The University of Jordan
School of Engineering
Industrial Engineering Department

الجامعة الاردنية
كلية الهندسة والتكنلوجيا
قسم الهندسة الصناعية

First semester 2016 – 2017

Course Title : Metallurgical Processes course No. : IE0906513 Final exam
Instructor : Prof. Dr. Issam S. Jalham Providing Dept: IE Dept 02/01/2017 14:00-16:00

Q1: (a) Briefly explain why ferritic and austenitic steels are not heat treatable. *(3 marks)*

(b) Nickel is never added to high carbon steel, why? *(3 marks)*

Q2: Sketch the following thermal histories based on Figure 1. *(10 marks)*

100% Martensite	50% pearlite + 50% austenite	50% bainite + 50% martensite	Spherodite Approach1	Spherodite Approach2

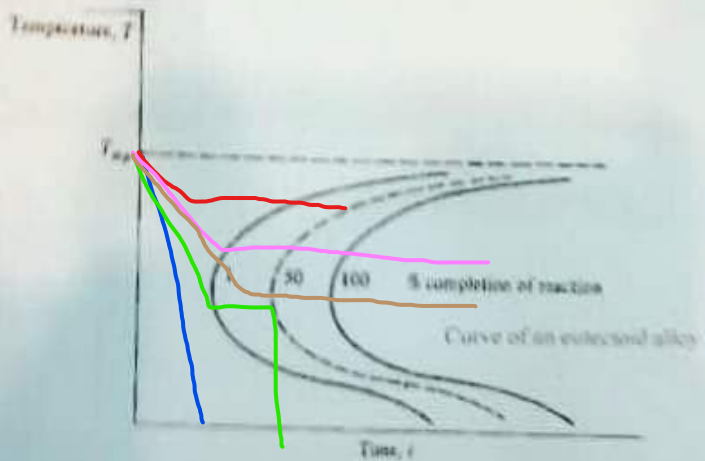

Figure 1

Q1 :Choose the right answer for the following: (20 X 2 Marks)

1. ***The recommended heat treatment process for the hacksaw is:***
Hardening B) annealing c) Normalizing d) Normalizing + hardening

2. ***The recommended heat treatment process for the car body is:***
a) Hardening B) annealing c) Normalizing d) Normalizing + hardening

3. ***The recommended heat treatment process for the I-beams used in building construction is:***
a) Hardening B) annealing c) Normalizing d) Normalizing + hardening

4. ***The recommended heat treatment process for the Drive half-shaft for a small car is:***
a) Hardening B) annealing c) Normalizing d) Normalizing + hardening

5. ***The severity of quenching media from high to low can be ranked as follows:***

A] 5% caustic soda, 20% brine, cold water, warm water, animal oil, mineral oil, vegetable oil, air, insulating material or furnace.

B] 5% caustic soda, 20% brine, cold water, animal oil, warm water, animal oil, mineral oil, vegetable oil, air, insulating material or furnace

C] 5% caustic soda, 20% brine, cold water, warm water, mineral oil, animal oil, vegetable oil, air, insulating material or furnace

D] 5% caustic soda, cold water ,20% brine, warm water, animal oil, mineral oil, vegetable oil, air, insulating material or furnace.

6. ***The cooling rate for the solution heat treatment process of Al-copper alloys is:***

A]Very fast B]moderate C] slow D] no matter

7. ***The cooling rate for the precipitation heat treatment process of Al-copper alloys is:***

A]Very fast B]moderate C] slow D] no matter

8. ***The overaging mechanism in Al-Cu alloys is:***

A] A result of the distortion in the lattice B] A result of the perfection in the lattice

C] A result of Alpha phase formation D] A result of the formation of a Mo-like structure

9. ***The formation of the graphite into a ball form in ductile cast iron is accomplished by:***

A] Adding Mn and Cerium B] Mo and Cerium C]Mn and Mo D] Mg and Cerium

10. ***Referring to Figure besides, the good designs to avoid shrinkage are:***

A]a and d B]a and c C]b and d D]b and c

Q2: *Referring to figure2 below, fill in the following blanks:*

17. ***The microstructure of (1) consists of:***
    a) Ferrite & Pearlite b) Ferrite & Austenite c) Pearlite & austenite d) Pearlite & cementite
18. ***The microstructure of (2) consists of:***
    a) Ferrite & Pearlite b) Ferrite & Austenite c) Pearlite & austenite d) Pearlite & cementite
19. ***The microstructure of (3) consists of :***
    a) Fine Pearlite b) Coarse Austenite only c) Fine austenite only d) Fine cementite
20. ***The microstructure of (4) consists of :***
    a)Fine Ferrite & Fine Pearlite b) Coarse Ferrite & Coarse Austenite
    c) Fine Pearlite & Fine austenite d) Coarse Pearlite & coarse cementite

