



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: February 2023

Module Number: ME3304

Module Name: Metallurgy for Engineers

[Three Hours]

[Answer all questions, each question carries 12 marks]

- Q1. a) Time Temperature Transformation (TTT) diagram is a plot of temperature versus the time for a metal alloy of definite composition and use to determine when transformations begin and end of a previously austenitized alloy.
- TTT diagram for 0.76% carbon steel is as shown in **Figure Q1(a)**. Describe the cooling paths 1, 2, 3 and 4. Phase formation during each step should be clearly mentioned.
[4.0 Marks]
 - Sketch microstructure of the above carbon steel at point D, E and F during cooling along path 1. Name the phase/es clearly.
[3.0 Marks]
- b) Mechanical properties such as hardness, ductility, wear resistance, etc., of most of the alloys can be altered by using heat treatments.
- Briefly discuss the difference between *bulk heat treatments* and *surface heat treatments* that can be applied to increase the hardness of steel components. Give one example in each case.
[2.0 Marks]
 - Wear resistance of a 0.1% C steel gear wheel ($\Phi = 20$ cm) is required to improve by heat treatment. Propose a suitable heat treatment to fulfill the above requirement and describe the process in brief.
[3.0 Marks]
- Q2. a) Metal alloy is a substance that combines more than one metal or mixes a metal with other non-metallic elements. Write short notes on following metal alloys.
- Nichrome
 - Nickel silver
 - Alnico
- [6.0 Marks]
- b) Explain briefly the *congruent* and *incongruent* phase transformations in binary phase diagram. Give an example in each case.
[3.0 Marks]
- c) Binary phase diagrams can be divided into three categories depends on the solid solubility of two components. Explain the above using suitable sketches.
[3.0 Marks]

- Q3 a) Corrosion is the deterioration of a metallic material as a result of the interaction with its surroundings and can occur at any point or at any time. Deterioration of the metal is started by forming the electrochemical cell.
- i) Describe the basic requirements for formation of an electrochemical cell.
[2.0 Marks]
 - ii) Discuss briefly the anodic and cathodic reactions occur during corrosion of metals under different environments
[2.0 Marks]
 - iii) States the differences between an electrochemical cell and electrolytic cell.
[2.0 Marks]
- b) "*Indirect cost* associated with corrosion is much higher than that of the *direct cost* associated with corrosion". Explain the above statement by giving appropriate examples.
[2.0 Marks]
- c) i) During construction of metallic structures or fabricating machine components that are likely to be exposed to the corrosive environment, close contact of dissimilar metals is normally avoided. If above criterion is not considered, identify the most probable type of corrosion that occurs in such metallic structures or machine component. Explain your answer with a neat sketch.
[2.0 Marks]
- ii) Discuss briefly the methods that can be applied to prevent / control the corrosion type mentioned in part (i).
[2.0 Marks]
- Q4. a) What is the role of limestone in the extraction process of iron from its oxide, Fe_2O_3 ?
[2.0 Marks]
- b) Among magnetite, hematite, limonite, and siderite, which form of iron ore is used by you for production of pig iron? Provide detailed description for your answer.
[3.0 Marks]
- c) Describe the process of pig iron production process using a clear labeled sketch of the corresponding furnace.
[5.0 Marks]
- d) Production of pig iron in the blast furnace using iron ores followed by two reduction processes called *direct reduction* and *indirect reduction*. Give examples for the reduction reaction in both cases.
[2.0 Marks]

- Q5. a) Differentiate between destructive and non-destructive tests of engineering materials. [2.0 Marks]
- b) Define the following Mechanical properties by using a typical stress-strain curve of a metallic material. [4.0 Marks]
- i) Strength
 - ii) Tensile strength
 - iii) Toughness
 - iv) Ductility
- c) After cold-working process, metals need to be annealed for releasing internal stresses or enhancing the ductility for further cold-working. Discuss the microstructural changes during *recovery*, *recrystallization*, and *grain growth* of cold-worked medium carbon steel sheet by using clear sketches. [3.0 Marks]
- d) Define the terms *slip plan* and *slip systems*. [1.0 Mark]
- e) Compare the differences between *slip* and *twinning* processes in metallic materials. [2.0 Marks]

