



UNIVERSITY OF GHANA

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**BSc. (ENG) MATERIALS SCIENCE AND ENGINEERING**

**END-OF FIRST SEMESTER EXAMINATIONS: 2016/2017**

**MATERIALS SCIENCE AND ENGINEERING DEPARTMENT**

**MTEN 411: PHYSICAL METALLURGY II (2 CREDITS)**

**TIME ALLOWED: 2 HOURS**

**Answer ALL Questions**

**ATTACH THE FIGURES TO YOUR ANSWER SHEET**

- 1) Consider the Pb – Sn equilibrium binary phase diagram given in Figure 1 and answer the following questions. An alloy of 60 wt%- Pb and 40 wt%- Sn is slowly cooled from 250 °C to 27 °C.
- a. Is this alloy hypoeutectic or hypereutectic? [2 marks]
  - b. What is the liquidus temperature of this alloy? [2 marks]
  - c. What is the composition of the first solid to solidify? [3 marks]
  - d. What are the amount in mass fraction and composition of each phase which is present at  $(183 + \Delta T)$  °C and  $(183 - \Delta T)$  °C? Where  $\Delta T$  is undercooling. [14 marks]
  - e. Sketch and label the microstructures at these two temperatures in 1(d). [4 marks]
- 2) a. Give a brief description of the following steel types and give an example each of their property and application [20 marks]
- i) Medium carbon steels
  - ii) Tool steels
  - iii) Hot-work steels
  - iv) TRIP steels
  - v) Mold steels

b. Explain the following terms:

[16 marks]

- i) Normalizing
- ii) Stress relieving
- iii) Austempering
- iv) Full annealing

3) a. As a Metallurgist working for a steel factory, you are approached to design steels based on Figures 2, 3, and 4. Provide approximate temperatures and times and sketch probable microstructure.

- i) A martempered AISI 1050 steel to produce a hardness of 62 HRC. [5 marks]
- ii) An austempered AISI 10110 steel to produce a hardness of 40 HRC. [5 marks]

b. Differentiate between martensite and bainite based on processing temperature, hardness range, microstructure, quenching media and crystal structure for a eutectoid steel. Follow the format in Table 1. [10 Marks]

Table 1: The Martensite - Bainite comparison

Steel	Process Temp.	Hardness range	Microstructure	Crystal structure	Quenching media
Martensite					
bainite					

c) Recommend temperatures for type AISI 10145, 1050, and 1090 steels for normalizing, spheroidizing, and process anneal using Figures 2 & 4. [9 marks]

4) a. Write short notes on ferritic, duplex and austenitic stainless steels. [9 marks]

b. i) Aluminum alloys have three main classifications based on use and method of strengthening, name them. [6 marks]

ii) What is a GP zone? [2 marks]

iii) In the Al industry, the casting of this metal is based on grain refinement. Explain the practical steps for the refinement process and give two elemental examples. [3 marks]

Index No.....

Signature.....

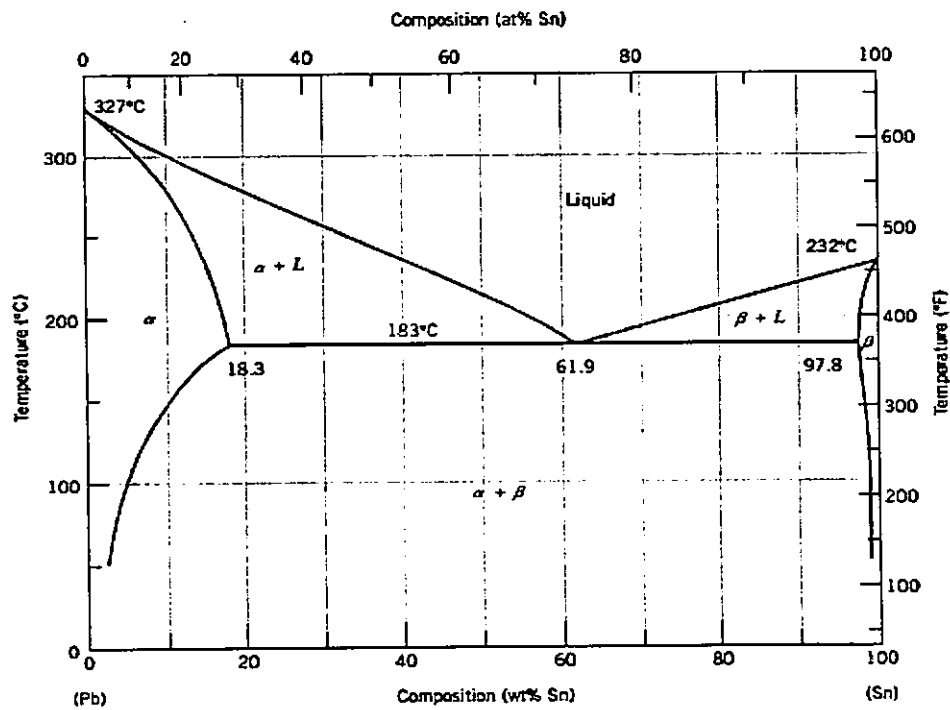


Figure 1: The Pb - Sn phase diagram (Askeland et al., 2010).