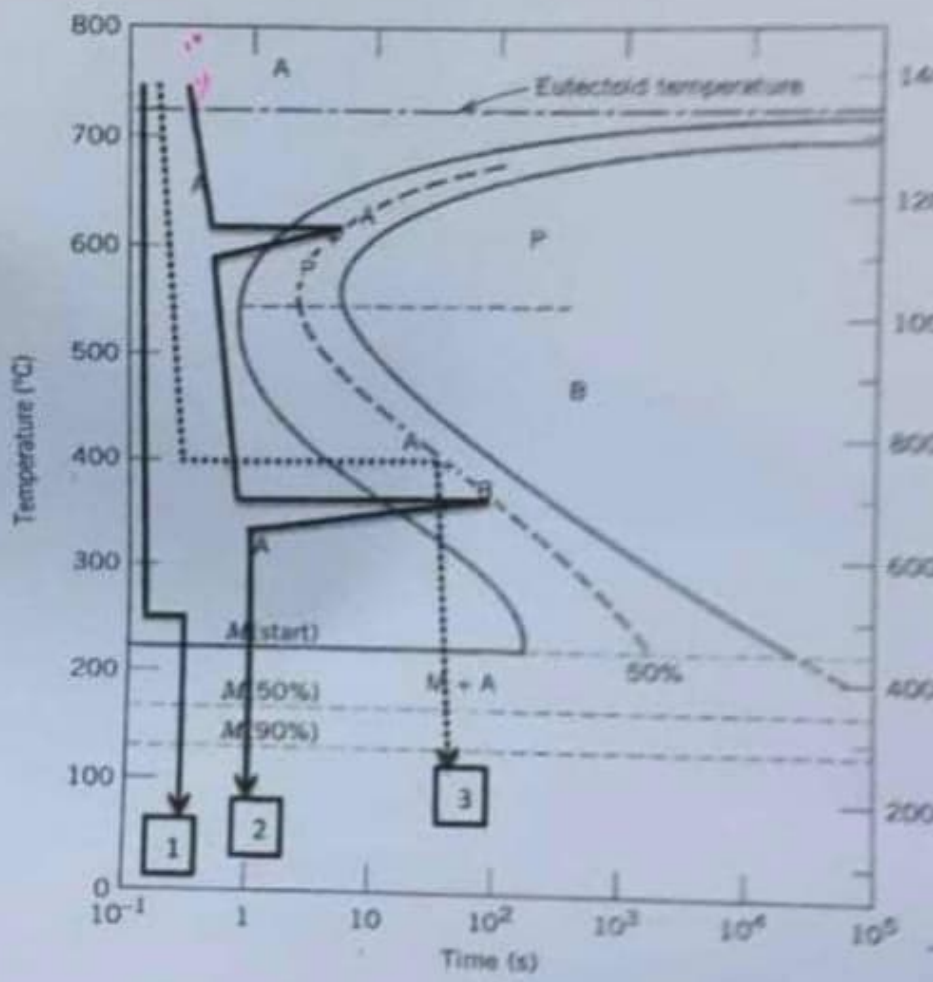

Figure 1 The complete isothermal transformation diagram for an iron–carbon alloy of eutectoid composition: A, austenite; B, bainite; M, martensite; P, pearlite.

Q2: ***Referring to figure2 below, fill in the following blanks:***

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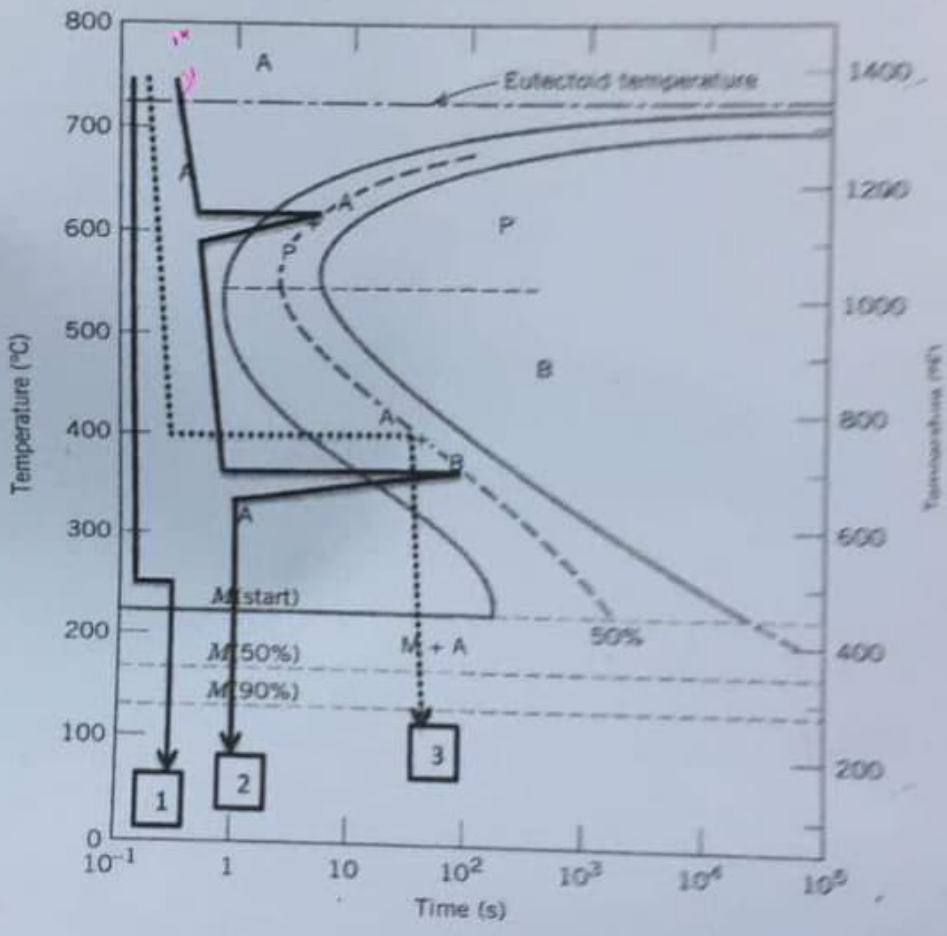


