



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: July 2022

Module Number: ME3304

Module Name: Metallurgy for Engineers

[Three Hours]

[Answer all questions, each question carries 12 marks]

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- Q1. a) Sketch a named diagram of a Blast Furnace which produces pig iron. What are the reactions which can be taken place inside of the furnace? [4.0 Marks]
- b) **Figure Q1** shows an electric arc steel making furnace, describe the process of it. [4.0 Marks]
- c) What are the advantages and the disadvantages of above mentioned process? [2.0 Marks]
- d) What are the suggestions to improve the process mentioned in **Figure Q1 (b)**? (Consider the efficiency, wastages, etc.) [2.0 Marks]
- Q2. a) What is the difference between interstitial solid solution and substitutional solid solution? [2.0 Marks]
- b) How can plain carbon steel be classified? Write three applications of each. [4.0 Marks]
- c) What are the effects of adding alloying elements to the steel? [2.0 Marks]
- d) Write a note on "Stainless steel" (Properties, types and uses, etc.). [4.0 Marks]
- Q3. Microstructure of steels can be altered by heating the steel components at different temperatures without changing the composition. This will enhance the mechanical properties of steel.
- a) List the major factors to be considered before heat treatment of steel components. Explain briefly the effect of **one of them** on properties of the steel component after the heat treatment process. [3.0 Marks]
- b) Discuss the differences between **full annealing** and **quenching** heat treatment processes of medium carbon steel by paying attention on application, processing conditions and resulting microstructure. [4.0 Marks]

c) **Figure Q3 (c)** shows the Fe-Fe₃C phase diagram. Based on the diagram, answer the following questions.

i) Find the **eutectic composition, eutectic temperature** and write down the **eutectic reaction**.

[1.0 Mark]

ii) Find the maximum solubility of carbon in ferrite and austenite phases.

[1.0 Mark]

iii) Sketch microstructure for a steel sample contains 1.75 wt% of C under equilibrium cooling at 1100°C, 800°C and 500°C. Label all the phases.

[3.0 Marks]

Q4. a) Knowledge and understanding of phase diagrams are important to the mechanical engineers. Explain briefly the statement.

[2.0 Marks]

b) Define the terms **component** and **phase**. Give example for each.

[2.0 Marks]

c) Construct the binary phase diagram for alloy containing metal A and B between 200°C and 1200°C using following information. (Use graph sheet provided to plot the phase diagram)

Melting temperature of metal A is 1100°C.

Melting temperature of metal B is 900°C.

Eutectic reaction occurs at 700°C and at the composition of 60 wt% B - 40 wt% A.

Maximum solubility of B in A is 25 wt% B, which occurs at 700°C.

Maximum solubility of A in B is 80 wt% B, which occurs at 700°C.

Solubility of B in A at 300°C is 5 wt% B.

Solubility of A in B at 300°C is 95 wt% B.

[6.0 Marks]

d) Name all phase regions, solvus line and solidus line in the phase diagram constructed in part (c).

You may use following information.

α - Solid solution of B in A

β - Solid solution of A in B

L - Liquid

[2.0 Marks]

Q5. Corrosion is the gradual destruction of metallic materials and finally the catastrophic failure of the metallic structure by chemical or electrochemical reaction with their environment.

a) Identify the type of corrosion in the following situations and explain. Your answer should be clearly mentioned the anodic area, cathodic area, anodic reaction and cathodic reaction in each case. Use clear sketches whenever possible.

i) When two large copper plates fixed with a small steel nut and bolt as shown in **Figure Q5 (a)-i**

ii) When two steel plates fixed with a steel nut and bolt as shown in **Figure Q5 (a)-ii**

[4.0 Marks]

b) Write short notes on followings;

i) Weld decay in welded austenitic stainless steel sheets.

ii) Knife-line attack (KLA) in welded stabilised austenitic stainless steel sheets.

[4.0 Marks]

c) Discuss briefly the properties and applications of two nickel alloys of **Nichrome** and **Nitinol**.

[4.0 Marks]

