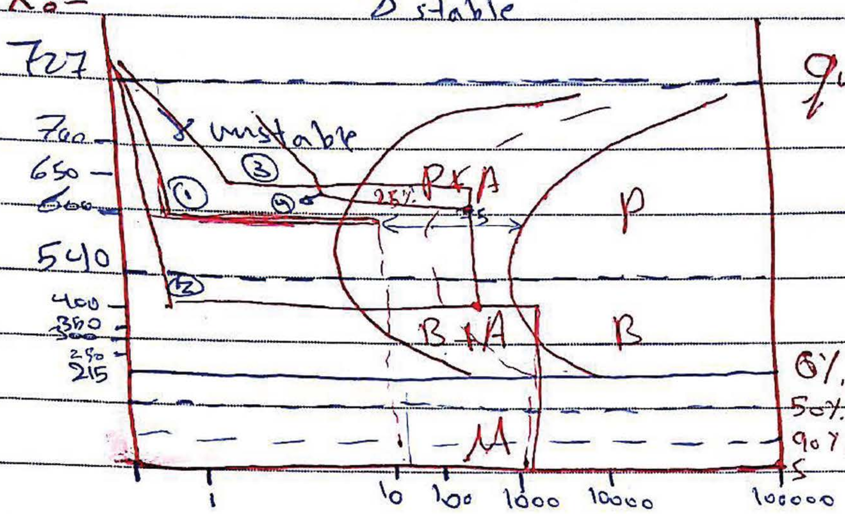
this ← ① shifting to longer time the nose (تغيّر) of the austinite to pearlite transformation (also proeutectoid nose if exists)

② Formation of a separate (فصل) Bainite nose

* plain carbon steels:- the prime (تعني) alloying element (سبيكة مركبة) is carbon



Ex:-



Quench:- Rabid cooling at ambit

Bainit this
Austnite علوية

① 25% P + 75 M ② 100% B ③ 100% B ④ 50% B + 50 P

Fin pearlite عال 600

P ← يتحول γ

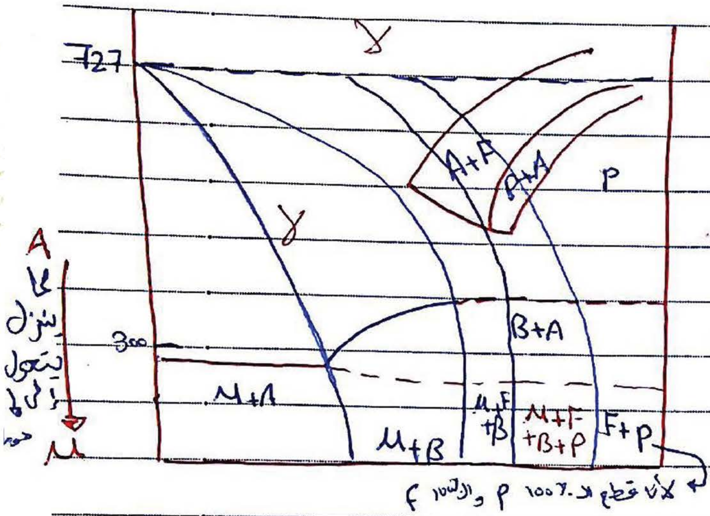
① Rapidly cool to 350°C, hold for 10^4 s & Qunch to Room Temp ∴ 100% B

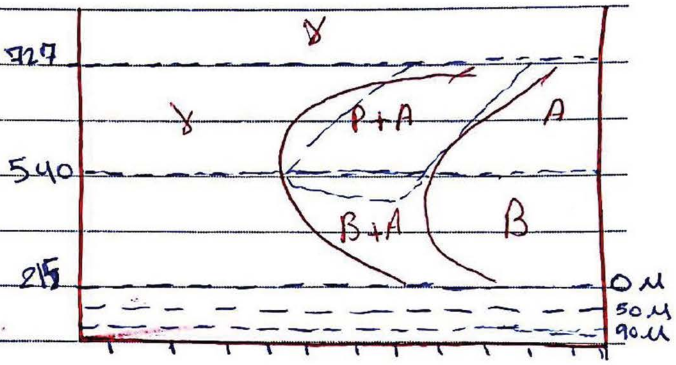
② Rapidly cool to 250°C, hold for 100 sec & quench to Room Temp ∴ 20% B + 80% M

