

University of Saskatchewan
ME324.3 Engineering Materials

Mid-Term Examination (C)

Student ID

Instructor: _____

J. Odeshi

Time Allowed: 2 h

October 22, 2008.

1. Answer ALL questions.
2. One formula sheet is allowed but must be turned in with your answer script(s).

| Question 1 - 25 points | Points |
|------------------------|--------|
|------------------------|--------|

a. What do you understand by the term *dislocation*? List 2 sources of dislocation in metallic alloys
- In order for dislocation to occur, plastic deformation must occur. This results in the breaking and reforming of bonds. There are 3 types of dislocation, line, screw, and edge. Dislocation also compromises the strength of a material.

Two Sources: Edge and Screw dislocation!

b. How are strength and dislocation motion in metals related?

The strength of a metal is related to the amount of dislocation motion. The more motion there is, the more ductile and weaker the specimen becomes.

c. Briefly explain slip systems and state how the mechanical property of a metal is determined by the number of slip systems in its crystal structure. A slip system is composed of a slip plane and slip directions. Dislocation occurs along a slip system. The more slip systems there is the more dislocation takes place.

Ductile because extensive plastic deformation is possible when there is a high number of slip systems present.

Brittle if there are a low number of slip systems present.

- d. A zinc single crystal is being pulled in tension with the normal to its slip plane (0001) inclined at 60° to the tensile axis and with the slip direction $[1\bar{1}20]$ inclined at 40° to the tensile axis.
- What is the resolved shear stress, τ acting along the slip direction when a tensile stress of 0.5 MPa is applied?
 - What tensile stress is necessary to reach the critical resolved shear stress (τ_{CRSS}) of 0.90 MPa?
 - What happens when the resolved shear stress along the slip direction in the single crystal becomes greater than the critical resolved shear stress?

i). $\tau_a = \sigma \cos \phi \cos \lambda = (0.5 \text{ MPa}) \cos(60^\circ) \cos(40^\circ)$

$\tau_a = 0.1915 \text{ MPa}$ $\tau_a = 0.19 \text{ MPa}$

ii). $\sigma_y = \frac{\tau_{CRSS}}{\cos(60^\circ) \cos(40^\circ)} = \frac{0.90 \text{ MPa}}{\cos(60^\circ) \cos(40^\circ)} = 2.34973 \text{ MPa}$

$\sigma_y = 2.35 \text{ MPa}$

iii). Yielding will occur when $\tau_a > \tau_{CRSS}$.

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- e. Briefly explain why pure metals are usually weaker than their alloys

Pure metals are usually weaker than their alloys due to a much higher carbon content. This makes the metals very brittle making them susceptible to fracture.

- f. Give one reason why it is more difficult for dislocation to move across grain boundaries than to move within the grains. How is this effect used in strengthening metallic materials?

It is more difficult for dislocation to move across a grain boundary because it will be forced to change direction. This

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g. How is the strength of a metallic material affected by plastic deformation at a temperature below its recrystallization temperature? Give reason for your answer

- The strength of a material will be greatly reduced ~~if~~ this were to happen because the bands would be broken due to plastic deformation, but would not reform because we are below recrystallization temp.

h. What is recrystallization? Can recrystallization occur in a ceramic material? Give reason for your answer. 3

Recrystallization involves the formation of a new set of strain free and equiaxed grains forming low dislocation densities.

3 - Because grain boundaries move during recrystallization, plastic deformation must occur, \therefore This process cannot occur in a ceramic material.

Total Scores for Question 1

17

13

a. Distinguish between iron and steel making processes

3

The iron making process involves the extraction of elemental iron from the ores found in nature. Whereas, the steel making process involves taking the molten pig iron and form various steels.

b. State two functions of limestone in blast furnace reduction of iron ore

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- Limestone attracts the impurities in a blast furnace, which in turn forms slag that floats on top of the molten iron.
- Used as a flux.

c. State two differences between blast furnace reduction and direct reduction of iron ore. Which of the two iron making process will produce pig iron? Why is pig iron considered unsuitable for structural application? Blast Furnace uses coke gas, and limestone to reduce the

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iron ore, whereas DRI the iron is reduced by a reducing gas. Also the Blast Furnace produces pig iron and the DRI produces sponge iron.

- Blast furnace reduction produces pig iron.

- pig iron is too hard and brittle, due to a high carbon content, for engineering purposes. Also it cannot be worked.

d. In terms of carbon content distinguish between steel and cast iron

1

Cast iron has a higher content than steel.