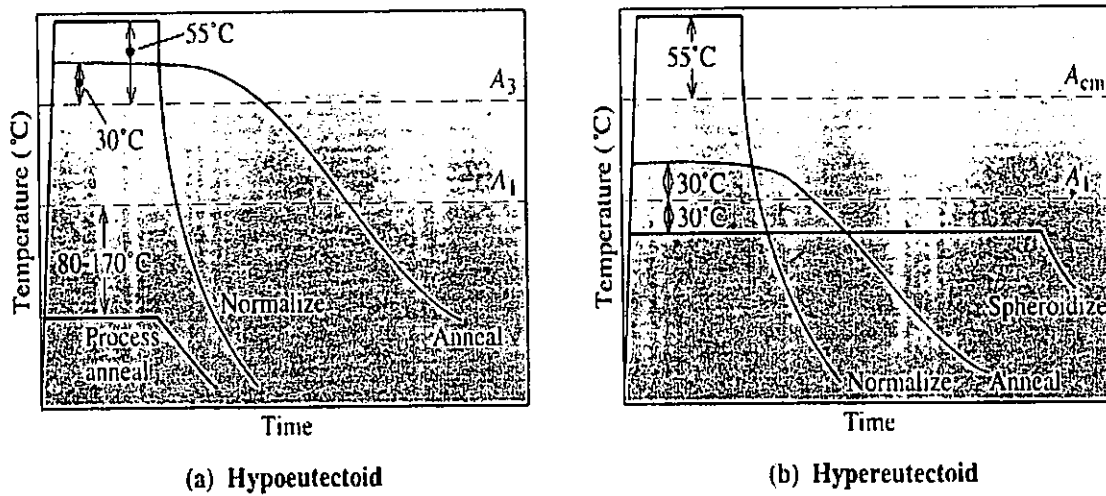


Figure 2: Hypo and hypereutectoid HTs (Askeland et al., 2010).

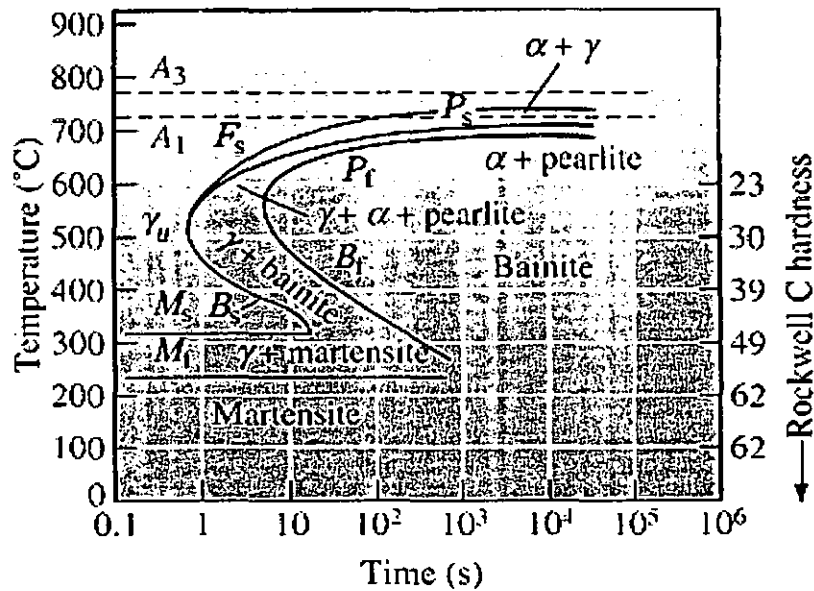


Figure 3: The TTT diagram for a 1050 steel (Askeland et al., 2010).

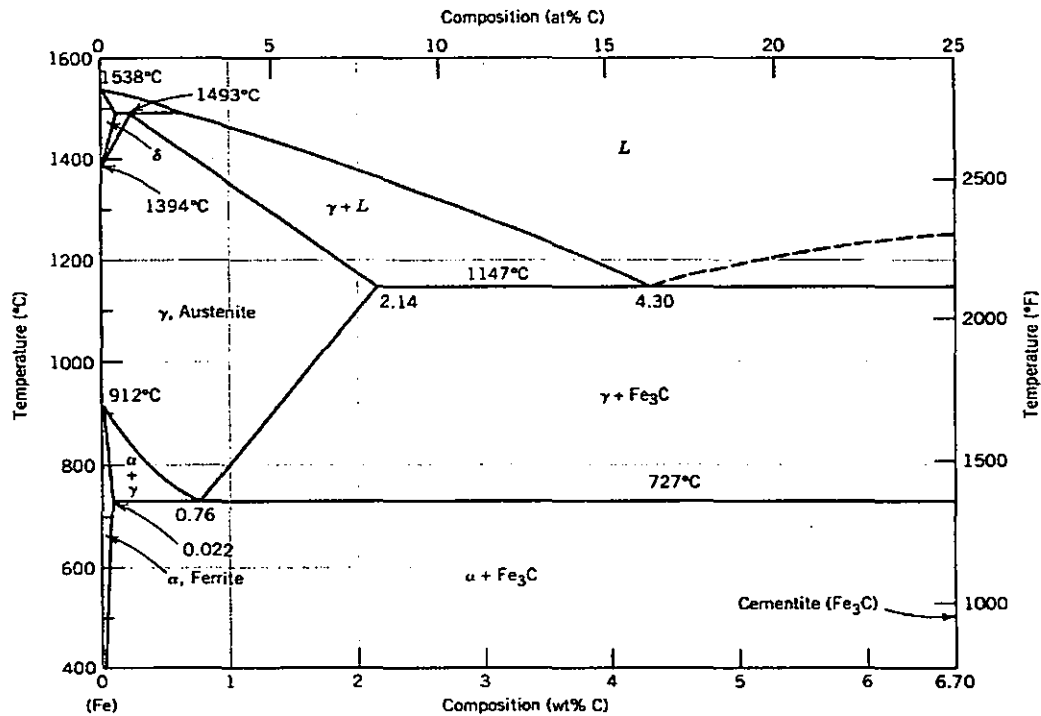


Figure 4: The Fe - C phase diagram (Callister and Rethwisch, 2014).