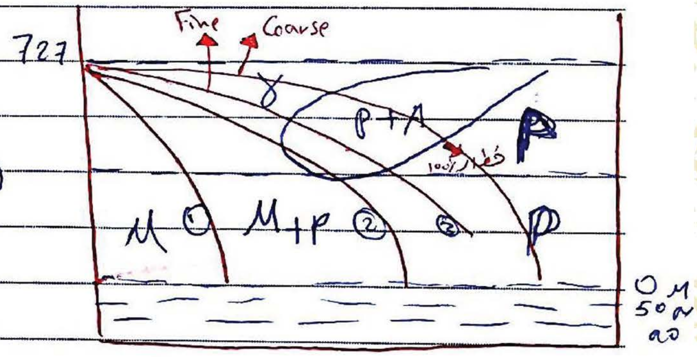
③ Rapidly cool to 650 °C, hold for 20 s, Rapially cool to 400 °C, hold for 10^3 s of quench 100% B

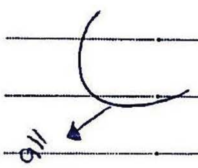
10,6] Continous Cooling Transformation Diagram:-

Iso thermal تسخين ↑









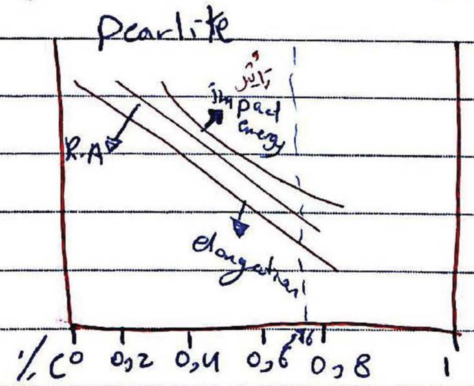
① Martensite ③ Pearlite 100%

%C 0,76 eutectoid لأنه

Fine ◀ أسرع ◀ أقل T ↓ لأنه

10,7] Mechanical Behavior of iron Carbon Alloys:-

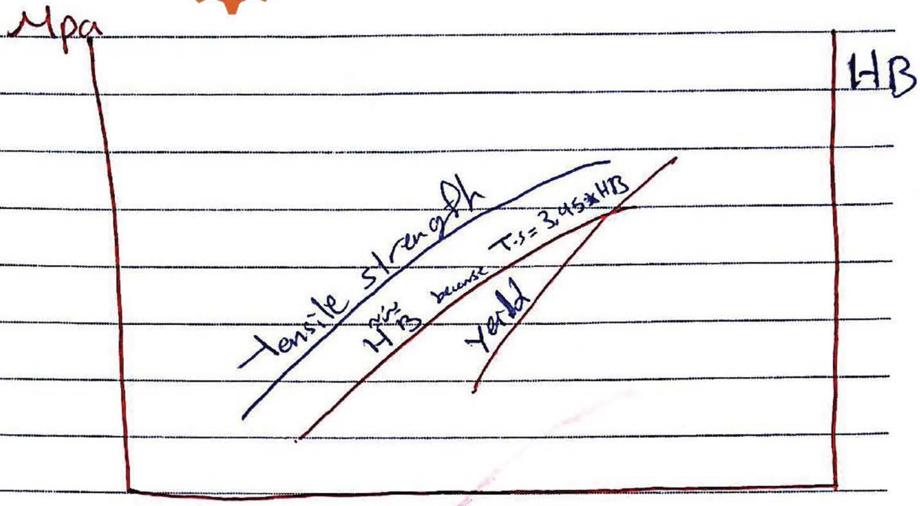
*Ductility:-



impact energy:- تأثير الطاقة

(R.A) Reduction of Area:- تخفيض المساحة

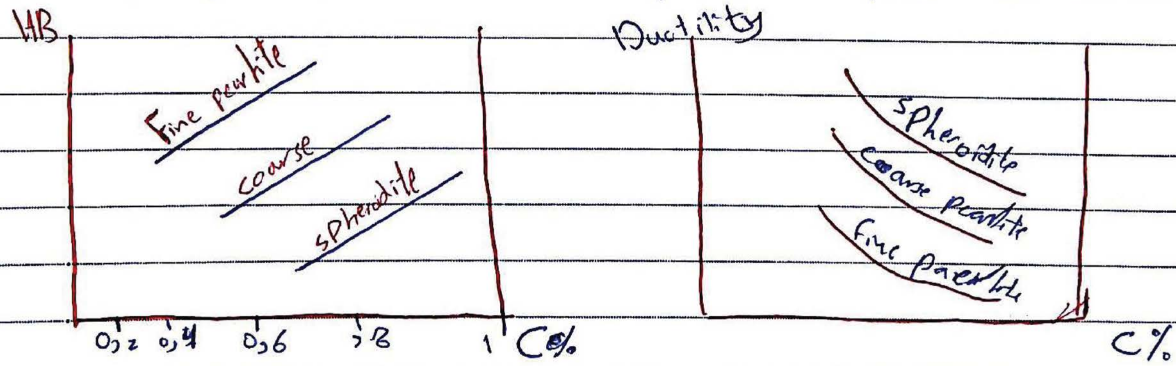
elongation:- التغير بالطول



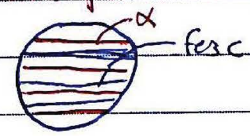
* Tensil yeild & Brinell increases.
increase the carbon → Cementite
⇒ More Britle
Less ductility (elongation & Reduction of area) R.A تخفيض
what happen: ↑C ↓Toughness