Figure 1 The complete isothermal transformation diagram for an iron–carbon alloy of eutectoid composition: A, austenite; B, bainite; M, martensite; P, pearlite.

11. ***Referring to Figure besides, the major segregation effect is shown in:***

A] a B]b C]c D] a and b

12. ***The main distinct welding zones are:***

A]Weld metal, HAZ, and Base metal

B] Weld metal, HAZ, and Knife effect in Base metal

C]Weld metal, and Knife effect in Base metal

D] HAZ and Knife effect in Base metal

13. ***Weldability of Plain carbon steel, medium, and High carbon steels are:***

A]Fair, good, poor respectively

B] Good, fair, poor respectively

C] Good, poor, fair respectively

D] Good, fair, fair respectively

14. ***The microstructure that resulted from the cooling curve no.1 is:***

a) Martensite only

b) only bainite

c) Pearlit + martensite

d) spherodite

15. ***The microstructure that resulted from the cooling curve no.2 is:***

a) pearlite +bainite+Martensite

b) Pearlite+bainite

c) Bainite+ martensite

d) Pearlite+Martensite+spherodite

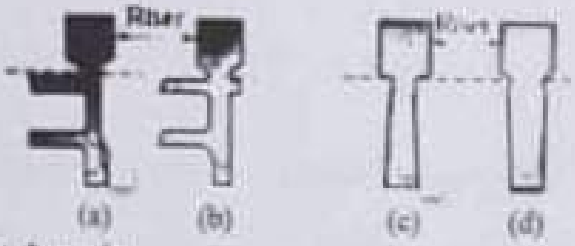
16. ***The microstructure that resulted from the cooling curve no.3 is:***

a) Martensite +bainite

b) Pearlite+bainite

c) Pearlit + martensite

d) pearlite +bainite+Martensite



11. ***Referring to Figure beside, the major segregation effect is shown in:***

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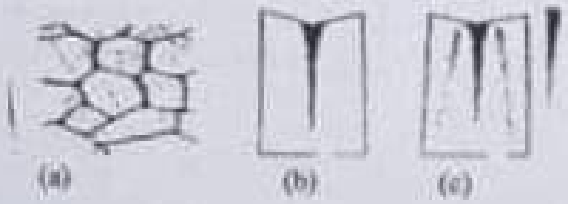


12. ***The main distinct welding zones are:***

A]Weld metal, HAZ, and Base metal

B] Weld metal, HAZ, and Knife effect in Base metal

C]Weld metal, and Knife effect in Base metal

D] HAZ and Knife effect in Base metal

13. ***Weldability of Plain carbon steel, medium, and High carbon steels are:***

A]Fair, good, poor respectively

B] Good, fair, poor respectively

C] Good, poor, fair respectively

D] Good, fair, fair respectively

14. ***The microstructure that resulted from the cooling curve no.1 is:***

a) Martensite only

b) only bainite

c) Pearlit + martensite

d) spheroidite

15. ***The microstructure that resulted from the cooling curve no.2 is:***

a) pearlite +bainite+Martensite

b) Pearlite+bainite

c) Bainite+ martensite

d) Pearlite+Martensite+spheroidite

16. ***The microstructure that resulted from the cooling curve no.3 is:***

a) Martensite +bainite

b) Pearlite+bainite

c) Pearlit + martensite

d) pearlite +bainite+Martensite

7. *The casting should cool:*

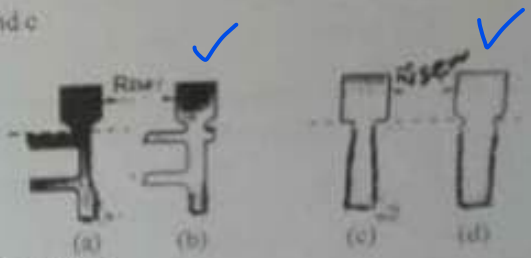
A] Before the riser B] After the riser C] with the same rate as riser D]No matter

8. *The formation of the graphite into a ball form in ductile cast iron is accomplished by:*

A] Adding Mn and Cerium B] Mo and Cerium C]Mn and Mo D] Mg and Cerium

9. *Referring to Figure besides, the good designs to avoid shrinkage are:*

A]a and d B]a and c C]b and d D]b and c



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A] a B]b C]c D] a and b

11. *The main distinct welding zones are:*

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C]Weld metal, and Knife effect in Base metal D] HAZ and Knife effect in Base metal

12. *Weldability of Plain carbon steel, medium, and High carbon steels are:*

A]Fair, good, poor respectively B] Good, fair, poor respectively

C] Good, poor, fair respectively D] Good, fair, fair respectively

Q3: Suggest a method of getting a mixture of 25% Pearlite, 50% Bainite & 50% Martensite in an eutectoid steel. Illustrate with a sketch.

