



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: July 2016

Module Number: ME 3302

Module Name: Metallurgy for Engineers

[Three Hours]

[Answer all questions, each question carries 12 marks]

- Q1. a) i) Define the Pilling-Bedworth Ratio.
ii) Express the Pilling-Bedworth Ratio in terms of molecular weight of metal oxide and atomic weight of metal with other usual notations.
iii) Given the following metal-Pilling-Bedworth Ratio (PBR) combinations (Table Q1), select metals which are not expected to form protective oxide coatings? Explain your answer.

[4 Marks]

Table Q1

Metal	PBR
Aluminum	1.28
Copper	1.68
Lithium	0.57
Molybdenum	3.40
Iron	2.10
Magnesium	0.81

- b) Write notes on "Design considerations for corrosion prevention". Use suitable diagrams to illustrate your answer whenever possible.
- c) Propose and describe the most appropriate method (with a neat sketch) to protect an underground steel pipeline from corrosion.
- d) Compare the differences between Electrochemical cell (Galvanic cell) and Electrolytic cell.

[3 Marks]

[3 Marks]

[2 Marks]

- Q2. a) Coke and Limestone are used in blast furnace for smelting iron ores. Briefly discuss the functions of coke and limestone during pig iron production.

[4 Marks]

- b) Compare grey and malleable cast irons with respect to composition, microstructure, and mechanical properties.

[4 Marks]

c) Steels are made by different methods using pig iron. List four different steel making processes.

[2 Marks]

d) What are the roles of slag in steel making?

[2 Marks]

Q3. a) i) Define grain and grain boundary.

ii) How does the presence of grain boundary affect the physical and mechanical properties of materials?

[3 Marks]

b) Write short notes with neat sketches on

i) Ductile-brittle transition and how to measure the transition temperature

ii) Creep failure in metallic materials

iii) *Hot shortness* in hot rolled steel sheet

[6 Marks]

c) Fracture of the materials can be divided into brittle or ductile. Discuss the differences between brittle and ductile fractures by using appropriate examples.

[3 Marks]

Q4. a) List three different types of strengthening mechanisms available for strengthening of materials and explain one of them briefly.

[3 Marks]

b) Differentiate followings using appropriate diagrams.

i) Toughness and Hardness

ii) True stress-strain curve and Engineering stress-strain curve

iii) Slip and Twinning

[6 Marks]

c) Discuss the microstructure development during recovery, recrystallisation and grain growth of cold-worked mild steel sheet from an engineering view point.

[3 Marks]

Q5. Heat treatments are extensively used in various industries to enhance the physical and mechanical properties of metallic materials.

a) List four different types of heat treatment methods which are carried out to alter the **properties of surface** of metallic materials and discuss one of them.

[4 Marks]

b) Using Figure Q5, draw microstructures which are developed under equilibrium cooling from austenite region for the following steels. Name all the phases.

i) Steel containing 1.50% of carbon (At the points: A, B and C)

ii) Steel containing 0.76% of carbon (At the points: D and F)

iii) Steel containing 0.40 % of carbon (At the points: G, H and J)

[4 Marks]

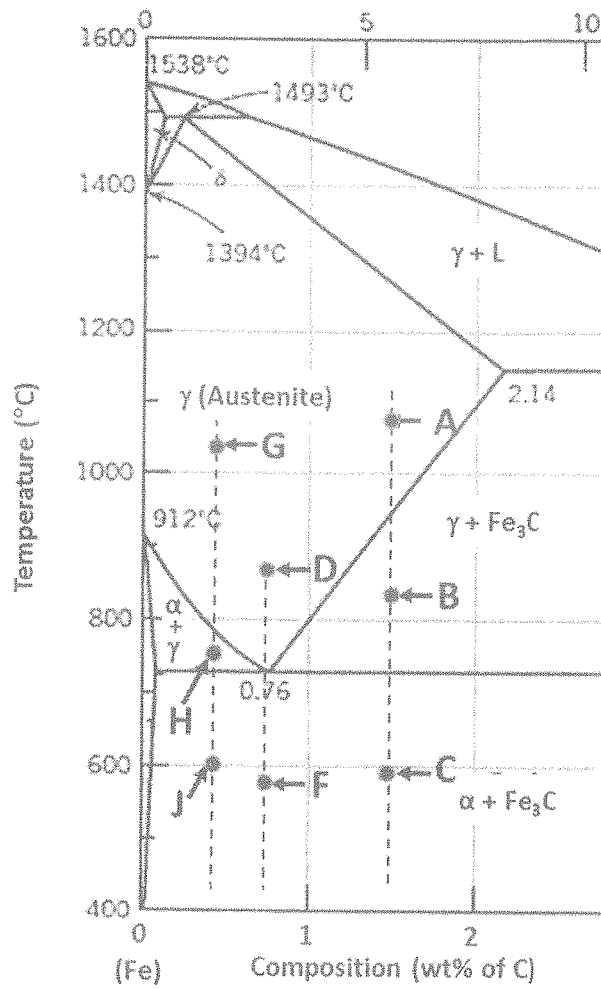


Figure Q5: Part of the Iron-Iron carbide (Fe_3C) diagram

- c) i) What do you mean by TTT diagram?
- ii) Briefly explain the phase transformations in 0.76% carbon steel (eutectoid steel) which is cooled from 800°C (austenite region) to room temperature at different cooling rates using TTT diagram.

[4 Marks]