10.7] Mechanical propartes of iron-carbon alloys:-

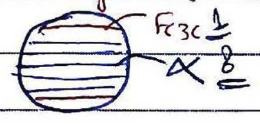
550-650 (Fine pearlite) 660-700 (coarse p) 700 (spheroidite)



Fine peerlite:-



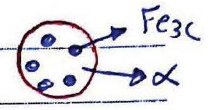
Coarse perlite:-



↑ Yeild لماذا
المادة تصبح أقوى

Coarse pearlite:- is More ductile than Fine perlite لأن المسافات أكبر
⇒ strong & Rigid Cemantit (صلبة) stricts (يعيق) the deformation of α
No dislocation Less Hardness More ductile

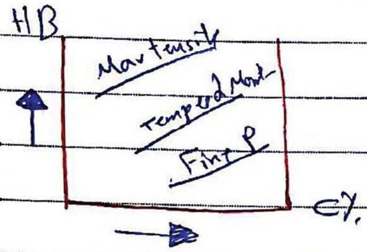
(s,w) * spheroidite :-

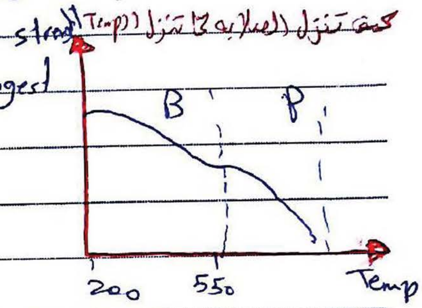


- Soft & Weak - ductile More than coarse pearlite

Bainite :- it has fine structure stronger & harder than (fine P)

* Martensite :- it's the hardest & strongest



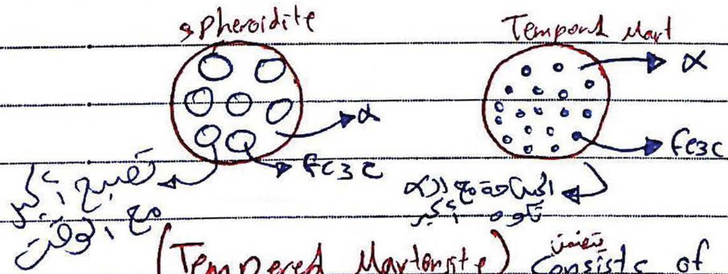


- Strength & Hardness of Martensite (not Related to Microstructure) علاقة
- Austinite is densier أكثف than Martensite

upon quenching → net volume increase → Crack تشقق upon quenching (%C > 0.5%)

(دوت) Tempered تسخين Martensite :-

Martensit is very brille & it can't be used for Most application
When Heating → enhance ductility & toughness
Tempering is carried out at Temperatures between (250-650 c)
Martensite (BCT, single phase) —H→ Tempred Martensite ($\alpha + Fe_3C$)



(Tempered Martensite) consists تتضمن of very small & uniformly بشكل موحد cementite particles in a continuous (Ferrite Matrix)

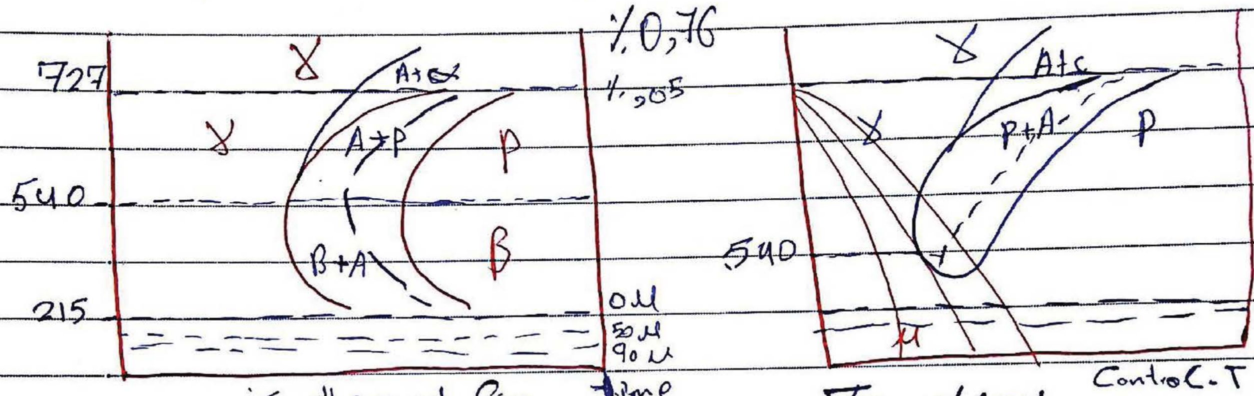
* Same as (spheroidit) except cementite paticles are Much smaller