(ABET question (C)) (5 Marks)

gure2 below shows a continuous cooling (CCT) curve of X- steel
cture of this alloy after cooling by following: *(18 mar*

a) Curve No.1 will be...martinsite 100%.....
b) Curve No.2 will be....bainite + martinsite...
c) Curve No.3 will be.....bainite.....
d) Curve No.4 will be...Pearlite + bainite + martinsite
e) Curve No.5 will be..Pearlite + bainite.....
f) Curve No.6 will be.....spherodite.....

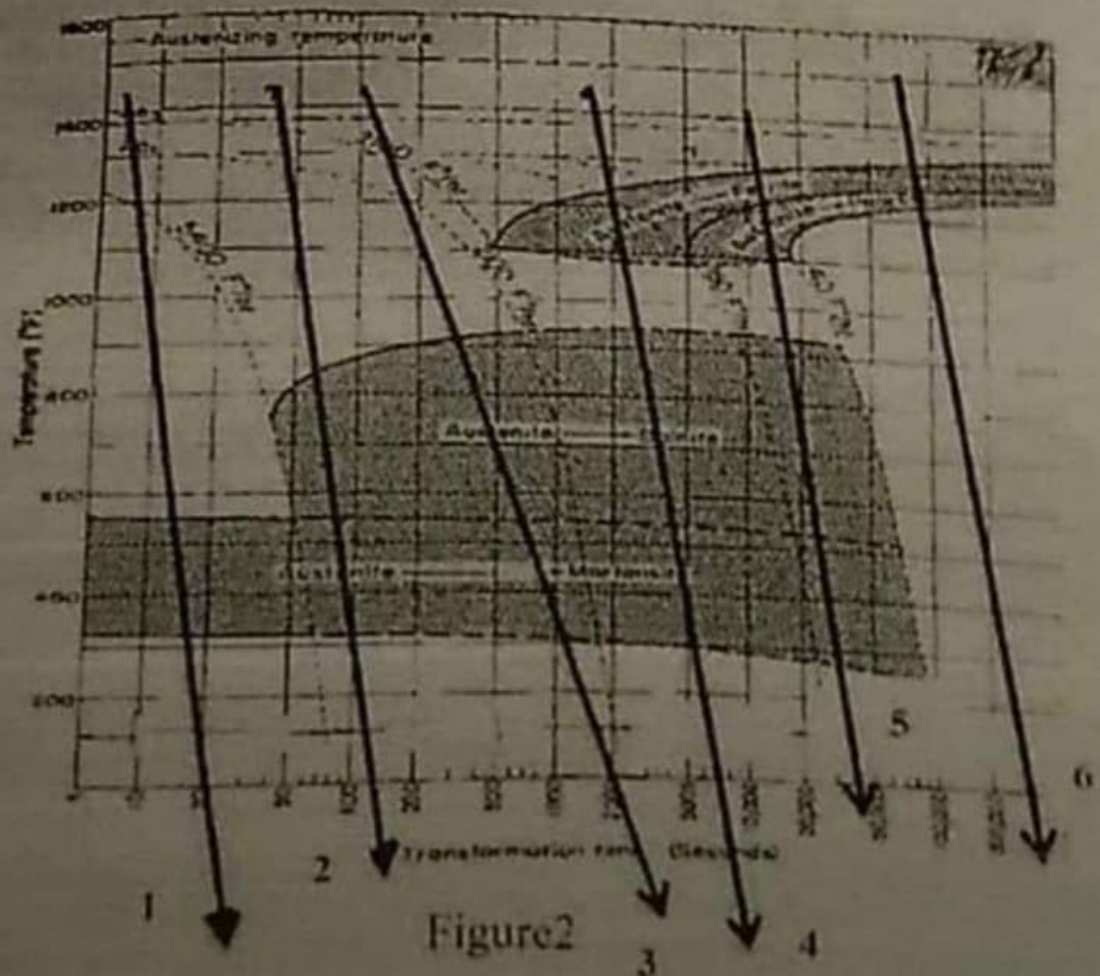


Figure2

Q3: The figure2 below shows a continuous cooling (CCT) curve of X- steel alloy. The microstructure of this alloy after cooling by following: *(18 marks)*

a) Curve No.1 will be 100% martensite
b) Curve No.2 will be bainite + martensite
c) Curve No.3 will be bainite
d) Curve No.4 will be pearlite + b + m
e) Curve No.5 will be pearlite + bainite
f) Curve No.6 will be spherodite