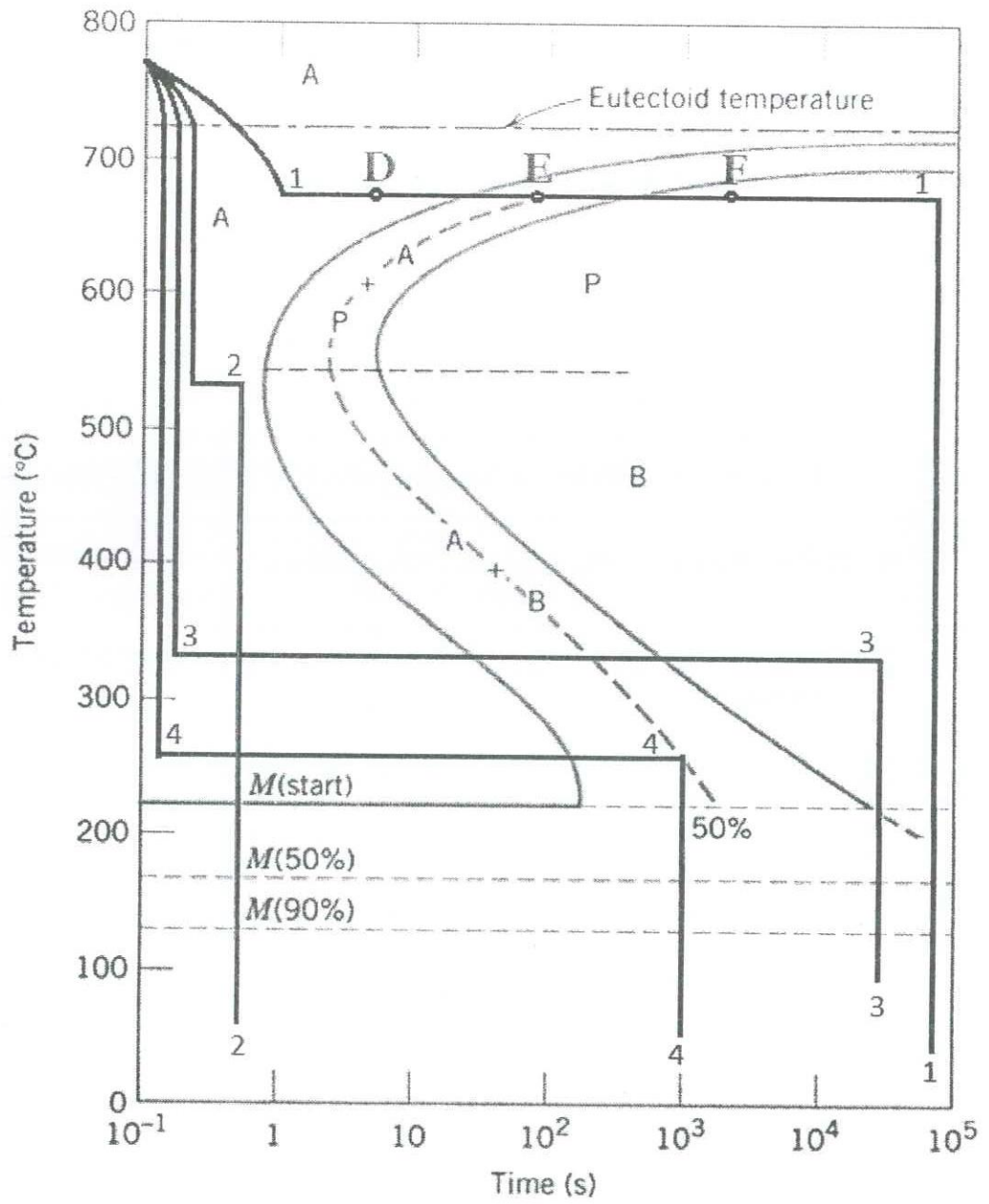


Figure Q1(a)