* Tempered Martensite hardness is less a little than Martensite But (More ductile & Tough)

* (hardness of strength due to α - Fe_3C Boundery area)

Table 10.7 → (seen)

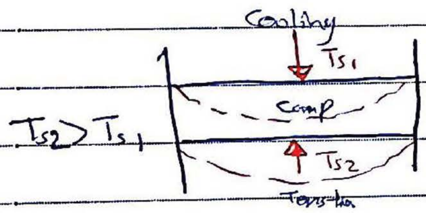
Barnait can't chang to Martinsite → single phase (BCT)



iso-thermal fig

Contro C.T

$\nabla_{Th} = \alpha \Delta T L$



* Tempered Martensite continued.

increasing particles (جزئ) Volume of cementite ⇒ decrease ferrite - cementite Boundary Area (تركيز)

⇒ Softer & weaker (spheroidite)

Tougher & More ductile

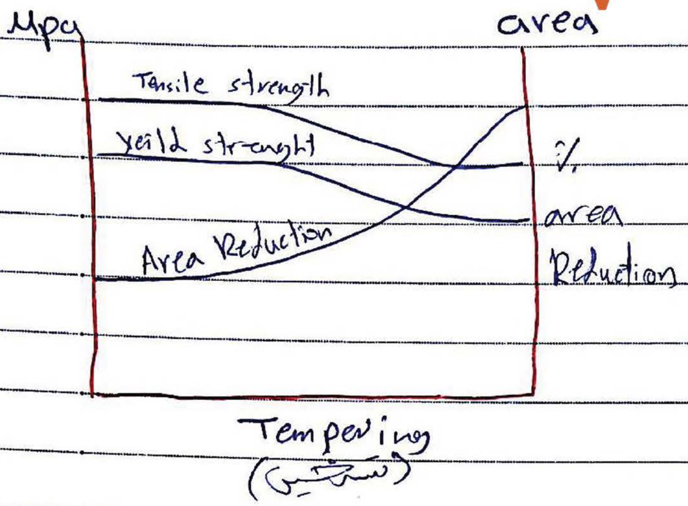
More stiffness

Tempered Martensite -

increasing temp ⇒ accelarate diffusion of carbon (انتشار الكربون)

⇒ Rate of softening

⇒ spheroidite يصبح 18h لو سخنته

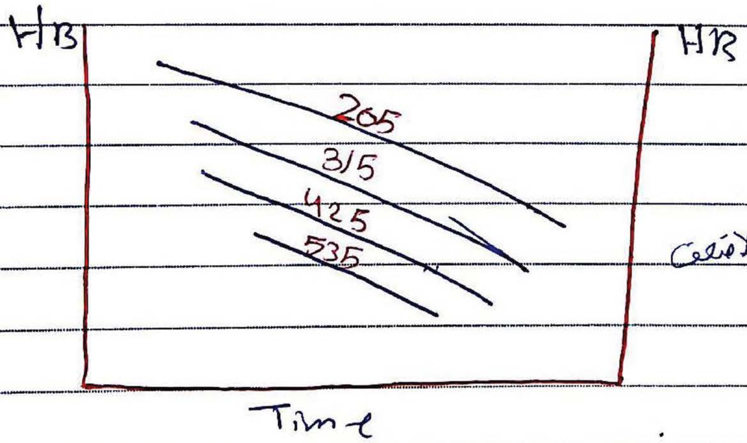


مع التسخين
يزيد كلا من
↑ Elongation ↑ Toughness ↑ Ductility

* Temper embrittlement (هشاشة تقصف) :- (Reduction of toughness)
steal is heated from 375_575 to above 575 C
then slow cooling to Room Temp

* the steel has to much impurities :-
① Nickel (Ni) ② Phosphorous (S) ③ Mangnize (Mg)

* it shifts the ductile to Brittle transition to higher temp



205° 535°
425° 315°
لو رتب من الأعلى الى الأصغر

end CH-10