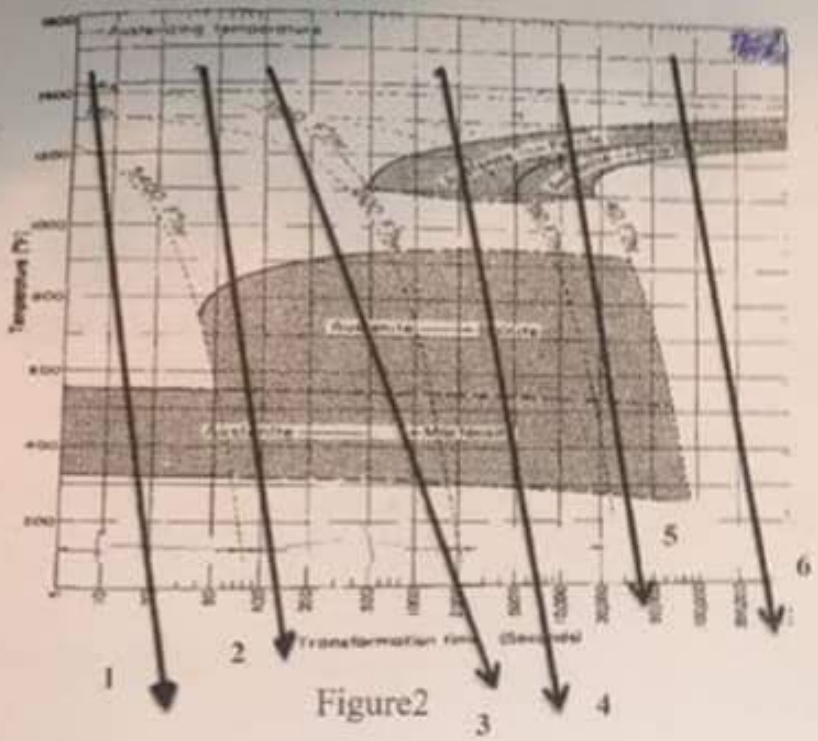


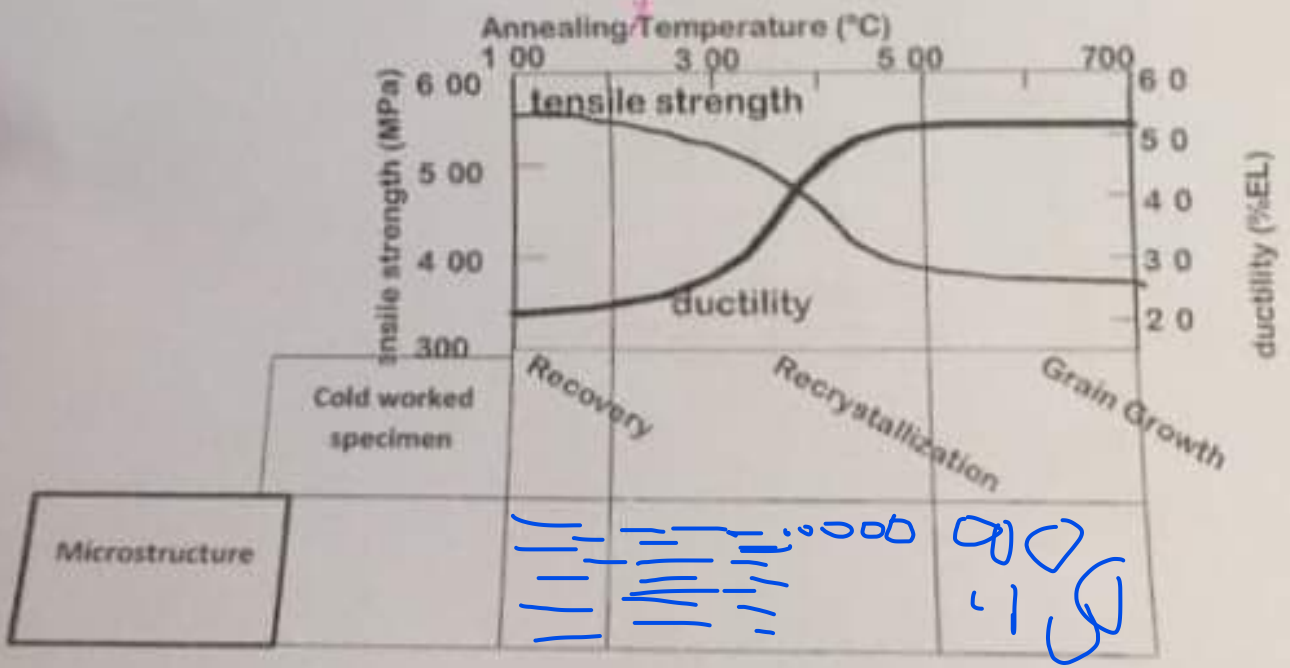
Figure2

Q4: Cold working of aluminum is often done immediately after solution heat treatment and before aging begins. Do you agree with this expression? Why? *(4 marks)*

Q2: Low carbon steel is heat treated by normalizing for machining purposes. Do you agree with this expression? Why? (4 marks)

Because.....