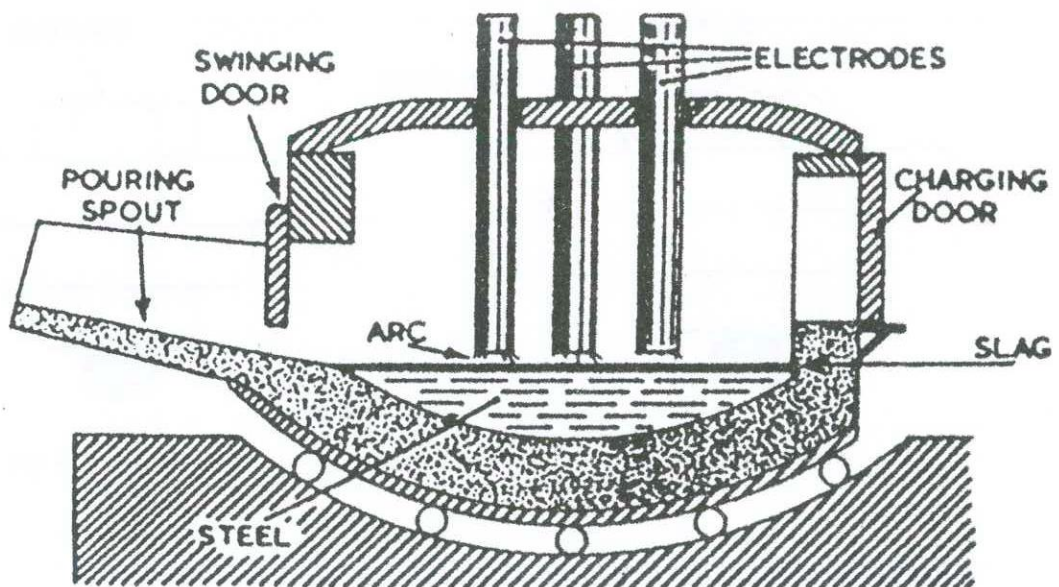


Figure Q1

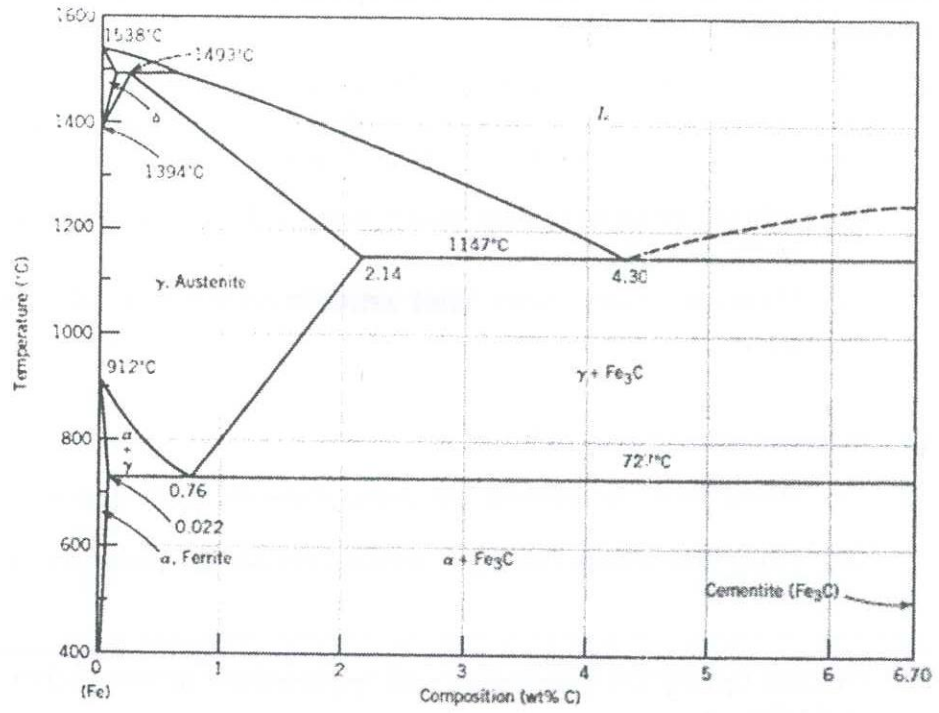


Figure Q3 (c)

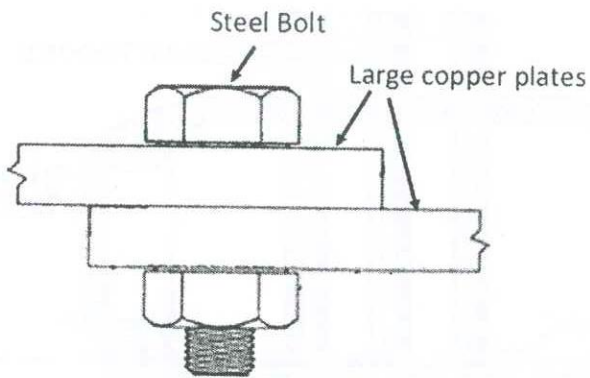


Figure Q5 (a)-i

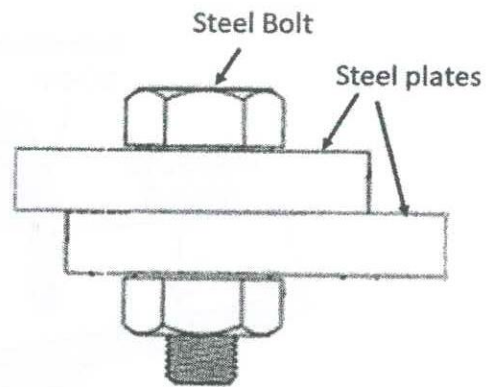


Figure Q5 (a)-ii