Use the Fe-Fe₃C equilibrium phase diagram in Fig. 1 to answer questions 2e – 2h

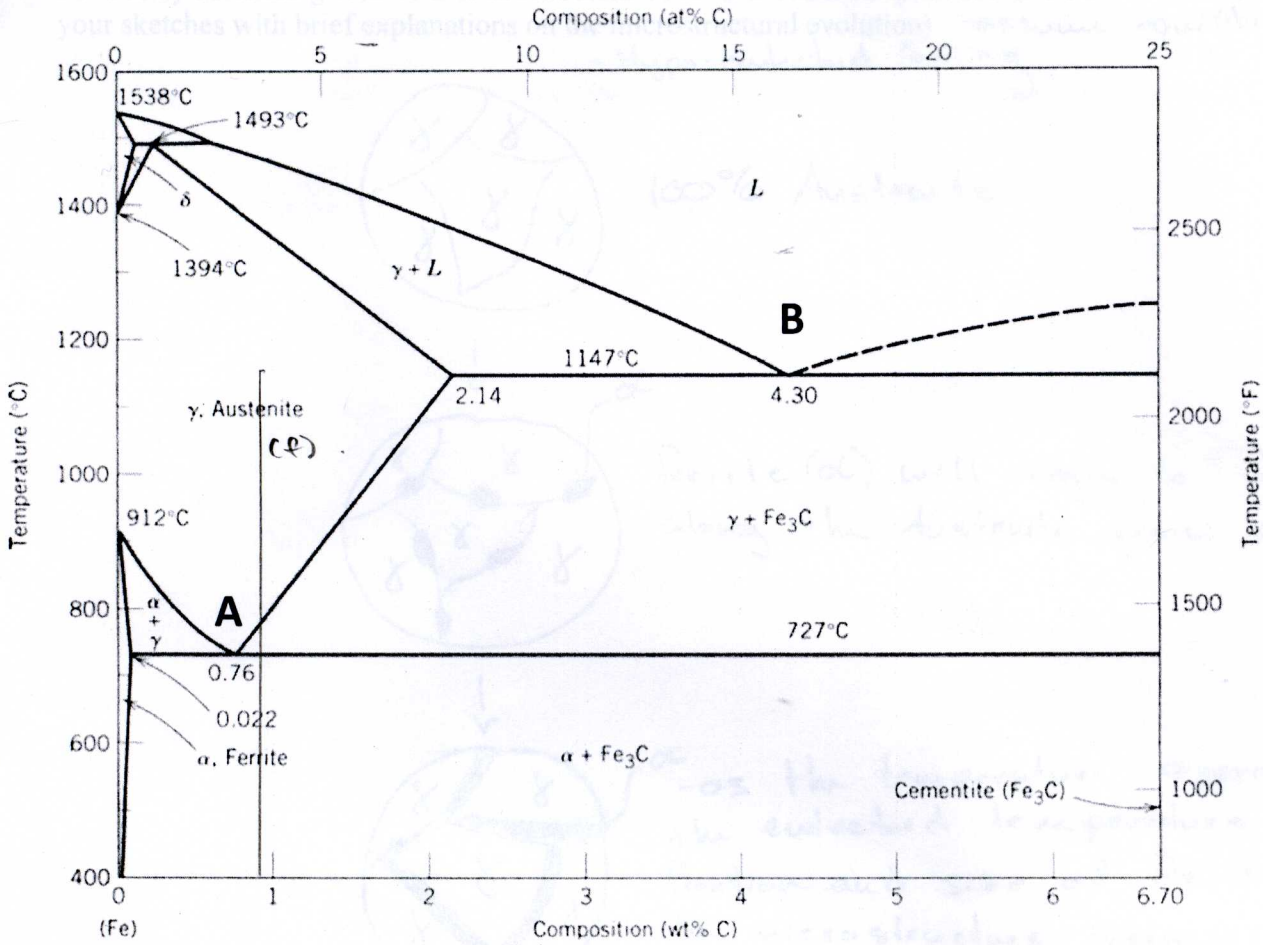
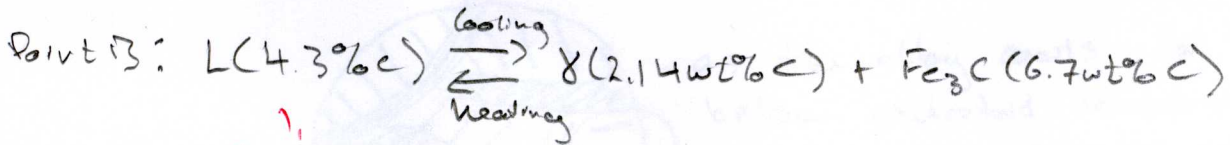
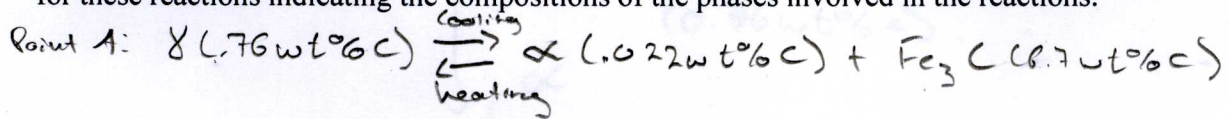


Fig. 1: Fe – Fe₃C equilibrium diagram

e. Name the equilibrium reactions that occur at point A and at point B in Figure 1. Write the equations for these reactions indicating the compositions of the phases involved in the reactions. 3



Name!

2

f. Under what cooling condition can proeutectoid ferrite be obtained in a Fe-C alloy containing 0.85 wt. % carbon? 2

Hyper eutectoid cooling

X