Q3: Sketch the microstructure related to the mechanisms in annealing stages, which are shown below: (8 marks)



Q1. State whether the following statement are true or false: (12 Marks)

1. Covalent bond has the smallest bonding energy comparing with other types of bonds. ( )
2. The condition to decide that we have a fine grained structure is when the number of grains N = 5:8 only ( )
3. Body centered tetragonal crystal structure is when a= b≠c and has an atom in the centre. ( )
4. The limitation of the phase diagram for heat treatment purposes is that it does not show the effect of cooling rate ( )
5. The distance between the tap and the quenched end in Jominy end quench test is 24 mm. ( )
6. The severity of quenching media from high to low can be ranked as follows: 5% caustic soda, 20% brine, cold water, warm water, animal oil, mineral oil, vegetable oil, air, insulating material or furnace. ( )

Q2: Choose the right answer for the following: (24 Marks)

1. ***The descending order of strength based on microstructure is:***

   A] Martensite, spherodite, fine pearlite b] fine pearlite, spherodite, bainite

   C] T martensite, bainite, fine pearlite d] Spherodite, Tmartensite, martensite

2. ***If the nose of the TTT diagram is for an alloy at the zero time line,***

   A] It would be easy to harden it B] it is impossible to harden it

   C]It is difficult to harden it D]Special furnace is needed to harden it

3. ***The Ms temperature on the TTT diagram is a function of carbon content as follows:***

   A] The higher the %C, the higher the Ms temperature

   B]The higher the %C, the lower the Ms temperature

   C] There is no change in Ms temperature

   D] There is a slight change in Ms temperature

4. ***The cooling rate for the solution heat treatment process of Al-copper alloys is:***

   A]Very fast B]moderate C] slow D] no matter

5. ***The cooling rate for the precipitation heat treatment process of Al-copper alloys is:***

   A]Very fast B]moderate C] slow D] no matter

6. ***The averaging mechanism in Al-Cu alloys is:***

   A] A result of the distortion in the lattice B] A result of the perfection in the lattice

   C] A result of Alpha phase formation D] A result of the formation of a Mx[illegible]

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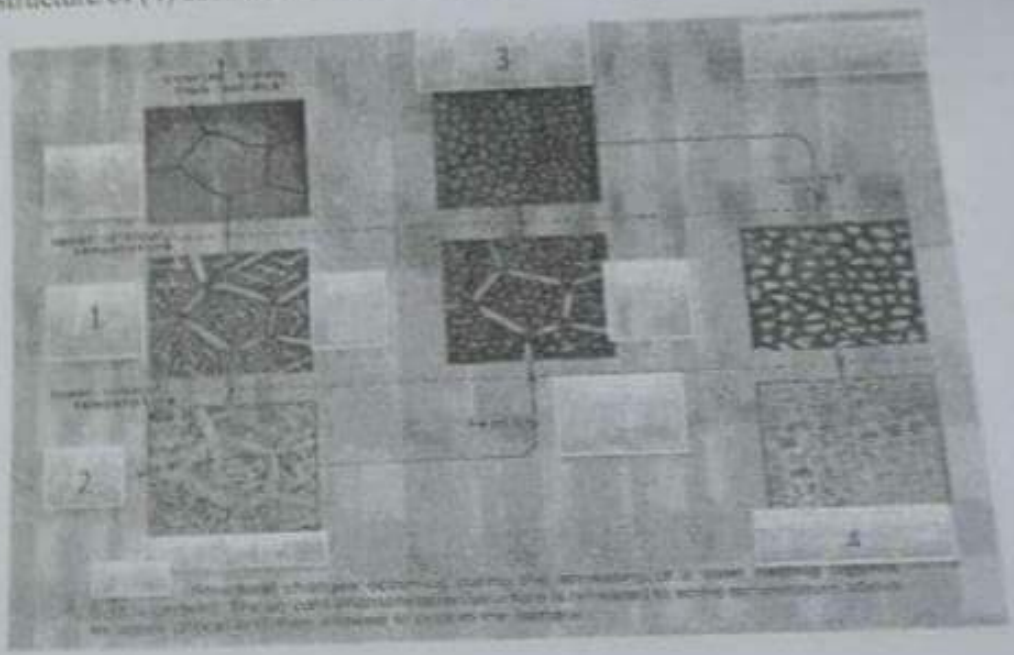
Q4. **Suppose that you have a crack in a piece of plain carbon steel. How can you decide whether it is caused by a heat treatment?** (ABET question (E)) *(5 Marks)*

Q5: ***Referring to the figure below, fill in the following blanks:*** (4 Marks)

1. The microstructure of (1) consists of ..... and .....
2. The microstructure of (2) consists of ..... and .....
3. The microstructure of (3) consists of ..... and .....
4. The microstructure of (4) consists of ..... and .....



Q5: What are the main steps to produce malleable cast iron from white cast iron? (5 marks)

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5. (a) Fusion welding means ..... *(1 mark)*

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(b) Solid state welding means ..... *(1 mark)*

.....

(c) Brazing and soldering means ..... *(1 mark)*

.....

(d) Sketch the main metallurgical zones in welding. *(4 marks)*

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The End

Q1 :Choose the right answer for the following: (20 X 2 Marks)

1. ***The recommended heat treatment process for the hacksaw is:***
Hardening B) annealing c) Normalizing d) Normalizing + hardening

2. ***The recommended heat treatment process for the car body is:***
a) Hardening B) annealing c) Normalizing d) Normalizing + hardening

3. ***The recommended heat treatment process for the I-beams used in building construction is:***
a) Hardening B) annealing c) Normalizing d) Normalizing + hardening

4. ***The recommended heat treatment process for the Drive half-shaft for a small car is:***
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5. ***The severity of quenching media from high to low can be ranked as follows:***

A] 5% caustic soda, 20% brine, cold water, warm water, animal oil, mineral oil, vegetable oil, air, insulating material or furnace.
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10. ***Referring to Figure besides, the good designs to avoid shrinkage are:***

A]a and d B]a and c C]b and d D]b and c

Q1. State whether the following statement are true or false: (12 Marks)

1. Covalent bond has the smallest bonding energy comparing with other types of bonds ( )
2. The condition to decide that we have a fine grained structure is when the number of grains N = 5-8 only ( )
3. Body centered tetragonal crystal structure is when a=b≠c and has an atom in the centre ( )
4. The limitation of the phase diagram for heat treatment purposes is that it does not show the effect of cooling rate ( )
5. The distance between the tap and the quenched end in Jominy end quench test is 24 mm ( )
6. The severity of quenching media from high to low can be ranked as follows: 5% caustic soda, 20% brine, cold water, warm water, animal oil, mineral oil, vegetable oil, air, insulating material or furnace ( )

Q2. Choose the right answer for the following: (24 Marks)

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   A] Martensite, spherodite, fine pearlite   b] fine pearlite, spherodite, bainite

   C] T martensite, bainite, fine pearlite   d] Spherodite, Tmartensite, martensite

2. ***If the nose of the TTT diagram is for an alloy at the zero time line,***

   A] It would be easy to harden it   B] it is impossible to harden it

   C]it is difficult to harden it   D]Special furnace is needed to harden it

3. ***The Ms temperature on the TTT diagram is a function of carbon content as follows:***

   A] The higher the %C, the higher the Ms temperature

   B]The higher the %C, the lower the Ms temperature

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Q1 :Choose the right answer for the following: (10 X 2 Marks)

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Hardening B) annealing c) Normalizing d) Normalizing + hardening

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a) Hardening B) annealing c) Normalizing d) Normalizing + hardening

3. ***The recommended heat treatment process for the I-beams used in building construction is:***
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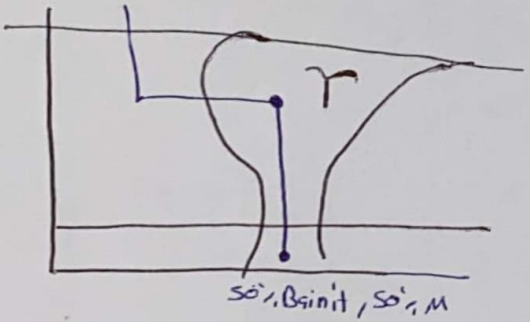
A] Adding Mn and Cerium B] Mo and Cerium C]Mn and Mo D] Mg and Cerium

10. ***Referring to Figure besides, the good designs to avoid shrinkage are:***

A]a and d B]a and c C]b and d D]b and c

third exam :-

- The phase digram doesn't show the affect of cooling rate.
- The distance between the top and the quenched end 12.5 mm
- strength based on microstructure : T-martensite , bainite , fine pearlite.
- if the nose of the TTT diagram is for an alloy at the zero line it's impposible to harden it .
- The higher %c the lower Ms tempreture.
- The casting should cool befor the riser.
- 25% pearlite , 50% Bainite , 50% martensite .



• first exam :~

Q1a: Briefly explain why ferrite and Austenite are not heat treatble?

sol: ferrite and Austenite steels are not heat treatbge, since "heat treatble" is taken to mean that martensite may be made form with relative ease upon quenching austenite from an elevated tempreture.

by heating austenite to make martensite is not possible to be tranformed.

Q1b: Nickel is never added to high carbon steel?

sol: because nickel have a very large atom and will'nt interstitial with carbon, and it has graphitizing influence on cm.

Q3: [illegible]

Q4: Cold working of Aluminum is often done immediatly after solution heat treatment and before aging begins? Do you agree?

sol: because it will be more machinable and less hardness and aging will increas the hardness of the Al - alloy.

Q5: what are the main steps to produce mellable cast iron from white cast iron?

sol: 1. heat to about 1700°F (927°C) 2. hold at this temp for about 15 hrs.
3. slow cool to about 1300°F (704°C). 4. hold for 15 hrs.
5. air cool to room temp.

Q6 :- fusion welding : process that uses heat to join or fuse two or more materials by heating them to melting point, some cases adding filler

- Solid state welding: melting doesn't happen. no filler is added.

- Brazing and soldering means: they both melt the filler metal (braze or solder)
the difference is the tempreture at which each process takes place.

Q1 A) Ferritic and Austenitic steels are not heat treatble, since heat treatble is taken to mean that martensite may be made to form with relative ease upon quenching austenitic from an elevated temp.

by heating austenite to make martensite is not possible to be transformed

Q2 B) because nickel have avery large atom and will not interstitial with carbon, and in martensite producing nickel will reducing carbon content and improve weldability.

Q3) a) 100% martensite b) 50% bainite + 50% martensite
c) beinite d) pearlite + beinite + martensite
e) pearlite + bainite f) spheroidite

Q4) yes I agree, because it will be more machinable and less hardness, then aging will increase the hardness of the AL alloy

Q5) 1) heat to about 1700°F (927°C).
2) hold at this temp for about 15 hrs → this breakdown iron - carbide to austinite + graphite.
3) slow cool to about 1300°F (704°C).
4) hold at this temp to 15 hrs.
5) Air cool to room temp.

...velent bond has the smallest bonding energy comparing with other typess of bonds (F).

2- the condition to decide that we have a fine grained structu... is when the number of grain N= only (T).

3- Body centred tetragonal crystal structure is when [crossed out] a = b ≠ c and has an atom in the centre (T).

4- the limitation of the face diagram for heat treatment p... is that in does not show the effect of cooling rate (T).

5- the distance between the tap and the quenched end in J... and quench test is 24 mm (F)

6- the severity of quenching media from high to low can... ranked as follows 5% caustic soda, 30% brine cold wate... warm water, animal oil, mineral oil, vegetable oil ...... (F

Q2/

① the descending order of strength based on micrustructure...
C: T.martensite, bainite, fine Pearlite.

② if the Nose of the TTT digram is for an alloy at the... zero time line:-

③ the MS temp on the TTT digrams is a function of carb... as follows:-
C: there is no change in MS temPreature.

④ the cooling rate for the solution heat treatment Proc... of Al-copper alloys is:- A: very fast.

⑤ the cooling rate for the Precipitation heat treatment ... of Al-copper alloys is:- D: No matter.

⑥ the averaging mechanism in Al-cu alloys is:-
D: A result of the formation of Al-C...

⑦ the casting should cool :-

A: Before the riser.

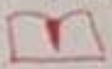
⑧ the formation of the graphite into a ball from in ductile cast iron is accomplished by :-

D: mg and cerium.

⑨ referring to figure besides, the good designs to avoid shrinkage are :

C: b and d

⑩ referring to figure besides, the major segregation effect is shown is :-

B: b 

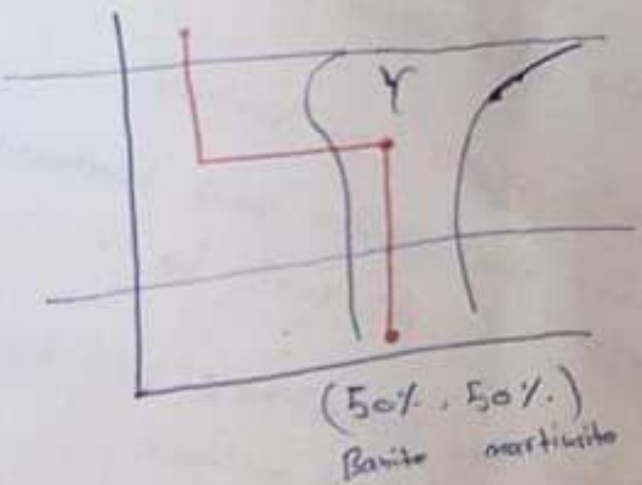
⑪ the main distinct welding zones are :

A: weld metal, HAZ, and Base metal

⑫ weldanbility of plain carbon steel, medium and hight carbon steels are :-

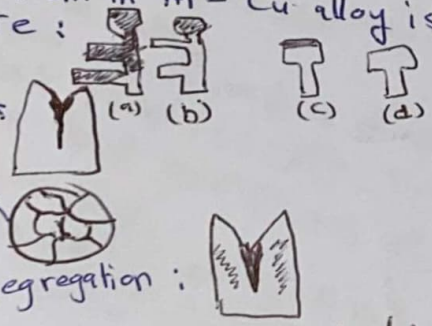
B: Good, fair, Poor rerpactively.

suggest method of getting mixture 25% Perlite, Bainite 50% & 50% martenite in an eutectoid steel, illustrate with sketch:



- second exam :-

1. The recommend heat treatment process for the hack saw is : Hardening ✓
2. " " " " " " " car body " : Hardening ✓
3. " " " " " " " I-beams in building : Annealing ✓
4. " " " " " " " Drive half-shaft for a small car : ~~Annealing~~ Hardening ✓
5. The severity of quenching media from high to low can be ranked as follows: 5% caustic soda, 20% brine, cold water, warm water, mineral oil, animal oil, vegatible oil, air, insulating material or furnance.
6. Cooling rate for the solution heat treatment process of Al-copper is : very fast.
7. Cooling rate for the percipitation heat treatment process of Al-copper is : no matter
8. The formation of the graphite into a ball form inductile cast iron : Mg and Carrium.
9. avoid shrinkage are : distortion of the lattice : ~~A result of the formation of a ms-li~~ b and c
10. Major segregation :
11. Minor segregation :
12. Major and inverse segregation :



13. Weldability of Ferrous alloys : plain carbon steel : good, medium carbon steel : Fair, High carbon steel : poor, low alloy steel : fair, High alloy steel : good, stainless steel : weldable, cast iron : varied weldability.